TP 13682E

# Evaluation of an EPIRB with an Integrated GPS Receiver

**Prepared for**
**Transportation Development Centre**
**Safety and Security**
**Transport Canada**

**by**
**W. Street**
**Northern Airborne Technology Ltd.**

**OCTOBER 2000**

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Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

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16. Abstract

This report details the various field trials conducted on a previously developed prototype Emergency Position Indicating Radio Beacon (EPIRB) with an integrated Global Positioning System (GPS) receiver, and outlines the results of those field trials. Three field trial phases consisted of Dry Land Tests, Lake Tests, and Sea Tests. A modified EPIRB was tested to verify the successful reception of GPS satellite signals and to verify that location data was included in the 406 MHz message transmitted by the EPIRB. An unmodified EPIRB was tested to verify that location data can be transmitted to both the Cospas-Sarsat satellites and the geostationary satellites. The results of these tests proved that the GPS-EPIRB can determine its own location using the integrated GPS receiver and transmit this position in the message of the 406 MHz signal. It was also successfully demonstrated that the geostationary satellites can receive a near-instantaneous alert with location data. With this information, Search and Rescue (SAR) forces will be able to respond faster and have a much smaller search area. This will save money and, more importantly, save more lives.

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16. Résumé

Ce rapport rend compte des essais en vraie grandeur d'un prototype de radiobalise de localisation de sinistres (EPIRB, *Emergency Position Indicating Radio Beacon*) à récepteur GPS intégré, développé dans une phase antérieure. Les essais ont eu lieu sur la terre ferme, sur lac et en mer. Un EPIRB modifié a également été mis à l'essai afin de vérifier si les satellites GPS recevaient bien les signaux et si le message émis sur 406 MHz comprenait bien les données de position. Les essais de l'EPIRB non modifié voulaient vérifier si les données de position pouvaient être transmises autant aux satellites du système COSPAS-SARSAT qu'aux satellites géostationnaires. Les essais ont confirmé l'aptitude de l'EPIRB à GPS intégré de déterminer sa position et de communiquer celle-ci sur 406 MHz. Il a également été démontré que les satellites géostationnaires peuvent recevoir un signal de détresse quasi instantané, en même temps que des données de position. Grâce à cette information, les équipes de recherche et sauvetage (SAR) pourront intervenir plus rapidement et dans une zone beaucoup mieux circonscrite, ce qui permettra d'économiser les ressources et, plus important encore, de sauver plus de vies.

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## EXECUTIVE SUMMARY

This project is the logical conclusion to several previous initiatives sponsored by the National Search and Rescue Secretariat New SAR Initiatives Program. These initiatives include two Industry Canada, Communications Research Centre projects for the design and development of 406 MHz Personal Locator Beacons, as well as Transport Canada, Transportation Development Centre projects for the design and development of a 121.5/406 MHz Emergency Position Indicating Radio Beacon (EPIRB) and an EPIRB with an integrated Global Positioning System (GPS) receiver. This project details the testing, evaluation, and certification of the GPS-EPIRB.

The field trials included the Kelowna and West Coast Trials, the Newfoundland Trials, and the Department of National Defence (DND) Northern Field Trials. The Kelowna and West Coast Trials consisted of Dry Land Tests, Lake Tests, and Sea Tests. The Dry Land Tests were conducted on the roof of Northern Airborne Technology in Kelowna in order to determine the GPS acquisition characteristics for a GPS-EPIRB mounted in a ground plane to simulate the unit floating in water. These tests were successful even when the ground plane was rocked to simulate wave action. The GPS signal was acquired and maintained, and the location data was successfully included in the 406 MHz signal and received using a hand-held tester.

The Lake Tests involved deploying two GPS-EPIRBs in a calm-water environment. One EPIRB was modified by replacing the 406 MHz antenna with a coaxial cable to monitor the information contained in the 406 MHz message. The second unit was unmodified and transmitted signals to the Cospas-Sarsat satellites and the geostationary satellites. The data from the modified unit showed that the GPS location data was successfully included in the 406 MHz message. The data collected by the Canadian Mission Control Centre (CMCC) for the unmodified unit showed that the signal with location data was received by the geostationary satellites 2 minutes and 34 seconds after activation with a location accuracy of 318 m. The time for the first Cospas-Sarsat satellite to receive data was 1 hour and 27 minutes, yielding a Doppler location accuracy between 2.7 km and 3.8 km.

The Sea Tests were conducted in a similar format as the Lake Tests except the location was on the ocean with sea levels at about 1 to 2 m. The first transmission was received by the geostationary satellite 1 minute and

31 seconds after activation. This message lacked location data. The first message with location data was received in 4 minutes and 12 seconds with a location accuracy of 138 m. The first Doppler location from the Cospas-Sarsat satellites occurred at 1 hour and 33 minutes. The location accuracy of this and subsequent satellite passes ranged from 580 m to 5120 m. This is typical.

These tests proved that using an EPIRB with an integrated GPS receiver can produce a near-instantaneous alert with location data, which will result in a significantly reduced search area and thus help save more lives as well as minimize Search and Rescue (SAR) resource time. This is a major step in the effort to increase the likelihood of survival by decreasing the alerting time as well as the time and cost of the SAR mission.

The full MPR Teltech report of the Newfoundland Trials conducted on the GPS-EPIRB is included as an appendix. A brief report on the DND Northern Field Trials is also included as an appendix. Other appendices include photographs of the Kelowna and West Coast Trials, data from the CMCC, and the GPS-EPIRB Field Trial Test Plan.

Subsequent to this project, the GPS-EPIRB was modified for production, type-approved, and launched as the SATFIND-406 GPIRB™. The GPIRB was the first fully approved beacon with an integrated GPS receiver. In its first year, the GPIRB received two prestigious international awards: SAIL magazine's Freeman K. Pittman Award and the Seatrade Award in the Safety at Sea category.

SOMMAIRE

Ce projet représente l'aboutissement logique d'un programme de recherche et développement de longue haleine coparrainé par le Fonds de nouvelles initiatives de recherche et de sauvetage du Secrétariat national, Recherche et sauvetage. Parmi les faits saillants de ce programme de R&D figurent deux projets du Centre de recherches sur les communications d'Industrie Canada, qui visaient la conception et le développement de radiobalises portatives, ainsi que des recherches pilotées par le Centre de développement des transports de Transports Canada visant la conception et le développement d'une radiobalise de localisation de sinistres (EPIRB) émettant sur 121,5/406 MHz, et d'un EPIRB à récepteur GPS intégré. Le présent projet comportait l'essai, l'évaluation et l'homologation de l'EPIRB-GPS.

Les essais en vraie grandeur se sont déroulés à Kelowna et sur la côte Ouest, à Terre-Neuve et sur une base du Nord du ministère de la Défense nationale (MND). Les essais de Kelowna et de la côte Ouest effectués sur la terre ferme (sur le toit de l'immeuble de Northern Airborne Technology à Kelowna) avaient pour objet de déterminer les caractéristiques d'acquisition des données GPS émises par un EPIRB à GPS intégré monté sur une plaque de masse simulant une embarcation flottant sur l'eau. Ces essais se sont révélés fructueux, même lorsqu'on faisait osciller la plaque de masse pour simuler l'effet des vagues. Le signal GPS était reçu et entretenu, et les données de position étaient comprises dans le signal émis sur 406 MHz et reçu à l'aide d'un appareil d'essai à main.

Les essais sur lac consistaient à déployer deux EPIRB-GPS dans des eaux calmes. Sur une des radiobalises, l'antenne 406 MHz avait été remplacée par un câble coaxial, qui permettait de contrôler l'information contenue dans le signal émis sur 406 MHz. L'autre radiobalise, non modifiée, émettait vers les satellites du système COSPAS-SARSAT et vers les satellites géostationnaires. Le message émis sur 406 MHz par la radiobalise modifiée contenait effectivement les données de position GPS. Selon l'information recueillie par le Centre canadien de contrôle des missions (CCCM), les signaux contenant les données de position émis par la radiobalise non modifiée étaient captés par les satellites géostationnaires 2 min 34 s après l'activation de la radiobalise, et la localisation était précise à 318 m près. La première captation par un satellite du système COSPAS-SARSAT a eu lieu au bout de 1 h 27 min, et la localisation, compte tenu de l'effet Doppler, était précise à 2,7 – 3,8 km près.

Les essais en mer suivaient un protocole similaire à celui des essais en eaux calmes. Ils ont eu lieu dans l'océan, au milieu de vagues de 1 à 2 m. La première transmission a été reçue par le satellite géostationnaire 1 min 31 s après l'activation de la radiobalise. Mais ce message ne contenait pas les données de position. Le premier message contenant les données de position a été reçu en 4 min 12 s et le positionnement était précis à 138 m près. La première localisation tenant compte de l'effet Doppler effectuée par un satellite du système COSPAS-SARSAT a été reçue au bout de 1 h 33 min. Cette localisation et les localisations effectuées lors des passages subséquents des satellites étaient précises à 580 - 5120 m près, ce qui représente la marge d'erreur habituelle.

Les essais effectués ont confirmé l'aptitude de la radiobalise à récepteur GPS intégré à transmettre une alerte quasi instantanée en même temps que des données de position, permettant de beaucoup mieux circonscrire le secteur de recherche et d'ainsi sauver plus de vies en réduisant la durée des opérations de recherche-sauvetage. Il s'agit là d'une étape majeure dans les efforts pour accroître le taux de survie en diminuant le délai d'alerte, et pour réduire la durée et le coût des missions SAR.

Le rapport complet des essais de la radiobalise réalisés à Terre-Neuve par MPR Teltech figure en annexe, de même qu'un rapport succinct des essais menés par le MDN dans le Nord. Dans les autres annexes sont présentés des photographies des essais de Kelowna et de la côte Ouest, des données du CCCM et le plan des essais en vraie grandeur de l'EPIRB-GPS.

À la suite de ce projet, le GPS-EPIRB a été modifié pour une production en série, il a subi les essais d'homologation et il a été commercialisé sous le nom de SATFIND-406 GPIRB$^{MD}$. Le GPIRB est la première radiobalise à récepteur GPS intégré à avoir reçu toutes les approbations nécessaires. Dès sa première année sur le marché, le GPIRB a reçu le Prix Freeman K. Pittman 1999 du magazine *Sail*, et le prix *Seatrade* dans la catégorie Sécurité maritime.

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# GLOSSARY

| | |
|---|---|
| CCG | Canadian Coast Guard |
| CMCC | Canadian Mission Control Centre |
| D & E | Demonstration and Evaluation |
| DGPS | Differential Global Positioning System |
| DND | Department of National Defence |
| EEPROM | Electrically Erasable Programmable Read Only Memory |
| EPIRB | Emergency Position Indicating Radio Beacon |
| GOES | Geosynchronous Orbiting Environmental Satellite |
| GPIRB™ | Global Position Indicating Radio Beacon |
| GPS | Global Positioning System |
| HDOP | Horizontal Dilution of Precision |
| LEO | Low Earth Orbiting |
| MCC | Mission Control Centre |
| SAR | Search and Rescue |
| TDC | Transportation Development Centre |
| UIN | Unique Identification Number |

# 1 INTRODUCTION

This document is the final report for the project entitled *Evaluation of an EPIRB with an Integrated GPS Receiver*, sponsored by the Transportation Development Centre (TDC).

## 1.1 Objectives

The objectives, as set out in the contract's Statement of Work, are as follows:

### 1.1.1 Project Objective

To test and evaluate a prototype GPS-EPIRB through various trials. These trials include:

- Kelowna and West Coast Trials
- Newfoundland Trials
- Department of National Defence (DND) Northern Trials

### 1.1.2 R&D Objective

To develop models and systems, and manage experimental trials in support of SAR and other CCG operations seeking improvement in safety and efficiency.

### 1.1.3 R&D Sub-objective

To develop search planning tools and detection technologies, and conduct validation experiments to reduce search time and improve the efficiency of marine SAR operations.

## 1.2 Background

Due to the orbitography (low altitude polar orbit) and the number of search and rescue Cospas-Sarsat satellites now in space, a beacon alert message can take anywhere from 30 minutes to 5 hours to be initially detected by the ground station. Typical detection times for Canada average about 2 hours. The integration of a GPS receiver in a 406 MHz Cospas-Sarsat beacon combines location coordinates and a near-instantaneous distress alert. Needless to say, these enhancements would reduce the overall time required to complete a rescue operation.

This project represents the realization of several previous initiatives sponsored by the National Search and Rescue Secretariat New SAR Initiatives Program. These initiatives include two Industry Canada Communications Research Centre projects for the design and development of 406 MHz Personal Locator Beacons (PLBs), as well as Transport Canada TDC projects for the design and development of a 121.5/406 MHz EPIRB and an EPIRB with an integrated GPS receiver. This GPS-EPIRB is unique in the world and permits the encoding of the position coordinates into a 406 MHz beacon's message, providing a near-instantaneous distress alert via geostationary satellite. The GPS-EPIRB prototype is now complete, and evaluation, testing, and certification is required before production units can be built.

## 1.3 Scope

The scope of the report is to outline the various field-trial tests and present the results of those tests.

# 2 FIELD TRIALS

## 2.1 Kelowna and West Coast Trials

### 2.1.1 General

Two prototype GPS-EPIRBs were used for the field trials. One of the prototype units was modified to substitute a 50Ω coaxial connection in place of the 406 MHz antenna. This allowed for direct monitoring of the 406 MHz transmitter without the signal being transmitted to the satellite. A cable was attached between the GPS/EPIRB interface board and a laptop computer to monitor the data directly from the GPS engine. Testing for this portion of the field trials was completed in accordance with the *GPS-EPIRB Field Trial Test Plan*, which is included as Appendix C. The modified unit is termed the 50Ω Unit, while the second unit is termed the Unmodified Unit.

A selection of photos of the Kelowna and West Coast Trials appears in Appendix A. The raw data obtained from the Canadian Mission Control Centre is listed in Appendix B.

### 2.1.2 Objectives

The objectives of these field trials were:

- to evaluate the GPS acquisition characteristics while the GPS-EPIRB was mounted on a ground plane at various tilt angles.

- to evaluate the GPS acquisition characteristics while the GPS-EPIRB floated in a calm lake environment, and to observe the correct transmission of the location data on the 406 MHz signal.

- to evaluate the GPS acquisition characteristics while the GPS-EPIRB floated in a sea environment, and to observe the correct transmission of the location data on the 406 MHz signal.

### 2.1.3 Test Plan

The *GPS-EPIRB Field Trial Test Plan* (see Appendix C) outlines the proper procedure and precautions required for conducting these tests. The tests were divided into three phases: Dry Land Tests, Lake Tests, and Sea Tests.

### 2.1.4 Dry Land Tests

The Dry Land Tests were conducted on the roof of Northern Airborne Technology in Kelowna, B.C.

#### 2.1.4.1 *Purpose*

To determine how the tilt of the unit will affect GPS satellite acquisition.

To observe the transmission of the location protocol on the 406 MHz signal.

#### 2.1.4.2 *Equipment*

The 50Ω Unit was mounted on a 29-inch diameter aluminum ground plane, which was assembled onto a tilt table. An inclinometer was used to determine the angle of tilt of the ground plane.

A laptop computer was used to download the GPS information and a beacon test set was used to decode the 406 MHz transmission (long message format).

#### 2.1.4.3 Procedure

The unit was activated and, when the GPS was acquired, the location and time were recorded. The GPS location information was then downloaded into the EPIRB's EEPROM. This location information was included in the 406 MHz message using the Cospas-Sarsat Standard

Location Protocol and was transmitted on the next 406 MHz burst. The location information remained in the EEPROM regardless of the information presented by the GPS engine. Updates to the 406 MHz message were done once every hour. The maximum allowable update rate is 20 minutes.

Once the unit had acquired GPS data, the angle of the ground plane was increased incrementally up to 75° to determine whether acquisition would be lost.

The tests were done with the unit facing North, South, East, and West.

### 2.1.4.4 *Dry land tests results*

Table 1. Dry Land Tests -Testing Information

| | |
|---|---|
| **DATE:** | September 16, 1996 |
| **TESTED BY:** | WS/RB |
| **UIN** | 279C270008FFBFF |
| **TEST LOCATION COORDINATES:** | 49°52.75' N, 119°27.40' W |

Table 2. Dry Land Tests - Measured Data

| AZMTH | TILT | # SATs ACQR'D | ACQT'N (Y OR N) | TIME (UTC) | COORDINATES (LAPTOP) | COORDINATES (BEACON TESTER) |
|---|---|---|---|---|---|---|
| N | 0° | 3 | Y | 201436 | 49°53.04' N, 119°27.61' W | 49°53.00' N, 119°27.60' W |
| | 10° | 5 | Y | 202443 | 49°52.73' N, 119°27.43' W | |
| | 20° | 4/5 | Y | 202627 | 49°52.73' N, 119°27.46' W | |
| | 30° | 4/5 | Y | 202751 | 49°52.74' N, 119°27.46' W | |
| | 40° | 4/6 | Y | 202919 | 49°52.74' N, 119°27.46' W | |
| | 45° | 5 | Y | 203108 | 49°52.74' N, 119°27.46' W | |
| | 50° | 5/3/5 | Y | 203249 | 49°52.74' N, 119°27.46' W | |
| | 55° | 3/0/5 | Y/N/Y | 203541 | 49°52.74' N, 119°27.46' W | |
| | 60° | 3/6 | Y | 204042 | 49°52.75' N, 119°27.51' W | |
| | 65° | 3 | Y/N/Y | 204255 | 49°52.75' N, 119°27.49' W | |
| | 70° | 3/6 | Y | 204439 | 49°52.69' N, 119°27.37' W | |
| | 75° | 5/3/5 | Y | 204533 | 49°52.69' N, 119°27.37' W | |
| | 0° | 5 | Y | 205207 | 49°52.73' N, 119°27.44' W | 49°52.73' N, 119°27.40' W |
| | 10° | 3 | Y | 205545 | 49°52.73' N, 119°27.44' W | |

| AZMTH | TILT | # SATs ACQR'D | ACQT'N (Y OR N) | TIME (UTC) | COORDINATES (LAPTOP) | COORDINATES (BEACON TESTER) |
|---|---|---|---|---|---|---|
| S | 20° | 3/5 | Y | 205625 | 49°52.73' N, 119°27.44' W | |
| | 30° | 5 | Y | 205723 | 49°52.73' N, 119°27.45' W | |
| | 40° | 3/5 | Y | 205833 | 49°52.73' N, 119°27.43' W | |
| | 45° | 3/5 | Y | 205925 | 49°52.71' N, 119°27.42' W | |
| | 50° | 4/5 | Y | 210004 | 49°52.73' N, 119°27.44' W | |
| | 55° | 3/2/5 | Y/N | 210044 | 49°52.73' N, 119°27.44' W | |
| | 60° | 2/4/2 | N/Y/N | 210236 | 49°52.73' N, 119°27.44' W | |
| | 65° | 2 | N | 210419 | 49°52.73' N, 119°27.44' W | |
| | 70° | 3/4 | Y | 210612 | 49°52.73' N, 119°27.44' W | |
| | 75° | 3 | Y | 210721 | 49°52.73' N, 119°27.44' W | |
| E | 0° | 6 | Y | 212919 | 49°52.74' N, 119°27.49' W | 49°52.73' N, 119°27.47' W |
| | 10° | 6 | Y | 213227 | 49°52.74' N, 119°27.49' W | |
| | 20° | 6 | Y | 213347 | 49°52.74' N, 119°27.49' W | |
| | 30° | 5/6 | Y | 213414 | 49°52.74' N, 119°27.49' W | |
| | 40° | 6/5 | Y | 213452 | 49°52.74' N, 119°27.49' W | |
| | 45° | 3/3 | Y | 213546 | 49°52.74' N, 119°27.49' W | |
| | 50° | 3/5 | Y | 213658 | 49°52.74' N, 119°27.49' W | |
| | 55° | 5 | Y | 213728 | 49°52.74' N, 119°27.49' W | |
| | 60° | 5 | Y | 213814 | 49°52.74' N, 119°27.49' W | |
| | 65° | 3/5 | Y | 213852 | 49°52.74' N, 119°27.49' W | |
| | 70° | 3 | Y | 213927 | 49°52.74' N, 119°27.49' W | |
| | 75° | 3 | Y | 213959 | 49°52.74' N, 119°27.49' W | |
| W | 0° | 5 | Y | 214237 | 49°52.74' N, 119°27.34' W | 49°52.73' N, 119°27.33' W |
| | 10° | 6 | Y | 214449 | 49°52.74' N, 119°27.39' W | |
| | 20° | 5 | Y | 214718 | 49°52.73' N, 119°27.40' W | |
| | 30° | 3 | Y | 214755 | 49°52.73' N, 119°27.40' W | |
| | 40° | 3 | Y | 214850 | 49°52.73' N, 119°27.40' W | |
| | 45° | 3 | Y | 214918 | 49°52.73' N, 119°27.40' W | |
| | 50° | 3 | Y | 214942 | 49°52.73' N, 119°27.40' W | |
| | 55° | 3 | Y | 215031 | 49°52.73' N, 119°27.40' W | |
| | 60° | 3 | Y | 215106 | 49°52.73' N, 119°27.40' W | |
| | 65° | 3 | Y | 215134 | 49°52.73' N, 119°27.40' W | |
| | 70° | 3 | Y | 215223 | 49°52.73' N, 119°27.41' W | |
| | 75° | 3 | Y | 215321 | 49°52.73' N, 119°27.41' W | |

The location accuracy was determined from the 406 MHz burst received by the beacon tester. The received long message was decoded and the location accuracy was compared to the test location coordinates as shown in Table 1.

Table 3. Dry Land Tests - Decoded Long Message and Location Accuracy

| TIME (UTC) | LONG MESSAGE | LAT | LONG | ∆d from actual position |
|---|---|---|---|---|
| default | FFFE2F93CE1380047FDFF8E9D1C083E0F1AF | | | |
| 201600 | FFFE2F93CE138004322EF5F395401BC26721 | 49°53.00' N | 110°27.60' W | 591 m |
| 205347 | FFFE2F93CE138004322EF5F395401D029F48 | 49°52.73' N | 119°27.40' W | 29 m |
| 213041 | FFFE2F93CE138004322EF5F395401D028A72 | 49°52.73' N | 119°27.47' W | 84 m |
| 214402 | FFFE2F93CE138004322EF5F395401D02A000 | 49°52.73' N | 119°27.33' W | 89 m |

### 2.1.4.5 *Analysis*

As shown in Table 2, the unit had trouble maintaining acquisition at about 55° facing north and facing south. No problems were experienced facing east or west. The problem may have been attributable to the GPS satellite distribution during the test or may possibly have been a GPS antenna pattern problem. Further testing may be warranted to determine if there are any nulls in the GPS antenna pattern when mounted on top of the EPIRB.

In addition to the above tests, a rocking test was done to see if acquisition could be achieved and maintained while simulating a sea environment. The beacon was mounted on the ground plane and activated. The ground plane was manually rocked approximately ±75° from horizontal at an approximate repetition rate of 1 second. The unit acquired the GPS satellites and maintained acquisition very well. Occasionally, the unit lost acquisition but re-acquired it very quickly (1 to 3 seconds). The test was conducted with the ground plane rocking in a north-south plane and then an east-west plane.

The Standard Location Protocol was successfully downloaded into the EPIRB’s EEPROM once valid location data was acquired from the

GPS receiver and transmitted on the 406 MHz signal. As shown in Table 3, the data was decoded to confirm that the correct location data was transmitted on the burst.

### 2.1.5 Lake Tests

The Lake Tests were conducted on Okanagan Lake at the Central Okanagan Small Boat Association pier.

#### 2.1.5.1 *Purpose*

To determine the characteristics of acquiring and maintaining acquisition of the GPS satellites using the 50Ω Unit floating in a freshwater lake.

To determine the characteristics of acquiring and maintaining acquisition of the GPS satellites using the Unmodified Unit floating in a freshwater lake and transmitting data to the Cospas-Sarsat satellites and the geostationary satellites (GOES 8 and GOES 9).

#### 2.1.5.2 *Equipment*

The 50Ω Unit and the Unmodified Unit were used in this test.

#### 2.1.5.3 *Procedure*

Both units were deployed in the lake simultaneously. Data was collected on the 50Ω Unit which could be correlated to the data received by the CMCC from the Unmodified Unit.

A laptop computer was used to download the GPS information and a beacon tester was used to decode the 406 MHz transmission (long message format) from the 50Ω Unit. Data from the Unmodified Unit was obtained from the CMCC (event query from the Cospas-Sarsat satellites and raw ASCII data from the GOES satellites).

## 2.1.5.4 *Lake tests results*

Table 4. Lake Tests -Testing Information

| | |
|---|---|
| **DATE:** | September 17, 1996 |
| **TESTED BY:** | WS/RB |
| **UIN: 50Ω Unit**<br>**Unmodified Unit** | 279C270008FFBFF<br>279C270004FFBFF |
| **TEST LOCATION COORDINATES:** | 49°49.94' N, 119°29.36' W |

Table 5. Lake Tests - Measured Data

| Modified EPIRB | | | | Unmodified EPIRB | | | |
|---|---|---|---|---|---|---|---|
| Event | TIME (UTC) | GPS Coord (Laptop) | GPS Coord (Beacon Tester) | GPS Coord from GOES 8 (from MCC) | TIME (UTC) | LEO Doppler Shift Coord (from MCC) | Δd from actual position |
| Unit ON | 174200 | | | | 173900 | | |
| 1st Data | 174407 | 49°49.94' N, 119°29.45' W | 49°49.93' N, 119°29.40' W | default | 173952 | | |
| GPS Lost | 182148 | | | 49°50.07' N<br>119°29.53' W | 174134 | | 318 m |
| 2nd ReAcq | 184237 | 49°49.94' N, 119°29.48' W | 49°49.93' N, 119°29.47' W | | 190600 | 49°47.9' N, 119°29.1' W | 3.8 km |
| 3rd ReAcq | 194207 | 49°49.98' N, 119°29.43' W | 49°50.00' N, 119°29.40' W | | | | |
| 4th ReAcq | 204037 | 49°49.89' N, 119°29.40' W | 49°49.87' N, 119°29.40' W | | 204538 | 49°48.5' N, 119°29.9' W | 2.7 km |
| Unit OFF | 210000 | | | | | | |

The location accuracy was determined from the decoded 406 MHz burst received by the beacon tester. The received long message was decoded and the location accuracy compared to the test location coordinates as shown in Table 4.

Table 6. Lake Tests - Decoded Long Message and Location Accuracy

| TIME (UTC) | LONG MESSAGE | LAT | LONG | Δd from actual position |
|---|---|---|---|---|
| default | FFFE2F93CE1380047FDFF8E9D1C083E0F1AF | | | |
| 174500 | FFFE2F93CE13800431EEF6E287C093809102 | 49°49.93' N | 119°29.40' W | 51 m |
| 184400 | FFFE2F93CE13800431EEF6E287C09380843B | 49°49.93' N | 119°29.47' W | 133 m |
| 194340 | FFFE2F93CE13800431EEF6E287C093C09C28 | 49°50.00' N | 119°29.40' W | 121 m |
| 204200 | FFFE2F93CE13800431EEF6E287C093409345 | 49°49.87' N | 119°29.40' W | 138 m |

#### 2.1.5.5 *Analysis*

As shown in Table 5 and Table 6, the Standard Location Protocol was successfully downloaded into the EPIRB's EEPROM once valid location data was acquired from the GPS receiver. The data was successfully decoded to confirm that the correct location data was transmitted on the burst. The results from GOES 8 show the default location data on the first burst. After 2 minutes and 34 seconds, the GOES satellite received the distress location with an accuracy of 318 m. The time for the first Cospas-Sarsat satellite to receive the transmissions was 1 hour and 27 minutes after activation, with a Doppler location accuracy of 3.8 km.

### 2.1.6 Sea Tests

#### 2.1.6.1 *Purpose*

To determine the characteristics of acquiring and maintaining acquisition of the GPS satellites using the 50Ω Unit deployed in an open sea environment.

To determine the characteristics of acquiring and maintaining acquisition of the GPS satellite signals using the Unmodified Unit deployed in an open sea environment and transmitting data to the Cospas-Sarsat satellites and GOES satellites.

#### 2.1.6.2 *Equipment*

The 50Ω Unit and the Unmodified Unit were used in this test.

#### 2.1.6.3 *Procedure*

Both units were deployed in the sea simultaneously. Data was collected on the 50Ω Unit which could be correlated to the data received by the CMCC from the Unmodified Unit.

A laptop computer was used to download the GPS information and a beacon tester was used to decode the 406 MHz transmission (long message format) from the 50Ω Unit. Data from the Unmodified Unit was obtained from the CMCC (event query from the Cospas-Sarsat satellites and raw ASCII data from the GOES satellites).

### 2.1.6.4 *Sea tests results*

Table 7. Sea Tests - Testing Information

| | |
|---|---|
| **DATE:** | September 24, 1996 |
| **TESTED BY:** | WS/RB |
| **UIN: 50Ω Unit**<br>**Unmodified Unit** | 279C270008FFBFF<br>279C270004FFBFF |
| **TEST LOCATION COORDINATES:** (from ship's DGPS equipment) | 49°07.34' N, 123°17.86' W |

Table 8. Sea Tests - 50 Ω Unit Results.

| TIME (UTC) | HEX ID | LAT | LONG | Accuracy |
|---|---|---|---|---|
| 174000 | 279C270008FFBFF | - | - | - |
| 174707 | 279C270008625ED | 49°07.26' N | 123°20.66' W | 273 m |

Table 9. Sea Tests - Results from Cospas-Sarsat Satellites

| EVENT ID | SAT | TIME (UTC) | HEX ID | LAT | LONG | Probability (%) | Accuracy |
|---|---|---|---|---|---|---|---|
| 52494 | C04 | 191000 | 279C270004FFBFF | 49°07.30' N | 123°15.80' W | 50 | 2.49 km |
| 52527 | S06 | 194600 | 279C270004FFBFF | 49°07.60' N | 123°18.20' W | 98 | 0.65 km |
| 52534 | S04 | 194900 | 279C270004625ED | 49°07.60' N | 123°17.60' W | 95 | 0.58 km |
| 52571 | C04 | 205800 | 279C270004625ED | 49°07.60' N | 123°17.60' W | 95 | 0.58 km |
| 52627 | S06 | 212500 | 279C270004625ED | 49°05.30' N | 123°20.70' W | 94 | 5.12 km |

Table 10. Sea Tests - Results from GOES 8 and GOES 9

| SAT | TIME (UTC) | BEACON ID | LAT | LONG | Accuracy |
|---|---|---|---|---|---|
| | 173700 | UNIT ACTIVATED | | | |
| GOES 8 | 173929 | 93CE1380027FDFFD8A192883EECD90<br>279C270004FFBFF | - | - | - |
| GOES 8 | 174112 | 93CE138002312F69BD7EE89D22CC77<br>279C270004FFBFF | 49°07.27' N | 123°17.80' W | 138 m |
| | | | | | |
| GOES 9 | 173831 | 93CE1380027FDFFD8A192883E0F1AF<br>279C270004FFBFF | - | - | - |
| GOES 9 | 174240 | 93CE138002312F69BD7EE89D22CC77<br>279C270004625ED | 49°07.27' N | 123°17.80' W | 138 m |

### 2.1.6.5 *Analysis*

Table 11. Sea Tests - Summary of Sequence of Events

| TIME (UTC) | Δ time (hh:mm:ss) | Description |
|---|---|---|
| 173700 | - | Units activated |
| 173831 | 00:01:31 | 1st default message received by GOES 9 |
| 173929 | 00:02:29 | 1st default message received by GOES 8 |
| 174112 | 00:04:12 | GPS location message received by GOES 9 |
| 174240 | 00:05:40 | GPS location message received by GOES 8 |
| 191000 | 01:33:00 | LEO Doppler location from C04 |
| 194600 | 02:09:00 | LEO Doppler location from S06 |
| 194900 | 02:12:00 | LEO Doppler location from S04 |
| 205800 | 03:21:00 | LEO Doppler location from C04 |
| 212500 | 03:48:00 | LEO Doppler location from S06 |

The tests were completed at the test location as shown in Table 7. The 50Ω Unit was deployed and acquired the GPS location data within 7 minutes and 7 seconds, with a location accuracy of 273 m as shown in Table 8. This relatively large location error was due to the fact that the GPS data from the first acquisition was used. Typically, subsequent data points are more accurate as the GPS receiver Horizontal Dilution of Precision (HDOP) improves. For future designs, the HDOP threshold should be lowered so that the first data point is delayed until the set HDOP is reached, or the first data point received should be ignored. The 10th data point would perhaps be more useful (approximately 10 seconds after the first data point).

The results in Table 9 show the Doppler locations as determined by the Cospas-Sarsat satellites. The results vary between 580 m and 5120 m, and are somewhat typical of the Cospas-Sarsat system operation.

The results in Table 10 show the initial results of the GOES 8 and GOES 9 satellites. GOES 9 received the GPS location data 4 minutes and 12 seconds after EPIRB activation. GOES 8 received the GPS location data 5 minutes and 40 seconds after the EPIRB was activated. The location error was 138 m. Table 11 shows a summary of the sequence of events for the Sea Tests.

## 2.2 Newfoundland Trials

The Newfoundland sea trials were completed by MPR Teltech with a subcontract to OCEANS Ltd. of St. John's, Newfoundland. These tests were completed in December 1995 and the report was published in May 1996.

The complete report entitled *Report on the Initial Sea Trials of the Prototype GPS-EPIRB Off Newfoundland*, Issue 1, dated May 14, 1996, is included as Appendix D.

## 2.3 DND Northern Field Trials

In May 1997, NAT submitted a GPS-EPIRB to the DND for the purpose of conducting a Demonstration and Evaluation (D&E) to test the viability of using geostationary satellites for receiving 406 MHz transmissions.

A brief report from the DND on this testing is included in Appendix E.

# 3 CONCLUSIONS

The field trials for the Kelowna and West Coast tests is presented. The first phase of the Kelowna trial consisted of Dry Land Tests to verify the static operation of the GPS-EPIRB on a tiltable aluminum ground plane. The tests verified that the unit could acquire GPS satellite signals and maintain the signals when tilting through ± 75°. The tests also verified that the unit could acquire and maintain acquisition of GPS signals when the unit and ground plane were rocking at a rate of 1 second per tilt cycle.

The second phase consisted of Lake Tests to verify the operation of the GPS-EPIRB while the unit was floating in a calm water environment. The tests verified that the GPS location data was properly downloaded into the EPIRB's EEPROM and transmitted successfully on the 406 MHz message using the Standard Location Protocol. Data was successfully received at the CMCC from GOES 8. This satellite received the distress signal with the GPS location data in 2 minutes and 34 seconds, with an accuracy of 318 m. The first pass of a Cospas-Sarsat satellite occured at 1 hour and 33 minutes after activation.

The Sea Tests consisted of testing the GPS-EPIRB in an open sea environment. The CCG Hovercraft Unit from Richmond B.C. assisted in transporting the team out into the open water. GPS data for the 50Ω Unit was obtained in approximately 7 minutes. This data was successfully encoded onto the 406 MHz transmission. The Cospas-Sarsat satellites determined a Doppler position in 1 hour and 33 minutes. Location accuracies of this pass and subsequent passes varied between 580 m and 5120 m. The GOES 9 and GOES 8 satellites reported a position within 138 m, 4 minutes and 12 seconds, and 5 minutes and 40 seconds, respectively, after activation.

The results of these field trials demonstrated an overwhelming improvement in the system's capability to provide a near-instantaneous alert with location data for a distress situation. With such improvements, valuable SAR forces can be utilized more efficiently, thus reducing the time and cost for search and rescue. The combination of dispatching SAR forces sooner and reducing the

search area could mean the difference between life and death for an accident victim.

# 4 ADDENDUM

Following the completion of these tests, Northern Airborne Technology Ltd. made the necessary modifications in order to commercialize this GPS-EPIRB. Cospas-Sarsat Type Approval testing was successfully completed. The required national approvals were obtained and the NAT product SATFIND-406 GPIRB™ was introduced in 1998. The GPIRB was the first ever approved EPIRB with an integrated GPS receiver. In 1999, the GPIRB captured two very prestigious design awards: SAIL magazine's Freeman K. Pittman Award and the Seatrade Award in the Safety at Sea category.

## BIBLIOGRAPHY


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6. *Performance Standard for 406 MHz Satellite Emergency Position Indicating Radio Beacon (EPIRB) Class I and II* (TP 4522E), Transport Canada/Canadian Coast Guard, March 1995.

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8. *Report on the Initial Sea Trials of the Prototype GPS-EPIRB Off Newfoundland*, MPR Teltech Ltd., May 1996.

9. *Specification for COSPAS-SARSAT 406 MHz Distress Beacons* (C/S T.001 Issue 3), Cospas-Sarsat Secretariat, November 1995.

# APPENDIX A: Photographs of Kelowna and West Coast Field Trials

## DRY LAND TESTS

PHOTO 1: Rooftop Tilt Test – Top Side

PHOTO 2: Rooftop Tilt Test – Bottom Side

## LAKE TESTS

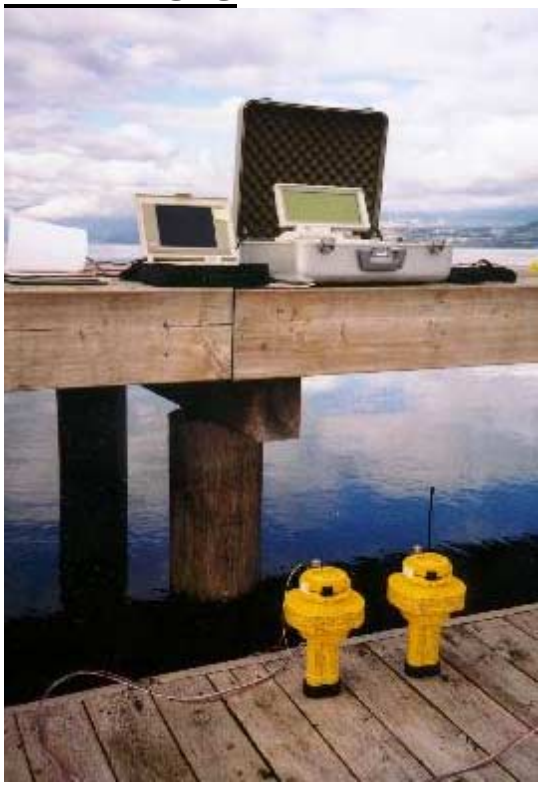

PHOTO 3: Lake Tests – Equipment Set-Up

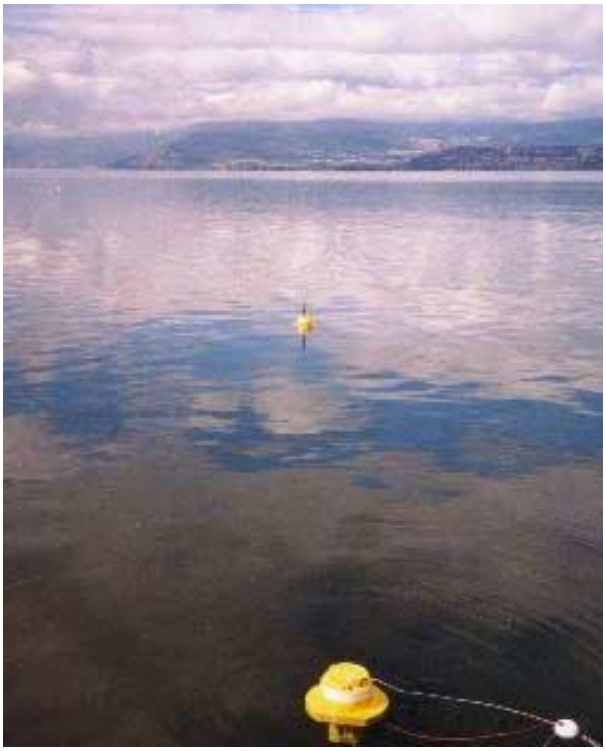

PHOTO 4: Lake Tests – 50Ω Unit (nearest) and Unmodified Unit (farthest)

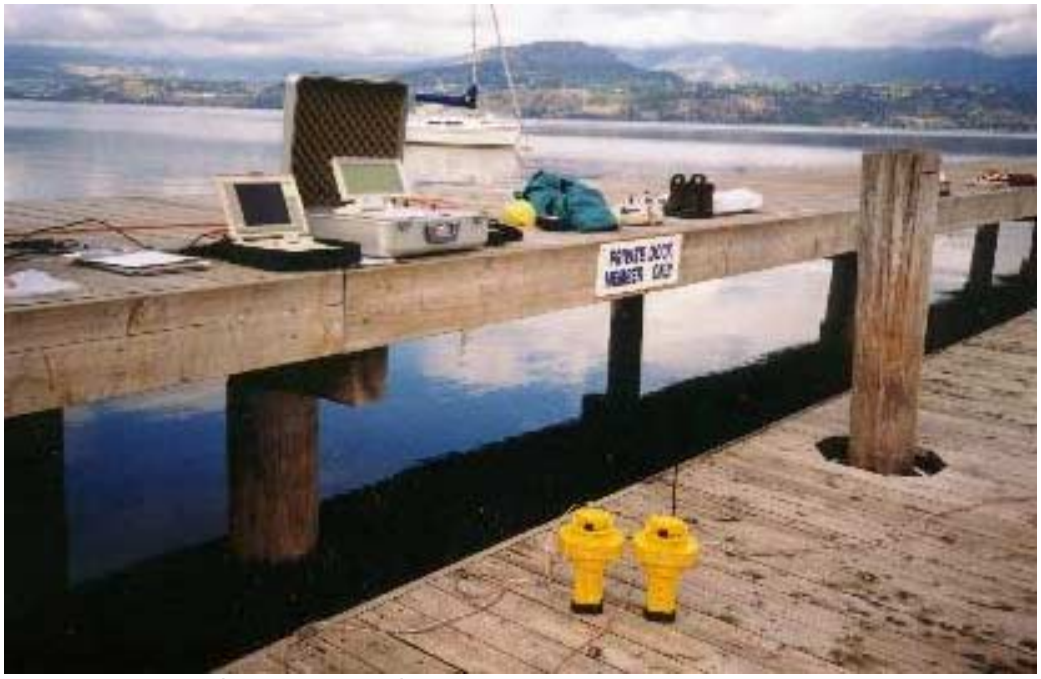

PHOTO 5: Lake Tests – Equipment Set-Up

PHOTO 6: Lake Tests – 50Ω Unit and Unmodified Unit

## SEA TESTS

PHOTO 7: Hovercraft

PHOTO 8: GPS-EPIRBs Deployed in Open Sea


PHOTO 9: SATFIND-406 GPIRB™

PHOTO 10: 1999 SATFIND-406 GPIRB™ Awards

# APPENDIX B: Data from Canadian Mission Control Centre, Trenton

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# APPENDIX C: GPS-EPIRB Field Trial Test Plan

*Electronic format not available/*
*Format électronique non disponible*

# APPENDIX D: Report on the Initial Sea Trials of the Prototype GPS-EPIRB Off Newfoundland

*Electronic format not available/*
*Format électronique non disponible*

# APPENDIX E: DND Northern Field Trials

*Electronic format not available/*
*Format électronique non disponible*