Test Results of GPS Dropwindsonde and Application of GPS in Precision Airdrop Capability Using the TIDGET GPS Sensor

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BIOGRAPHIES

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Dennis Caffery is a member of the NAVSYS Product developmtnt staff. His responsibilities include design and development of Radiosonde, Sonobouy & Translator systems for GPS applications. He is also responsible for intergration of these systems to range or standalone configurations. Mr. Caffery received his BS degree from the University of Nevada, Las Vegas and his post graduate studies at the University of California, Fullerton. Mr Caffery has worked for the last 11 years with the Navy Department Of Defense in GPS instrumentation development.

Amir Matini
Amir Matini is a member of the NAVSYS technical staff. His responsibilities include design and development of antenna, RF, and microwave systems for GPS applications. He is also responsible for the resolution of electromagnetic compatibility and electromagnetic interference problems. Mr. Matini received his BSEE and MSEE degrees from the University of Colorado at Colorado Springs and is continuing studies towards a PhD. His research interests include electromagnetic thermography, antennas, RF and microwave circuits.

ABSTRACT

Delivery of supplies and equipment by aerial transport is a critical component of the United States military global mobility strategy. In many cases precision airdrops of cargo and supplies is desirable over landing of the transport aircraft. It is extremely important to insure the parachuted cargo lands at the desired site on the ground and not be intercepted by hostile forces or be lost. A key factor in calculating the correct dispensing point for the airdrop is accurate information on wind direction and speed verses altitude. It is also highly desirable to be able to track the cargo decent to the ground from the release aircraft or from the ground. This would provide confirmation of a successful drop and allow the receiving ground personnel to locate the item more rapidly, especially in poor visibility conditions.

The NAVSYS GPS TIDGET tracking system is ideally suited for providing wind measurements information and providing tracking/ location information on the airdropped cargo.

This paper describes the test data taken at Yuma Proving Grounds for NAVSYS Dropwindsondes released from a C141 aircraft. In cooperation with WPAFB Improved Precision Airdrop Capability (ImPACt) program, measurements were made from the aircraft and the ground using the TIDGET tracking system. The TIDGET tracking system is a low cost GPS based system utilizing real-time processing and differential GPS correction for improved accurcy. The TIDGET GPS Sensor is an "instant on" device that does not require initialization or time to acquire GPS satellites. It has many performance advantages over standard GPS receivers which will be summerized in the paper. Data will be presented showing the wind velocity and direction verses altitude. The position of the Dropwindsonde verses altitude will also presented with application for using the same system in cargo tracking. Included in the paper will be an overview of the TIDGET technology and system operation.

OVERVIEW

The TIDGET Dropwindsonde tracking system is a GPS translator based system capable of generating position and velocity information in near real-time. The system provides instantaneous velocity measurements rather than differencing the position between two fixes over the

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traveled time. **Figure 1** shows a block diagram of the TIDGET Dropwindsonde tracking system.

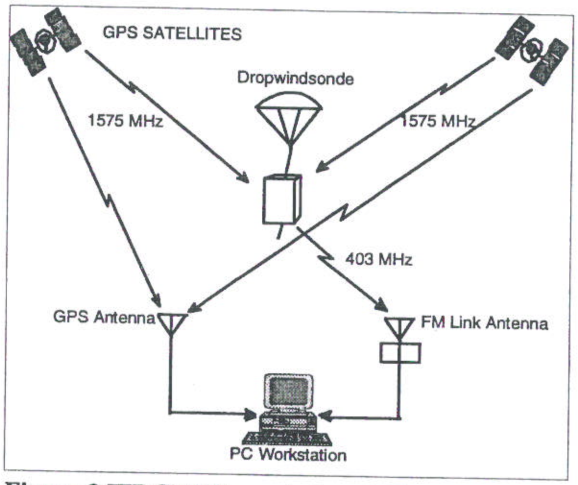

Figure 2 TIDGET Dropwindsonde System

The TIDGET GPS sensor includes fewer components than a GPS receiver card, which results in a smaller package size, lower power consumption, and lower cost in volume. The digitized GPS data provided by the TIDGET sensor is FM modulated and transmitted to the ground processing station. The system uses the 400 MHz frequency range already allocated to the meteorological applications for

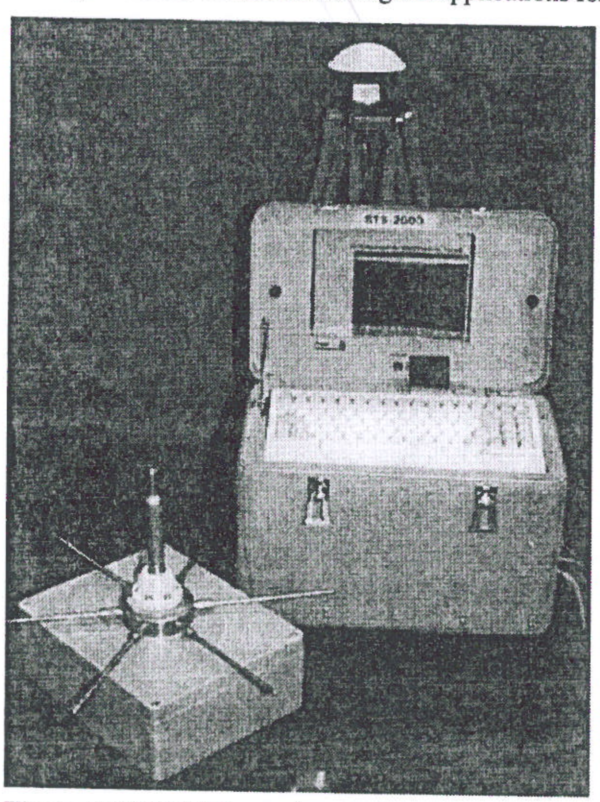

Figure 1 TIDGET Processing Station

data transition. The ground processing station uses internally generated differential correction for greater accuracy. The preparation of the sensor prior to release is minimal and no calibration is required. The TIDGET tracking system is a PC based system and is enclosed in a rugged and compact housing. A photo of the ground processing system is shown in **Figure 2**. The wind profile information is available for display on the monitor, or as an output through a serial port, and / or can be logged to disk.

SYSTEM ARCHITECTURE

The system consists of an airborne segment (TIDGET dropwindsonde) and a ground station processing segment which is a PC based system.

TIDGET Dropwindsonde

The TIDGET sensor is a digital GPS translator with a small physical size (less than 6 cu.in. including the GPS antenna). A block diagram of the TIDGET dropwindsonde is illustrated in **Figure 3**. The TIDGET sensor operates at the L1 frequency and can be programmed to automatically output periodic data packets.

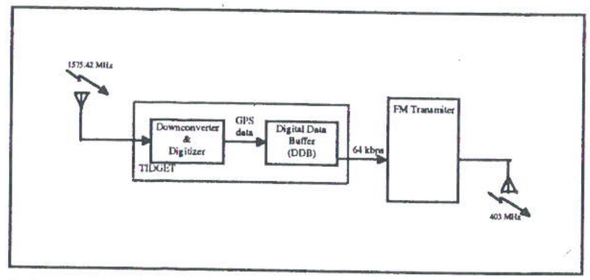

Figure 3 TIDGET Dropwindsonde Block Diagram

The transmitted data is in the form of packets. Each packet contains a snapshot of the raw GPS data plus other information. The TIDGET also has a 16 channel multiplexing capability which allows it to include optional sensor data in each packet. Although the TIDGET default output data bit rate is set to 64 kbps, it may be programed from 200 Hz to 2 MHz using an EEPROM. The TIDGET is interfaced to a FM transmitter for data modulation and downlink over the 400 MHz meteorological bandwidth of the frequency spectrum.

TIDGET Workstation

The TIDGET workstation is a portable PC which interfaces to two antenna modules, one for the GPS reference receiver, and one for the 403 MHz FM link.

The portable PC which handles all the processing contains a synthesized FM receiver card, a data interface card, a Digital Signal Processing card, and a commercial GPS card. The processing station which is shown in Figure 2 has physical dimensions of 17"W x 10.5"D x 13"H and weighs about 30 lbs.

Both RF antenna modules are active devices and are powered by the PC power. The FM receiver handles the reception and the demodulation of the telemetry link signal. The interface card receives the demodulated data packets and hands the GPS data over to the DSP card. The DSP card processes the data for tracking the GPS satellites and provides navigation solutions. The system is capable of taking advantage of the differential correction using the information provided by the reference GPS card included in the processing station. The TIDGET workstation block diagram is shown in **Figure 4**.

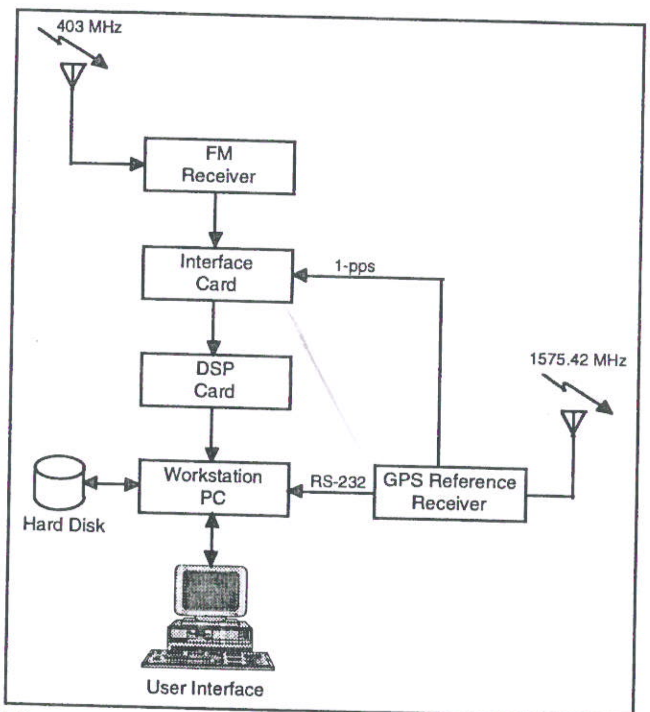

Figure 4 TIDGET Workstation Block Diagram

TEST RESULTS FROM DROPWINDSONDE TEST AT YUMA, AZ

At Yuma there was two scheduled flight test. The first test was schedule for Monday 3/4/96, this flight was designed to carry the base station inside the C-141 durning the dropwindsonde test (relative differential GPS). The GPS signals were distributed in the aircraft via repeaters that were connected through coax to a GPS antenna on top of the aircraft. The repeaters then re-broadcast the GPS signals through a small antenna in the cargo hold. With the reference receiver antenna within 4 feet of the repeater, C/No values were 4 to 6 dB below standard of open air GPS broadcast would provide. The UHF antenna was a small blade type on the belly of the aircraft. Post analysis tests showed that the UHF antenna was tracking the sonde in the aircraft. The system had to be setup for operation by the C-141 aircrew and a batch file was created. Problems with the power required a reboot of the system 5 minutes before drop. GPS time for the reference receiver in the aircraft was obtained two minutes before drop time. The drop was a complete success and the data was logged for post analysis. **Figure 5** and **6** is the graphic test results of first drop in a 3D graphic representation generated by MatLab. In Figure 5, the center line is the track, the bottom and wall lines are the shadows on the 3-D graphic walls.

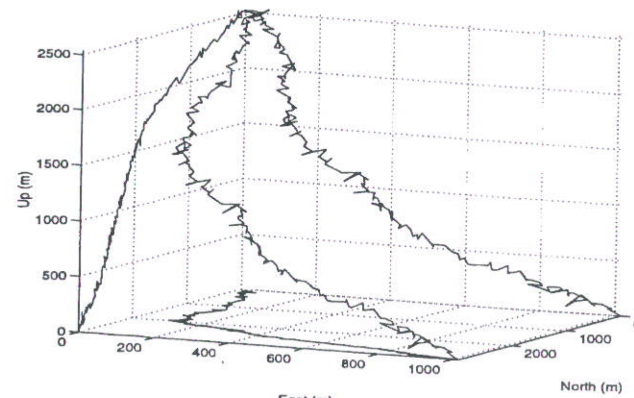

Figure 5 Position track of dropwindsonde test with base station in aircraft

In **Figure 6** the North, East and Down velocities are shown.

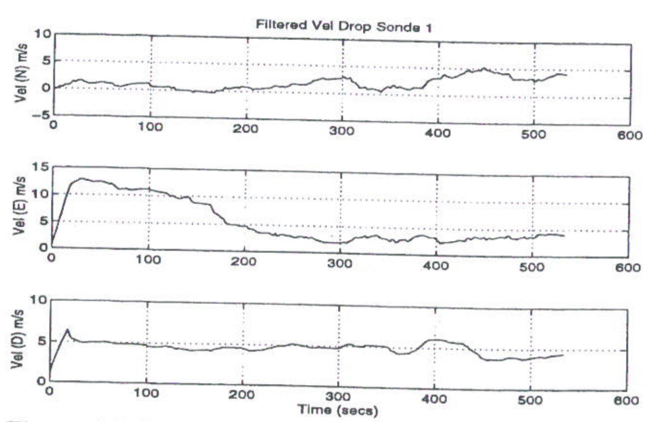

Figure 6 Wind velocity of dropwindsonde test with base station in aircraft

The second test was schedule for tuesday 3/5/96, this flight was designed to have base station on the ground, near the drop zone durning the dropwindsonde test. The system was started 10 seconds before the drop and tracking was monotored until the FM link subsided. Data was logged for post analysis. **Figure 7** and **8** is the graphic test results of first drop in a 3D graphic representation generated by MatLab. In Figure 7, the center line is the track, the bottom and wall lines are the shadows on the 3-D graphic walls.

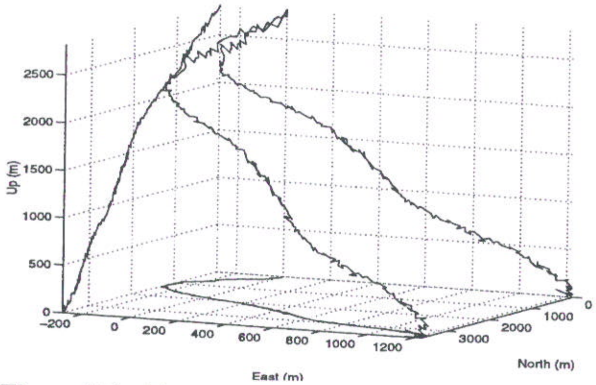

Figure 7 Position track of dropwindsonde test with base station at drop zone

In **Figure 8** the North, East and Down velocities are shown.

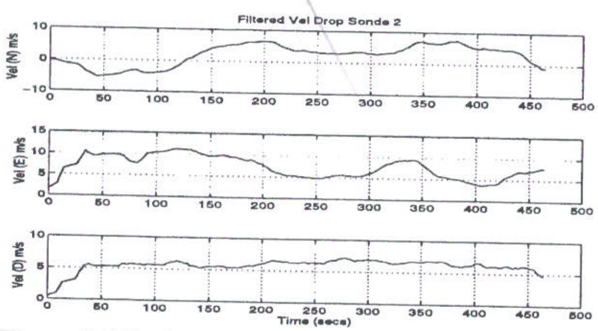

Figure 8 Wind velocity of dropwindsonde test with base station in aircraft

CONCLUSIONS

The NAVSYS TIDGET Dropwindsonde tracking system provides near real-time position, wind speed, wind direction and velocity profiling for delivery of supplies and equipment by aerial transport. The NAVSYS Dropwindsonde can track cargo or give vital wind information so that the parachuted cargo lands at the desired site on the ground so not to be intercepted by hostile forces or be lost.

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