NAVSTAR GPS HOST VEHICLE TELEMETRY SYSTEM

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ABSTRACT

The Navstar Global Positioning System (GPS) is presently undergoing full-scale engineering development by the Department of Defense. A unique telemetry system has been developed to support field test and evaluation of the GPS user equipment. Most of the field testing is being conducted at the U.S. Army Yuma Proving Ground, which is equipped to receive and process GPS telemetry. The telemetry system allows real-time processing of GPS test data to support rapid on-site test planning, operations, and analysis.

Telemetry transmission hardware has been integrated on a variety of GPS host vehicles. These include the Air Force’s C-141 cargo aircraft, B-52G bomber, and F-16A fighter, the Navy’s Convair 880 and A-6E attack aircraft, and the Army’s UH-60 helicopter and M-35 truck.

Portable test station (PTS) units have also been developed to support the telemetry system. The PTS will function as ground support equipment for host vehicle modification center installation checkout, staging area premission checks, and telemetry transmission system troubleshooting. it also functions as a GPS-unique self-contained, man-portable telemetry receiving station for real-time GPS performance demonstrations and for remote range telemetry display and processing.

INTRODUCTION

The Global Positioning System (GPS) is the culmination of approximately 30 years of evolutionary development in satellite navigation systems. The Navy’s Transit System, originally supporting the fleet ballistic missile force, became operational in 1964 and is now widely used in both Government and commercial applications. Transit provides intermittent positioning accuracy of better than 100 meters. Both the Timation and 621B programs proceeded through hardware demonstrations and, in 1973, were combined into a common, joint-service development. DCP-133, authorizing concept validation of GPS, was signed in January 1974, with the Air Force assigned executive service responsibilities. All of the military services and the Defense Mapping Agency have been involved from the beginning of GPS, with the Department of Transportation and NATO joining later in the development.

Concept validation of GPS, involving the launch of two Timation and six GPS development satellites, establishment of an interim control segment, and development and test of a variety of user receiver equipments, was successfully completed with a DSARC II decision in July 1979 to proceed with full-scale engineering development.

The present Phase II full-scale-development contractors are Magnavox and Rockwell Collins in a competitive program for user sets. This equipment is being tested on multiservice class sets of host vehicles to demonstrate military utility. A DSARC III (full production) decision is scheduled for October 1984.

The operational testing of these user sets is being conducted primarily at the Army Yuma Proving Ground in Arizona and at the Navy SOCAL Range off San Clemente Island, California. Telemetry of user set performance is being utilized on a variety of aircraft and ground mobile host vehicles doing test missions at Yuma Proving Ground. These telemetry-equipped host vehicles are being staged out of El Centro Naval Air Facility in California, Fairchild Air Force Base in Washington, and Yuma Proving Ground. This paper describes the development, integration, and the operational performance of the GPS host vehicle telemetry system its associated portable test station.

SYSTEM DEVELOPMENT

For successful operational testing of the GPS user sets, the GPS Joint Program office needed a host vehicle telemetry system that could support rapid on-site test planning, allow real-time control of test operations, and facilitate quick-look test data analysis. The system had to provide real-time display and processing of the GPS test data with simultaneous dual mission capability over a 50 mile range link. The JPO generated the telemetry system technical requirements shown in Table I to meet mission requirements. Subsequently, in November 1981, Loral Data Systems in San Diego, California, was awarded the contract for system development and hardware production. Pre-production installation and kitproofing were performed in May 1982 on a Convair 880 aircraft from the Naval Air Test Center, Patuxent River, Maryland. Flight testing out of El Centro Naval Air Facility and over Yuma Proving Ground was immediately successful, and full-scale production and integration on other host vehicles were initiated. Figure 1 is a photograph of the host vehicle telemetry system hardware.

SYSTEM INTEGRATION

The integration of the host vehicle telemetry system was accomplished with guidelines and participation by the GPS Joint Program Office to each individual host vehicle modification center. Special interest was given to antenna aperature installation locations for each vehicle to avoid blockage and poor link margins. See Table II for link margin calculations. Power conditioning was not required for the telemetry system was designed to accept the worst-case host vehicle power. Heat dissipation in the power amplifiers was anticipated to be a potential integration problem, and a thermal shut down circuit was designed into the amplifiers to avoid hardware failure. Temperatures at Yuma Proving Ground often exceed 110°F, and cycling of the shutdown circuit was anticipated during extreme temperature environments. Figure 2 illustrates a typical host vehicle installation and interface to GPS sets.

OPERATIONAL RESULTS

Performance of the GPS host vehicle telemetry system has been highly successful. Human factors relating to equipment servicing and mission configuration set up has also been progressing smoothly with a rapid learning curve with operational personnel.

Interaction with range receiving and data processing personnel has been structured for high mission success rate. The success rate is an extremely important factor in most real-time systems, and with GPS user equipment testing involving a large amount of resources, it has been a critical requirement.

The reliability of the telemetry system has allowed the range operations center to rapidly process display plots from the real-time data, reducing the quick-look data evaluation time. Magnetic tape recorders on board the aircraft also record similar data and can be used for comparisons or backup to the telemetry data.

PORTABLE TEST STATION

A portable test station (PTS) was also developed to support field deployment of the host vehicle telemetry system. The PTS is a rugged self-contained, man-portable test unit capable of receiving and displaying GPS host vehicle telemetry data. Figure 3 illustrates the PTS mechanical design. The PTS provides telemetry system functional checkout and troubleshooting capability, which has proven to be very valuable at the host vehicle modification centers for installation checkouts and at the staging areas for pre-mission system checks. With its own self-contained RF antenna and receiver, the PTS also functions as a stand-alone telemetry receiving station that provides real-time display of GPS test data during mission execution. In its normal configuration, the PTS has a nominal

RF receiving range of approximately 15 miles. However, the PTS can be interfaced with other telemetry antennas and/or receivers to increase its range. It has a number of input and output ports which can be connected to any compatible range receiving, data processing, and RS-232C compatible equipment. This feature can instantaneously provide a limited upgrading of any telemetry receiving station or range that does not otherwise have GPS telemetry or data processing capability. Figure 4 illustrates these two functional applications.

CONCLUSIONS

The host vehicle telemetry system has proven to be an effective data system for real time field test planning and evaluation. Day to day mission planning will be made more effective and data will be available for source selections and DSARC decisions. Early data format and frame structure definition coordination with processing departments is very important. Proper attention to detail in documentation was found to be effective in reducing integration problems on the wide range of GPS user equipment host vehicles.

Table I. Technical Requirements

OUTPUT CHARACTERISTICS

Output Frequency:	2235.0 MHz 2275.0 MHz 2280.5 MHz 2289.5 MHz
Output Power:	20 watts nominal 15 watts minimum Over environments and supply voltage range into 1.5:1 maximum VSWR.
Output Impedance:	50 Ohms nominal. Unit employs internal isolator allowing operation into open or shorted output loads without damage.
Center Frequency Stability:	± .003%

MODULATION CHARACTERISTICS:

Type:	True FM
Input Impedance:	10K resistive minimum, shunted by 30 pf maximum
Frequency Response:	10 Hz - 300 KHz ± 1.5 dB
Deviation Sensitivity:	±100 KHz/v rms ±10%
Maximum Deviation:	±300 KHz
Distortion:	2% at ±250 KHz deviation
IFM:	±7 KHz over environments.

POWER REQUIREMENTS:

Voltage:	+28 VDC ±4 VDC
Current:	8 Amps maximum
Reverse Polarity Protection:	No damage from indefinite application of reverse power.

ENVIRONMENT:

Temperature:	-20°C to 70°C (baseplate)
Vibration:	10 G rms
Shock:	100 G peak 11 ms 1/2 sine 3-axis
Acceleration:	100 G peak 3-axis
Humidity	MIL-STD-810, Method 507
Altitude:	Unlimited
EMI:	IRIG 106-80 for antenna conducted and radiated. MIL-STD-461A (Notice 3) for power line conducted and radiated interference.

Table II. Telemetry Link Margins
For Yuma Proving Ground

Frequency	2250 MHz
Range	200 mi
Desired Fade Margin	20 dB
Bit Error Rate	1 x 10-6
Free Space Atten	152 dB
Misc. System Losses	-1.0 dB
Power Out	42 dB
Antenna Gain	28 dB
FM Improvement	3 dB
Total	80 dB
Noise Density	-174 dB
IFBW	+ 57 dB
Noise	+ 3 dB
C+N/N	14 dB
Total	100 dB

ACTUAL FADE MARGIN

Noise	100
Carrier	80
margin	20
T_x Maximum Gain	+ 3 dB
R_x Maximum Gain	+ 25 dB
Total	28 dB

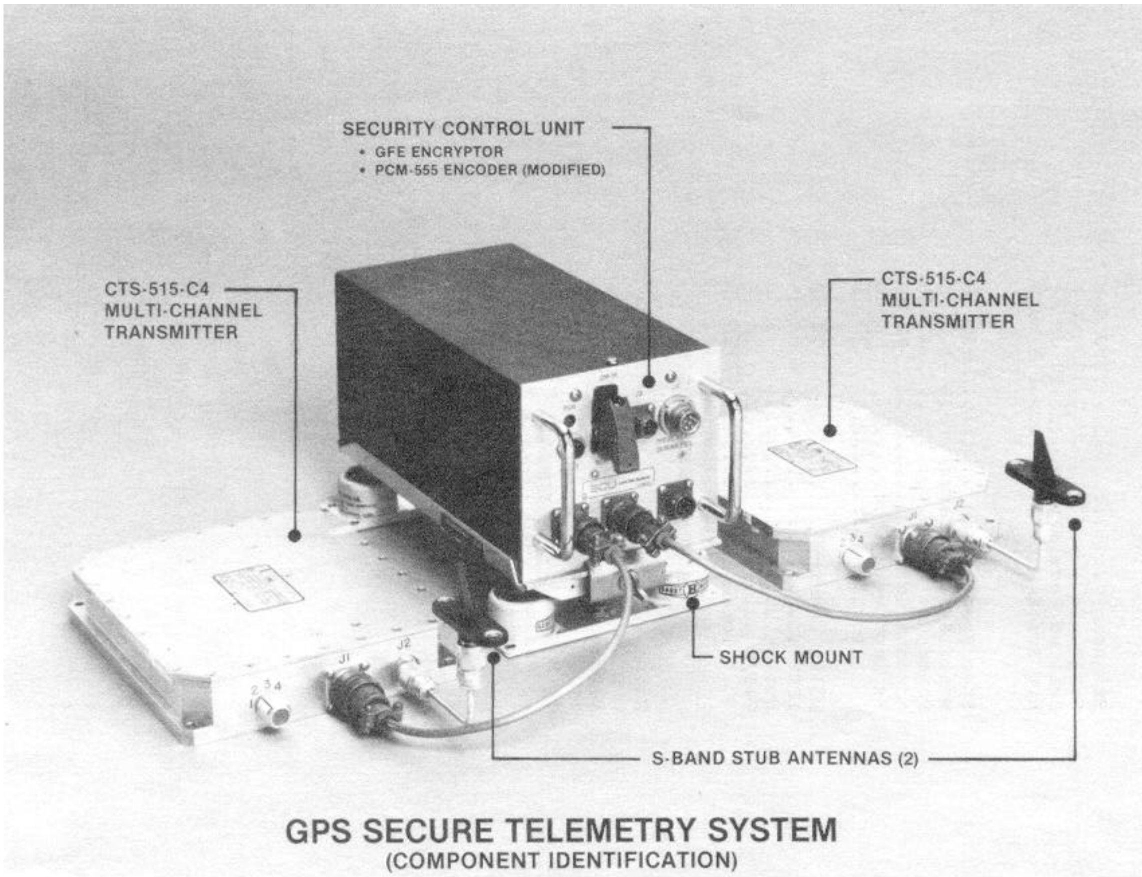

FIGURE 1

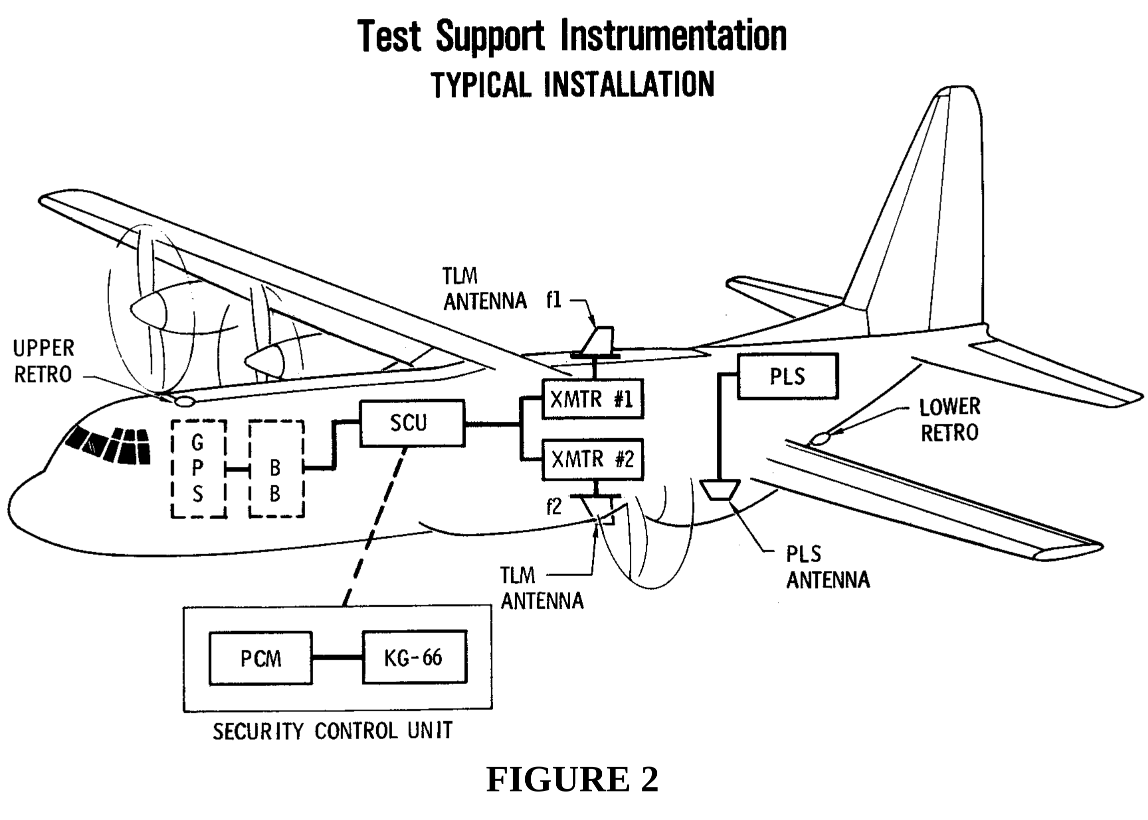

FIGURE 2

Portable Test Station
Mechanical Design

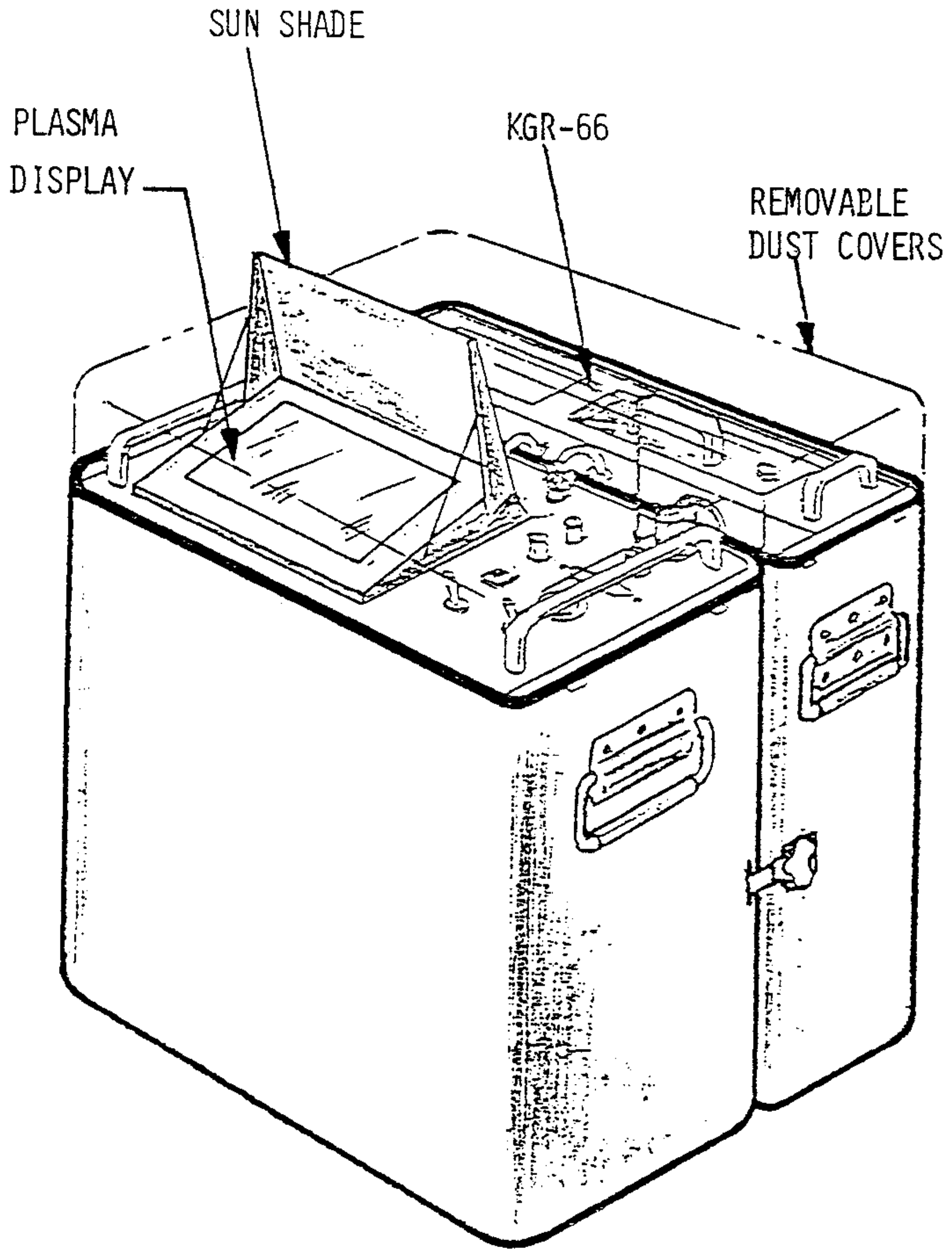

FIGURE 3

PTS Operation Remote Range Application

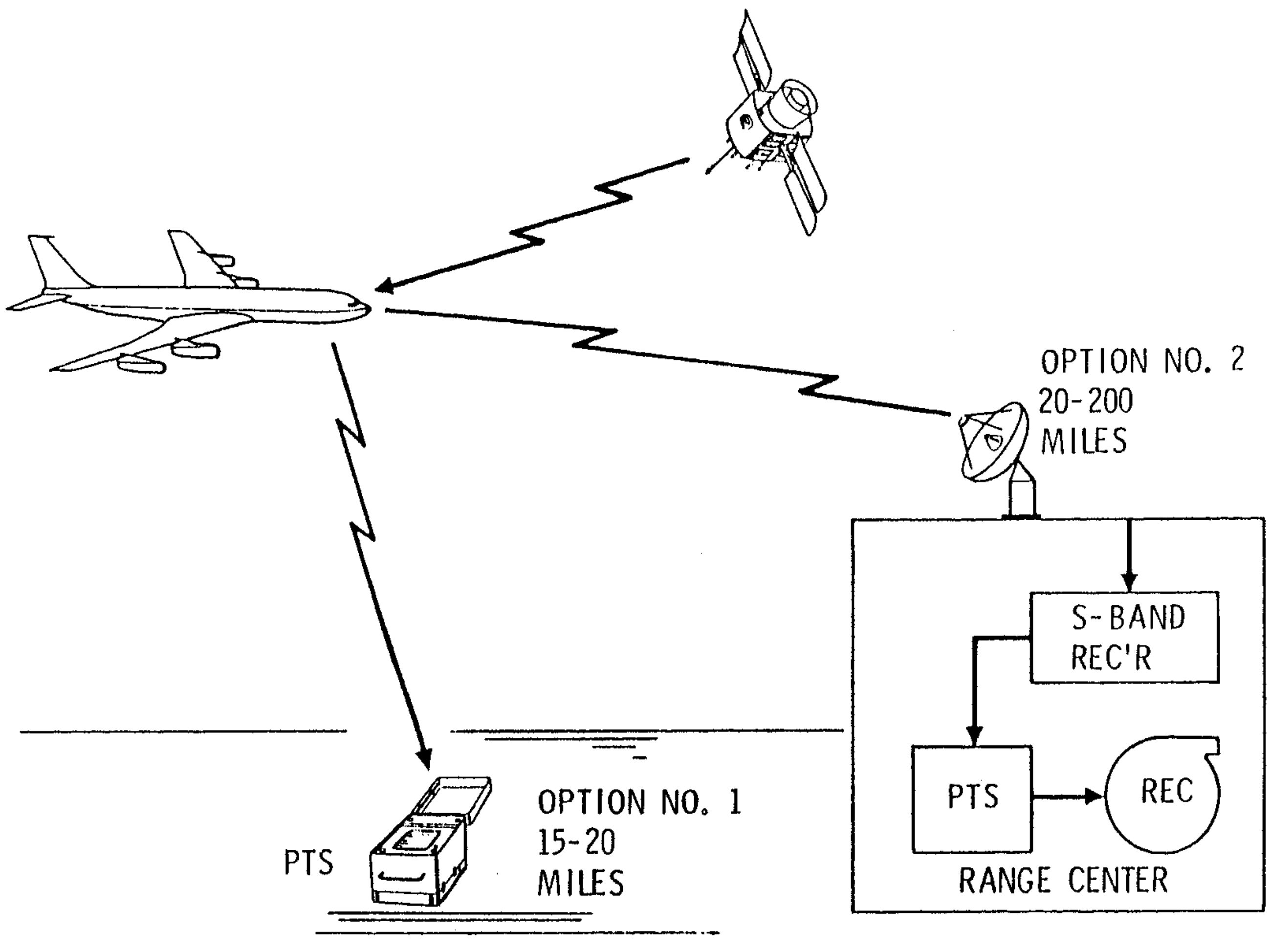

FIGURE 4