Panasonic Weather Solutions (PWS)
Predicting and Reporting In-Flight Icing

In-Flight Icing Users Technical Interchange Meeting (TIM)
February 25-26, 2015
Washington D.C

IN-FLIGHT
35 YEARS
INNOVATION
1979-2014

Heavy Toll – Icing Related Accidents

Comair 3272
9 Jan 1997

Colgan Air 3407 (?)
12 Feb 2009

American Eagle 4187
31 Oct 1994

Purpose

- Who is Panasonic Weather Solutions (PWS)

- Provide overview of Panasonic's
    "***Global Weather System***"

- Application to Inflight Icing…
    - *Forecasts*
    - *Detection*
    - *Reporting*

- Collaborate with Industry Stakeholders

Overview

- Panasonic Weather Solutions (PWS)

- Global Weather System Overview

- TAMDAR Sensor Detail

- Inflight Icing Potential Forecasts

- Colgan Air Flt 3407 accident case study

- Questions/Discussion

PWS Global Weather System
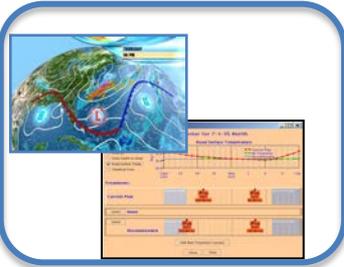
1 300⁺ PWS Sensor Equipped Commercial Aircraft

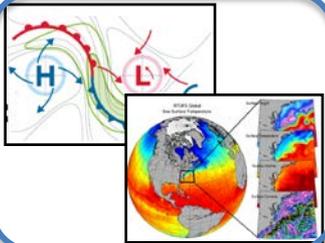**2** Iridium Global Data-Link Communication System

3 PWS Super Computers (Data Processing and Exploitation)

High Resolution Forecast Models

Customized Wx Products

PWS FlightLink TAMDAR Sensors

30,000-40,000
Observations per Day

Commercial
Aircraft
Sensor

Unmanned
Aircraft
Sensor

Measures and Reports

Temperature	GPS Position
Humidity	Altitude
Pressure	Time
Wind Speed	Icing
Wind Direction	Turbulence

Global Communications

- True global communications
- Bidirectional data link
  - Any equipped aircraft
  - Any altitude
  - Any location on the globe
- Low message latency (near real-time)
- Channel also available for:
  - Other payload data transmission
  - Voice calls
  - Aircraft tracking

Iridium satellite constellation
(global, high availability)
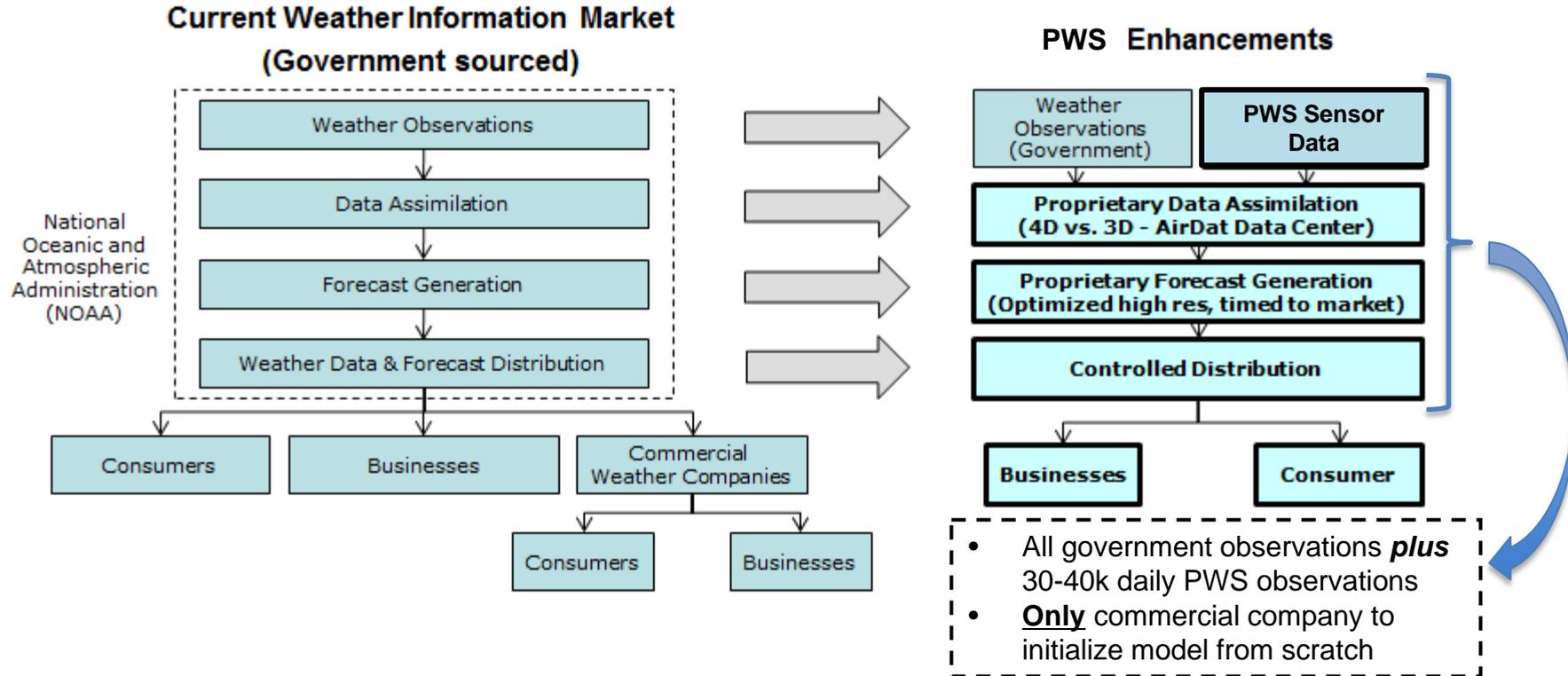
Data Processing and Exploitation

- Current "Tesla" computer with 1920 compute cores

- Installing new computer with 9820 compute cores

- Hardened facility with jet fuel powered redundant backup power

- Multi-tiered data quality assurance, assimilation and distribution

- Highly sophisticated proprietary weather forecast models[1]

**Current "Tesla" Liquid Cooled Super Computer**

1. *No other organization (civil, military, or government runs such sophisticated weather modeling algorithms)*

How PWS Produces Superior Forecasts

Current Weather Information Market (Government sourced)

National Oceanic and Atmospheric Administration (NOAA)

- Weather Observations
- Data Assimilation
- Forecast Generation
- Weather Data & Forecast Distribution

- Consumers
- Businesses
- Commercial Weather Companies
  - Consumers
  - Businesses

PWS Enhancements

- Weather Observations (Government)
- PWS Sensor Data
- Proprietary Data Assimilation (4D vs. 3D – AirDat Data Center)
- Proprietary Forecast Generation (Optimized high res, timed to market)
- Controlled Distribution

- Businesses
- Consumer

- All government observations *plus* 30-40k daily PWS observations
- **Only** commercial company to initialize model from scratch

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TAMDAR Icing Detection System

- TAMDAR Currently Provides Ice/No-ice Binary Data
- Dual Redundant IR Beams
  - LED/Photodiode (PD) Pairs
  - IR Beam Strengths Inversely Related To Ice Buildup In Gap
- Icing Cycle
  - Ice Buildup Reduces Photo Diode ADC Signal
  - When Signal Strength Drops Below Threshold Icing is Reported.
  - Sensor reports ice detection at 0.02"/min accretion, but reporting value is configurable
  - Heaters Engage And Deice Probe
  - Cycle Repeats If Icing Conditions Remain

Icing Gap
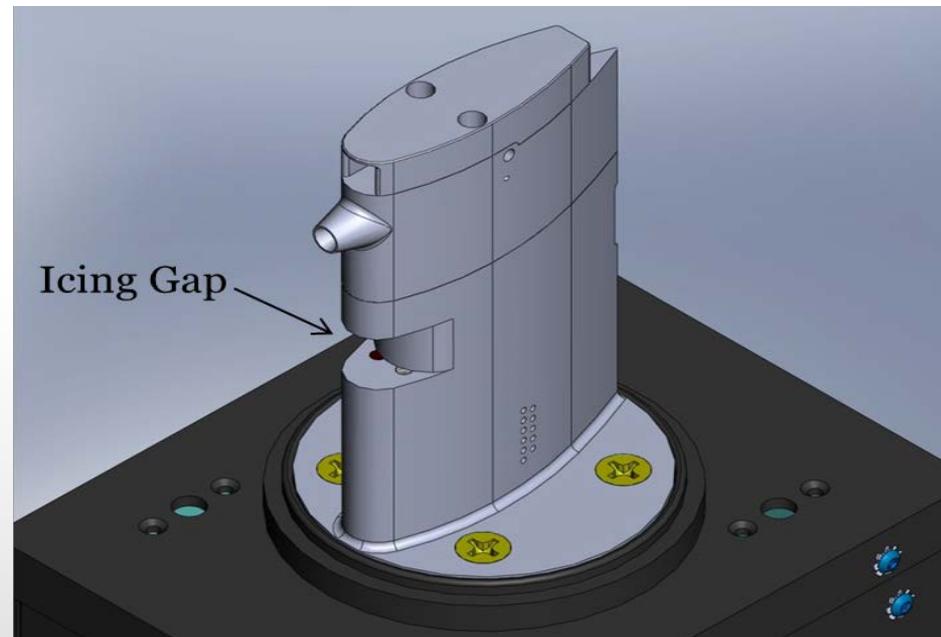
TAMDAR Ice Reporting Logic

- "L" flag: Ice detected from "D" (no ice) state. Triggers report

- "I" flag: Probe hasn't deiced and 1 minute has passed from L , I flag. Triggers report.

- "H" flag: heater is engaged. Does not trigger report.

- "C" flag: specified time from heater disengagement has not passed. Does not trigger report.

- "D" flag: No ice state (deiced)

# Mounting Location for Ice Detector

- Avoid stagnant air

- Avoid thick boundary layer

- Avoid regions of turbulence

- Generally the above conditions are met towards the nose

- If these conditions are not met, water particle sorting may occur by the airstream, and ice detector may ice up faster or slower than aircraft surfaces

- Computational fluid dynamics (CFD) analysis should be performed in any case because of particle sorting effect

Ice Accretion Rate

- Currently looking into ways to output an ice accretion rate (intensity) using data from the TAMDAR Sensor.

- Ice accretion rate formula

  - $W \alpha E \cdot m \cdot V \cdot n$

    - E is the collection efficiency

      - Narrow surface = higher efficiency

    - m is the liquid water content (LWC)

    - V is the true airspeed

    - n is the freezing fraction ($0<n<1$); n=0 means no ice can form

  - In theory, an accretion type detector such as TAMDAR can calculate LWC by solving the equation for m.

- Icing Wind Tunnel Testing

  - Looking at the ADC slopes while changing the LWC values to simulate different icing intensities.

  - Initial testing has been limited but future wind tunnel testing is desired.

Ice Accretion Rate
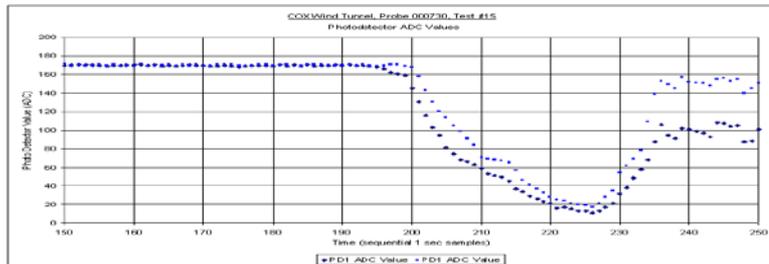
Plot of ADC (Voltage) values versus time (sequential 1 second samples)

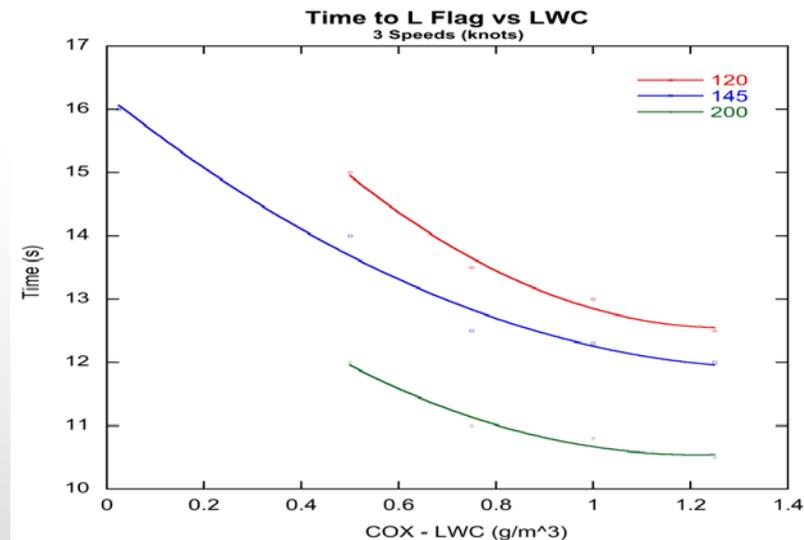*MVD = 20*
TAS = 145
Temp = -15
LWC = 0.50
Light
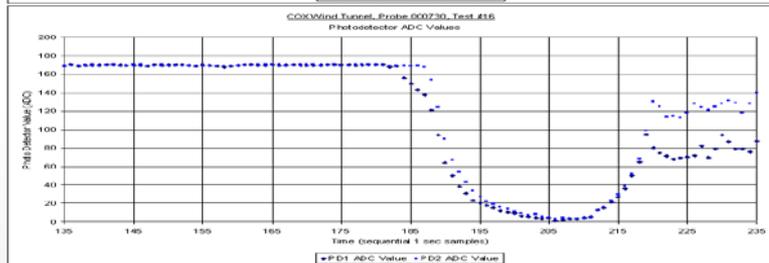
MVD = 20
TAS = 145
Temp = -15
LWC = 0.75
Moderate
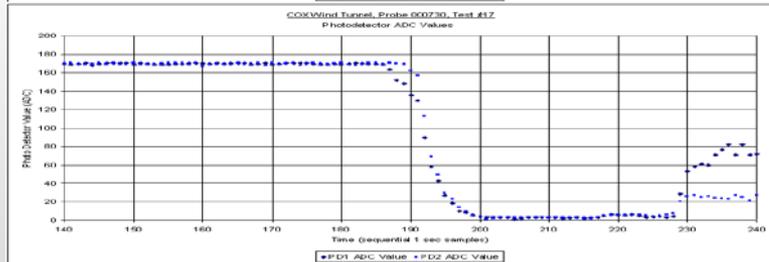
MVD = 20
TAS = 145
Temp = -15
LWC = 1.00
Severe

Intensity	Supercooled Water Content (g/m^3)
Trace	$0 - 0.1$
Light	$0.1 - 0.6$
Moderate	$0.6 - 1.2$
Severe	>1.2

FlightLink TAMDAR-Edge (UAS Sensor)

- Small, Light, and Low Power
- Fly on NASA Ikhana (Predator) this summer
- Developing next generation sensor capabilities
  - Accurately sense temp and humidity while deicing (heating)
  - New materials
  - Test bed for algorithm improvements
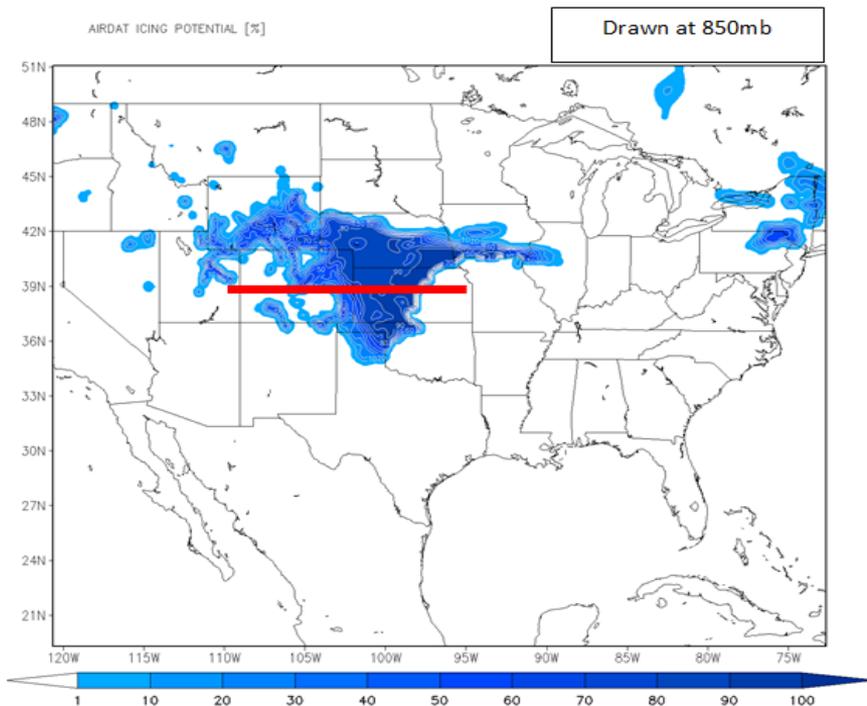   - Icing
    - Turbulence (EDR)

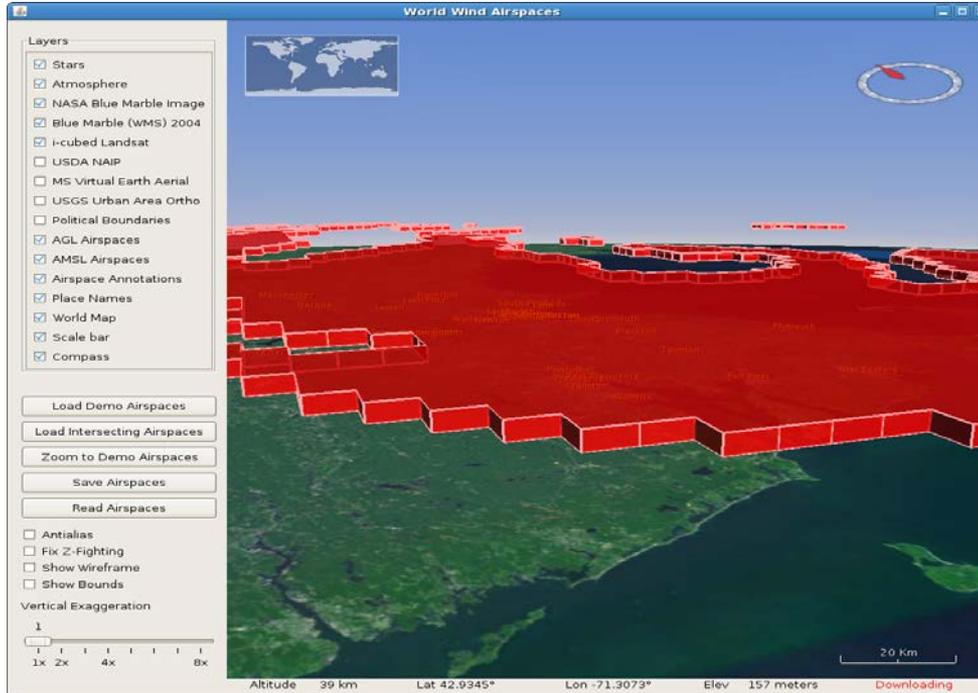| Total Power	Total Weight
17 W (not heating) 30 W (heating)	14.0 oz. (plus cabling)

Icing Potential Model

Drawn at 850mb

Vertical cross section at 39 degrees latitude depicted by the red line above
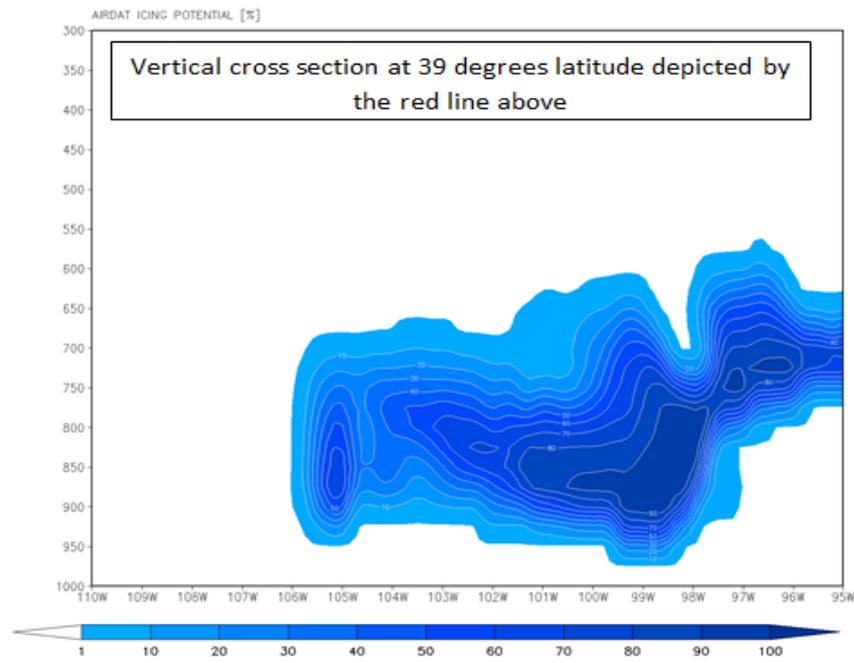
PWS Augmented Forecasts of Potential Aircraft Icing

Icing forecasts are improved with the use of aircraft measured TAMDAR observations of temperature, humidity, and reported icing data

STARS Icing Alerts
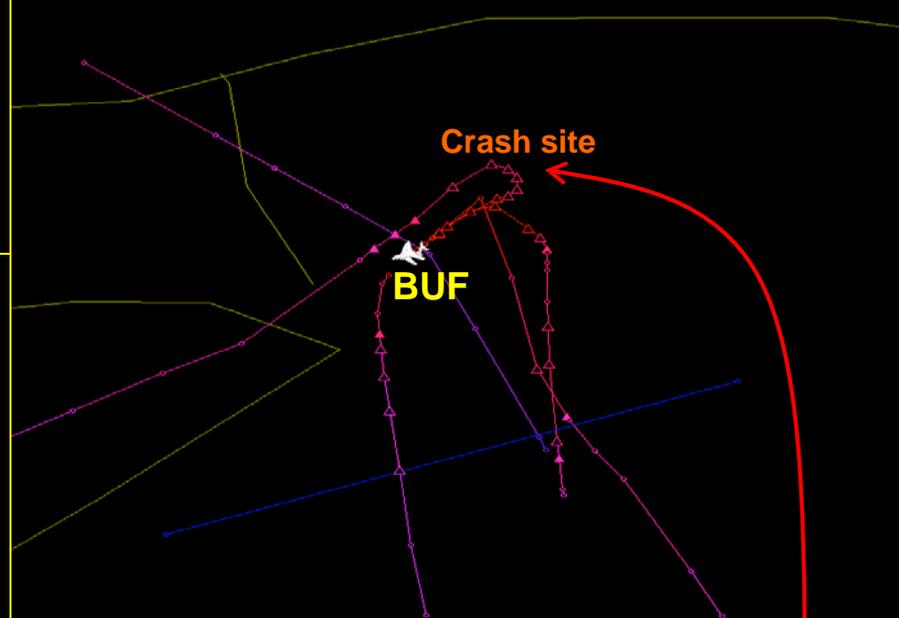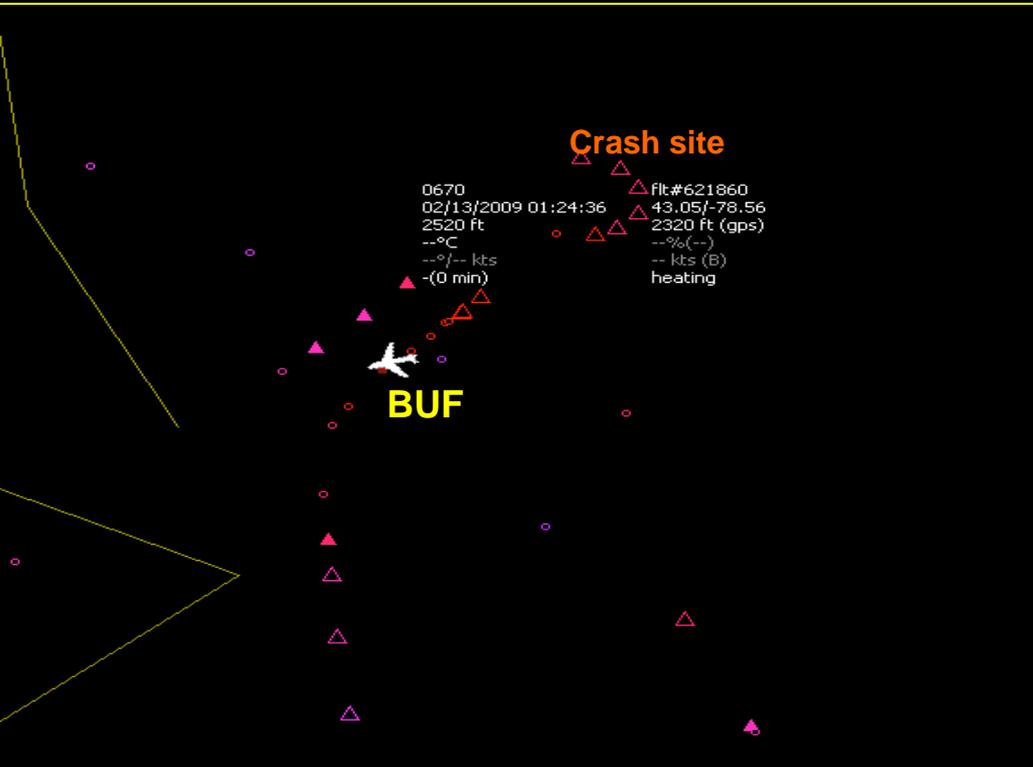*NextGen Net-enabled Weather*
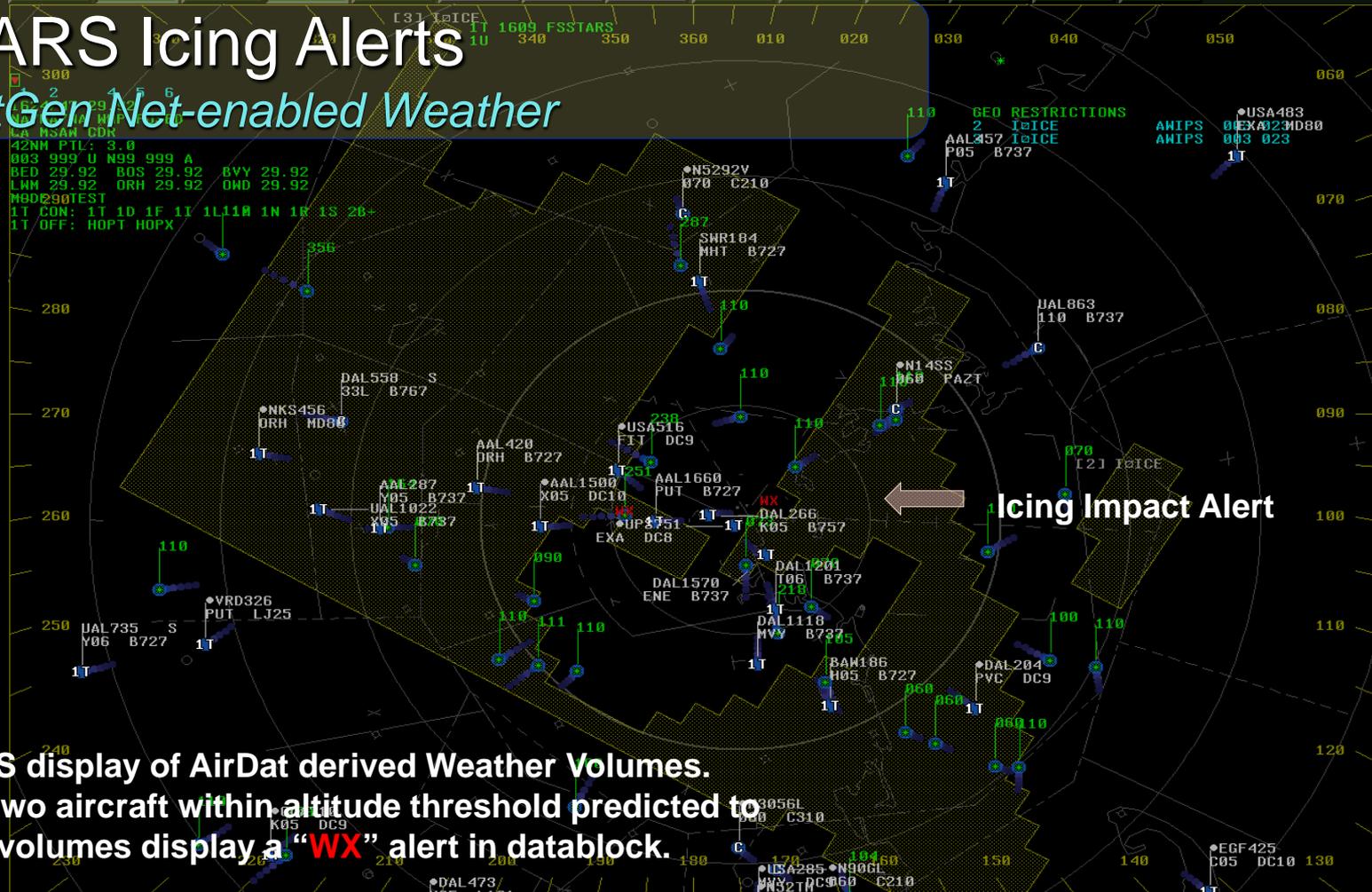
Icing Impact Alert

STARS display of AirDat derived Weather Volumes.
Note two aircraft within altitude threshold predicted to
enter volumes display a "WX" alert in datablock.

The 2 images show TAMDAR data from flights into/out of BUF +/- ~3h from 10 pm.

The solid triangles indicate icing, and the hollow triangles indicate icing with heaters activated.

Crash site

0670
02/13/2009 01:24:36
2520 ft
--°C
--°/-- kts
-(0 min)

flt#621860
43.05/-78.56
2320 ft (gps)
--%(--)
-- kts (B)
heating

BUF

Crash site

BUF

The TAMDAR heater *remains* activated throughout the descent, so the ice accretion rate is > 0.02" / min.

TAMDAR observations around the time of the Colgan crash

TAMDAR observations around the time of the Colgan crash
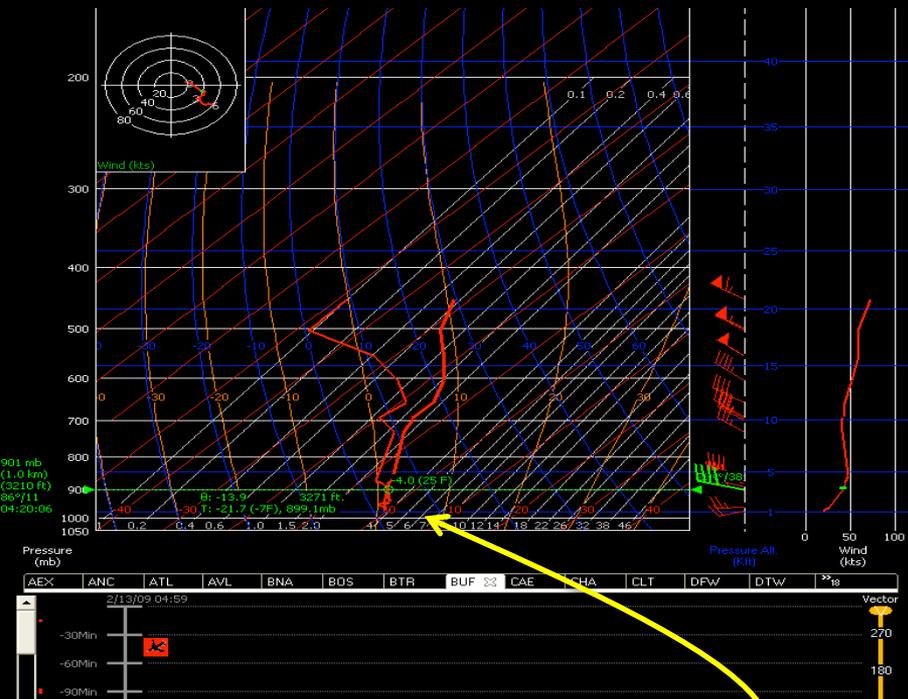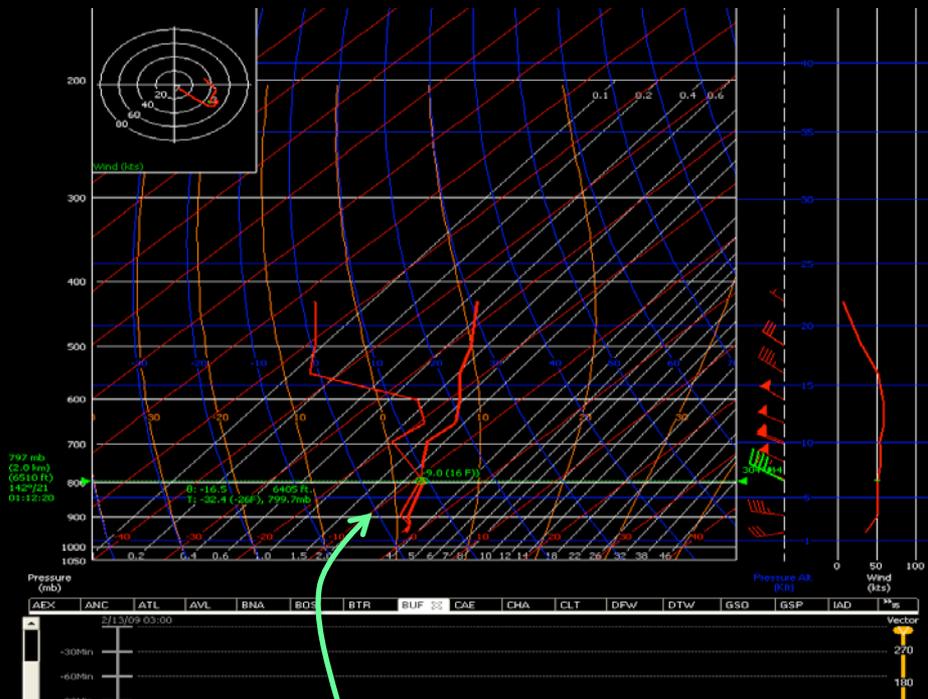
The first sounding, valid 9 pm, shows a substantial layer of saturated air below 6000' between -9 and -2C -- the temperature window that most supports the existence of supercooled water.

The second sounding, valid 11:20 pm, shows the sub-0C saturated layer has dropped to 3000' and below

Both soundings suggest favorable conditions for supercooled water to freeze upon airframe contact.

Questions/Discussion

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