

# Turbo Expo 2007: Aircraft Engine Panel Session Engine Icing Research (WC-1-5)

***Facility  
Requirements &  
Gaps***

***Research  
Opportunities***



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# Facility Requirements and Gaps

- Requirements: for ice crystals
  - Ability to faithfully replicate ice crystals that represent particle properties and atmospheric conditions associated with engine ice crystal events (*conditions of high ice water content that are possible in proximity to deep convective cloud and tropical storms*)
  - Instrumentation to measure ice crystal properties and define facility icing conditions performance
  - Capability to measure and record ice crystal formation mechanisms within an engine
  - Engineering development of test methods and scaling laws that translate ice crystal atmospheric conditions into sea-level (or atmospheric) facility operations for design and certification use

# Facility Requirements and Gaps

Gaps - for ice crystals. There are significant technical challenges in developing capabilities to simulate these atmospheric conditions.

Research history in icing has been principally been invested in Appendix C conditions in general, and hail and snow for Part 33. We need solutions for:

- Instrumentation
- Ice crystal/mixed phase delivery systems
- Test techniques
- Scaling methods

# Facility Requirements and Gaps

## Gaps - challenges

- Instrumentation
  - Measurement capabilities for ice crystal particles (larger sizes, non-spherical, etc.) and higher speed operations
- Particle delivery systems - shaver and/or nozzle
  - Content - very high delivery rates
  - Size, shape, distribution, and temperature control
  - Residence time - cooling effects and particle temperature stability
- Test methods
  - High speed, close up imaging to capture formation mechanisms
  - Scaling: sea level to altitude transfer function
  - Test techniques for routine ice crystal ingestion operations

# Research Opportunities

AIRA Mission: *... coordinate the conduct of collaborative aircraft icing research activities that improve the safety of aircraft operations in icing conditions.*

- Facilitate partnering for pre-competitive, mutually beneficial research tasks
  - leveraging both resources and expertise with other national organizations and industry
  - Shared need in research, complementary expertise
  - No exchange of proprietary or Export Control sensitive technology
  - Shared intellectual property and data rights

# Research Opportunities

- Example: Ice crystal characterization methods
  - Instrumentation adaptation and development of new measurement techniques to identify, catalog, and analyze ice crystal atmospheric properties and climatology of convective weather systems
  - AIRA Participants: EC, NASA, and NRC (also Cox and Company, the FAA, and Scientific Engineering Associates)
  - Shared technical plans between AIRA members and the FAA for developing instruments capable of measuring crystal content, size, distribution, and cloud properties
  - Partnering on significant technical challenges to adapt and develop instrumentation for flight and ground simulation use

*This group is in second year of development effort. They have identified performance and design limitations on a number of existing sensors and have embarked on development of new technologies to overcome measurement limitations.*

# Research Opportunities

1. Study of ice crystal formation mechanisms inside engine
  - Experimental studies
    - Flat plate and/or single blade static model testing
    - Cascade testing
    - Rotating rig
  - Imaging methods and non-intrusive means to capture formation visual record and aero-thermodynamic variables
2. Ice crystal delivery systems for ground facilities
3. New instrumentation development for measuring ice crystals

# Questions ?

