Canadian Development, Production and Testing of Sixty Prototype 406 MHz Personal Locator Beacons (PLBs)

Executive Summary

MPR TELTECH LTD

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Acknowledgement

MPR Teltech (MPR) acknowledges the funding and technical support it has received from DOC and NSS for the design of the COSPAS-SARSAT Personal Locator Beacons (PLBs).

Through this program, a successful implementation of the PLBs into the field has been achieved, leading towards lower cost and more responsive Search and Rescue. This will result in more saved lives in land based emergency and distress situations.

In addition, significant design information has been gained which is already being used on more portable and lower cost future units.

CONTENTS

1. INTRODUCTION

This report, the Executive Summary, is the final deliverable of MPR under SSC contract #36001-9-3531/01-ST, entitled Canadian Development, Production and Testing of Sixty Prototype 406 MHz Personal Locator Beacons (PLBs) valued at $347,939. It discusses objectives of the program, describes the project and the product and touches on commercialization and future developments.

2. OBJECTIVE

The objective of this project was to design a 406 MHz Personal Locator Beacon for use with the COSPAS/SARSAT Search and Rescue system, and deliver 60 Beacons and an equal number of spare batteries for a Field Trial in the Canadian North. The beacons had to be small, lightweight and durable such that they could be conveniently carried by individuals on trips to remote locations.

3. SCOPE

The work carried out by MPR Teltech consisted of the following main activities:

a. develop, test and package an Engineering Model PLB

b. test the Engineering Model PLB fully by the authorized Canadian government test facility

c. fabricate sixty (60) prototype 406 MHz PLBs, complete with sixty (60) operator manuals, and 60 spare battery packs

d. prepare an acceptance test procedure to test the prototype PLBs in-house. One prototype PLB was chosen by the Scientific Authority to be tested by the authorized Canadian government test facility, to ensure compliance with the specifications.

e. prepare monthly, interim and final reports.

4. PRODUCT DESCRIPTION

4.1 Introduction

The following are high level descriptions of the mechanical and electrical designs of the PLB and the final specifications/data sheet. For more detailed information refer to the interim reports and documentation package. Please refer also to the picture/datasheet in Appendix 1.

4.2 Mechanical Design

The PLB consists of an electronics assembly, a battery pack, an antenna, a carrying strap and labels. These components are described below.

4.2.1 Electronic Assembly

The electronic assembly contains all of the electronic circuits for the PLB. The battery pack, the antenna, and the carrying strap connect to this assembly.

The enclosure for the electronic assembly was designed to be rugged to ensure the reliable performance of the PLB. The enclosure consists of a housing, in which the PC boards are mounted, and a cover. The two enclosure parts are milled out of an aluminum alloy.

The cover of the enclosure is installed with a waterproof rubber seal. Two rectangular printed circuit boards are stacked using spacers and mounted in the housing. Metal shields are used on the printed circuits boards to reduce the coupling between the various components of the assembly.

4.2.1.1 Activation Switch

The enclosure includes a three position rotary activation switch. The three positions are ON, OFF, and TEST. The switch locks in the ON and the OFF positions and automatically returns from the TEST position to the OFF position. This ensures that the test mode is only operational for a short period. The test function duration is also limited by internal logic.

The rotary switch connects to the electronic assembly through two small magnets, which couple to reed switches inside the enclosure, and is recessed to protect it from being accidentally knocked into the ON position. In addition, a button has to be pushed before rotating the switch to on.

4.2.1.2 Operation Indicator

Operation and test of the PLB is confirmed by a visual light indicator. An LED, mounted on the internal PC boards, is viewed through a clear plastic window in the enclosure.

4.2.2 Antenna

The antenna has been selected for ruggedness, good radiation pattern and minimum inconveniences to the user. A half wave whip antenna provided the required electrical performance, since it is not dependent on a good ground plane.

MPR's electronic assembly provides a storage location for the flexible whip antenna. It is possible to store the antenna by folding it into a grove in the enclosure to avoid damage. Deployment for operation is easy by pulling the antenna out of the enclosure and orienting it. The antenna is mounted on a swivel joint which allows the user to orient it for optimum performance.

4.2.3 Battery Pack

The battery pack connects to the bottom of the electronic assembly, and is locked in place making a waterproof electrical connection. The pack contains the batteries, a thermal fuse, a current fuse and diodes for safety. Holes are provided in the pack to allow venting in the rare instance of a battery venting. The batteries are covered by special paint to prevent short circuits should water penetrate.

4.2.4 Carrying Strap

A carrying strap connects to the enclosure of the electronic assembly to allow the user to carry the PLB over the shoulder.

4.2.5 Labelling

Labelling is provided on the PLB for the following in both english and french.

1. battery safety;
2. battery expiry date and replacement action required;
3. operation;

4. test;
5. maintenance;
6. operating temperature;
7. manufacturer's identification;
8. serial number;
9. applicable standards;
10. instructions for finder of PLB.

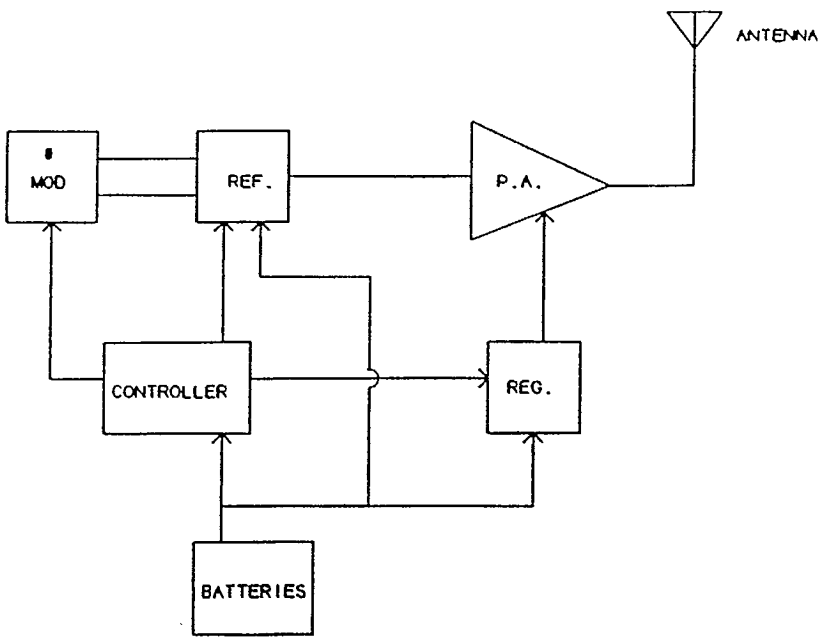
4.3 Electrical Design

The PLB consists of the following major electrical components

1. Frequency Reference
2. Modulator
3. Controller
4. Power Amplifier
5. Antenna
6. Battery

Figure-1 shows a block diagram of the PLB. These components are discussed in detail in the interim reports number 1 and 2.

FIGURE 1 - PLB Block Diagram



5. PROJECT DESCRIPTION

5.1 Development

The PLB evolved from much of the work that MPR had previously done on the EPIRB. Therefore, many of the potential problems were understood. Even so, significant challenges in the design of a compact unit had to be faced.

Follow on design of the unit from breadboard to first prototype to engineering model was usually based on a few (two or three) units. It was found that performance consistency became a problem as larger numbers were built for manufacturing. A thorough pilot run of about 15 to 20 units with provision for redesign if necessary before larger production runs would have been better. The size of the development contract excluded this.

5.2 Testing

The testing of the Engineering Model of the PLB required putting into place specialized test equipment necessary for the COSPAS/SARSAT measurements. Besides the existing MPR test equipment, a custom test fixture was designed to measure the carrier phase jitter and burst modulation parameters. A special modulation code was generated to allow accurate and easy (real-time monitoring as the unit was being tuned) measurement of the modulation parameters with the modulation analyzer. The burst fixture confirmed that the parameters did not change during actual transmission.

The measurement of the short and medium term frequency stability also required a custom designed test fixture. These measurements are required to be done on a burst signal, therefore the fixture was used to produce a burst trigger with timing to extract portions of the burst for measurement on a synchronizable frequency counter.

Even with this equipment, there was some uncertainty in the correlation of our test results with other test lab setups and cross-correlation testing was done. The phase deviation specifications are very tight and were particularly difficult to meet, particularly over the full temperature range.

Difficulties in testing the Engineering Model sufficiently concerned us to redesign the modulator circuitry for the EPIRB which was being designed separately for a mass production factory environment. Ease of tunability was one of the key improvements. This modulator was then designed into the final 60 units of the PLB.

A significant amount of temperature testing of the PLB was required. Extensive thermal testing was done on the Engineering Model and a decision was made to temperature test all production units to -40°C to ensure that all specifications were met over the temperature range. The main parameters of concern were spurious emissions and the modulation parameters.

5.3 Fabrication

Fabrication of the engineering model was done largely at MPR as custom hand build unit. This portion of the project went much as expected.

Fabrication of the 60 "production" units was partially subcontracted to within the BC Tel Group.

Assembly of the printed circuit boards was done by Microtel.

Significant effort was applied to achieve and maintain a high quality product as boards were cleaned, or reworked, or conformally coated and retested. Only one person was allowed to do any soldering on the assembled boards, for repairs or rework.

One of the main problems encountered during fabrication was the consistency of the performance of the frequency reference oscillators. The reject rate was high (15%). This caused delays in the manufacturing schedule. A special incoming inspection had to be undertaken.

5.4 Shipment

The nature of the PLBs is such that the units will be shipped long distances, often by air. A unique problem with the shipment of the lithium based batteries exists, since lithium comes under the classification of dangerous goods. Special packaging and shipping procedures were required. This was instituted at MPR specifically for the emergency beacon program. Similar procedure and attendant costs would be required by any other manufacturer. Changes to the shipping regulations are underway and may affect the shipment of future equipment.

6. ACCOMPLISHMENTS

This project was undertaken on a very tight schedule and a limited budget. Therefore as much available technology as possible from previous beacon development was used. The design of very stringent performance at -40°C was a challenge. Nevertheless MPR has satisfied all requirements and developed, tested and shipped the 60 beacons in time for a successful field trial start. Feedback from the Canadian arctic so far is very good.

MPR has been working with people responsible for the field trial, suggesting tests, encouraging feedback and responding immediately to questions and service claims. Suggested tests included performance measurements with respect to various antenna settings beside steep rock cliffs and performance in heavy forested areas and under snow.

For the duration of the project, MPR has given thought to future improvements for cost, size and weight. The outcome of this activity has been a proposal to design a Mini PLB, extensively using micro-electronic circuits such as VLSI, SMT and Thick film. At the time that this report is being written, MPR has started this miniaturization activity.

7. COMMERCIALIZATION

Before completion of the project, MPR had received an order for five additional PLBs from the Department of Energy Mines and Resources for the Polar Shelf project. These beacons were delivered by the end of April 1990.

Further interest in the PLB was shown by the BC Ministry of Forests, INCO, Ontario Hydro, DND, Search and Rescue in Oregon and India. MPR is following up on those leads. We have also opened the dialogue with Search and Rescue in Denmark (for Greenland) and are marketing in New Zealand and Australia for the Antarctica. It is our plan to sell approximately 60 Beacons before the Mini PLB will be available. MPR is marketing the PLB directly and the manufacturing is undertaken within the BC Tel group of companies under MPR direction.

The unit price for the PLB is $3,250. The price for a spare battery is $250. This is based on a small run of 60 units.

The miniaturization of the PLB will allow for substantial price reductions and manufacturing in large quantities.

8. RECOMMENDATIONS

MPR feels that this project has been very successful as a first step in the introduction of PLBs into the outdoors community of hunters, geologists, forestry recreation resource management etc. However, to be successful from a systems and product point of view, smaller, lighter and lower cost units will be essential. A list price of $1,500 should be a target. Direction Finding equipment at 406 MHz will also be essential and will have to be be made available to large users (Corporations) and Search and Rescue groups.

Marketing of the beacons internationally has also shown that several users still insist on having a 121 MHz home-in transmitter. Provision for this may be required in future developments. The alternative is substantial education in 406 MHz DF and the availability of this equipment. Requests have also been received to allow the beacons to transmit various levels of emergency. A careful review of how Search and Rescue would respond to this information would be required before proceeding further with this option.

APPENDIX 1: Data Sheet

SATFIND-406™ Personal Locator Beacon (PLB)

COSPAS-SARSAT Search and Rescue System

Search and Rescue (SAR) involves the identification, location, and rescue of people involved in sea, air, or land emergencies. In such emergencies, a radio beacon transmits a signal from the distress location. Traditionally, emergency location was provided by passing aircraft or ships. The COSPAS-SARSAT satellite system now provides rapid global detection and determines position to within 5 km, thereby reducing the search area by a factor of 20.

COSPAS-SARSAT equipment is carried on the American NOAA meteorological satellites and the Soviet COSPAS satellites. The satellites receive both 121.5 MHz and 406 MHz signals and downlink the combined signals to a ground station or Local User Terminal (LUT). The LUT determines the beacon location as the satellite travels over the activated radio beacon. Position information is then relayed to the national Mission Control Centre (MCC) who alert the SAR forces to carry out the rescue mission. The 121.5 MHz transmission is useful primarily for short range home-in purposes in marine applications.

SATFIND-406 PLB™

A Personal Locator Beacon (PLB) is used in land-based emergencies in isolated locations. When activated, the PLB transmits a distress signal at 406 MHz which alerts SAR authorities via the COSPAS-SARSAT satellite system. The signal is coded to allow positive identification and accurate location of the distressed party.

The SATFIND-406 PLB maintains high frequency stability for accurate position location. High quality design and manufacturing ensures that the SATFIND-406 PLB will operate at temperature extremes of -40°C to 55°C for over 24 hours to guarantee detection by SAR agencies. The

SATFIND-406 PLB has been tested to demanding standards in the rugged arctic environment. MPR Teltech's cost-effective and reliable design ensures that the SATFIND-406 PLB will provide the best value for your safety needs.

Carry the SATFIND-406 PLB—your life may depend on it!

MPR Teltech Ltd

- An interdisciplinary technology company with the largest research and development capability in Western Canada.
- Member of the B.C. Tel Group and affiliated with GTE Corporation of Stamford, Connecticut.
- Employing over 400, with facilities in Burnaby, B.C., and Ottawa, Ont., Canada.
- Designed and developed the satellite ground segment communications network for the North Warning System (DEWLine replacement) under contract to NORAD.
- Developed 406 MHz PLB and EPIRB for operation in the rapidly evolving COSPAS-SARSAT environment.

Technical Specifications

406 MHz TRANSMITTER

Frequency:	406.025 MHz
Power:	5 Watts
Modulation:	Phase modulation of ± 1.1 radians.
Short Term Stability:	$< 2 \times 10^{-9}$
Medium Term Stability:	$< 1 \times 10^{-9}$

GENERAL

Packaging:	
Main Unit:	Corrosion resistant aluminum alloy with carrying strap attached.
Battery Pack:	High-impact resistant plastic.
Colour:	Orange
Antenna:	Folded whip antenna is easily deployed.
Operation:	Modes: Standby, Test and Transmit. ON, OFF, TEST via rotary switch. Two conscious actions required for ON. Light indicates correct operation.
Operating Life:	Minimum 24 hours at -40°C
Operating Temperature:	-40°C to 55°C
Storage Temperature:	-55°C to 65°C
Battery Type:	Lithium Sulphur Dioxide. External venting, current and thermal fuses, diode protected for maximum safety.
Battery Replacement:	User-replaceable battery pack every 5 years.
Weight:	1.7 kg (3.7 lbs)
Size:	35 cm (14″)L x 8 cm (3.2″)W x 7.5 cm (3″)H. Antenna 42 cm (16.8″)L when deployed.
Water Immersion:	1 meter depth for 2 hours
Rain:	24 hours guaranteed
Dustproof:	Sealed against dust
Labelling:	Safety, operation, and maintenance labels.
Approvals:	Certified to COSPAS-SARSAT Specification C/S T.001, Iss. 2, Rev. 1, Oct/89.

Specifications subject to change

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