National Aeronautics and Space Administration

PROPULSION SYSTEMS LABORATORY (PSL) ENGINE ICING MODIFICATIONS GLENN RESEARCH CENTER

Thomas R. Hoffman – PSL Facility Manager

Objectives

- Establishment of a ground-based, ice-crystal environment, engine test capability that includes altitude effects.
- Better understanding of how ice accretes inside an engine and how it effects engine performance and operability.
- Investigation of test methods and techniques that enables the effective and efficient study of engine icing due to ice-crystals along the path of airflow through the core of an engine.
- Development of validation sets required to enable the creation of a system of computer codes that can be specifically applied to assess engine icing susceptibility, as well as engine performance, and operability effects.
- Collaboration with industry partners to utilize system to meet objectives.

Technical Challenges

- Design and build an icing system that is versatile so it can be refined to meet developing engine icing requirements.
- An assessment of PSL's capability to simulate conditions that lead to engine core icing events.
- The establishment of conditions inside the engine under which ice can accrete, both before and after accretion occurs at a given point in the simulated flight trajectory (altitude).
- Test methods for conducting pertinent engine core icing tests in PSL.
- The creation of methods and techniques needed to measure/monitor engine core ice accretions.
- A knowledgebase of engine core icing from which engineering tools to address the problem can be further developed.

Technical Approach

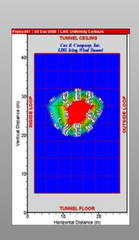
Icing system was designed and built to requirements established by collaboration with industry and government experts

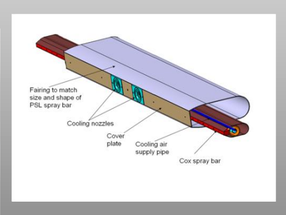
Icing System Requirements

Specification	Minimum	Maximum
Altitude (pressure)	4000 ft	40,000 ft
Inlet Total Temperature	-60°F	15°F
Mach Number	0.15	0.80
Air Flow Rate	10 lbm/sec	330 lbm/sec
IWC (icing water content)	0.5 g/m^3	9.0 g/m^3
MVD (median volumetric diameter)	40µ	60µ
Run Time	Continuous up to 45 minutes	

Analysis

Proof of concept tests, instrumentation evaluation and PSL simulation were performed at Cox & Co icing wind tunnel.



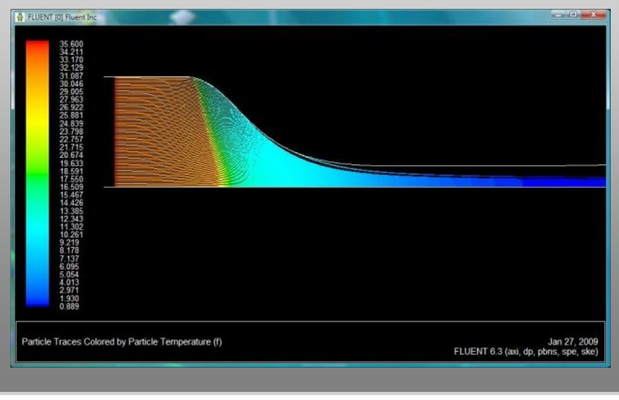


Spray Bar Prototype

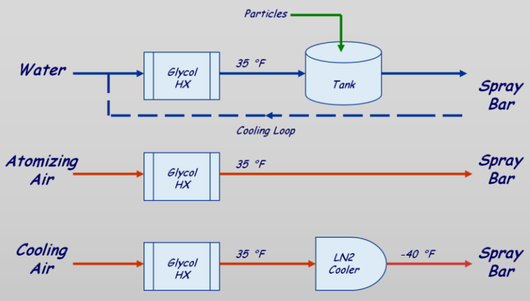
Instrumentation Evaluation

Analysis

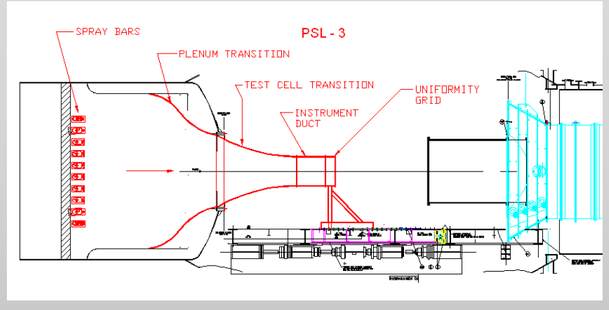
Computer simulation using Fluent software was performed and evaluated by NASA and Cox and Co.



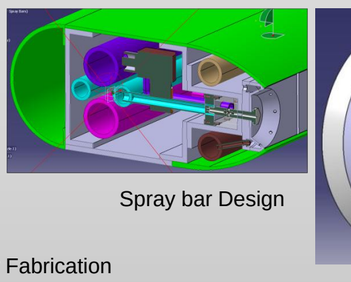
Results



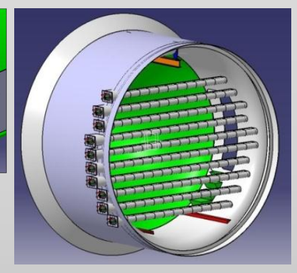
Subsystem Design and Installed Hardware



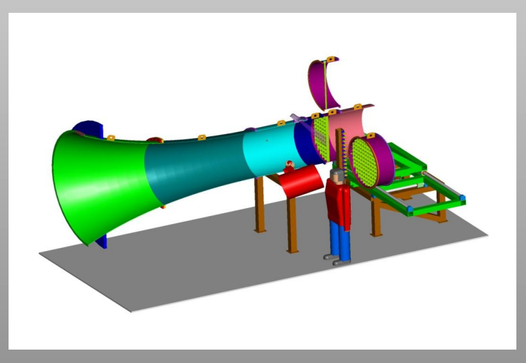
Test Cell Layout



Spray bar Design



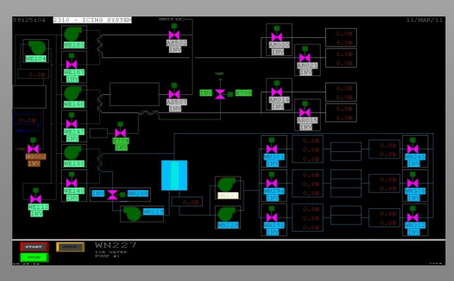
Spray Bar Fabrication



System Calibration Concept

System Control Displays

Spray Bar Controls



Icing System Controls

Spray Bar Nozzle Pattern Control

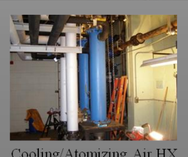
Water Tank

Air Dryer

Glycol Chiller

Outside Test Cell
Water Supply and Return Pipe
Atomizing and Cooling Air Supply

Controls



Cooling/Atomizing Air HX

Progress/Plan

- **Main Icing System Installation** (complete 6/2011).
  - Construction at 90% complete.
  - Spray bar installation nearly complete.
- **Test Cell Calibration/Engine Transition Hardware** (complete 11/2011).
  - Fabrication set to begin.
  - Includes instrumentation, camera systems.
- **Integrated Systems Test** (complete 1/2012)
  - Systems Checkouts.
  - Full up Icing System Integrity and Check.
- **Calibration Test** (complete 6/2012).
  - Verify Requirements are met and easily achievable
  - Document System Capabilities.
- **Validation Test** (start 10/2012).
  - Seeking a cooperative test with engine manufacturer
  - Validate against existing flight data.