10B.1 Development of an In-Situ GPS Reference System

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1. INTRODUCTION

The U. S. has been testing radiosonde manufacturer's radiosondes for many decades at test facilities around the country and has developed a number of test techniques for verifying performance. Recent advances in measuring the upper air atmosphere utilizing state-of-the-art referencing technologies and the development of new test techniques within the U.S. are now available for evaluating radiosonde performance to meet the more stringent climate monitoring requirements and numerical weather prediction models. Each reference technology can play an important role in the *Consensus Reference Concept;* whereby, data are integrated into information bases from which statistical techniques would be applied to the time-based and pressure/height candidate instrument measurements of say, temperature, moisture variables, cloud bases, and winds as compared to the references in use.

This extended abstract covers one aspect of the Consensus Reference Concept; namely, the development of an *In-Situ GPS Reference* for independent measurements/calculations of geometric heights, geo-potential heights, derived-pressures, and the u- and v-components for calculating winds aloft. Previous extended abstracts covered other aspects of this concept which should better help the reader understand the development of these processes.

2. STERLING FIELD SUPPORT CENTER

The Sterling Field Support Center (SFSC) facility is used quite extensively during radiosonde testing by the NWS. Systems configured at the facilities for testing radiosondes include NWS upper air systems, surface systems, and a GPS Integrated Precipitable Water sensor. These are all within close proximity of each other at the test facility. The balloon inflation building launch area is oriented east-west and the benchmark which was provided by the National Geodetic Survey (NGS) within NOAA installed the in-ground monument for the NWS as seen in Figure 1. The monument will be surveyed to within centimeters of accuracy in latitude, longitude and height. This provides a very precise starting point for the launching of radiosondes or other balloon-borne packages.

A Continuously Operating Reference System (CORS) will be relocated to an area within 25 meters to the south of the benchmark. CORS serves as an independent reference for evaluation of the test instruments. The interested reader is referred to the CORS website for complete details:

http://www.ngs.noaa.gov/CORS/cors-data.html

Figure 1. NGS Benchmark and future CORS site installed at the SFSC.

2.1 Consensus Reference System

The Consensus Reference System (CRS) at the SFSC consists of the following components:

- One or more ground systems for tracking radiosondes and reference instruments
- Surface systems
- Remote systems including GPS-IPW
- Precision Digital Barometer
- Data Base Management System/Display

See accompanying papers for further details on this topic. The real challenge with CRS is integrating datasets from the diversity of technologies and synchronizing them within the frames-of-reference as discussed in previous extended abstracts.

2.2 Pressure/Height Referencing

Pressure/height referencing is the most well behaved of upper air measurements since these are very stable and heights are easily calculated if not measured directly. Refer to Figure 2 for examples. However, radiosonde vendors use a wide variety of GPS engines which have different characteristics and specifications to acquire this data. Also, vendors use different methods for removing the pendulum effects as the radiosonde package ascends. Radiosondes use these engines to determine geo-potential heights from the geometric heights acquired, pressure profiles by transformation of the Hypsometric Equation, and computation of wind speed and direction throughout the sounding from changes in the radiosonde's position (Figure 3 illustrates this concept).

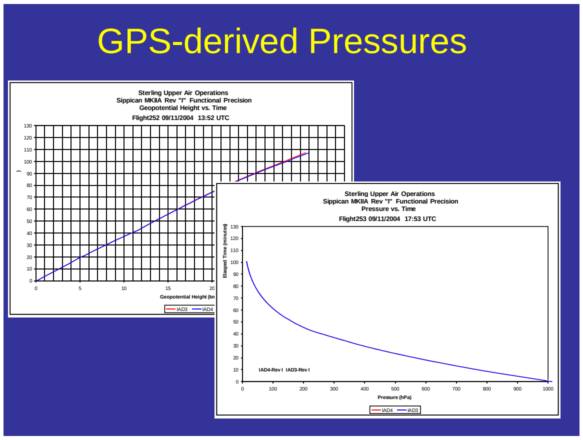

Figure 2. Pressure/Heights from candidate test radiosondes.

3. IN SITU (GPS) REFERENCE SYSTEM (ISRS)

The basic concept being envisioned by the NWS for the ISRS is to use a precise a GPS engine – accuracy of measurements in the x, y, and z planes approximately 1 meter although technology is advancing so fast, low-cost gps engines measuring centimeter accuracy is potentially available. The ISRS package would be launched from the benchmark as an extension of the CORS On-line Positioning User Service (OPUS) providing GPS users easier access to the National Spatial Reference System (NSRS). The actual technique for using OPUS/NSRS is under development and will be discussed in another paper.

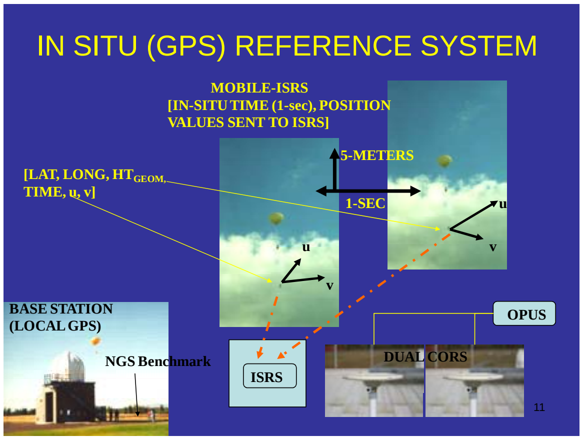

Figure 3. Referencing and candidate test systems converted to similar frames of references.

Figure 4 illustrates a block diagram NWS plans to use for developing this reference concept. Note NWS is still ascertaining whether a dual CORS configuration is required. ISRS only requires a precision GPS providing its data in an OPUS-friendly format; in effect translating the surface benchmark position throughout the flight aloft. Test radiosondes will be attached in a dual sounding configuration with the ISRS GPS package. A database of all these measurements will then be developed to process the results for reports on each candidate radiosonde's performance.

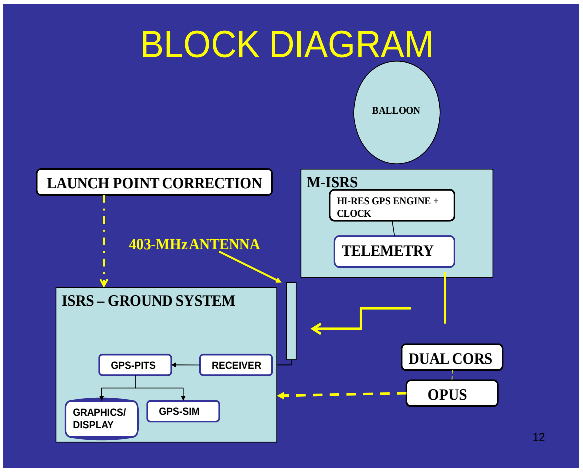

Figure 4. Block diagram for ISRS.

3.1 Possible Output Products

One of the key elements of ISRS will be the products derived from the reference and GPS data derived from candidate test radiosondes. The radiosonde data would be collected from the vendor-supplied Signal Processing System (SPS) using the NWS program “Protocol Interface Test Suite” (PITS). PITS files would then be normalized into one-second interval data using an NWS utility called *Convert PITS*.

The goal here is to determine how accurately the test radiosonde reproduces heights, pressures and winds, and identify areas where these diverge from the reference. Once these comparisons are processed as shown in Figures 5a and 5b, the NWS can ascertain if any changes are needed by the vendors within their radiosondes or processing software.

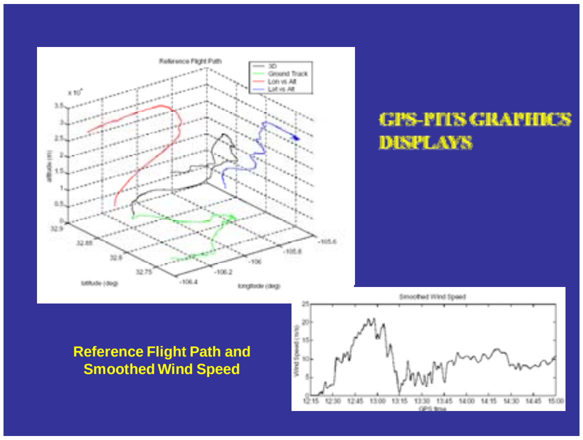

Figure 5a. Example outputs for the ISRS.

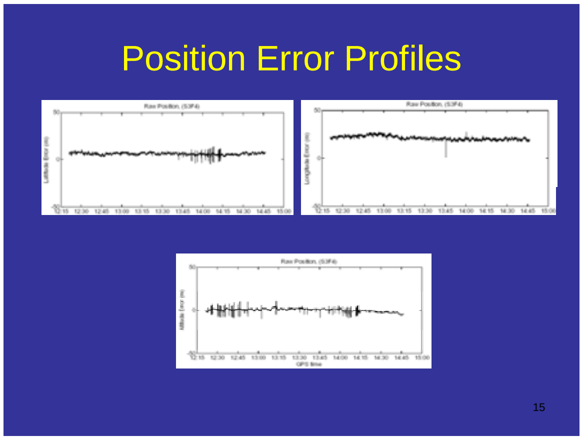

Figure 5b. Additional examples.

3.2 Similitude Testing

Another aspect in the process will be the utilization of a GPS simulator and a NWS environmental pressure/temperature chamber in concert for evaluating test instruments without launching assets into the atmosphere. The great advantage with this approach is the deferral of cost and reduction of resources needed to carry out these tests. The technique would be developed as follows:

1. Since the ISRS reference is a continuous, very accurate measuring system, the first step is to fly and record all the pertinent data from one or more ISRS packages. Both low wind and high wind conditions would be acquired.

2. These data sets will be incorporated into the GPS Simulator as a library of case studies. The NWS environmental chamber allows the radiosonde to be suspended within a simulated atmosphere down to 3 hPa with the radiosonde providing its interpretation of the GPS simulated data.

3. Having known values from ISRS versus the test radiosonde interpretations of these same data can be of great value in diagnosing problems and ascertaining true performance.

4. Figure 6 illustrates this possible system configuration.

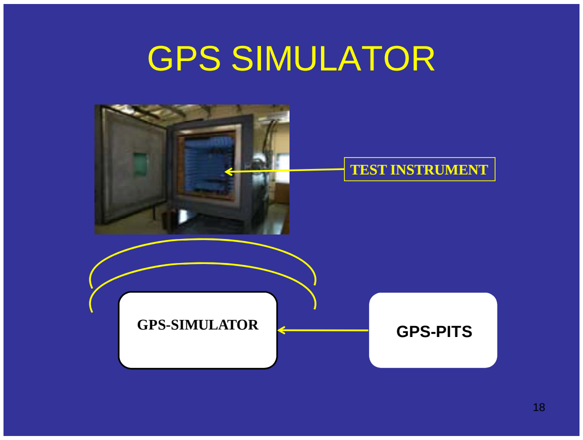

Figure 6. Simulator and environmental chamber configuration.

4. CONCLUSIONS

The purpose of this paper is to inform the meteorological and climate communities about the potential for a consensus reference concept, whereby an ensemble of tests are conducted and the results standardized to formulate a consistent pattern for evaluating upper air instrumentation and systems.

The concept of the ISRS has important benefits for assessing atmospheric pressure/heights and winds. Once the methods discussed in this paper are further developed and proven, the plan is to document them into a catalogue and new abstracts for use by the wider community. Other techniques can also be developed as interested parties contribute their thoughts and ideas in concert with the CRS process..

5. ACKNOWLEDGEMENTS

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