American Meteorological Society
25th Conference on International Interactive Information and Processing Systems (IIPS)

Session 4A: Advances and Applications in Transportation Weather, Surface and Aviation

Testing and Deployment of the Water Vapor Sensing System II

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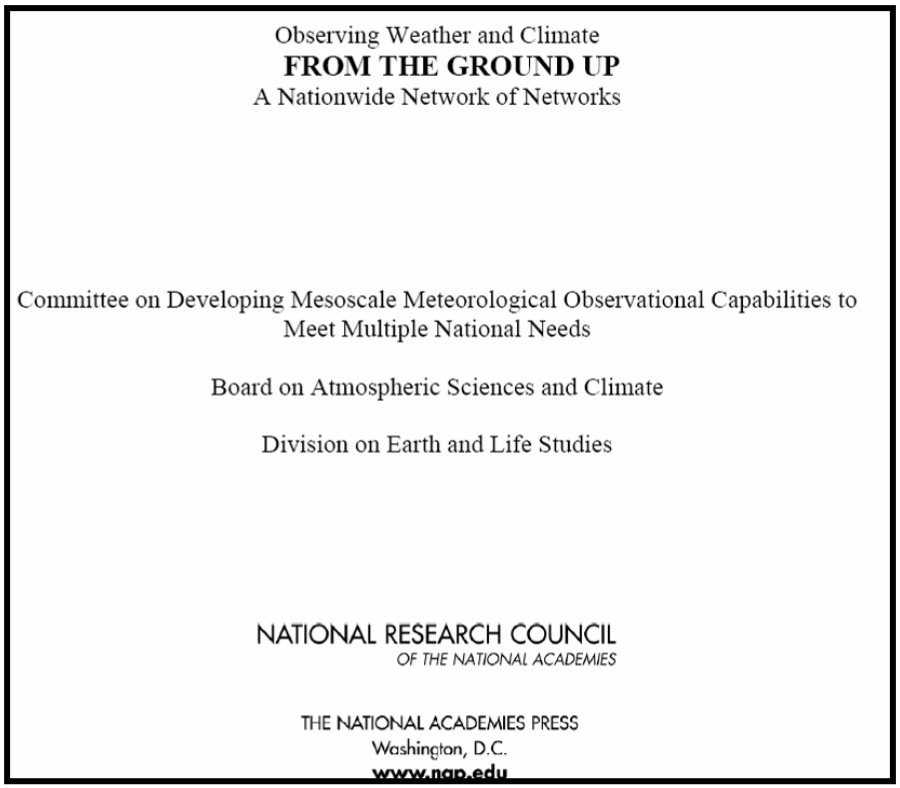
Outline

- Project Background
- 2008 Sensor Re-Design
- Sterling Upper-Air Test Facility (SUATF) Assessment
- Factory Test and Calibration Protocols
- Follow-up Testing and Assessment:
  - SUATF Cabin Environment Simulation Testing
  - DWD Chamber Tests
  - NOAA P-3 Flight Tests
  - CIMSS AERIBAGO Field Test
  - Statistical Model Inter-Comparisons
  - Ad Hoc GPS-Met and Radiosonde IPW Inter-Comparisons
- Deployment Timeline
- Next Steps

Project Background:
What is the Benefit?


Observing Weather and Climate
FROM THE GROUND UP
A Nationwide Network of Networks

Committee on Developing Mesoscale Meteorological Observational Capabilities to Meet Multiple National Needs

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

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Washington, D.C.
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Town Hall Meeting
Wednesday, 14 January,
12:15–1:30 p.m.; Room 125A

Infrastructure Needs: **Mesoscale observations above and below the atmosphere's lowest ten meters are particularly inadequate.**

The highest priority observations needed to address current inadequacies are:

- **Height of the planetary boundary layer**
- **Soil moisture and temperature profiles**
- **High resolution vertical profiles of humidity**
- **Measurements of air quality and related chemical composition above the surface layer**

Second tier national observing gaps:

- **Direct and diffuse solar radiation**
- **Vertical profiles of wind**
- **Sub-surface temperature profiles (e.g., under pavement)**
- **Icing near the surface**
- **Vertical profiles of temperature**
- **Surface turbulence parameters**

Recommendation: **Collect atmospheric profiles nationally at approximately 400 sites (~125 km resolution) to continually monitor lower tropospheric conditions.**

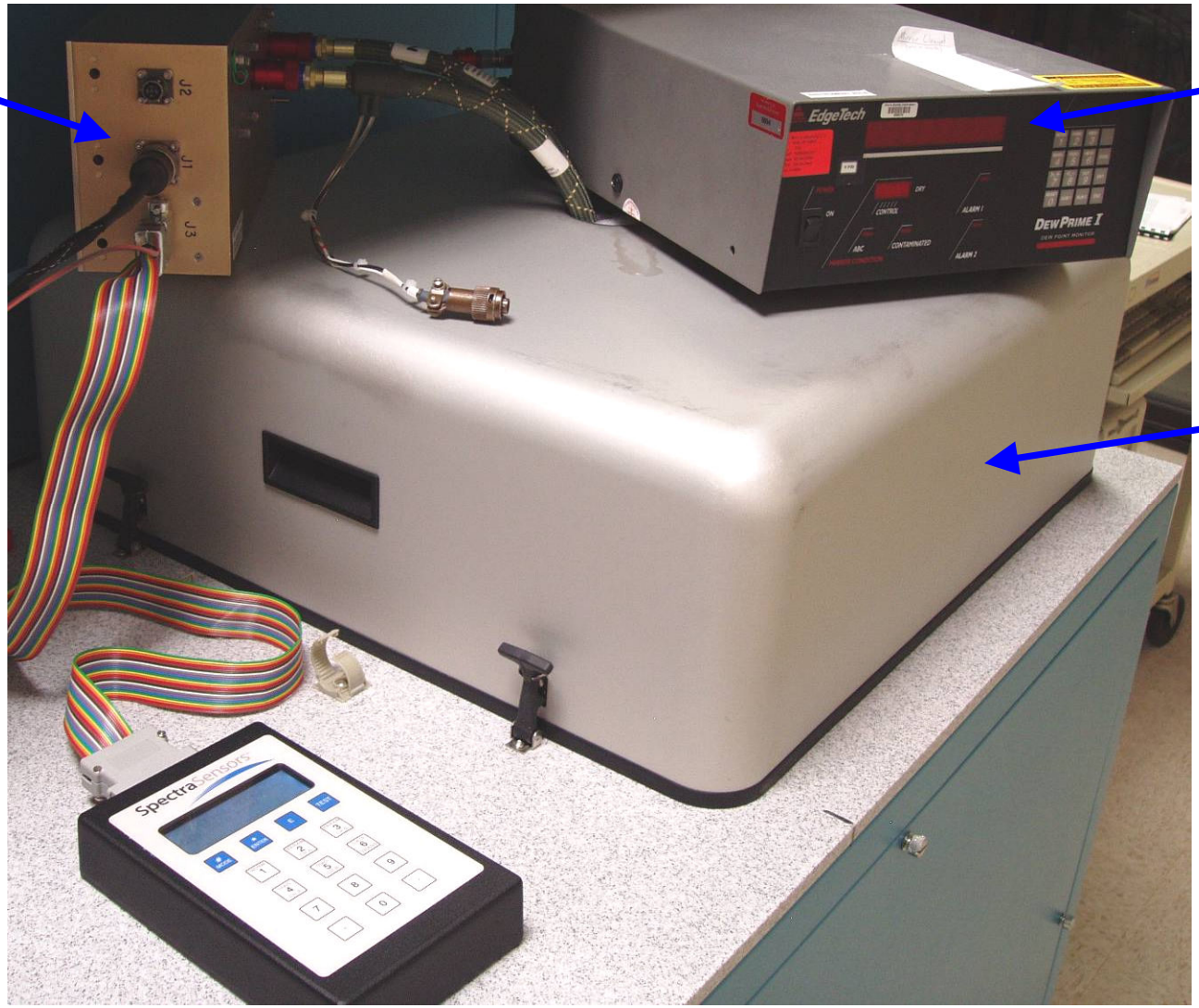
Project Background

- WVSS R&D completed under contract through UCAR, 1998-2006
- WVSS I first flown on 30 United Parcel Service (UPS) B-757 aircraft in 1999
- 25 WVSS II “alpha” version replaced WVSS I sensors in 2005
- WVSS II “beta” replaced “alpha” version in 2006

SSI 2008 Sensor Re-Design

- **Improve the laser head seal.**
  - Eliminated moisture intrusion into the laser head cavity (wet bias).
  - Improved the sensor stability over time (long term sensor stability).
- **Modified the signal processing circuit to improve the thermal insensitivity.**
  - Improved the observed dry bias by component and circuit upgrades.
  - Improved the performance over changing temperature by temperature measurement upgrades.
- **Improved the laser thermal control loop.**
  - Improved the laser wavelength stability by an improved thermal control loop.
- **Upgrades to the processor from the petrochemical board experiences.**
  - Improvements to noise levels and thermal insensitivity.
- **Upgrade the thermal management of the system.**
  - Isolate the SEB from the fuselage structure to improve the thermal environment for the electronics and laser head.
  - Isolate the laser head from the sample cell to improve the thermal environment for the laser head.
  - Upgrade the gas temperature monitor and gas temperature management to assure that the gas temperature is correct in the concentration computation.
  - Increased thermal heating of the gas heating system.
- **Added a test connector to the exterior of the SEB**
  - Allows SSI to perform the final functional and calibration testing after the SEB is completely assembled and enclosed.
  - Provides for a post installation functional test to assure that the units are working after installation. SSI recommends a breakout box for this testing.

NOAA Sterling Upper-Air Test Facility Assessment



SUATF Assessment Results: WVSSII vs. Reference Sensor

- WVSSII and Reference Sensors tested to within 5.1% of each other at the Sterling Upper-Air Test Facility

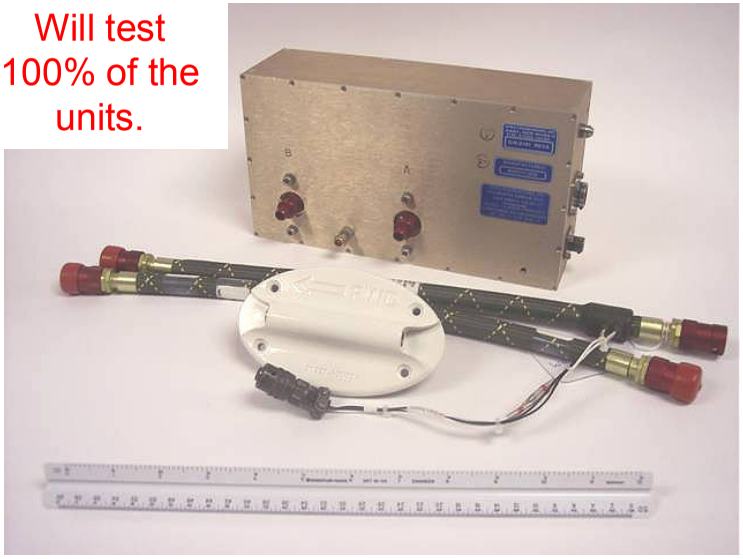
Summary - % Differences at Sterling between 3 WVSS units and Chilled Mirror					
Test Point	Pressure (mBar)	Setpoint (ppmv)	SN300	SN301	SN302
1	200	23.9			
2	200	76.2			
3	500	575	-5.1%	-4.1%	-1.3%
4	500	1929	-1.4%	-3.9%	-1.1%
5	500	3028	0.7%	-3.0%	-0.2%
6	700	1314	-2.7%	-5.1%	-1.1%
7	700	4390	-0.9%	-2.0%	-0.6%
8	700	8370	-0.3%	-1.3%	0.3%
9	1000	1856	0.4%	-3.8%	-1.9%
10	1000	6203	-0.2%	-0.9%	-0.8%
11	1000	11870	-0.8%	0.4%	-0.6%
12	ambient (1005)	6423	0.3%	-1.5%	-0.2%
13	ambient (1005)	21679	0.3%	-1.2%	-1.2%
14	ambient (1005)	30648	0.7%	-1.3%	-1.3%

Test Results: September 3-5, 2008

Factory Testing and Calibration Protocols

- Modified enclosure for improved assembly and testing
- Infant burn in of all units (laser and SEB)
- Extensive SSI internal testing.
  - Functional
  - Pressure/Temperature cycling
  - Purge and leak testing
  - Heater system testing
  - Calibration (Pressure and Temperature)
  - Post Installation testing
    - Breakout box
  - Long term testing (2 units – 1 year to 18 months)

Will test 100% of the units.



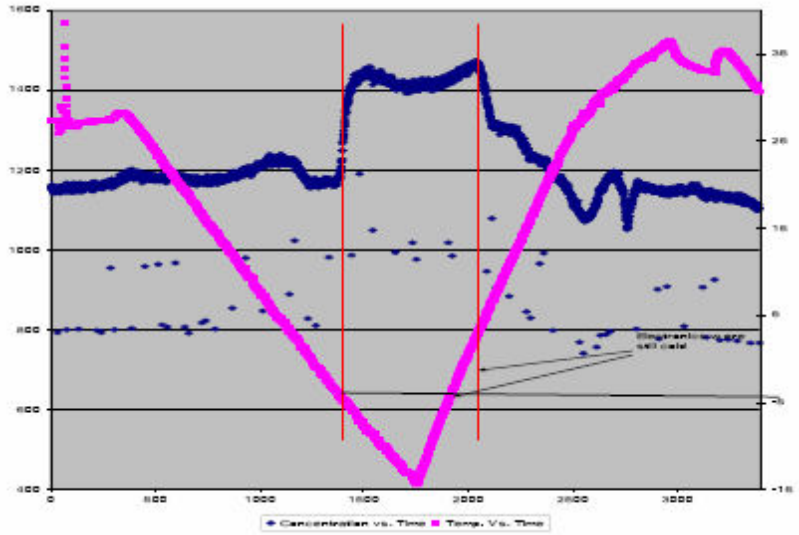
Calibration Changes to the Pressure/Temperature Matrix

- Previous WVSSII calibration was not tailored to individual sensors, but rather used 16 different pre-generated matrices, selecting the one of 16 P/T matrices which most closely optimized senor output.
- Despite 2008 improved sensor electronics, the WVSSII performance at the factory and on NWS test stand was not performing to required standards.
- SSI conducted an analysis of the P/T calibration methodology and made the following changes:
  - Software allows for calibration of non-linear values below 3,000 PPMV
  - Improved accuracy of the P/T matrix mapping by using a single matrix tied to each sensor's 3rd degree polynomial calibration coefficients
  - Computed rather than stored P/T matrix.
  - Advantage of P/T matrix is that the software is the same for every system with the only difference being in the coefficients of the terms of the equation.

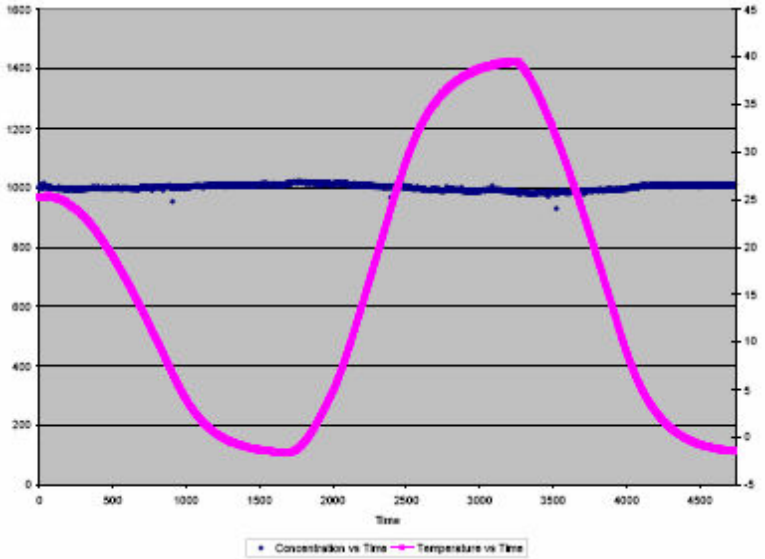
WVSSII Design Change Impact:
2006 verses 2008 Performance

- Input gas 1000 PPMV calibrated gas over temperature from -15 to + 35 Deg. C for 2006 and 2008 versions of WVSSII
- 2008 unit includes the upgraded spectrometer, upgraded electronics, vacuum sealed laser head, a corrected P/T matrix and a P/T matrix point-to-point interpolator.

2006: >25% Variance



2008: <3% Variance



WVSSII
Contract Milestones

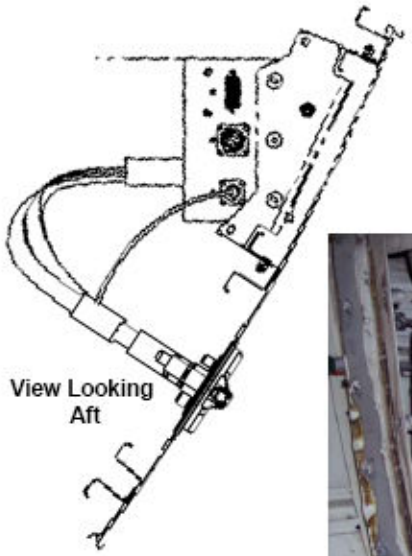
- Completed Tasks:
  - NOAA Solicitation: August 2006
  - Contract Award to ARINC/SSI/SWA: June 2007
  - Critical Design Review: March 19, 2008
  - Parts Ordered: June 1, 2008
  - Government Chamber Tests: July and September, 2008
  - Production Readiness Review: October 28, 2008
- Future Milestones:
  - Receive Special Type Certificate (STC) and Parts Manufacturing Authority (PMA) for B-737, B-757: January 2009
  - Production Run: Build/Test 80 WVSSII units: January 2009
  - Install 31 WVSS II on Southwest B-737: February-April 2009
  - Replace 25 WVSSII on UPS B-757: February-April 2009

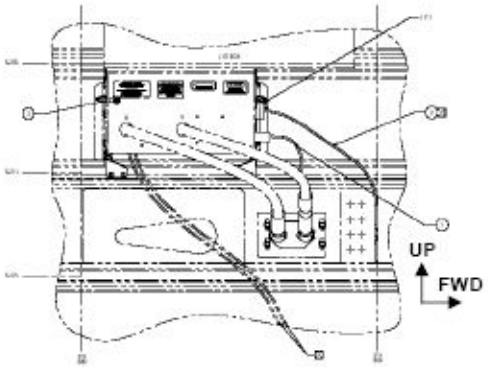
Remaining WVSSII Test Objectives

- Sterling Upper-Air Test Facility:
  - Cabin Bay Simulation Test: SEB environmental temps from -5C to 30C
  - Re-test units using expanded test protocol points and latest EPROM calibration coefficients
- Conduct flight test on NOAA P-3 with reference sensor
- DWD/KLM will provide independent testing opportunities (chamber and extended flight tests)
- CIMSS/AERIBAGO Field Test:
  - 1 week test after first 10-15 2008 WVSSII units installed on B-757 (Mar-Apr 2009)
  - 1 week test after all 25 2008 WVSSII units installed on B-757 (Jun-Jul 2009)
- Develop a monitoring database of AMDAR and GPS-Met Integrated Precipitable Water (IPW) at co-incident time/space “pairs”
- Assess ARINC monitoring web page for WVSSII

WVSSII Installations: 31+25 by April 2009 Generating ~800 Soundings/Day

Southwest Airlines B-737 Schematics for WVSSII Installation





United Parcel Service B-757 WVSSII Installation

"Cargo-Door" View WVSSII
WVSSII Located on Forward-Port Side of UPS B-757

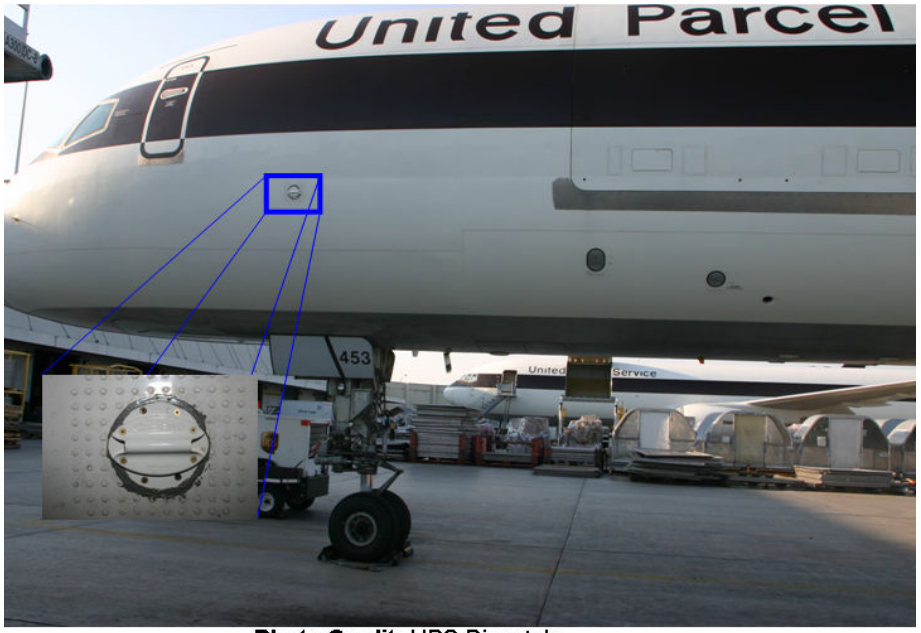


Photo Credit: UPS Dispatch
Contact for Usage: Randy Baker/UPS; Email: air1rtb@ups.com

Future NOAA/NWS Water Vapor Program

- NOAA posted a second Water Vapor Request For Proposals (RFP) for contract solicitations on November 10, 2008, with a December 10, 2008 closing date.
- NOAA options within this RFP include:
  - Extending or expanding the AirDat contract for data access to its TAMDAR observations
  - Increasing the number of WVSSII sensors installed on AMDAR equipped aircraft
  - Other options, as determined by RFP solicitations
- Despite budget pressures, NOAA continues to receive support for its aircraft water vapor program, and the potential exists for growth in future budget years.
- Success of the NOAA aircraft water vapor program will be enhanced with greater programmatic coordination with our National Meteorological Service partners in AMDAR and with U.S. Federal Agencies (DOT/FAA in particular).

Questions???

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NOAA AMDAR Web Page: http://amdar.noaa.gov/