

# **BA609 ICE PROTECTION SYSTEM CERTIFICATION PROCEEDING TO FLIGHT TESTING**

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Fort Worth, Texas**



# SUMMARY

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- Aircraft description
- DR&O, missions
- Certification basis : Mix of 23, 25, 29 and TR
- IPS description
- Icing tunnel tests
- A&M scale model testing
- Clear air ice shapes system demonstration
- HISS testing objectives
- Planning for natural icing flight test

# Design Features

## Sub-Systems

- Triplex 3000 psi Hyd Sys
- 3 DC GENS + 28AhBatt
- 2 PMG's + 2 FCC BATT's
- 2 AC GENS

## Power Plant

- PWC PT6C-67A
- 1940 shp - T/O SHP
- 30-sec ,2 min OEI Rating

## Fuel System

- 370 gal capacity
- 10 crashworthy cells



## Ice Protection

- Rotor Anti-ice / De-ice
- Wing De-ice Boots
- Windshield Heated
- Engine inlet de-ice boots and inertial bypass system
- Automatic Control System

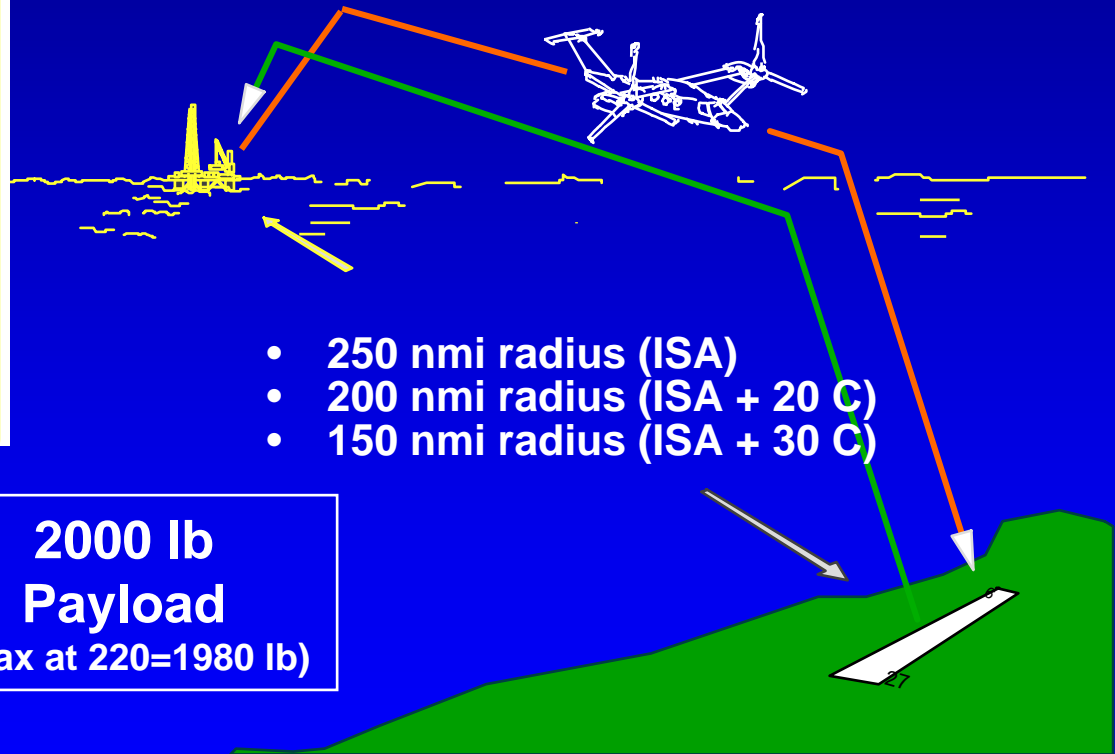
## Flight Controls / Avionics

- Triplex Digital FBW FCS
- Collins Proline 21 Avionics
- Dual Pilot IFR

## Fuselage

- Composite Pressurized Fuselage
- 3 Emergency Exits
- Vapor Cycle Air Conditioning
- Crashworthy Seating
- 50 cu.ft. Baggage Compartment

# Oil Rig to Runway Operation

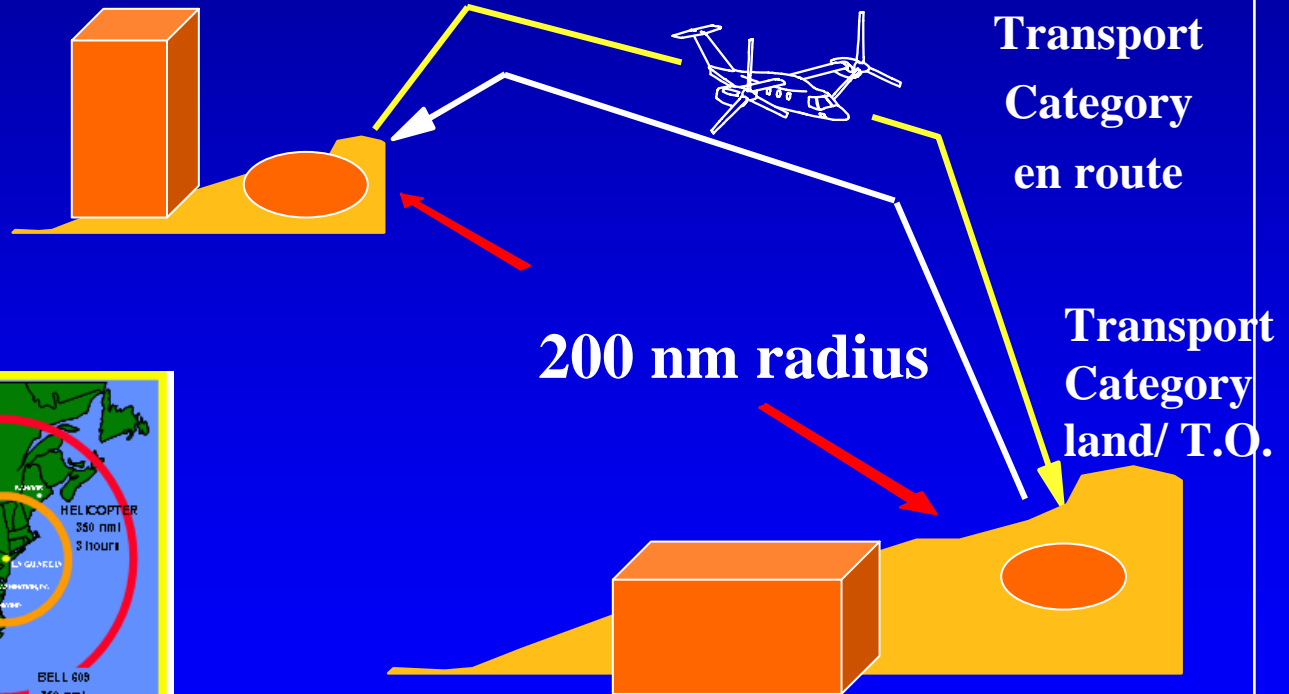


- 250 nmi radius (ISA)
- 200 nmi radius (ISA + 20 C)
- 150 nmi radius (ISA + 30 C)

**2000 lb  
Payload**  
(9pax at 220=1980 lb)

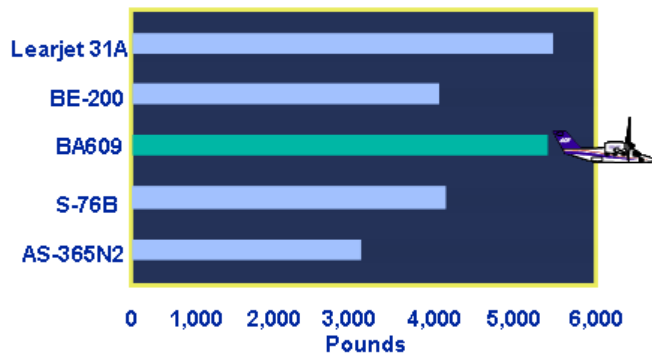
# Helipad Operation

**Transport Category (60x60) Pad**  
**Vertical**  
**6 pax @ 220 lbs**  
**ISA+20 DEG C day**

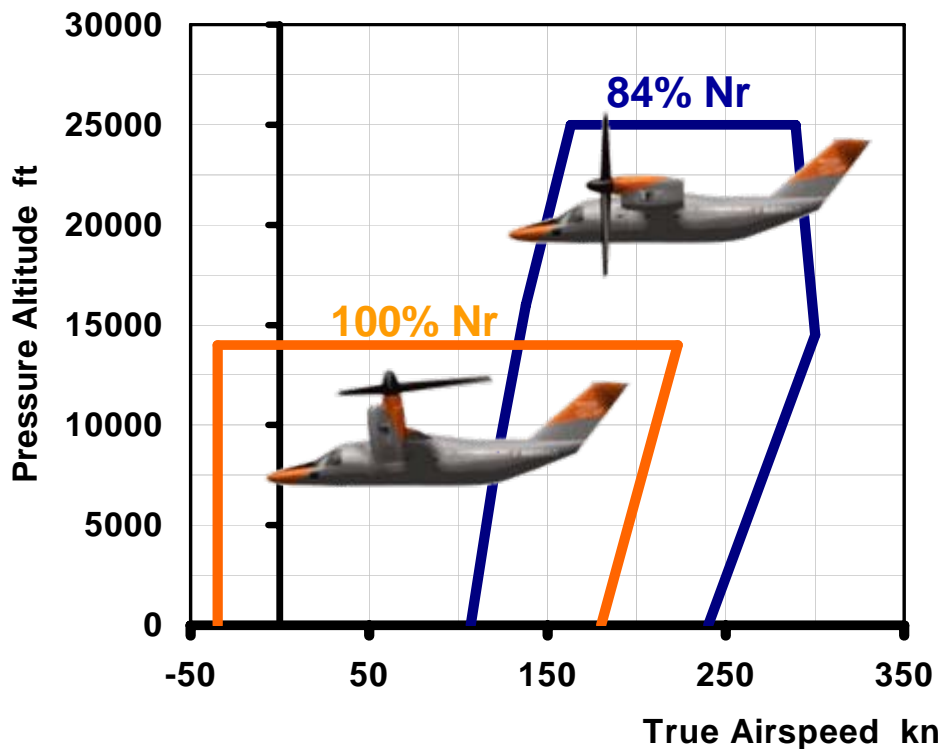
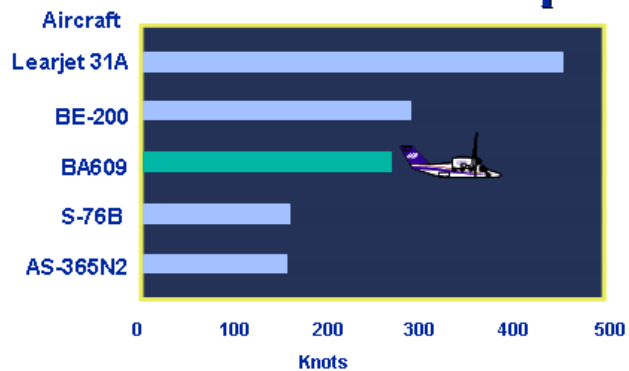


# Flight Envelope

**Useful Load**

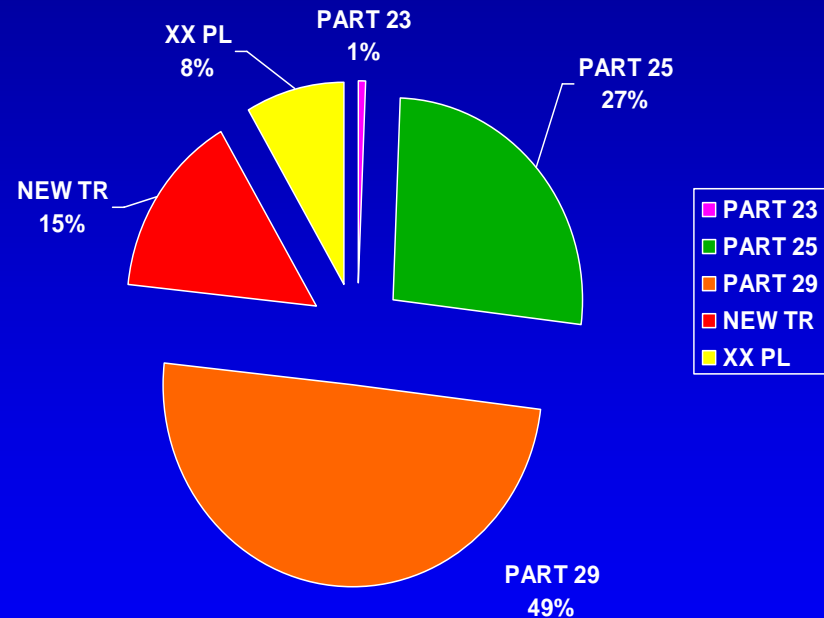


**Maximum Cruise Speed**



# Civil Certification

- **Powered Lift Category, Tiltrotor Class Aircraft designed to Transport Standards**
  - Dual pilot IFR/Flight into known icing/Flight >50nm over water.
  - Transport and Normal Category Performance
- **Concurrent FAA Type Certification & EASA Type Validation underway.**



Total BA 609 Current Certification Basis

# Ice Protection Specific Certification Plan

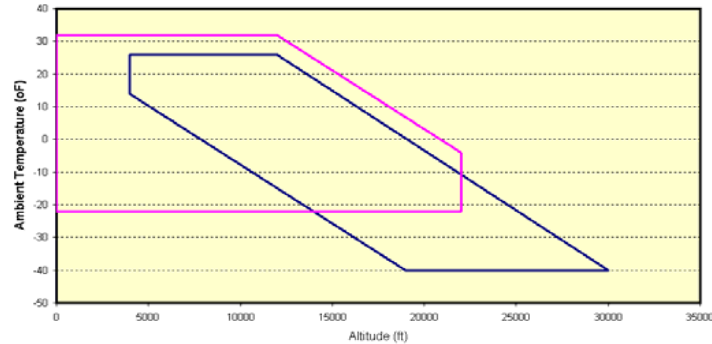
The Bell Model BA609 Tiltrotor is to be certified by the Federal Aviation Administration (FAA) Southwest Region, Rotorcraft Directorate, Rotorcraft Certification Office (ASW-170). This aircraft is to be certified to the applicable design requirements of FAR Part 25, Transport Category Airplanes; FAR Part 29, Transport Category Rotorcraft (Category A); and Special Tiltrotor Requirements.

Subpart F - Equipment	Safety Equipment	29.1419 Ice protection.	XX.1419 Ice protection.	25.1419 Ice protection
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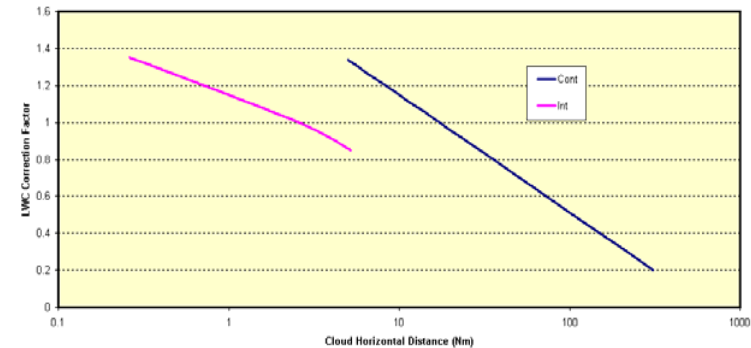
**TR.69, TR.103, TR.143, TR.251, 25.629, 25.773, 25.775, 25.875, TR.875, 29.901, 25.929, 29.939, 29.951, 29.975, 29.997, 29.1041, 25.1093, 29.1093, 29.1301, 29.1305, 29.1323, 29.1325, 25.1326, 25.1403, TR.1416, 25.1419, 25.1455, TR.1505**

# Design Icing Envelope

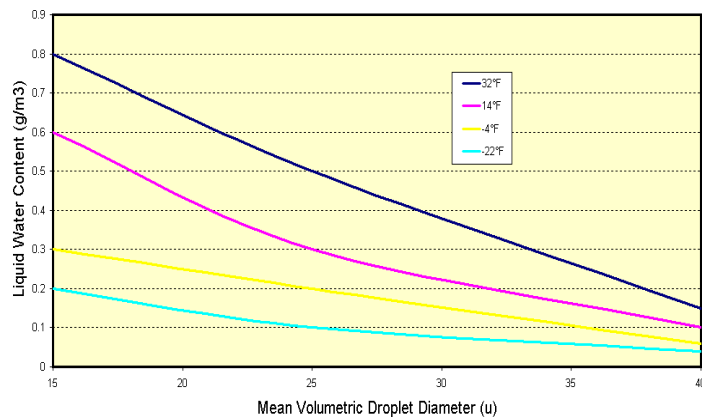
**Appendix C, FAR 25 Maximum Atmospheric Icing Conditions**



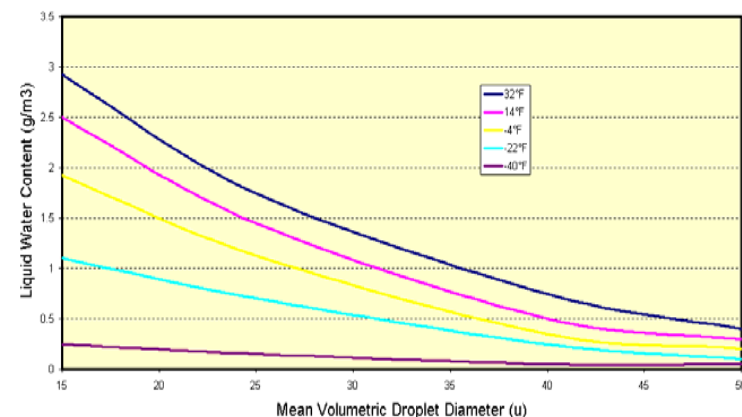
**Liquid Water Content Factor vs Continuous Maximum Horizontal Distance**



**Appendix C FAR25 Continuous Maximum**



**Appendix C FAR25 Intermittent Maximum**



# Appendix X (Draft)

- **Primary ice detectors :**

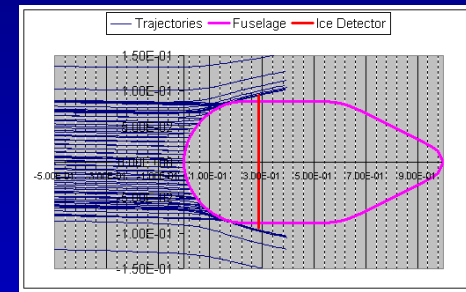
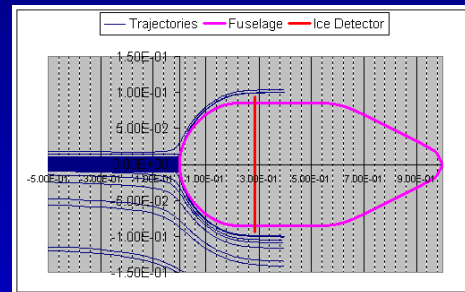
- Located to include Appendix X detection

- **Visual cues :**

- Side windows
- Wing/Spinner
- Wing inspection light

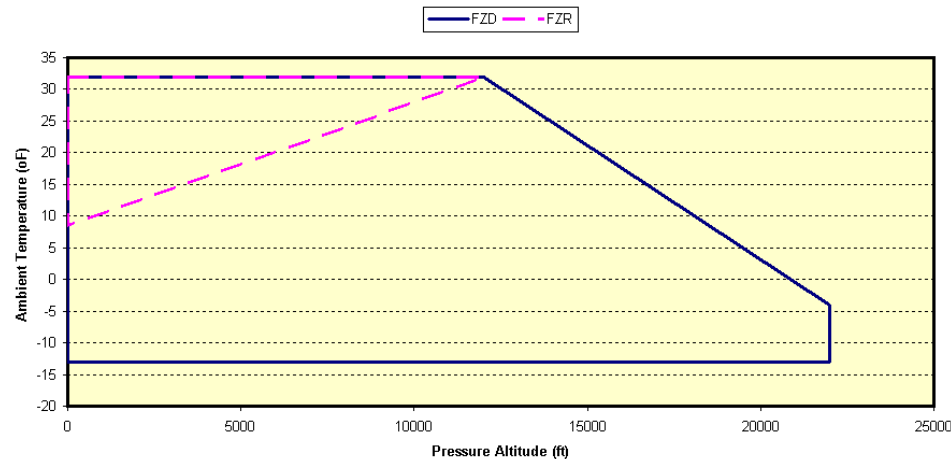
- **Safe exit :**

- Failure mode



### Draft Appendix X Temperature and Altitude

Max vertical extent : 7,000ft  
Horizontal extent : 17.4 nm



# Icing Certification; Part 25 vs 29

Subpart F - Equipment	Safety Equipment	29.1419 Ice protection.	<del>XX.1419</del> Ice protection.	25.1419 Ice protection
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## §29.1093 Induction System Icing Protection

### (b) Turbine engines

(1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)-

(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in Appendix C of this Part; and

(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.

## §25.1093 Induction System Icing Protection

### (b) Turbine engines.

(1) Each turbine engine must operate throughout the flight power range of the engine (including idling), without the accumulation of ice on the engine, inlet system components, or airframe components that would adversely affect engine operation or cause a serious loss of power or thrust--

(i) Under the icing conditions specified in appendix C, and

(ii) In falling and blowing snow within the limitations established for the airplane for such operation.

# Icing Certification; Part 25 vs 29

## •29.1093(b)(ii) and AC29-2C :

- Holding capability : 30 min
- Time to exit icing : 15 min
- Inadvertent icing :
  - In practice, natural icing may pose unacceptably severe problems for helicopter not equipped with rotor ice protection

## •25.1093(b)(1) and Draft AC25-XX :

- Holding capability : 45 min/3in**
- Time to exit icing : 22.5 min/1.5in
- Inadvertent icing :
  - Three natural fan sheds
  - Requires tanker or natural icing tests

## •AC23.1419 2c :

- Failure detection**
- Crew decision + ATC notification**
- Exit = 180o turn + 46 nm**

# Snow Certification; Part 25 vs 29

## •29.1093(b)(1)(ii) and AC29-2C :

### •List

- Ground (20 min),
- IGE Hover (5 min),
- Level Flight (1 hr),
- Descent and Landing

### •Conditions

- Visibility <1/4 mile
- OAT between 25oF to 34oF

### •Limitations

- Not appropriate to include time limitations for level flight

## •25.1093(b)(1)(ii) and AC25-XX :

### •List

- Taxi,
- Taxi/Hold,
- Takeoff,
- Cruise,
- Holding,
- Descent and Landing

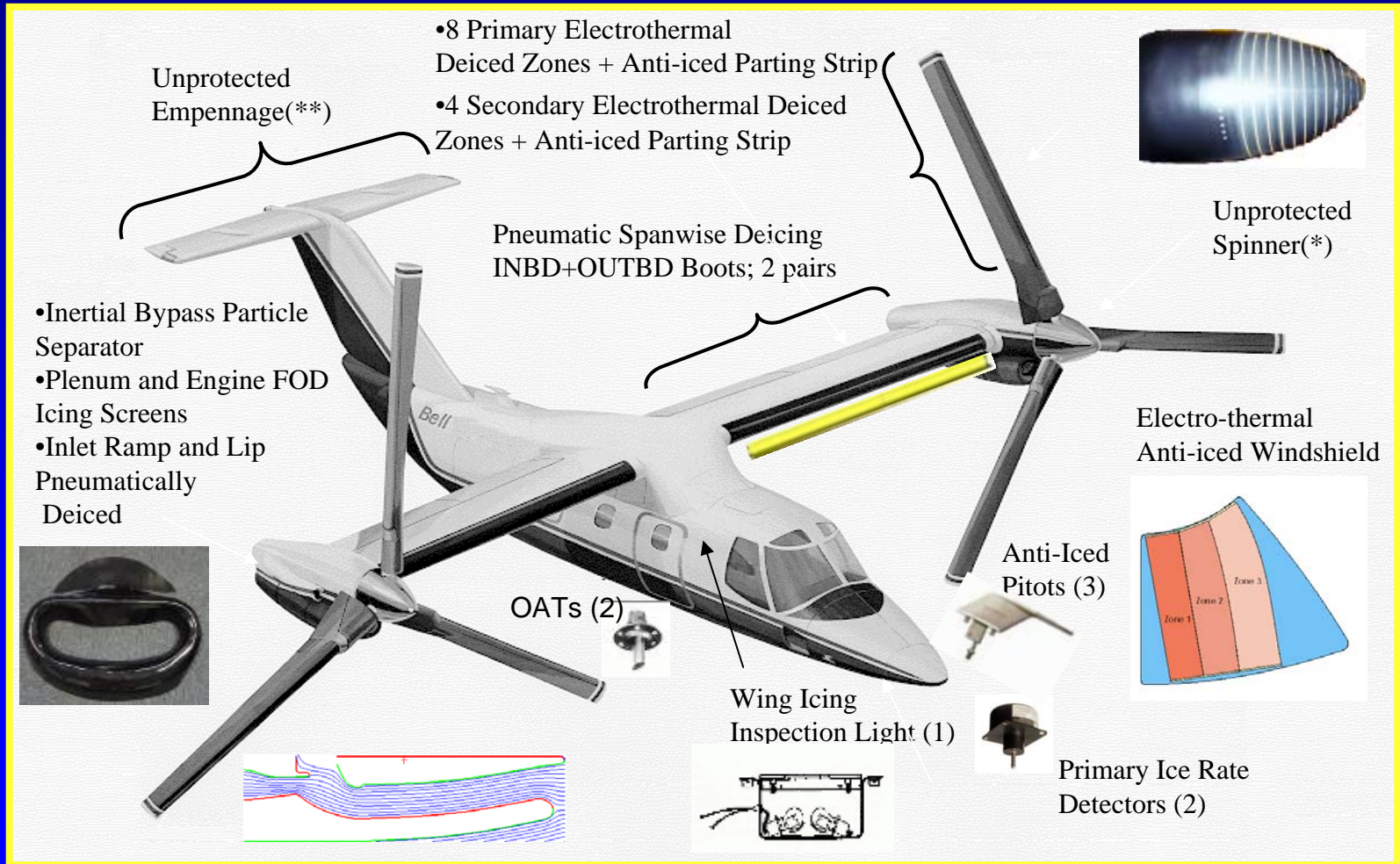
### •Conditions

- Same

### •Limitations

- Visibility or time restrictions that may allow limited airplane dispatch in certain snow conditions are not acceptable

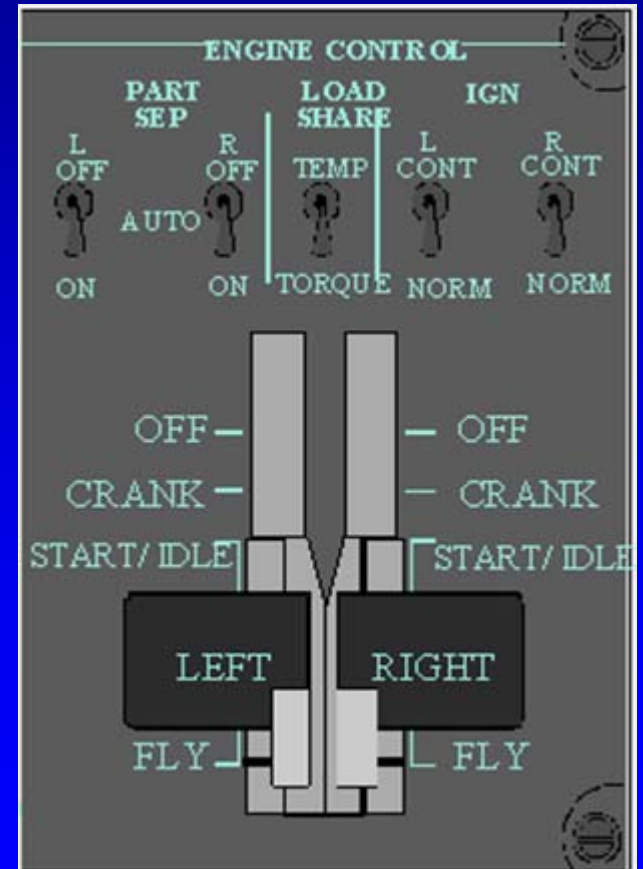
# Aircraft Ice Protection



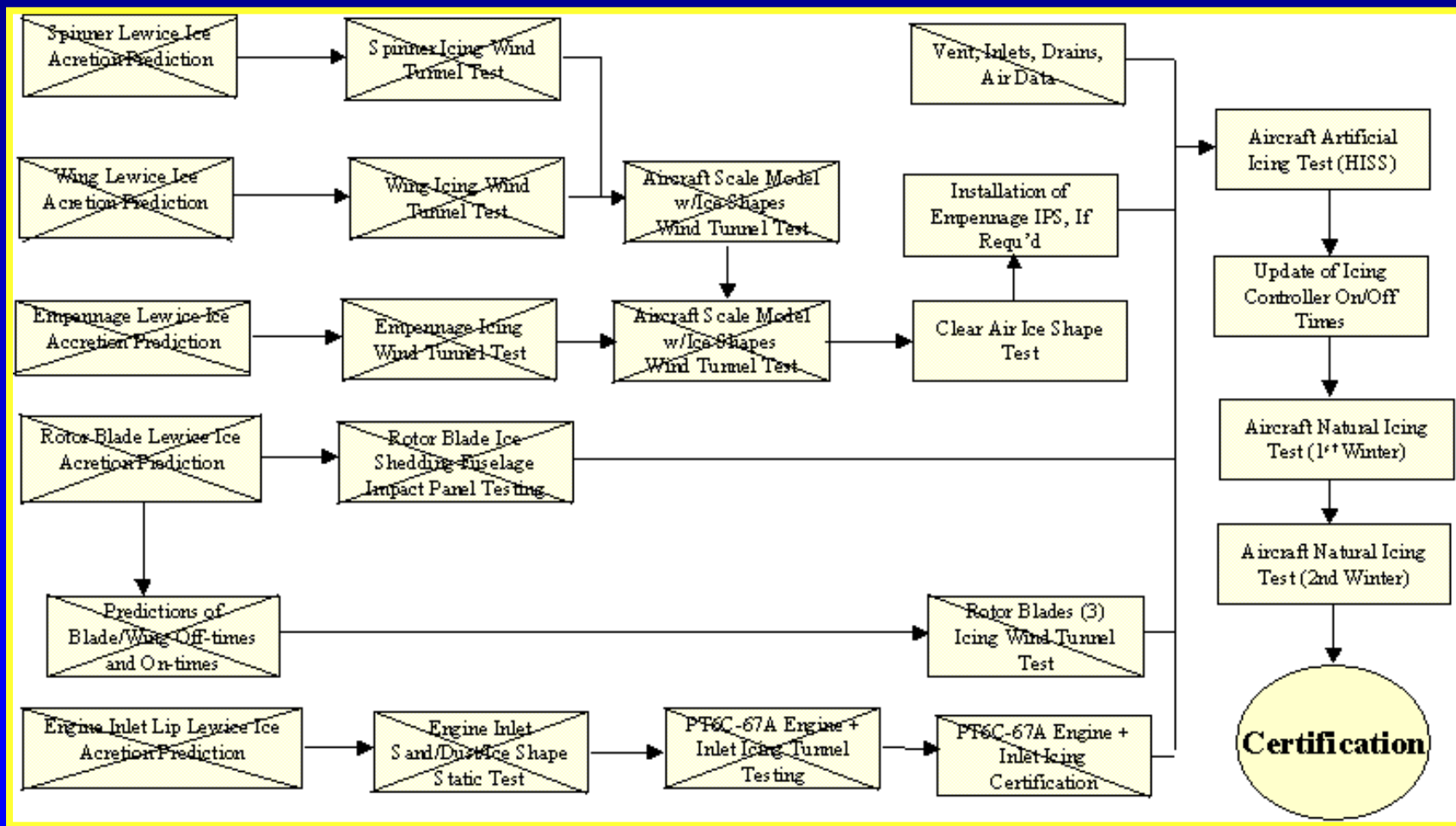
# Aircraft IPS Control Panel



## Over Head Console



# BA609 Plan to Certification



# Icing Tunnel Tests



Engine/Inlet at NRC



Impact Test at BHC



Blade(s) in BRAIT



Vertical Tail in IRT



Horizontal Tail in IRT



Spinner/Inlet in IRT



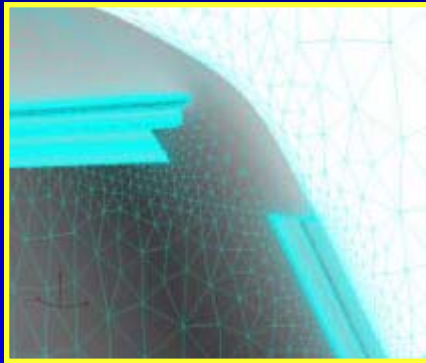
Wing in IRT

# Texas A&M 0.15 Scale Model Test

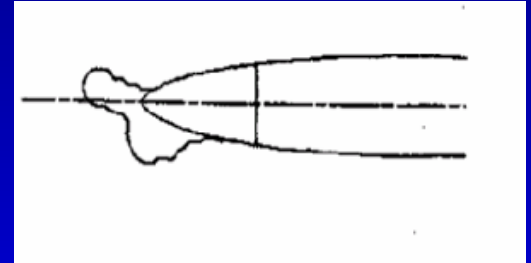


- Failure : 15 min
- Unprotected : 45 min

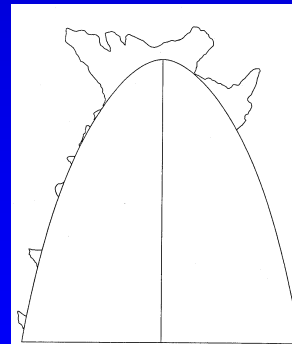
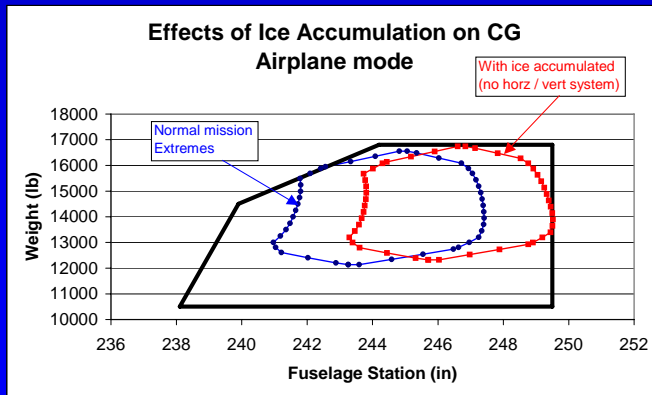
# Empennage Ice Shapes



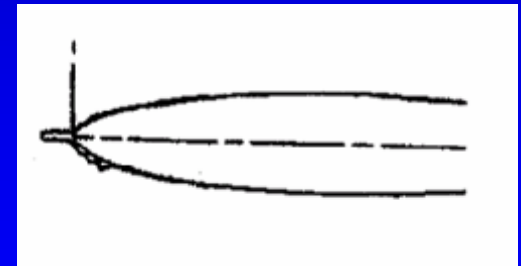
Horizontal Stabilizer



Unprotected



Vertical Stabilizer



Failed Boot

# Nacelle Ice Shapes



Spinner 45 minutes holding



Inlet 45 minutes holding

# Clear Air Icing Simulation Test Objectives

## •Evaluate Aircraft Handling and Performance with Tunnel Ice Shapes fitted onto the aircraft

- Obtain data for horizontal stabilizer protection decision
- Demonstrate engine handling with simulated ice shapes and screen blockage
- SLD

## •Perform Ice Protection system shakedown

- Verify windshield and rotor blade electro-thermal protection surface and internal temperatures at OAT of -22°F, -4, 14, and 45
- Primary/Secondary switching
- Power generation management
- Cooling margins
- IFR/Night operation

# Clear Air Ice Shape Testing

## 45 minutes holding ice shapes :

- Nose
- Spinner
- Vertical stabilizer
- Horizontal stabilizer(\*)(\*\*)
- Wing residual
- Engine and Inlet Screen blockage

## Normal Operation

### Inter-cycle ice shapes :

- Wing boots
- Engine inlets
- Protected Horizontal stabilizer(\*)(\*\*)

(\*) *SLD Condition*

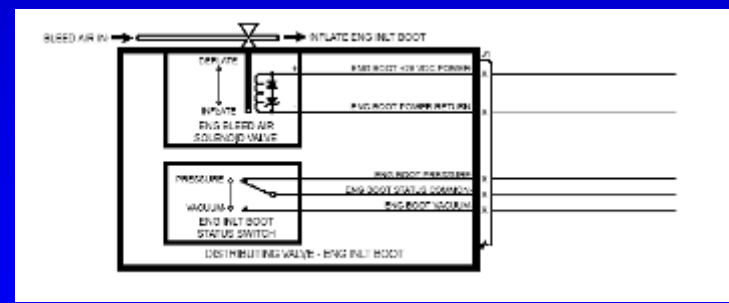
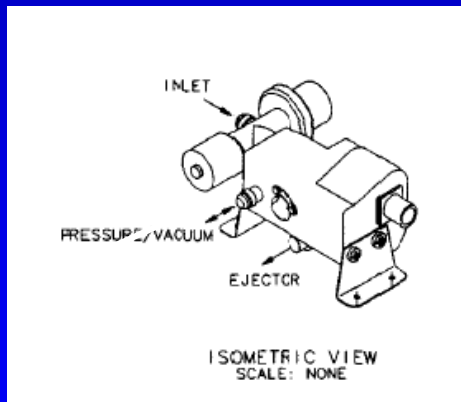
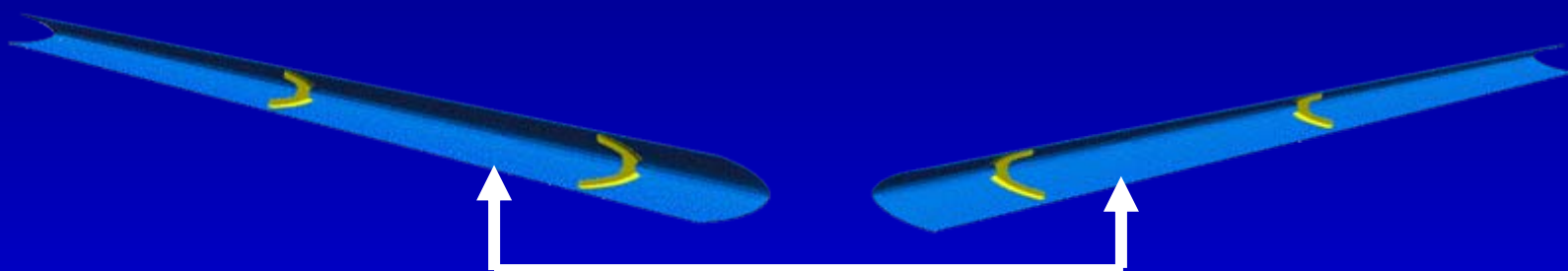
(\*\*) *Protected vs Unprotected*

## Failure Simulation

### ~15 minutes ice shapes :

- Wing boots(\*)
- Engine inlets
- Protected Horizontal stabilizer(\*)(\*\*)
- Engine and Inlet Screen blockage, bypass closed

# Provisions for Horizontal Stabilizer Protection



Flow tapped between regulator and valve for wing boots

# Planned Instrumentation

## Environmental :

King air probe or Nevzorov (LWC)  
FSSP (MVD<45 microns)  
OAP (MVD>45 microns)  
Altitude, speed, OAT  
Vernier Accretion Meter (VAM)

## Engine :

Engine P3 pressure (LH + RH)  
Engine Ng, MGT, Np, Q (LH + RH)  
Fuel pump supply pressure (LH + RH)  
Fuel tank temperature (LH + RH)

## Nacelle Cooling :

Upper nacelle compartment Temps, see cooling test (LH + RH)  
AC generators brush temps (LH + RH)  
AC Generators (Voltage, Current, Phase A, B and C)

## Inlet deicing :

Surface RTD on wing valves (LH + RH)  
Bus information of pressure switch status (LH + RH)  
Valves supply pressure (upstream of DRV, LH + RH)  
Valves output pressure and vaccum (Downstream of DRV - LH)  
Inlet plenum static pressures (4 fwd + 4 aft, LH + RH)  
Valves supply temperature (upstream of DRV, LH + RH)  
Video recording of inlet coanda screen (LH + RH)  
Video recording on engine screen (LH + RH)  
Video recording of inlet deicing boot (LH + RH)  
Still pictures of cooling inlets (LH + RH)  
Still pictures of inlet drains/vents (LH + RH)  
Bus information on bypass door status, blower rpm, command

## Ice Detector(s) :

Output signals (Failures, voltages, counts..., LH + RH)

## Windshield :

External Surface RTDs (Center post + outbd, Pilot + Copilot)  
Internal Surface RTDs (Center post + outbd, Pilot + Copilot)

## Main and Spare Blade

Internal RTDs for Aircraft 1 (Clear air) and Aircraft 3 (Icing) :  
External RTDs for Aircraft 1 (Clear air) and Aircraft 3 (Icing) :  
Video recording of rotor + Spinner with freeze frame capability  
Strain measurements (LH and RH)  
Vibrations (LH + RH)  
Loads (pitch links..... LH + RH)

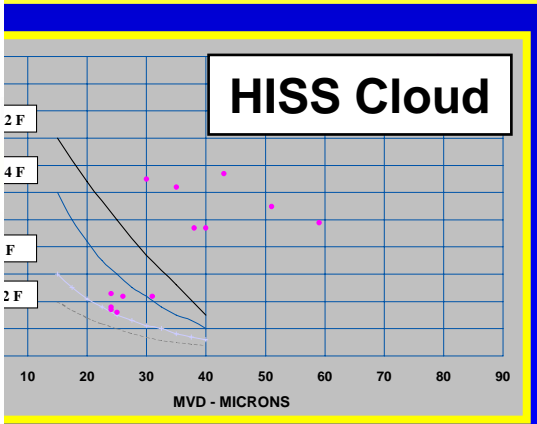
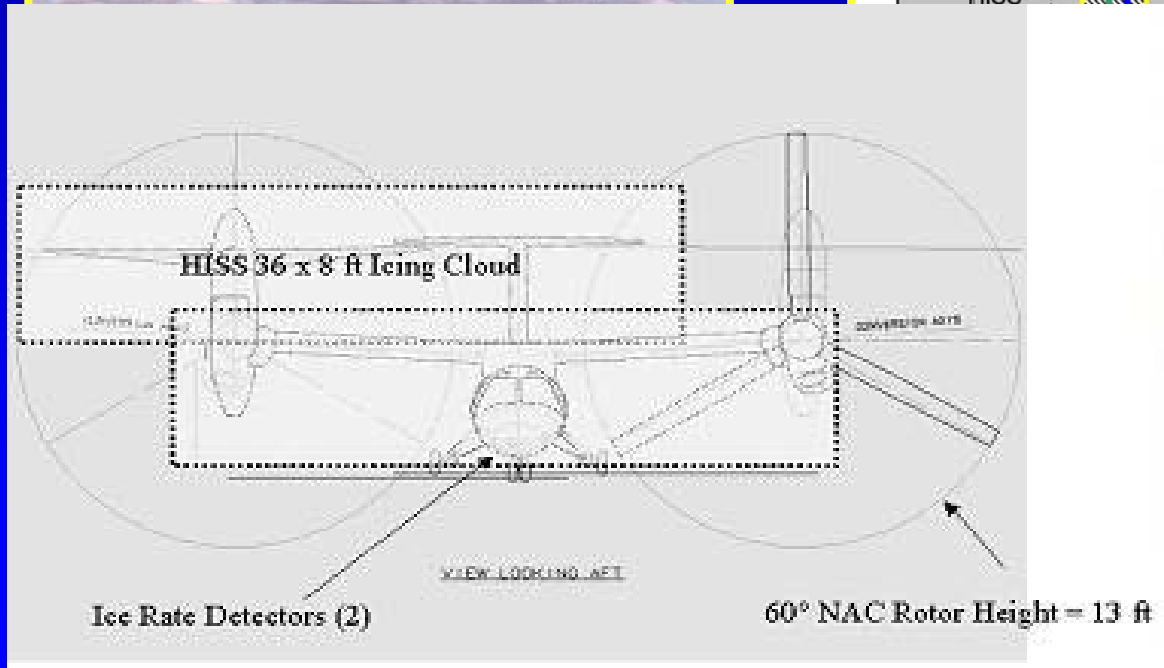
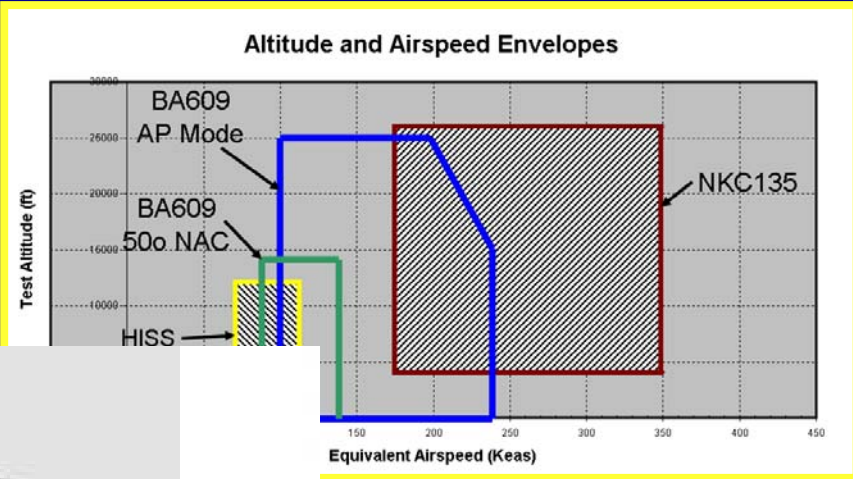
## Fuselage :

Empennage if protected : Video recording of horizontal boot (LH + RH)  
Empennage : Still pictures of horizontal and vertical (LH + RH)  
Still pictures of drains/vents/cooling inlets/AOAs/Pitots/Statics  
Video coverage of landing gear (NLG + LH/RH MLG)  
Still pictures of windshield wipers (LH + RH)  
Still pictures of side windows (LH + RH)

## Wing deicing :

Surface RTD on wing valves (inbd + Outbd)  
Bus information of pressure switch status (inbd + outbd)  
Valves supply pressure (upstream of PRRV, inbd + outbd)  
Valves output pressure and vaccum (Downstream of DDV - Inb)  
Valves supply temperature (upstream of PRRV, inbd + outbd)  
Video recording of wing deicing (LH + RH)  
Still pictures of fuel tank vents (LH and RH)  
Still pictures of wing VGs

# HISS Cloud vs BA609 dimensions

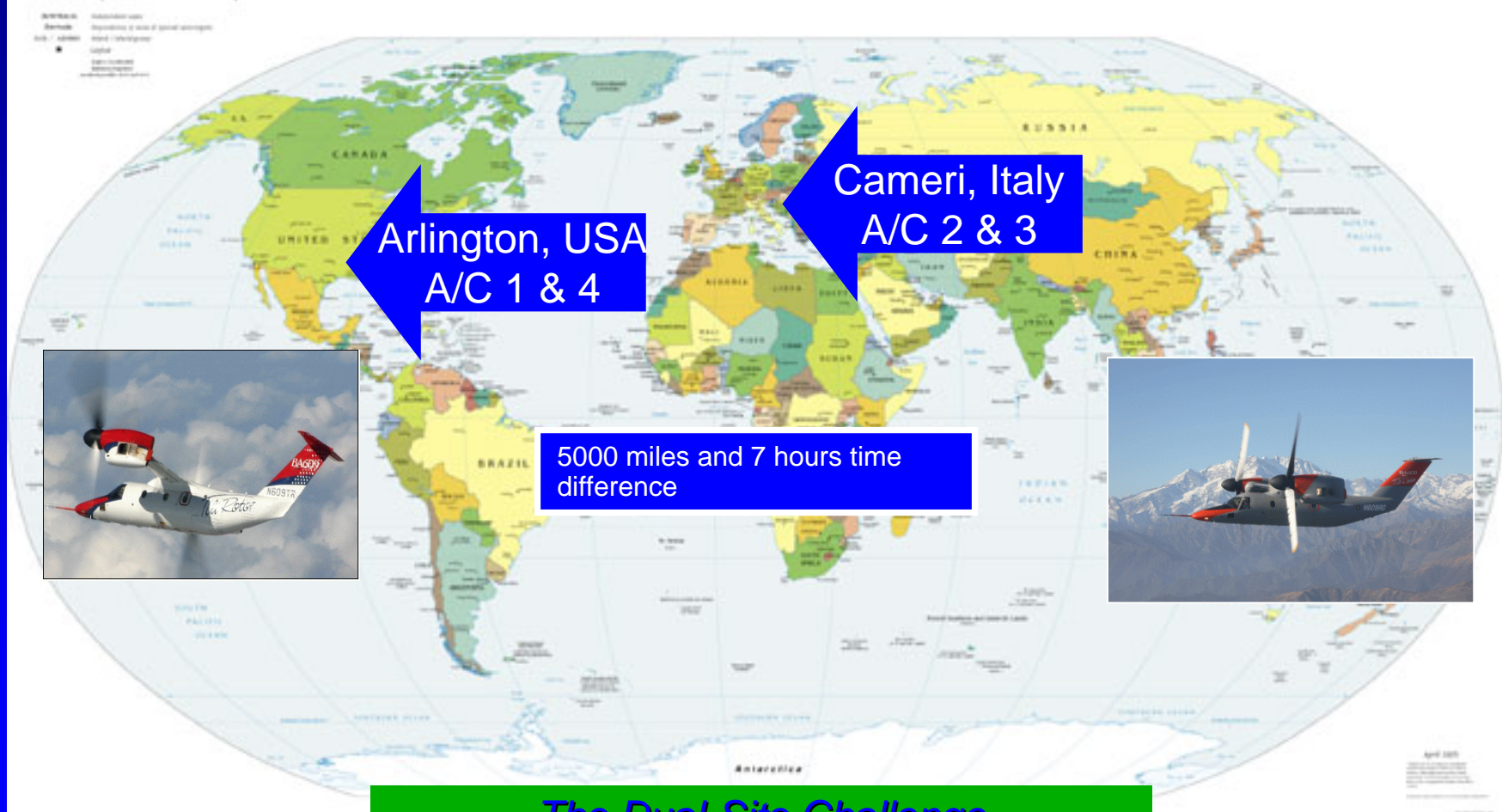


# HISS Test Objectives

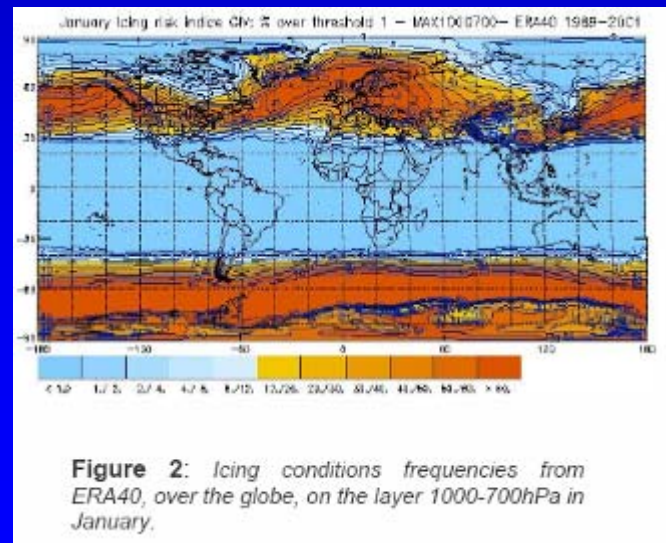
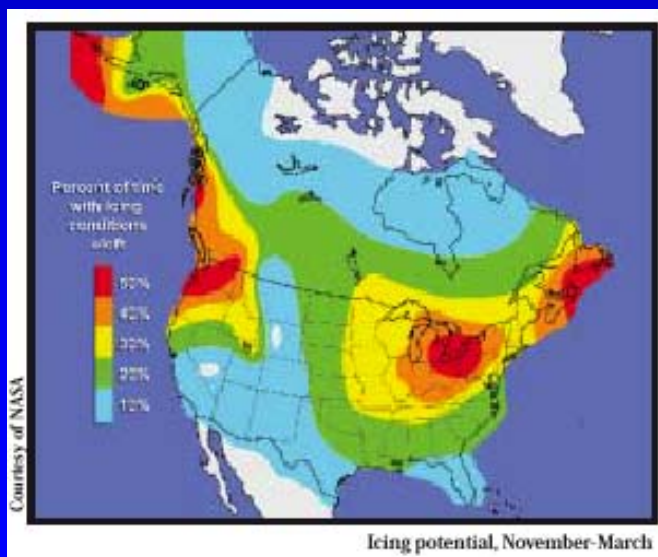
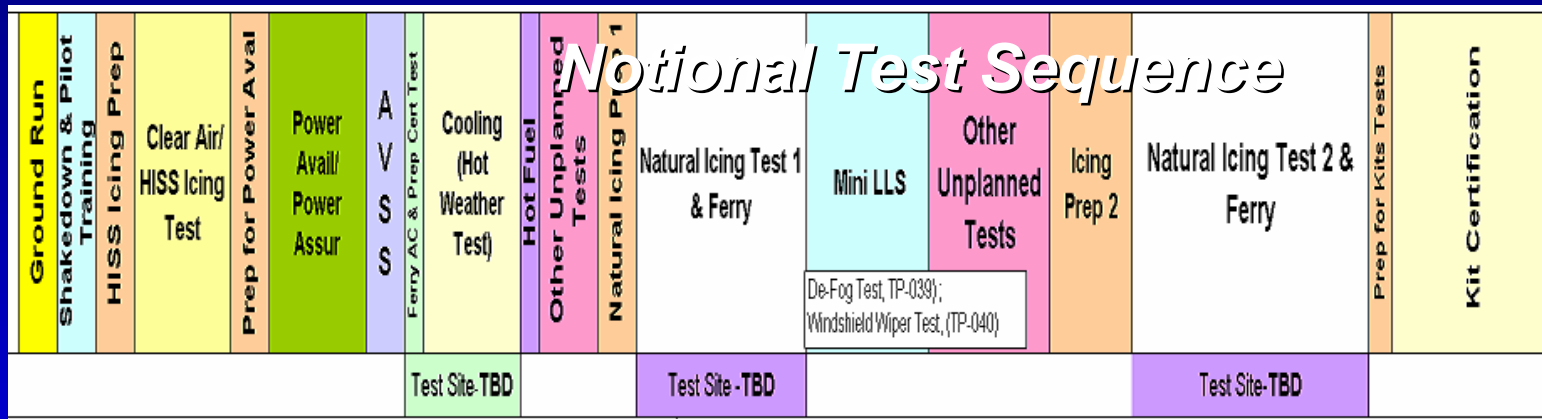
- Evaluate Aircraft Handling and Performance behind Tanker
- Correlate Selected baseline Ice Rate Detector location with control system algorithm established from tunnel testing
- Evaluate Rotor ice protection system failures modes
- Finalize Fuselage Protection Shield design (Testing only)
- Validate ice shapes collected during tunnel test (Spinner, Wing, Empennage, Inlet)
- Verify windshield and rotor blade electro-thermal protection surface temperatures at all corners of 25-1419 Appendix C

# Planning for Natural Icing Flight Test

Political Map of the World, April 2005



# Natural Icing Test location



# Natural Icing Test Objectives

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- Satisfy Type Certification Requirements
- Perform Operation in Snow Certification
- Validate De-icing Control Algorithm
- Validate Predicted Handling and Performance
- Verify cooling margins
- Drains/Vents blockage
- Verify engine handling
- Validate Flight Manual instructions

# Questions

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***Thank you for your time***