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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

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[illegible] MHz Global Positioning System/ Emergency Location Transmitter for Search and Rescue Satellite Operations

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15 April 1985

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This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The SARSAT (Search and Rescue Satellite) has demonstrated the use of 121.5/243.0 MHz beacons to locate victims of aircraft and marine accidents. An experimental 406 MHz Emergency Location Transmitter (ELT) has been developed by NASA allowing a digital message containing identification and timing information as an alternative to the tone modulation signal provided on the 121.5/243.0 MHz ELT. Utilization of Global Positioning System (GPS) information with the 406 MHz ELT could greatly enhance the accuracy of the SARSAT system by including GPS position coordinates within the digital message. Location

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19. KEY WORDS (Continued)

20. ABSTRACT (Continued)

accuracies of less than 100 meters could be provided worldwide, which is ten times better than that available with the experimental 406 MHz ELT.

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FIGURES

I. INTRODUCTION

Rapid detection of an aircraft crash or a marine distress is the most important feature to the survival of the victim. Studies have shown that those who have survived the initial crash have less than a 10 percent chance of survival if rescue is delayed beyond 2 days. If the rescue is accomplished within 8 hours, survival rate increases to 50 percent (Ref. 1). The SARSAT system contains 121.5/243.0 MHz and 406 MHz transponders on a low earth-orbiting spacecraft which can detect emergency signals from aviation or maritime vessels on a worldwide basis (including the polar regions). At this time of writing, two proposed SARSATs (from the United States) and three COSPAS satellites (from the Soviet Union) will carry these transponders. A joint agreement between Canada, France, the Soviet Union, and the United States has been established to provide emergency signal detection from 1985 to the end of the next decade.

Current technology of ELTs or Emergency Position Indicating Radio Beacons (EPIRB) used by civilian and military vehicles emits a tone modulated beacon on 121.5 MHz and 243.0 MHz frequencies. These signals are detected by receivers on low-orbiting SARSAT/COSPAS satellites yielding a position accuracy of 10 to 20 km (rms). An experimental 406 MHz ELT is being tested by the SARSAT/COSPAS project (Ref. 2) where the signal contains a digital message format indicating identification and elasped time information. SARSAT position accuracy is estimated to be between 2 to 5 kilometers for 406 MHz without any position reporting information within the digital message. Positioning is determined by utilizing the beacon identification from each transmission burst of the ELT. The frequency is measured and time tagged in the spacecraft processor. These parameters provide time and frequency values as input to a weighted least-mean-squares (WLS) position determination algorithm, yielding an accuracy of 2 to 5 km (rms). Hardware tests conducted by the Soviet Union yielded a position accuracy of 3 km (rms) (see Ref. 3).

II. USE OF GPS DATA

GPS receivers are expected to be used widely in the military aviation, civilian aviation, and maritime communities because of their accurate position locating capability. A GPS receiver contacts all GPS satellites within view in order to determine time and position information. The receiver software controls the activities of the receiver, maintains a navigation data base, estimates location, and monitors system performance. Time, latitude, and longitude come from the receiver software.

NAVSTAR satellites (GPS satellites) will be launched beginning in 1986 with a full operational system by 1988. Approximately 10,000 military user receivers are expected to be deployed over the same period. The majority of military GPS users will be aircraft, ships, ground vehicles, and ground troops. At this time, the number of civilian users has not been defined; however, civil aviation (commercial and private), maritime vessels (commercial and private), and ground vehicles are expected to use GPS navigation. The Federal Aviation Administration has committed to use GPS navigation as a secondary system for enroute navigation, with ongoing studies toward incorporating GPS for primary navigation. Several shipping industries and automobile companies have expressed interest in using GPS navigation capabilities. Positioning with a GPS receiver is expected to be within 100 meters (2σ) for civilian applications and 30 meters (2σ) for military applications.

III. SYSTEM DESIGN

Combining the accuracy of GPS receivers and the rapid detection capability provided by the SARSAT will reduce time locating victims from hours to within a few minutes and the area of search from 2 to 5 kilometers to 30 to 100 meters. Figure 1 illustrates the concept of using the 406 MHz ELT with an onboard GPS receiver. When a ship or an aircraft is in distress, an activation device initiates the ELT. Assuming the GPS receiver is working at the moment of impact, the position (latitude and longitude) and universal time (UTC) coordinates are incorporated within the digital message. The ELT will transmit the digital message containing identification of the aircraft (or ship), position, and time from an omni antenna to SARSAT. The SARSAT package receives and relays the digital messages to the Local User Terminal (LUT). No satellite processing for positioning will be necessary because the LUT will receive the exact loaction of the ELT. Digital messages can be stored within the satellite if a LUT is not within receiving range. Precise positioning is most beneficial to distressed aircraft or ships in remote regions where even the 3 km (rms) area provided by SARSAT would be too large to ensure prompt rescue (see Fig. 2). The GPS/ELT values are based upon the assumption that the GPS receiver is operating at the moment of impact. Small discrepancies may exist if the GPS deactivates less than 10 minutes before impact. If the GPS receiver is not operating under 10 minutes before an emergency occurs, nominal SARSAT processing will be needed for position determination.

The block diagram of the GPS/ELT, shown in Figure 3, consists of using a typical GPS receiver (see Ref. 4) and a modified 406 MHz ELT. The current time and position data generated by the GPS receiver enters a modified 406 MHz ELT through a RS232 or similar data bus, and is generated as part of the digital message. Aircraft (or ship) identification, country, and position coordinates are formulated and transmitted from a 406 MHz omni-directional antenna to SARSAT. The 406 MHz ELT also consists of a remote monitor and controller for testing and manual control of the unit. The activation sensor acts as a switch for automatic startup of the ELT during impact. Both the remote monitor and activation sensor interact with the power control, supplying the battery power to the 406 MHz electronics. The ELT memory is an active unit for storing the most recent GPS position information. An internal clock inside the ELT compares time with the GPS receiver time. If the time

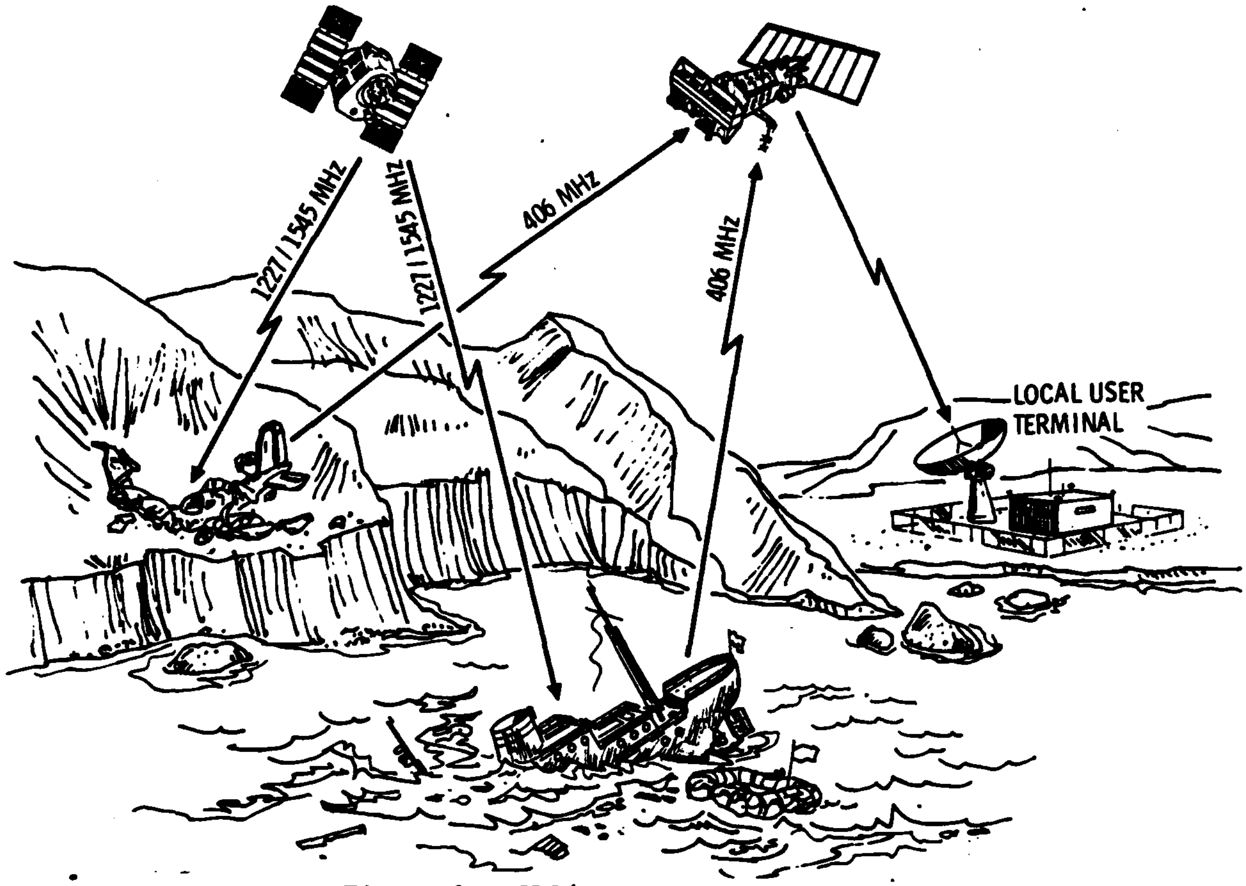

Figure 1. GPS/ELT System Overview

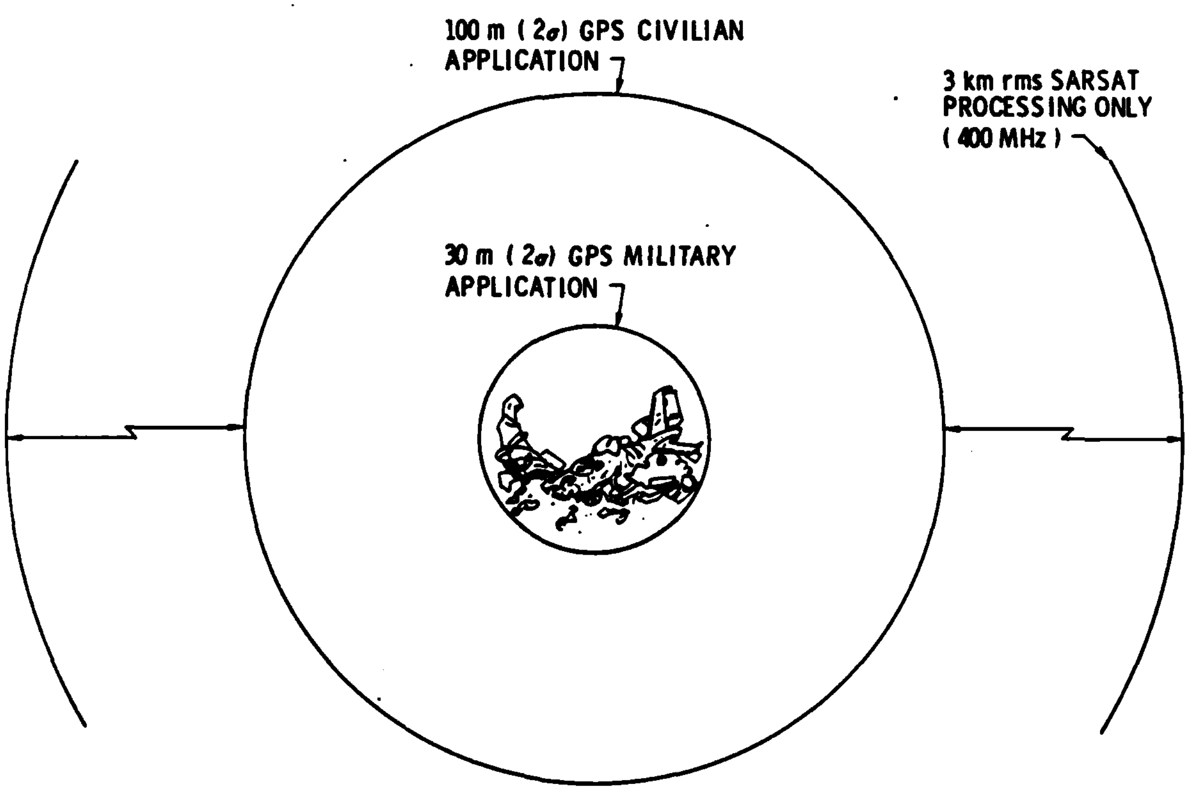

Figure 2. Position Location Accuracy Using GPS/ELT with SARSAT Operations

differential is greater than 10 minutes, no position information from the GPS receiver is used within the digital message. Therefore, normal SARSAT position processing will be necessary in determining the location of the ELT. The digital message is modulated over the 5 kHz bandwidth with a central frequency of 406.025 MHz. The signal is phase-modulated with bi-phased "L" (Manchester) data encoding with a specified data rate of 400 bps. Modifications in the digital message format extend transmission time to 605 msec.

The message generated by the ELT follows a format set up by the participating nations in the SARSAT/COSPAS program and is illustrated by Figure 4 (Ref. 5). However, it has been modified to adopt to GPS positioning accuracy by increasing the number of bits in the latitude and longitude slots. A bit synchronization pattern consisting of "1's" occupies the first 15 bits position, followed by a frame synchronization pattern occupying the 9 bits position. The format flag following the frame synchronization is a flag bit used to indicate the short or long message format. The long message format is designed to transmit 56 bits for latitude, 64 bits for longitude and 4 bits for time (UTC). The short message format is the same as the long message format except it does not include the last 132 bits. This format would be used if the time differential were greater than 10 minutes. Type of vehicle and country are indicated within the message with an individual identification code unique for each user. Error correction coding is based upon the Bose-Chaudhuri parity code. Following code correction, the nature of emergency or elapsed time since activation is coded within the digital message. A special code may also be provided by indicating testing of the ELT, thereby reducing the large amount of false alarms plaguing ELT detection today. Latitude, longitude, and time [Universal Coordinated Time (UTC)] coordinates are received directly from the GPS receiver and coded into the message format. However, the choice of geodetic datum has not been determined at this time.

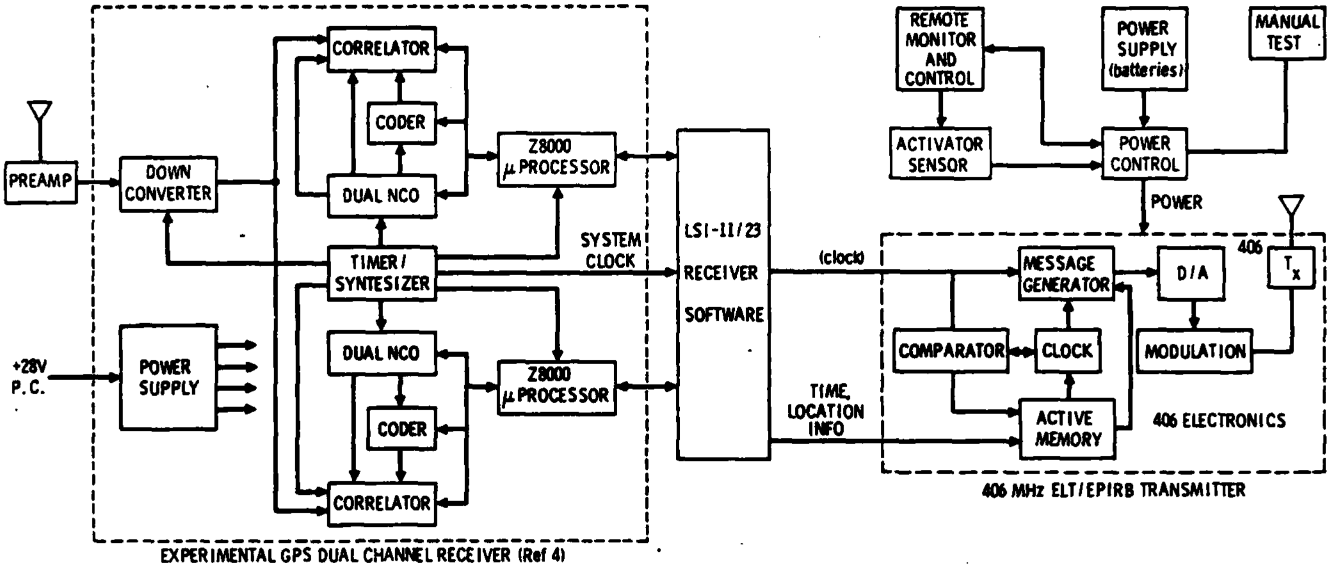

Figure 3. Block Diagram of GPS/ELT System

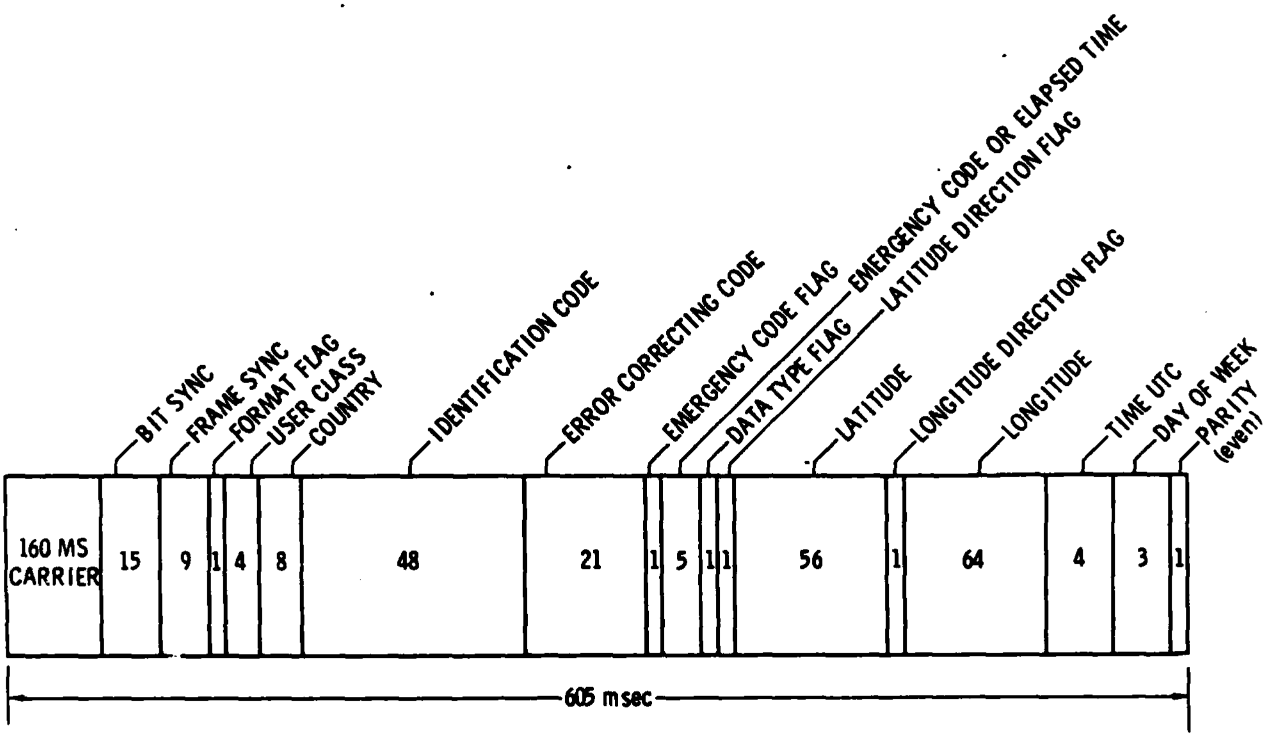

Figure 4. 406 MHz Digital Message Format

IV. CONCLUSION

The SARSAT/COPSPAS project has already demonstrated its usefulness by detecting 121.5/243.0 MHz ELT signals leading to rescue of crash victims. Nevertheless, SARSAT operations can be improved by using GPS accuracy, provided by GPS receivers, within the digital message detected by SARSAT. Thus, SARSAT acts as a relay by sending the message to the Local User Terminals within the Search and Rescue operation centers. Using the GPS concept requires no modification to the GPS set and small modifications in the 406 MHz ELT in the form of a data bus hookup, active memory, and internal clock. No modification is necessary to the SARSAT/COSPAS transponders or processing system. The digital message format has been established to incorporate future position and time information where the position slots have been extended to accommodate GPS accuracy. The combination GPS/ELT offers prompt rescue from a marriage of two space systems—NAVSTAR and SARSAT/COSPAS.

REFERENCES

1. COSPAS-SARSAT System Summary, December, 1981. National Aeronautics and Space Administration.

2. Douglas R. Kahle "Development of Satellite Location System for Aircraft and Boat Distress Beacon" (IEEE Aerospace and Electronic Systems, New York, NY, 1982) p 1-4.

3. Y. Zurabov, V. Bogdanov, Y. Makarov, and V. Rogalskiy, "The First Results of the COPSPAS-SARSAT System Flight Test" (IEEE, Aerospace Electronic System, New York, NY, 1982) p. 310-313.

4. Anthony Buige, Raymond R. LaFrey, and Steve D. Campbell, "The Design and Measured Performance of an Experimental GPS Navigation Receiver for General Aviation." (IEEE, Aerospace and Electronic Systems, New York, NY, 1982), p 5-12.

5. Specification for the SARSAT Experimental 406-MHz ELT and EPIRB Electronics; National Aeronautics and Space Administration, October, 1981.

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