11.2 MODERNIZATION OF THE STERLING NATIONAL WEATHER SERVICE WIND TUNNEL FOR EVALUATING ACCUARCY OF WIND OBSERVATIONS

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1.0 INTRODUCTION

Cyberdata Technologies, in conjunction with the National Weather Service's (NWS) Sterling Field Support Center (SFSC), are currently modernizing the meteorological laboratories located in Sterling, Virginia. Among the laboratories is a High Speed Wind Tunnel equipped to test the accuracy and durability of a wide range of wind sensors that serve in the NWS's backbone of observing programs: Automated Surface Observing System, Upper Air, and Buoy Platforms, as well as other types of sensor suites developed for or within NWS and other government agencies.

2.0 PURPOSE

The SFSC wind tunnel, at one time, was a prominent testing laboratory within the NWS. Multiple cup & vane as well as sonic anemometer vendors were tested in the lab. The tunnel also provided speed and direction validation as well as some calibrations to the field. However, Budget and subsequent Full Time Employee (FTE) cuts to the facility put the laboratory as a secondary function, unable to keep up with its maintenance as well as testing schedule. The SFSCs goal is to resurrect the wind tunnel lab, comprised of a low speed and high speed wind tunnel, to the prominence it once was in order to resume and perform quality assured data.

Generally, the effort will result in wind measurements tied back to a National Standard that will be promulgated into NWS observations via the SFSC testing programs. These testing programs utilizing the Wind Tunnel measurements ultimately provide guidance on the most accurate wind sensor available on the market for NWS to purchase with a budget on the order of millions of dollars.

3.0 WIND TUNNEL DESCRIPTIONS

SFSC utilizes two different wind tunnels; one low speed which is housed in the chamber area of SFSC, and one high speed which is housed in its own separate building behind the main SFSC building. Both tunnels are open circuit.

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3.1 HIGH SPEED WIND TUNNEL

The high speed wind tunnel (Figure 1) is an open circuit wind tunnel approximately 94 feet long, utilizing a 125 HP Variable Frequency Drive (VFD) motor and an eight foot diameter CORSAIR plane prop as the system designed to generate air flow. The tunnel was built in 1972 and moved to its current location in 2001. The tunnels speed range is 3-142 knots (1.54 – 73 m/s). The tunnel utilizes two testing areas: A 4' x 4' area where max winds on the order of 140 knots are generated and where most sensor testing occurs, and a 6' x 6' area where max winds on the order of 66 knots are generated and where larger sensor suite testing occurs. The tunnel also houses a multitude of temperature and humidity sensors inside the testing area, and just outside the intake. Data collection flows to a single workstation, while a separate workstation runs the motor via an in house LabView program.

3.2 LOW SPEED WIND TUNNEL

The low speed wind tunnel (Figure 2) was created in house at SFSC and is a smaller mockup of the high speed wind tunnel. The tunnel is open circuit, is approximately 18 feet in length, and utilizes a ¾ HP analog motor. The unit has a speed range of 0.06-8.10 knots (0.03 – 4.10 m/s). The test section is 3' x 3' and has a multitude of Pitot tube holes which can be utilized depending on the test units' size. The low speed wind tunnel serves to test sensors at lower speeds most commonly found at the surface as well as reporting starting speeds.

4.0 METHODOLOGY

The high speed wind tunnel sensor suite is comprised of two differential pressure sensors (MKS and Mensor), one total pressure sensor (Paroscientific), and one Pitot tube. A temperature/humidity sensor is located outside of the intake section, and a temperature platinum resistance thermometer (PRT) is located within the test 4' x 4' section. All meteorological variables are ingested into the data collection workstation, which then integrates all computed variable data into a text output, comprised of the input data as well as their respective wind speeds, utilizing Bernoulli's Principle/Equation. SFSC transfers these text files to in house created excel spreadsheets which graph the data.

Anemometer test points follow ISO-16622 standards and are tested for 30 second averages at the following speeds: 13, 22, 40, 70, and 125 knots. The testing unit is also rotated in five degree increments during the same time frame in order to test the unit for direction accuracy as well as quality.

5.0 RESULTS

As an early test on the quality of data, SFSC was able to utilize the National Institute of Standards and Technology (NIST) wind tunnel laboratory to calibrate the Pitot tube used in the SFSC wind tunnel. The Pitot tube utilized two different differential pressure sensors versus NISTs Laser Doppler Anemometer (LDA) which serves as their reference. For the five data points that SFSC utilizes in the high speed wind tunnel; the ratios were 1.001, 1.002, 1.002, 1.001 and 0.998 respectively (see Figure 3). These almost 1 - 1 ratios lead SFSC and NIST to come to the conclusion that there is no data degradation coming from the tube.

SFSC, in conjunction with NIST, will test their entire system (Pitot tube, differential pressure sensors, Vaisala 425 Ultra Sonic Anemometer) as a whole versus the LDA reference at NIST. Even though the new differential pressure sensors are NIST traceable, this test will allow scientists to be even more confident in the SFSC readings, and provide SFSC scientists with the utmost quality assurance.

6.0 SUMMARY

Previous data collection from NIST shows that the Pitot tube used at SFSC has no data quality issues with respect to the wind speed test points for the high speed wind tunnel, as seen with the ratios versus NISTs LDA. The wind tunnel QA with respect to data collection is the highest it has been since the mid 2000's when the tunnel was a prominent testing fixture in the NWS. Future testing at NIST will allow SFSC to see how the complete pressure system functions in a closed wind tunnel, which will allow possible differences to be applied to testing units due to turbulence. It should be noted however, that SFSC turbulence factors are low.

7.0 TABLES AND ILLUSTRATIONS

Tables

Table 1. This table provides results of the Pitot tube testing at NIST. The highlighted data signify the testing points for the high speed wind tunnel. Note the ratios are almost 1 to 1.

Vnist	Viut	Viut/Vnist
[m/s]	[m/s]	[-]
1.042	0.997	0.958
1.529	1.508	0.987
1.034	1.991	0.979
3.027	2.998	0.990
5.034	5.021	0.997
6.718	6.721	1.001
11.340	11.367	1.002
20.587	20.636	1.002
35.698	36.011	1.001
64.968	64.232	0.998

Figures

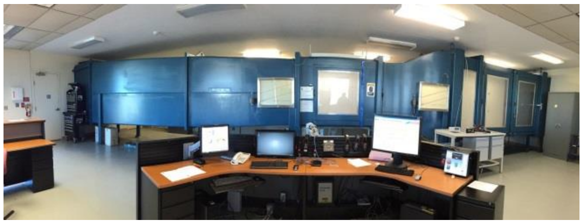

Figure 1. Overview of the high speed wind tunnel laboratory. 4'x4' (center) and 6'x6'(right) test sections are shown

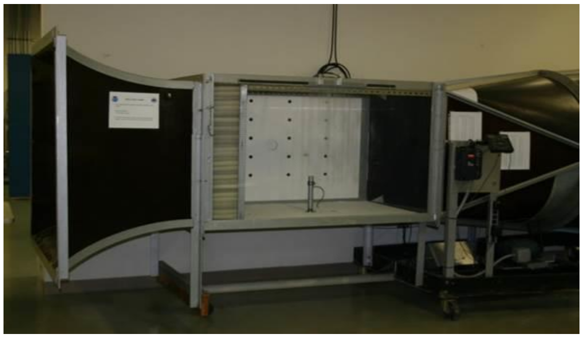

Figure 2. Low Speed Wind tunnel. 3'x3' section shown.