INTERMET 403 MHZ RADIOSONDE SYSTEM

Rodney D. Wierenga*, Joe Parini
International Met Systems, Grand Rapids, Michigan

1. INTRODUCTION

InterMet has developed a new, digital, high-accuracy upper-air 403 MHz radiosonde with a portable ground station that is applicable to synoptic as well as military applications. The ground station is small and light weight and is easily moved to a new site. It can be set up by one person in less than 10 minutes. For non-military applications, a C/A code GPS receiver is used, while, for military applications, a P(Y)-code SAASM compliant GPS receiver is used. The radiosonde uses the same high accuracy pressure, temperature and humidity sensors used on the InterMet radiosonde developed for the U.S. National Weather Service.

Setup of the radiosonde before launch is exceptionally easy. Radiosonde unique calibration coefficients are stored in the radiosonde, power is provided by dry cell batteries, and calibration before launch is not required. This paper presents details of the design and performance of the system.

2. iMet 1 403 MHZ RADIOSONDE

Figure 1 shows the iMet 1 403 MHz radiosonde. It has a polystyrene case, a non-hygroscopic wrapper, a temperature-humidity boom and an elastic string for attachment to a balloon. It has four electronics boards and a 4 AA dry-cell battery pack, which has enough power to last 3 hours.

The first board is the main board with the processor and interfaces to the other boards. The second board has the pressure sensor and its electronics. The third board has the 403 MHz transmitter with its antenna. The fourth board has the C/A code receiver for non-military users, an LNA, and a GPS antenna. The GPS board is replaced by a GPS front end for military users.

To prepare the radiosonde for flight, the user removes the radiosonde from the shipping bag and opens the top of the wrapper. This allows the user to bend the boom out to a 45 degree angle and feed the elastic string with a ring through the top of the wrapper for attachment to the balloon string. A Styrofoam door inside of the wrapper is raised to access two switches, via a hole in the wrapper, that are used to turn the power on and to set the transmitter to one of 8 frequencies in the 400.15-406 MHz range. There is no need to insert a battery pack, connect the battery pack or fill a battery with water. The mail back bag is accessible from the open flap so the user can write the launch data on the bag. A flap is provided to access the mail back bag for someone who may find the radiosonde after a flight.

Figure 1: InterMet iMet 1 Radiosonde

*Corresponding author address:
Rodney D. Wierenga, PhD, InterMet Systems,
4460 40th St SE, Grand Rapids, MI 49512; e-mail:
rwierenga@intermetsystems.com.

The size of the radiosonde is 150 mm high by 90 mm by 90 mm and it weighs 260 grams.

While in storage, the temperature-humidity boom is bent down over the top of the radiosonde and protected by the top flap of the wrapper.

3. C/A CODE GPS RECEIVER

The C/A code receiver is a single chip low-power, high-quality miniature C/A code receiver. It has 12 channels with continuous tracking capability. C/A code receivers use the L1 frequency (1575.42 MHz). A hot start of the receiver can be done in 2 seconds (90%) using information from the ground station. A cold start is done in 84 seconds (90%). Outputs of GPS position and velocity are provided at a 1 Hz rate. A right-hand circular polarized micropatch GPS antenna is used which is mounted just inside the Styrofoam on top of the radiosonde. The accuracy is 8 m (90%) horizontal and 16 m (90%) altitude and 0.06 m/s (RMS per axis) with selective availability (SA) off. Smoothing of the received data is done on the ground to remove the motion of the radiosonde swinging below the balloon with a resultant wind accuracy of 1 m/s (2-sigma).

4. P(Y) CODE GPS RECEIVER

The P(Y) code receiver is split into two parts. A P(Y) code front end replaces the single chip GPS receiver in the radiosonde. The front end collects GPS data over a 5 to 10 msec period for each position fix. The data is transmitted by the 403 MHz transmitter down to the ground part of the GPS receiver. This data is used by a P(Y) code processor in the ground equipment to determine position and velocity of the radiosonde. With this approach, the P(Y) code is only located in the ground equipment and no classified hardware or software is in the radiosonde. There is no concern that the radiosonde may be lost and get into the wrong hands. The P(Y) code is handled in the ground receiver using the U.S. military SAASM approach. The P(Y) GPS antenna is also mounted on top of the package and is a right-hand circular polarized micropatch antenna. The position accuracy is 16 m (3-D SEP) and the velocity accuracy is 0.1 m/s (RMS per axis).

5. 403 MHZ TRANSMITTER

The transmitter has a crystal controlled oscillator that controls the selected channel frequency. It has a linearly polarized dipole antenna and transmits FM modulated signal containing digital PTU and GPS data. For P(Y) code GPS, the bandwidth of the transmitter is increased to accommodate the larger amount of GPS data that is transmitted to the ground.

6. TEMPERATURE-HUMIDITY BOOM

The temperature-humidity boom is shown in Figure 2. It is a one-piece assembly. A high reflectance (88%) vacuum deposited aluminum coating with very low emittance (0.02) covers the thermistor, thermistor wires, and surrounding mounting structure. The humidity sensor is placed under a white cap to protect it from direct contact with water and ice.

7. TEMPERATURE SENSOR

The temperature sensor is a very small glass bead. Its small size allows a fast response time (<3.6 sec at sea level with 5 m/s ventilation). The aluminum coating minimizes solar and infrared heating.

8. HUMIDITY SENSOR

The humidity sensor is a variable capacitance device. It has a polymer dielectric insulator with a permittivity that varies with relative humidity. Due to its small size it has a fast response time (2 seconds at sea level and 20 deg C). There is very little performance degradation after long-term saturation with nearly instantaneous de-saturation. There is no performance degradation after immersion and thawing.

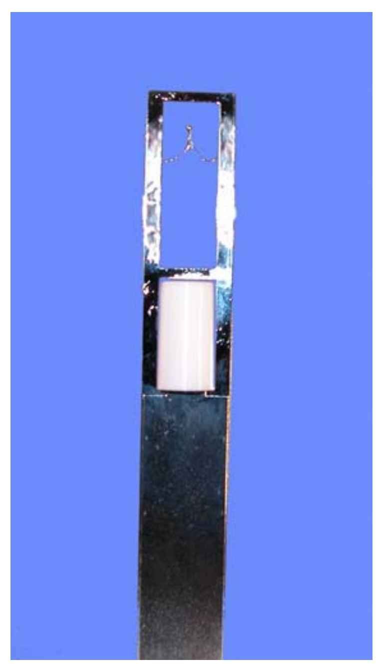

Figure 2: Temperature-Humidity Boom

9. PRESSURE SENSOR

The pressure sensor is a compensated piezo-resistive silicon device. It is very small and has excellent long-term stability. It is an outgrowth of the medical and automotive instrumentation industries. It has a resolution of better than 1 part in 100,000.

10. DATA PROCESSING

The radiosonde microprocessor manages the PTU and GPS data. The PTU data is A-to-D converted and the PTU and GPS data are transmitted in digital format. The ground station down converts the telemetered data to a baseband signal. It also performs calculations to recover the PTU and GPS data. With a C/A code receiver, a ground station GPS receiver is used to correct the position and velocity measured by the GPS receiver in the radiosonde. With a P(Y) code receiver, the data transmitted from the radiosonde is processed to determine radiosonde position and velocity.

11. PERFORMANCE

The performance characteristics are listed in Table 1. These are 2-sigma numbers, meaning that 95.5% of the errors in the measurements are within the listed numbers.

12. GROUND EQUIPMENT

The ground station is housed in an unbreakable, watertight, dustproof, chemical resistant and corrosion proof case. It has a 403 MHz receiver, a decoder, a processor, a GPS receiver, a laptop computer, and rechargeable batteries. In the C/A code case, for non-military applications, the GPS consists of a GPS receiver, similar to that in the radiosonde, for differential corrections. In the P(Y) code case, for military applications, the GPS receiver consists of a SAASM compliant receiver for processing GPS data from the radiosonde. A notebook computer is included to process P(Y)-code receiver data, for military applications, and to process and display weather data. The size of the case is 48.6 cm by 39.2 cm by 19.2 cm and it weighs 9.1 kg (20 pounds).

A second case of the same type is used to carry the antennas and antenna cables. Enough cable can be carried to allow for remotely locating the GPS and 403 MHz antennas up to 100 meters away from the ground station. Several different antennas options are available.

Table 1: Performance

Pressure		
	Range	2 to 1070 hPa
	Resolution	0.01 hPa
	Accuracy	±1.8 hPa (> 400 hPa, -80 to +40 Deg C) ±0.5 hPa (< 400 hPa to 4 hPa, -80 to +40 Deg C)
	Response Time	1 sec
Temperature		
	Range	-95 to +50 deg C
	Resolution	0.01 deg C
	Accuracy	±0.3 deg C (-80 to +40 deg C)
	Response Time	3.6 sec (1013 hPa, -80 to +40 deg C, ventilation speed of 4.5 to 5.0 m/s)
Humidity		
	Range	RH: 0% to saturation
	Resolution	0.1%
	Accuracy	±5% (-60 to +50 deg C) ±2% change after near saturation
	Response Time	2 s (5 m/s vent speed, 1013 hPa, +25 deg C) 60 s (5 m/s vent speed, 1013 hPa, -35 deg C)
GPS Velocity		
	Range	±150 m/s (north & east)
	Resolution	0.1 m/s
	Accuracy	±0.06 m/s instantaneous, ±1 m/s smoothed (estimated wind)
GPS Position		
	Range	lat, lon: any alt: -50 m to 42 km
	Resolution	lat, lon: 0.01 arc sec alt: 0.1 m
	Accuracy	lat, lon: ±10 m alt: ±30 m

13. CONCLUSIONS

This InterMet 403 MHz upper-air system is light weight, portable, rugged and has excellent accuracy. It can be used for either military or non-military applications. For non-military application, a commercially available GPS receiver is utilized, while for military applications, a SAASM compliant GPS receiver is used.

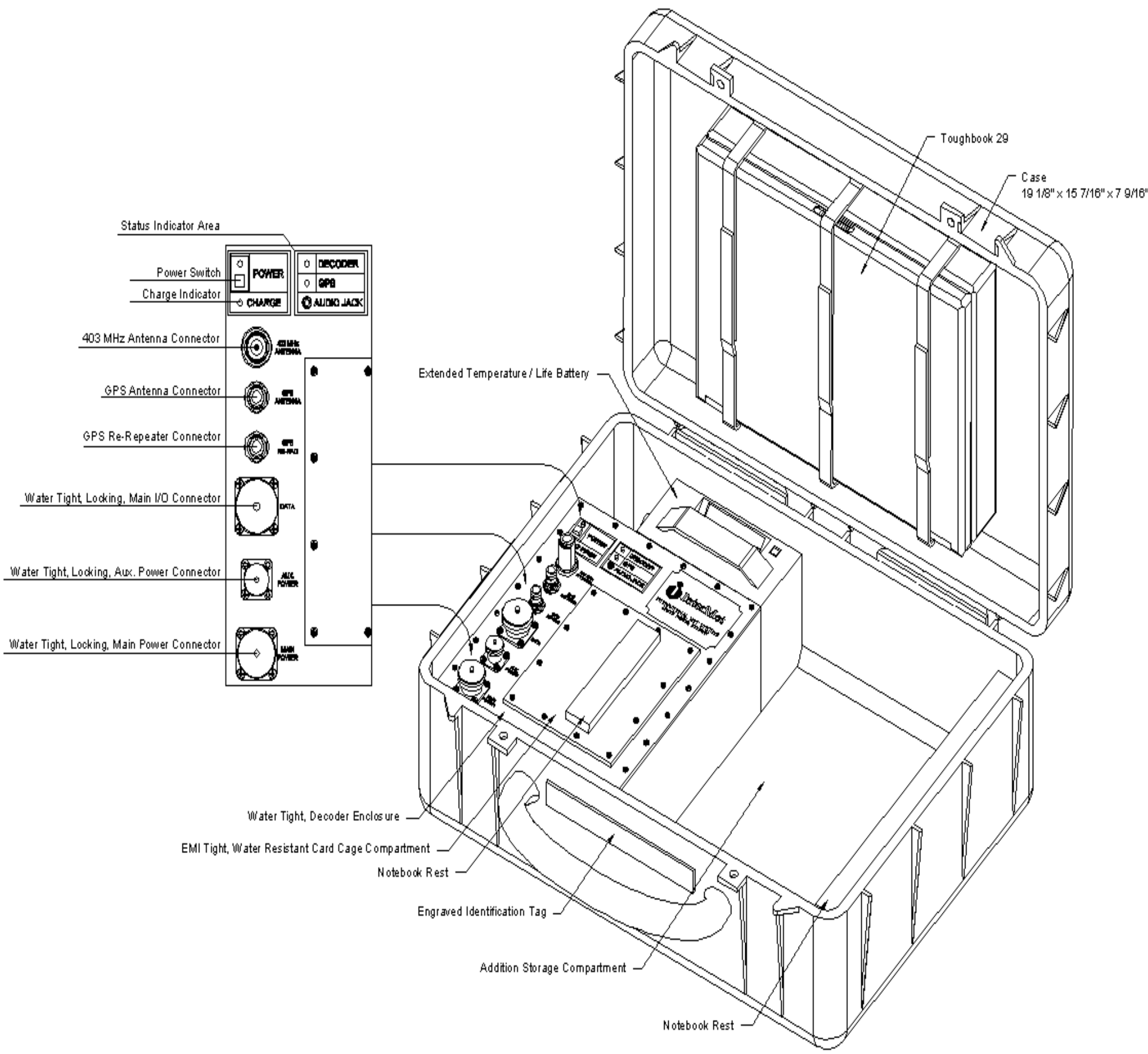

Figure 3: Portable 403 MHz Radiosonde System Ground Station