Evaluation of 406 MHz Location Protocol Distress Beacons

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Author and Publisher

Principal Author: Douglas S. Ritter

Publisher: Equipped To Survive Foundation, Inc.
2211 W. Rockrose Place
Chandler, AZ 85248
Web Site: **http://www.equipped.org**

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Dedication

To Sue, without whose support and sacrifice this evaluation and all the good works of the Equipped To Survive Foundation would not be possible.

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Introduction

The self-locating performance deficits of some location protocol distress beacons that this evaluation has documented should not be interpreted as an indictment in any manner of the COSPAS-SARSAT Satellite Distress Alerting System or 406 MHz distress beacons in general. This system has proven to be an extremely reliable and effective means of distress alerting that has saved thousands of lives worldwide since its inception. Even if some of the beacons evaluated in this report have not reliably provided self-location data, they appear to provide the minimum acceptable level of distress alerting and Doppler locating performance expected from conventional, non-location protocol 406 MHz emergency beacons.

Sponsors

The conduct of this evaluation required considerable financial and equipment resources beyond that normally available to the Equipped To Survive Foundation. Sponsorship for the evaluation was solicited, both of financial assistance and of gifts in kind.

The two primary outside financial sponsors were:

BoatU.S. Foundation for Boating Safety & Clean Water (Alexandria, Virginia, USA – **https://www.boatus.com/foundation**), a non-profit 501(c)(3) organization that creates education and outreach campaigns, researches issues and products, and helps boaters and user groups learn specific actions they can take to be safer and better stewards of the environment while boating.

West Marine (Watsonville, California, USA – **http://www.westmarine.com**), a major U.S. headquartered, publicly traded marine chandlery chain and purveyor of marine safety equipment, both wholesale and retail. In addition, West Marine hosted the testing logistics out of their headquarters building, provided added logistical support, provided boats and equipment necessary for the marine testing, and assigned two employees to assist for the duration of the testing, as well as additional support both prior to and after the actual field testing.

Additional assistance was provided by:

Mr. Carl Ruhne (Santa Cruz, California, USA) generously donated the use of Willow, a Cal 2-46 ketch, as the “mother ship” for the maritime testing, with Carl captaining the Willow for our time onboard.

Mr. Peter Forey of Sartech Engineering Ltd (Surrey, United Kingdom – **http://www.sartech.com**) provided the use of two TSR406 406 MHz beacon receivers and graciously agreed to serve as our agent to maintain the chain of custody and to oversee the recoding of the McMurdo beacons in the U.K.

Mr. Robert Dubner of Dubner International, Inc. (Westwood, New Jersey, USA – **http://www.dubner.com**) wrote and donated a computer program to seamlessly translate and capture the data received by the Sartech TSR406 receivers and also provided donated database engineering and analysis services for the data generated by the field testing.

Mr. Bill Street of WS Technologies, Inc. (Kelowna, British Columbia, Canada – **http://www.wst-inc.ca**) donated the use of two BT100A 406 Beacon Testers, as well as his and an employee's services for the duration of the field test to operate the test sets.

The Protection and Survival Laboratory FAA Civil Aerospace Medical Institute (Oklahoma City, Oklahoma, USA - **http://www.cami.jccbi.gov**) particpated.

Iridium Satellite, LLC (Arlington, Virginia, USA – **http://www.iridium.com**) donated the use of an Iridium satellite phone and free airtime so that communications could be maintained when out of range of cellular phone service.

Roadrunner Fire & Safety Equipment (Glendale, Arizona, USA – **http://www.roadrunnerfire.com**) donated hose and fittings for use with our water pump to generate simulated rainfall.

Pentax USA (Golden, Colorado, USA – **http://www.pentax.com**) donated the use of a Pentax Optio 33WR Digital Camera

Olympus America Inc. (Melville, New York, USA – **http://www.olympus.com**) donated the use of an Olympus Stylus 300 Digital Camera

Stearns, Inc. (Sauk Rapids, Minnesota, USA – **http://www.stearnsinc.com**) donated insulated waterproof waders for use in wading down a creek to place beacons in an otherwise inaccessible gorge.

Concorde Aerosales (Hollywood, Florida, USA - **http://www.concordeaerosales.com**) donated the use of Mutifabs Survival Dry Suits and Thermal Protective Undergarments for use during the maritime tests for protection from the cold water.

Evaluation Limitations and Considerations

As with many evaluations of lifesaving equipment, this one has been subject to limitations imposed by financial constraints, time and practical safety considerations.

Ideally, it would be desirable to test multiple distress beacons of each model in each scenario. The larger sample size would serve to mitigate the effects of a random failure that might not be typical. The high cost of the distress beacons, particularly in view of the uncertainty as to whether beacon manufacturers would participate, and thus mitigate the purchase of the beacons at significant expense, made this approach prohibitive.

By the same token, it is generally accepted that lifesaving equipment must be exceptionally reliable. Because failure can be fatal, consumers have a reasonable expectation that lifesaving equipment will work the first time, every time. Lifesaving equipment failure is not considered an option by the consumer. As such, any beacon failure must be considered unacceptable and this mitigates the potential adverse effects of testing only a single distress beacon of each model in each scenario.

The time necessary to conduct the testing also limited the number of beacons that could be tested, as well as the number and scope of the scenarios to be evaluated. It also impacted the actual conduct of the testing when failure to acquire location more often than expected required on-scene modification of the testing in order to ensure completion within the available time. Additional time also translates to additional financial costs, not only for the evaluators, but also for the support personnel and organizations and the manufacturers who participated. The full week spent testing was the practical limit, and even then, some participants had to cut their attendance short.

Real world testing introduces numerous variables beyond the control of the evaluator. In the case of this evaluation, significant potential variables included weather, sea conditions, and GPS satellite visibility. All the manufacturers of the beacons tested signed on as participants, implicitly acknowledging that these variables were within accepted norms, and would not adversely impact the results if the evaluation were to be conducted in substantial accordance with the draft test protocols provided to them.

These distress beacons are meant to be used *in extremis*, often under the least favorable conditions of weather and, in the case of marine use, extreme sea conditions, often the cause for their necessary use by survivors. This evaluation was, for both practical and safety reasons, limited as to what tested environmental conditions could be experienced. Weather conditions were mild. Rainfall or exposure to drenching amounts of water in a marine environment was simulated for some scenarios, but was moderate, at worst, compared to what might conceivably be experienced under real life-threatening circumstances. Sea conditions varied from moderate, but unchallenging, at their worst to virtually dead flat seas at times, as noted in the scenario reports. Any failures must be viewed in this light, but the ultimate value of success in these tests must also be tempered by these limitations.

When reviewing the results presented here, care must be taken not to compare performance without consideration for the manifest differences between some beacons. Those beacons relying upon an external GPS source are fundamentally different in both operation and packaging to those having an internal GPS source. These differences must be taken into consideration when evaluating the performance of the beacons (they will be enumerated later on in this report).

The results presented here are for tests of particular beacons. Readers of this report are cautioned that it can be potentially erroneous to extend the self-location results for any particular beacon to any beacons not tested unless the combination of GPS chip, software, GPS antenna and relationship between the GPS antenna, and transmitting antenna are substantially the same due to the complex interactions involved.

Disclosures

Doug Ritter, Executive Director of Equipped To Survive Foundation, organizer and director of these tests and principal author of the report has had an ongoing professional and journalistic relationship with most 406 MHz beacon manufacturers for some time, with manufacturers providing “dummy” beacons for display and photographic purposes. At various industry events, beacon manufacturers’ representatives have treated Mr. Ritter to meals. Both ACR Electronics and McMurdo Ltd. have provided PLBs for Mr. Ritter to give away as door prizes during non-paid survival equipment presentations promoting 406 MHz PLB usage to various consumer groups. Mr. Ritter has, from time to time, recommended beacons from all the tested manufacturers to consulting clients and at times the beacons have been purchased via his contacts with the manufacturers or a manufacturer’s distributor.

The Equipped To Survive Foundation has received 10% of sales of both ACR and McMurdo PLBs made on the GetRescued.net retail web site operated by Pulver Technologies, Inc., which also hosts the Equipped To Survive web site. Dave Pulver is the majority partner in Pulver Technologies and is a director of the Equipped To Survive Foundation.

BoatU.S. Foundation has received price consideration from ACR for beacons purchased for their EPIRB rental program.

West Marine has sold both ACR and McMurdo beacons and other products produced by these companies. West Marine is an authorized service center for ACR.

Executive Summary

Simulated rainfall / spray drenching ACR GlobalFix EPIRB

This evaluation of 406 MHz Location Protocol Beacons was limited in scope to three beacon manufacturers; ACR Electronics (Ft. Lauderdale, Florida, USA – a subsidiary of Chelton/Cobham PLC United Kingdom – **http://www.acrelectronics.com**); McMurdo Ltd. (Portsmouth, United Kingdom – a subsidiary of Chemring Group PLC, United Kingdom – **http://www.mcmurdo.co.uk**); and Techtest Ltd. (Herefordshire, United Kingdom – a subsidiary of HR Smith Group, United Kingdom – **http://www.searchandrescue.com**), who produce beacons approved for the U.S. market and which are also sold worldwide. This evaluation was primarily concerned with the self-locating performance of these beacons in real-world conditions, as well as a limited specific set of other lesser issues, and not the beacons' performance vis-à-vis COSPAS-SARSAT or other regulatory standards, per se, nor for the most part any other specific performance parameters of the beacons except those few others specifically included. Beacons were divided into types; EPIRB (Emergency Position Indicating Radio Beacon, a marine distress beacon) or PLB (Personal Locator Beacon for personal use on land or in the maritime environment), by whether they used an external GPS source or an internal GPS source for self-location, and by whether they were off-the-shelf consumer beacons or a military derived PLB/ELT (aviation Emergency Locator Transmitter). While no beacon tested performed flawlessly, there were clear distinctions in self-locating performance among beacons during the evaluations. **All the beacons tested appear to provide the minimum acceptable level of distress alerting performance expected from conventional, non-location protocol 406 MHz emergency beacons.**

The following beacons were tested:

- ACR Electronics "RapidFix 406 MHz EPIRB" with GPS Interface, Model RLB-33 (external GPS), also sold by Northern Airborne Technology (NAT) under the brand name "GeoTrack 406 EPIRB"
- ACR Electronics "GlobalFix 406 MHz EPIRB" with Integral GPS, Model RLB-35 (internal GPS), also sold by Northern Airborne Technology (NAT) under the brand name "SatFind-406 Survival GEPIRB II"
- ACR Electronics "GyPSI 406 MHz PLB" with GPS Interface, Model PLB-100 (external GPS)

- McMurdo Ltd. “Precision 406 MHz GPS EPIRB” (internal GPS), also sold as the “G4 406 MHz GPS EPIRB”
- McMurdo Ltd. “Fastfind Plus 406 MHz Personal Location Beacon” or “Fastfind Plus 406 MHz PLB” (internal GPS)
- Techtest Ltd. Model 500-27 406 MHz GPS PLB with 121.5/243 MHz VHF 2-way voice communications (internal GPS)

The ACR and McMurdo beacons were literally off-the-shelf beacons from West Marine stock, taken from their warehouse and store shelves. The Techtest GPS PLB is a derivative of their 500-12 non-GPS, military derived PLB/ELT to their latest build standard. It was not off-the-shelf and the company paid for its inclusion in the testing. This beacon was unique in offering a 243 MHz military homing frequency and two-way voice communications on 121.5/243 MHz.

The beacons tested that do not have an internal GPS receiver are dependent upon an external GPS for self-location information. The reference GPS used for testing was a Garmin eTrex Legend, chosen because it is a WASS-enabled mid-range member of the most popular moderate priced portable handheld GPS line sold in the U.S. and because the manufacturer of the beacons tested, ACR Electronics, at various times has offered units from this line of handheld GPS as a package with their beacons, the ACR GyPSI 406 PLB and ACR SatFind 406 EPIRB. Our experience suggests that this GPS offers mediocre performance in comparison with better quality, and often more expensive, GPS receivers which were able to reliably acquire a location in circumstances when the Garmin eTrex did not. In these instances, had the beacons been interfaced with the better GPS, they would have been able to transmit a location. With these beacons, if the interfaced GPS gains a location, it will be transmitted. The self-locating performance of these beacons is entirely dependent upon the quality of the GPS chosen by the user for the interface.

McMurdo Fasfind Pluss PLB and reference GPS receivers

In the case of beacons using an external GPS source, the external GPS was turned off and the activation sequence initiated by turning on the GPS co-located with the beacon. It was logistically impracticable to achieve a full cold start of the GPS, but this ensured that the GPS was not transmitting a location achieved under more favorable conditions than those of the beacons with integral GPS. The warm start would be a likely scenario for PLB use in the wilderness, as the GPS would be expected to have been used for navigation within a short period of time of its use to interface with the beacon. For external GPS EPIRBs mounted on a boat and permanently interfaced with the boat’s GPS this would not be a factor at all. For a cold start using an external GPS, the typical cold start time to location acquisition can be derived experimentally or from the manufacturer. In the case of the Garmin eTrex

Legend reference GPS used in this evaluation, this would add “up to 5 minutes” according the manufacturer’s literature.

The evaluation revealed a marked difference in self-locating performance among the integral GPS beacons tested. The ACR GlobalFix 406 EPIRB and Techtest Model 500-27 PLB generally provided location information within a few minutes from activation under all but the most onerous scenarios tested, with a few exceptions.

By contrast, the McMurdo Fastfind 406 PLB and McMurdo Precision 406 GPS EPIRB generally failed to provide location information except under ideal conditions. Even in scenarios where there were strong signals from 4 or more GPS satellites, and often 6 or more, as shown on the Garmin eTrex GPS, these beacons failed to provide a location unless the sky view was virtually unimpeded over the full hemisphere and there was little or no movement of the beacon due to the motion of the water, in the case of the testing on and in the water. (In theory, a GPS receiver is capable of deriving a longitude and latitude with 3 satellites in view and locked on and all commercial units that the authors are familiar with will do so reliably.)

In the maritime testing, the McMurdo beacons failed to acquire a location in any of the planned test scenarios, effectively a total failure in the marine environment. The only acquisition, by the McMurdo Precision 406 GPS EPIRB, occurred when it was specially provided a unique opportunity under virtually ideal conditions with only the slightest swells and a glassy water surface.

In the baseline testing, the McMurdo Fastfind Plus PLB was the only integral GPS beacon that failed to acquire a new location after being moved, despite being provided an extra opportunity–two 20-minute update cycles.

The self-locating performance of these McMurdo beacons during the evaluation appears to contrast sharply with expected performance based upon the advertising and promotion by the company for its products, although it does not necessarily follow that these beacons do not meet required regulatory specifications which may not have any relation to real-world use with regards to self-location performance. This issue of ineffective international standards with regards to self-location performance has been previously identified by U.S. government sponsored testing and is confirmed by the results of this evaluation.

The field test portion of the evaluation was divided into three distinct phases: Baseline, Maritime, and Inland, with the results summarized in the tables that follow:

(Please note that the terms “success” and “fail” in these tables refers to the acquisition of a GPS-derived location and is not indicative of the alerting performance of the beacons.)

Summary of Baseline Testing

Baseline Scenario Description	Satellites in view and locked on per Garmin eTrex GPS Success or Failure to acquire a GPS location within 35 minutes[2] Time to acquisition if location was acquired in minutes:seconds					
	ACR RapidFix EPIRB[1]	ACR GlobalFix EPIRB	McMurdo Precision EPIRB	ACR GyPSY PLB[1]	McMurdo Fastfind Plus PLB	Techtest 500-27 PLB[4]
On jetty with expansive sky view and horizon	6 Success 0:52	6 Success 1:31	6 Success 3:04	7 Success 0:54	6 Success 27:25	7 Success 3:31
Relocation to beach with expansive sky view and horizon[2]	7 Success NA	7 Success NA	6 Success NA	7 Success NA	7 Fail[3] NA	7 Success NA
On jetty with expansive sky view and horizon, sprayed with water to simulate moderate rain.	7 Success 0:59	6 Success 2:03	7 Success 5:32	----	----	----

[1] External GPS source Garmin eTrex Legend– Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] For the relocation scenario, the beacons were hand-carried to a new location 400 yards distant to determine if the new location was acquired and transmitted at the 20-minute location update cycle.
[3] The McMurdo Fastfind Plus was allowed to remain on through 2 20-minute cycles at relocated position and failed to update location.
[4] Paid for inclusion in evaluation

Summary of Maritime Testing

Maritime Scenario Description	Conditions Seas, Skies	Satellites in view and locked on per Garmin eTrex GPS Success or Failure to acquire a GPS location within 35 minutes Time to acquisition if location was acquired in minutes:seconds					
		ACR RapidFix EPIRB[1]	ACR GlobalFix EPIRB	McMurdo Precision EPIRB	ACR GyPSY PLB[1]	McMurdo Fastfind Plus PLB	Techtest 500-27 PLB[5]
On aft deck of vessel, under mizzen boom	8 ft. swells with waves, partly overcast	4 Success 1:18	6 Success 6:28	5 Fail NA	4 Success 0:59	7 Fail NA	6 Success 16:14
In water tethered to Rigid Inflatable Boat	8 ft, swells with waves, partly overcast	6+ Success 1:16	6+ Success 4:25	6+ Fail NA	----	----	----
In water tethered to Rigid Inflatable Boat with simulated rain/spray	8 ft, swells with waves, partly overcast	Invalid Activation[3]	6+ Fail NA	6+ Fail NA	----	----	----
Held by swimmer in water with swimmer tethered to Rigid Inflatable Boat	2-3 ft, swells with waves, clear	----	----	----	8 Success 0:57	6-8 Fail NA	7 Success 1:51
Secured on simulated swimmer (inflated swimmer's vest) in water tethered to Rigid Inflatable Boat with simulated rain/spray	2-3 ft, swells with 0.5 ft. wind chop, clear	----	----	----	6 Success 0:44	7-8 Fail NA	5-8 Success 7:00
In 6-person life raft, canopy open	2-3 ft, swells with 0.5 ft. wind chop, clear	8 Success 1:00	7 Success 1:58	7 Fail NA	8 Success 1:00	7 Fail NA	9 Fail NA
In 6-person life raft canopy closed	2-3 ft, swells with calm surface, clear	Presumptive Success[2]	11 Success 1:29	Presumptive Fail[4] NA	Presumptive Success[2]	Presumptive Fail[4] NA	Presumptive Fail[4] NA
In 6-person life raft canopy closed, simulated rain	2 ft, swells with glassy surface, clear	Presumptive Success[2]	11 Success 1:40	Presumptive Fail[4] NA	Presumptive Success[2]	Presumptive Fail[4] NA	Presumptive Fail[4] NA
In water floating free	1-2 ft, swells with glassy surface, clear	----	----	11 Success 4:23	----	----	----

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] Presumed success due to the Garmin eTrex Legend GPS having acquired a location.
[3] External GPS was not held under water spray when activated
[4] Presumed failure as eliminated due to failure to acquire under less difficult acquisition circumstances in the same overall scenario
[5] Paid for inclusion in evaluation

Summary of Inland Testing

Inland Scenario Description	Satellites in view and locked on per Garmin eTrex GPS Success or Failure to acquire a GPS location within 35 minutes Time to acquisition if location was acquired in minutes:seconds		
	ACR GyPSY PLB[1]	McMurdo Fastfind Plus PLB	Techtest 500-27 PLB[6]
Large meadow, hill top, interrupted tree line	7 Success 1:14	5 Success 4:44	7 Fail[2] NA
Small clearing, solid tree line	4 Success 0:50	4 Fail NA	4 Success[3] 2:31
On jetty with expansive sky view and horizon, sprayed with water to simulate moderate rain.	7 Success 0:53	7 Fail NA	7 Success 10:41
Under forest canopy, no location on Garmin eTrex	Fail NA	Fail NA	Fail NA
Under forest canopy, no location on Garmin eTrex	Fail NA	Fail NA	Fail NA
Hidden from GPS satellite for initial start-up period, cover removed to allow GPS acquisition at 20 minute update	Not Tested[4]	8 Fail[5] NA	8 Success 1:03
The scenarios below were not specifically designed to test the location protocol capability of the beacon, as it was not expected that they would acquire a location. A lack of acquisition is not a technical failure, but success of the integral GPS is noted as a useful GPS performance data point.			
Laying on side, antenna parallel to ground – beach location	GEOS satellite Presumptive Success[7] LEO sat Doppler Location First Pass	GEOS satellite Unlocated Success LEO Doppler Location First Pass	6+ (not recorded) Success 2nd Data Burst 2:00 (estimated)
Laying on side, antenna tip grounded – small clearing, solid tree line	GEOS satellite Presumptive Success[7] LEO sat Doppler Location First Pass	GEOS satellite Unlocated Success LEO Doppler Location First Pass	4 Success 3rd data burst 3:00 (estimated)
In narrow and deep rock gorge – only 1-2 GPS satellites visible	GEOS satellite Unlocated Success LEO sat No data[8]	GEOS satellite Unlocated Success LEO sat Doppler Location Second Pass	GEOS sat Unlocated Success LEO sat Doppler Location Second Pass

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] Anomalous failure caused by internal disconnect of GPS antenna from GPS chip, fixed for production per manufacturer
[3] Initial self-test failure, per protocols battery replaced in lieu of beacon, further investigation revealed that instruction manual details remedy for passivated battery
[4] External GPS enabled beacon does not allow for updated location per COSPAS-SARSAT
[5] Allowed to run uncovered for 35 minutes through a second 20-minute update cycle
[6] Paid for inclusion in evaluation
[7] Presumed success due the Garmin eTrex Legend GPS having acquired a location
[8] No LEO satellite data in logs is an inexplicable anomaly that is being investigated as LEO reception failure at approx. 600 miles altitude does not make any sense with GEO sat reception at 22,300 miles altitude.

Lab testing of battery life at the PLBs' minimum operating temperatures, -20°C/-4°F for the McMurdo Fastfind Plus and Techtest 500-27 and -40°C/-40°F for the ACR GyPSI exceeded the minimum required 24 hours by a notable margin.

In November of 2003 the U.S. Coast Guard issued a report reviewing issues raised about the McMurdo Fastfind PEPIRBs they had purchased for use by Coast Guard boat crewmembers. (PEPIRB stands for Personal EPIRB, the designation given their version of the Fastfind PLB, which is coded as an EPIRB, not a PLB, and which is functionally the same as the Fastfind PLB, including the design of its antenna and antenna storage. It is not equipped with an integral GPS receiver) While the general contents of this report have been widely known, it was not until shortly prior to publication of this report that a copy of the Coast Guard's test plan and report was secured by the Foundation via a Freedom Of Information Act request (see Appendix 7).

The Coast Guard noted in its test plan that their studies "indicated that the beacons radiated power is extremely degraded by the presence of water in the antenna well." This conforms to our laboratory test findings in this regard. They conducted field tests to ascertain if this impacted the effectiveness of the beacons to provide an alert and Doppler derived location under operational conditions. Among the "lessons learned" presented in their report was that "when any amount of water is allowed to collect in the antenna storage well the signal is degraded and may prevent the COSPAS/SARSAT system from receiving the transmitted signal. After activation, boat crew members shall make every effort to keep the PEPIRB out of the water, the antenna and antenna storage well as dry as possible and the PEPIRB oriented so that the antenna has an unobstructed view of the sky." This conforms to our Conclusions and Recommendations in this regard (see Conclusion #7, page 88, and Recommendation #12, page 92).

Readers are encouraged to review the full report, including the background to the testing, testing procedures and results, in detail, to gain a better understanding of the issues raised in this Summary and to allow the reader to reach their own independent conclusions based on the facts. The full report can be ordered online at **http://www.equipped.org/406beacontest.htm**

Background to the Evaluation

NOAA (U.S. Department of Commerce's National Oceanic & Atmospheric Administration) and the U.S. Coast Guard organized a test of 406 MHz location protocol (GPS enabled) distress beacons in Key West, Florida, in March 2003, with a limited retest of one company's beacons in May 2003 in Hawaii. The testing was an effort to determine, at the request of COSPAS-SARSAT, why approximately 66% of all actual real-world alerts from GPS-enabled beacons (mostly EPIRBs) did not include the GPS-derived location coordinates, thus potentially slowing response to these emergencies. A report on this test was presented to COSPAS-SARSAT on June 11, 2003 (See Appendix 1).

Key West Test

The bulk of the testing was based at U.S. Coast Guard Group Key West facilities and has come to be referred to as the "Key West Test." In addition to Coast Guard and NOAA representatives, also attending were representatives from NASA, U.S. Air Force Rescue Coordination Center (AFRCC), COSPAS-SARSAT Secretariat (from the U.K.), and five beacon manufacturers (ACR Electronics, Artex, McMurdo Ltd., Microwave Monolithics, and Techtest Ltd). Also present was Doug Ritter, executive director of the Equipped To Survive Foundation, which provided some logistical support to the organizers as well as serving as an independent observer. As part of the agreement to encourage participation by the manufacturers, all results of the testing have been de-identified and participants agreed not to publicly identify particular beacons or discuss the performance of other manufacturer's beacons.

While conceived and conducted as a system test, the unexpected results of the testing showed that in other than ideal conditions, and in some cases even in ideal conditions, some beacons did not reliably provide location data within the first 30 minutes of operation. That was the testing limit established relating to the COSPAS-SARSAT certification requirements (**http://www.cospas-sarsat.org**) and beacon operating schemes. These beacons ostensibly meet all COSPAS-SARSAT requirements and have been so certified, and have been further certified by the FCC for sale in the U.S. In the case of the self-locating EPIRBs, the units have been for sale for a number of years. PLBs were first offered for sale in the continental U.S. in July of 2003, but have been available elsewhere in the world for some time.

Retailers report that sales of GPS enabled EPIRBs and PLBs have been very strong, despite incurring a considerable price premium. In interviews they suggest that a significant factor in these sales is the expectation on the part of consumers, based on promotion by the beacon manufacturers, SAR organizations and others, including the Equipped To Survive Foundation, of quicker notification and rescue from their distress circumstances. If the beacons do provide the location data, this is a reasonable expectation. Consumers have been willing to pay a premium of up to 50% for beacons with internal GPS to gain advanced distress alerting capability, which it appeared from the Key West Test results they may not necessarily reliably receive nor receive equally from all manufacturers' beacons.

The results of the Key West Test have not been able to be made public in a manner that provides the consumer easy access or understanding due in large part to the de-identification of the beacons required of the participants. In addition, the statistical analysis in the report is flawed in that it combined baseline tests with operational scenarios, artificially inflating the apparent success rate. It was also not specifically conducted as a test of the beacons, which opened it to some criticism and second-guessing regarding any assumptions made as a result of the performance witnessed.

Moreover, the regulatory bodies have been unable or unwilling to take any remedial action due to the anonymity promise of the Key West tests, and the fact that the beacons have been certified by COSPAS-SARSAT and the FCC as meeting the regulatory requirements, which is the only statutory or regulatory obligation. One of the report's recommendations (see Appendix 1) was, "Consider whether the 406 MHz Beacon Type Approval Standard (C/S T.007) adequately tests the acquisition of GPS location in operational conditions…" There is no indication that any such consideration is being treated as a priority or that it would result in a change to the standards in the near-term.

Meanwhile, absent any practical means to discriminate among beacons based on performance, consumers are purchasing these beacons that, if the results of the Key West Test were to be believed, do not appear to reliably provide the additional lifesaving benefits that consumers have been led to believe that they will provide, and which consumers have every right to expect to receive, especially so since they are paying a premium for them.

Until the Key West Test, the assumption throughout the government entities regulating these devices, the Search and Rescue community, retailers, and consumers alike has been that COSPAS-SARSAT certification was assurance that the emergency beacons all performed adequately, and that there was not a significant difference in distress alerting and self-locating performance between beacons utilizing GPS to obtain location information.

In part this assumption may have been aided and abetted because it is so difficult and expensive to conduct independent consumer-driven testing. As a result, consumer reporting on distress beacons has been primarily focused on easily distinguished differences in physical design, ergonomics, size, weight, and price and the gross performance differences that have been assumed to exist between various modes of operation, external vs. integral GPS, but not actual tested performance as is the standard for most such reporting.

Assuming the results were valid, the Key West Test suggested that the COSPAS-SARSAT certification testing cannot be relied upon at this time to ensure a comparable minimum level of performance among the various beacons on the market. Again, assuming the results of the Key West testing were valid, neither did it appear that marketplace competition or concerns over liability have encouraged adequate or better real world performance levels be achieved by all manufacturers.

These apparent performance deficits could have profound and potentially fatal consequences, as well as leaving the industry and COSPAS-SARSAT system open to potentially devastating negative publicity and liability, if a beacon's inadequate self-locating performance resulted in loss of life in circumstances where it would otherwise likely have resulted in a successful rescue due to the advantages that self-location would have been expected to provide.

The Equipped To Survive Foundation determined that there was a need to conduct an independent test of these beacons unrestricted by the limitations imposed upon the participants in the Key West Test, and with results that could be communicated to consumers. Consumers have an expectation that emergency lifesaving equipment will perform exceptionally reliably and to its maximum potential if needed to save their life. Consumers have a need for a means to determine if lifesaving equipment will meet these expectations, and the Equipped To Survive Foundation has a history of testing such equipment in order to provide this independent and unbiased information to consumers.

In addition, government regulators and standards-setting organizations have a need to determine if their regulations and standards designed to ensure minimum acceptable performance of lifesaving equipment in the real world are actually doing so. Such testing would also serve to determine if the performance witnessed in the Key West Test was an anomaly or if these results were reproducible, and therefore, the results validated.

The following 406 MHz beacon manufacturers who offer GPS enabled beacons were invited to participate on the basis that they either were currently offering their EPIRBs and PLBs for sale in the U.S. or were anticipated to do so in the near future:

> ACR Electronics, Inc. (Ft. Lauderdale, Florida, USA – a subsidiary of Chelton/Cobham PLC, United Kingdom – **http://www.acrelectronics.com**)
>
> McMurdo Ltd. (Portsmouth, United Kingdom – a subsidiary of Chemring Group PLC, United Kingdom – **http://www.mcmurdo.co.uk**)
>
> Microwave Monolithics (Simi Valley, California, USA – **http://www.micro-mono.com**)
>
> SERPE-IESM (Guidel, France – **http://www.serpe-iesm.com**).

Techtest Ltd. (Herefordshire, United Kingdom – a subsidiary of HR Smith Group, United Kingdom - **http://www.searchandrescue.com**), who offer their PLB as a Survival ELT (aviation Emergency Locator Transmitter) or as a military PLB in the U.S. and were therefore not originally invited, requested to participate.

Microwave Monolithics and SERPE-IESM declined to participate and since their beacons were not yet available for sale and were unobtainable by the organizers, they were not tested.

Due to financial constraints and considering that Techtest was not a significant factor in the consumer marketplace due to its high price and limited distribution, Techtest was advised that we would be unable to include their beacons in the evaluation. They countered with an offer to finance their inclusion in the testing. After consultation with the primary sponsors, it was agreed that they would be allowed to participate if they paid the pro-rata portion of the anticipated added cost of testing their beacon. They agreed and were included in the evaluation. The Techtest GPS PLB is a derivative of their 500-12 non-GPS military derived PLB/ELT to their latest build standard and not off-the-shelf. This should be taken into account in any comparison. This beacon was unique in offering a 243 MHz military homing frequency and two-way voice communications on 121.5/243 MHz.

The following beacons were tested:

- ACR Electronics "RapidFix 406 MHz EPIRB" with GPS Interface, Model RLB-33 (external GPS), also sold by Northern Airborne Technology (NAT) under the brand name "GeoTrack 406 EPIRB"
- ACR Electronics "GlobalFix 406 MHz EPIRB" with Integral GPS, Model RLB-35 (internal GPS), also sold by Northern Airborne Technology (NAT) under the brand name "SatFind-406 Survival GEPIRB II"
- ACR Electronics "GyPSI 406 MHz PLB" with GPS Interface, Model PLB-100 (external GPS)
- McMurdo Ltd. "Precision 406 MHz GPS EPIRB" (internal GPS) , also sold as the "G4 406 MHz GPS EPIRB"
- McMurdo Ltd. "Fastfind Plus 406 MHz Personal Location Beacon" or "Fastfind Plus 406 MHz PLB" (internal GPS)
- Techtest Ltd. Model 500-27 406 MHz GPS PLB with 121.5/243 MHz VHF 2-way voice communications (internal GPS)

(Information on additional branded versions of the tested beacons supplied by the manufacturer.)

In order to ensure that the consumer beacons tested were representative of those being purchased by consumers, West Marine supplied ACR and McMurdo beacons from their stock for the test, but expected to either be reimbursed by the Foundation or for the beacons to be replaced in stock. Due to the high cost of the beacons, even at wholesale approximately $18,500 for the ACR beacons and $17,500 for the McMurdo beacons, the manufacturers were offered the opportunity to participate in the evaluation in exchange for their providing the beacons to be tested. No matter their response, it was the organizers intention to test the ACR and McMurdo beacons, and initial fundraising goals were based on the presumption that they would not participate and the beacons would have to be paid for.

Those manufacturers who elected to participate would be required by agreement to either provide beacons for testing (9 EPIRBs and 15 PLBs of each model to be tested) in the case of those not readily available in the U.S., Techtest being the only one, or to replace beacons already obtained from West Marine and sequestered by the Foundation, the case with ACR and McMurdo. An agreement with the Foundation was signed by all participating manufacturers outlining requirements and responsibilities of the parties.

Those manufacturers who elected to participate were offered the opportunity to have a representative observe the testing, subject to signing a confidentiality agreement and a personal waiver of liability. McMurdo agreed to participate after considerable negotiations over legal and technical issues, but declined to send an observer, citing legal concerns over the liability waiver and confidentiality agreement requirements. Quoting Chris Hoffman, Technical Director of McMurdo, “I believe that the biggest stumbling block is the Personal Liability Waiver, with the Confidentiality Agreement being a secondary issue. I have spoken to our parent company and they still will not let us sign the waiver, I guess that USA and UK laws and liabilities, which I don't for a minute purport to understand, are different enough to create the problems. So how does this sound as a way forward, we have very nearly agreed the Main Agreement between us and are almost in a position where we would be happy to sign this, if we could sort out the last outstanding minor legal issue. However nobody from McMurdo would attend the trials as a witness as I am sure that you already have enough ‘experts’ and independent witnesses to cover anything that needs doing anyway. This then removes the issues with the Personal Liability Waiver and Confidentiality Agreement.” The Foundation agreed to this proposal and McMurdo did not have a representative present for the tests. ACR and Techtest did send representatives.

Pursuant to the agreements with the manufacturers as another inducement to participate, these manufacturers have also be given a preview of the draft report and were invited to offer a response if desired. McMurdo was the only one to do so and their response and associated correspondence between the parties are included in the report as Appendix9.
Invitations were also sent out to numerous Search and Rescue-related organizations. NOAA sent a technical representative. The AFRCC originally agreed to send a representative, but canceled at the last minute, reportedly due to a scheduling conflict. While U.S. Coast Guard headquarters and the Office of Search and Rescue declined to participate, the U.S. Coast Guard Office of Aviation Engineering authorized the Aviation Life Support Equipment Manager and Aviation Life Support Prime Unit Manager to participate. FAA sent a technical representative.

In November of 2003 the U.S. Coast Guard issued a report reviewing issues raised about the McMurdo Fastfind PEPIRBs they had purchased for use by Coast Guard boat crewmembers. (PEPIRB stands for Personal EPIRB, the designation given their version of the Fastfind PLB, which is coded as an EPIRB, not a PLB, and which is functionally the same as the Fastfind PLB, including the design of its antenna and antenna storage. It is not equipped with an integral GPS receiver) While the general contents of this report have been widely known, it was not until shortly prior to publication of this report that a copy of the Coast Guard’s test plan and report was secured by the Foundation via a Freedom Of Information Act request (see Appendix 7).

The Coast Guard noted in its test plan that their studies “indicated that the beacons radiated power is extremely degraded by the presence of water in the antenna well.” This conforms to our laboratory test findings in this regard. They conducted field tests to ascertain if this impacted the effectiveness of the beacons to provide an alert and Doppler derived location under operational conditions. Among the “lessons learned” presented in their report was that “when any amount of water is allowed to collect in the antenna storage well the signal is degraded and may prevent the COSPAS/SARSAT system from receiving the transmitted signal. After activation, boat crew members shall make every effort to keep the PEPIRB out of the water, the antenna and antenna storage well as dry as possible and the PEPIRB oriented so that the antenna has an unobstructed view of the sky." This conforms to our Conclusions and Recommendations in this regard (see Conclusion #7, page 88, and Recommendation #12, page 92).

How the COSPAS-SARSAT System Works

(Portions of this overview have been adapted from NOAA, NASA, and other public domain materials)

COSPAS-SARSAT is an international, humanitarian satellite-based distress alerting system that is credited with helping to save over 16,000 lives worldwide and over 4,600 lives in the U.S. since its inception in 1982 (totals as of January 1, 2004).

> SARSAT is an acronym for Search and Rescue Satellite-Aided Tracking. COSPAS is an acronym for the Russian words "Cosmicheskaya Sistyema Poiska Avariynich Sudov," which mean "Space System for the Search of Vessels in Distress," indicative of the maritime origins of this distress alerting system.

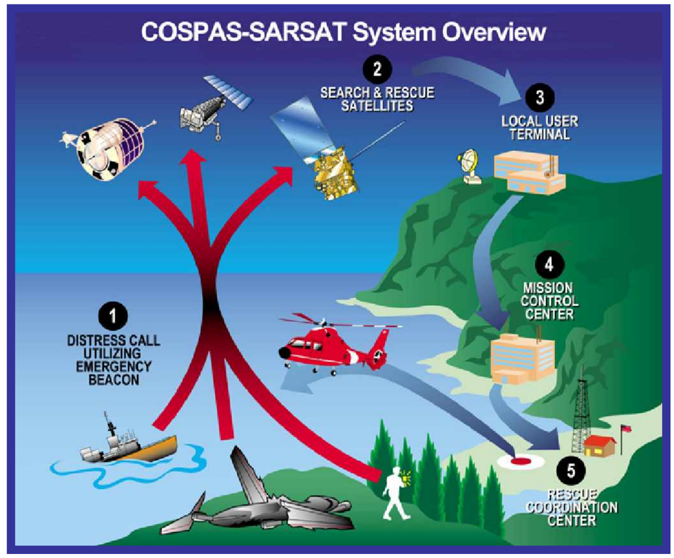
The system, which operates 24 hours a day, 365 days a year, detects and locates transmissions from emergency beacons carried by ships, aircraft, and individuals.

Sponsored by Canada, France, Russia, and the United States, the system aims to reduce the time required to alert rescue authorities whenever a distress situation occurs. The rapid detection and location of a downed aircraft, a ship, or an individual in distress are of paramount importance to survivors and to rescue personnel. Time is often the enemy in a survival situation and the sooner a rescue is affected, the more likely the successful outcome.

The COSPAS-SARSAT system consists of emergency radio beacons (distress beacons), equipment on satellites in low-earth polar and in geosynchronous orbits, ground receiving stations also called Local User Terminals (LUTs), Mission Control Centers (MCCs), and Rescue Coordination Centers (RCCs).

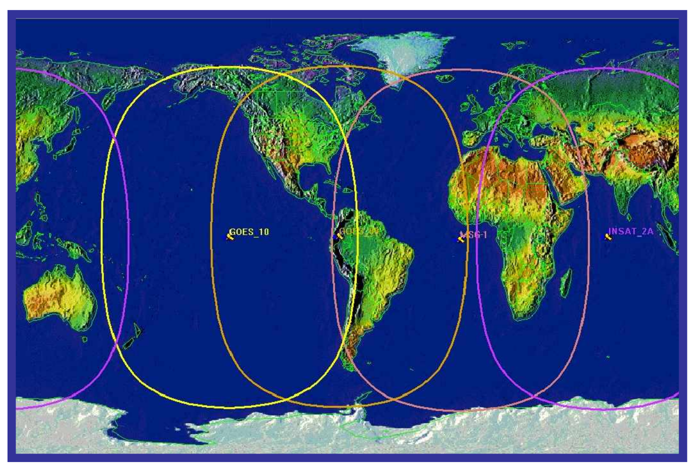
There are three types of emergency beacons: 1) Emergency Position Indicating Radio Beacons (EPIRBs) for maritime applications, 2) Emergency Locator Transmitters (ELTs) for aviation applications, and 3) Personal Locator Beacons (PLBs) for individuals in distress. Emergency beacons transmit on 121.5, 243 (military) and 406 MHz. Satellite notification of 121.5 and 243 MHz alerts are being phased out, with termination scheduled by February 1, 2009. 406 MHz has become the international standard, providing far better accuracy and fewer false alerts.

Beacons that transmit on 406 MHz send digitally encoded information that includes a beacon I.D. for accessing a user registration database. This database can supply the beacon type, its country of origin, the registration number of the maritime vessel or aircraft, name of the beacon owner, emergency contact phone numbers, and other data useful to prosecution of the search and rescue.



COSPAS-SARSAT System Overview

This digital data can also include location data derived from the Global Positioning System (GPS). Encoded location is of great value when using a geostationary (GEO) satellite for relaying beacon signals because a GEO satellite provides virtually immediate alerting, typically within 3 to 5 minutes. The addition of location data from the beacon itself provides virtually immediate location information and even greater accuracy.

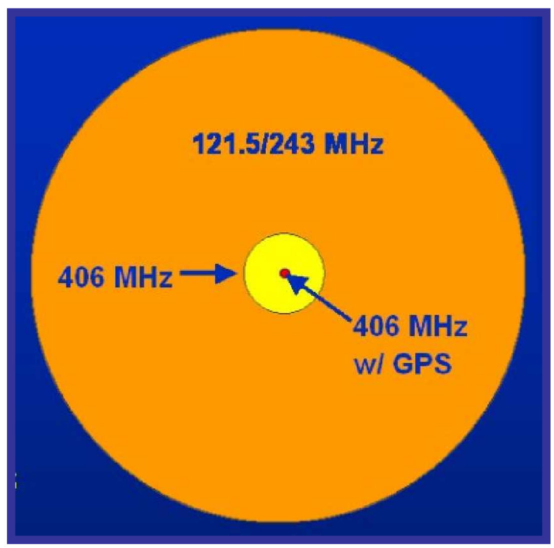


The system uses two different types of satellites: polar-orbiting satellites in low-Earth orbit (LEO) and GEO satellites in geosynchronous orbit. Russia and the United States provide the LEO satellite platforms. Canada, France, Russia, and the United States contribute components. The Russian NADEZHDA navigation satellites carry the COSPAS repeater packages, and NOAA weather satellites carry Sarsat packages. The LEO satellites are in polar orbits. U.S. Sarsat satellites orbit every 100 minutes inclined 99 degrees from the equator at an altitude of 528 miles (850 kilometers). Russian COSPAS orbits every 105 minutes at an altitude of 620 miles (1000 kilometers) and an orbital inclination of 83 degrees. There is up to a 1.5 hour delay before a LEO satellite passes over a beacon site and receives its transmission. The delay is longest at the equator and shortest at the poles. Within the continental U.S., the maximum delay is approximately 1 hour.

GEO satellites maintain a stationary position over the Earth's equator at an altitude of 22,300 miles (35,786 km), and continually view large areas of the Earth from approximately 70 degrees North to 70 degrees South latitudes; it can provide near-immediate alerting and identification of 406 MHz beacons if the beacon is successful in transmitting to the GEO satellite. With increasing latitude, the angle up from the horizon that the satellite is visible to the beacon decreases, with a complimentary increase in the likelihood the signal will be blocked by terrain or other impenetrable impediments to the line-of-sight signal. There are four GEO satellites; two are operated by the United States and one each by India and the European Union.

The COSPAS-SARSAT LEO system uses two modes of operation. In the Bent-Pipe or repeater mode, the Search and Rescue Repeater, or SARR, immediately retransmits received beacon signals to any LUT in the satellite's footprint. This mode is possible when the spacecraft is visible to both the beacon and the ground station simultaneously, an area approximately 2,500 miles (4,000 km) in diameter. This footprint is constantly moving as the satellite orbits the earth. Large portions of the globe, particularly of the southern hemisphere oceans, are not within sight of a LUT and consequently 121.5 beacons are not at all effective in those areas. Most populated areas are covered with the exception of the southern half of the African continent.

In the store and forward mode, the on-board Search and Rescue Processor, or SARP, receives and records search and rescue beacon transmissions from 406 MHz beacons only, and repeatedly retransmits them to LUTs as the satellite orbits the Earth. This provides true global coverage.



The signals received by LEO satellites are relayed to a network of LUTs that locate the beacon by measuring the Doppler shift caused by the motion of the satellite with respect to the beacon. This process can locate beacons within an accuracy of approximately 12.4 miles (20 km) for 121.5 MHz beacons and an accuracy of approximately 3 miles (2-5 km) for 406 MHz beacons with 1.5 miles being the average in actual experience. A low-power 121.5 MHz signal included in all U.S. 406 MHz beacons can assist rescuers to home in on the distress beacon. Beacons that provide a GPS-derived location are touted as being accurate within approximately 328 feet (100 meters). In reality, the actual accuracy can be somewhat worse, though in a worse case it is still orders of magnitude better than without GPS. GEO satellites communicate via a separate network of GEOLUTs.

The location data, no matter from what satellite source, is then relayed to an MCC that alerts the appropriate RCC or an MCC in another country. If the alert is in an area covered by a foreign MCC, that MCC is alerted, and in turn, notifies its own RCC. The RCC then begins the actual search and rescue operation.

NOAA (U.S. Department of Commerce's National Oceanic & Atmospheric Administration), the U.S. Coast Guard, and the U.S. Air Force operate the COSPAS-SARSAT system in the United States.

More information may be found at:

> **http://www.sarsat.noaa.gov**
> **http://poes.gsfc.nasa.gov/sar/sar.htm**
> **http://www.cospas-sarsat.org** (includes COSPAS-SARSAT type approval standards and other standards and documentation)

Advantages of Self-Locating Beacons

There are two primary components to a satellite-based distress alert. The first is the alert itself, a notification that persons are in distress. The second is the location of those in distress. Both elements must be present in order to effect a rescue.

With the COSPAS-SARSAT system, GEO satellites offer the potential for near-instantaneous alerting over a large portion of the globe representing the vast majority of human occupation and travel, between 70 degrees North and South latitudes.

If the MCC can speak to the emergency contact(s) obtained from the beacon registration database, assuming the beacon has been properly registered, and that contact can provide general or specific location information, then search and rescue operations can commence and a SAR mission may actually be launched. The registration information combined with the GEO satellite alert have led to a greatly reduced response time in a large number of cases, and even lives saved as a direct result of a GEO satellite alert, based on information received from the points of contacts on the registration form. Often, however, it is necessary to wait until a Doppler location is provided via a LEO satellite pass, a delay that can amount to over an hour. In some emergency situations, an hour’s delay could prove fatal.

With a self-locating beacon that transmits its location, this location is provided in the initial alert via the GEO satellite and rescue operations can commence very nearly immediately, potentially significantly shortening the time until rescue and increasing the likelihood of a successful rescue. Moreover, the location information transmitted by a self-locating beacon is derived from GPS and is potentially much more accurate than the location derived via Doppler, approximately 300 feet +/- vs. an average of 1.5 miles in actual experience (ranging from 2-5 km in theory), potentially further improving response time.

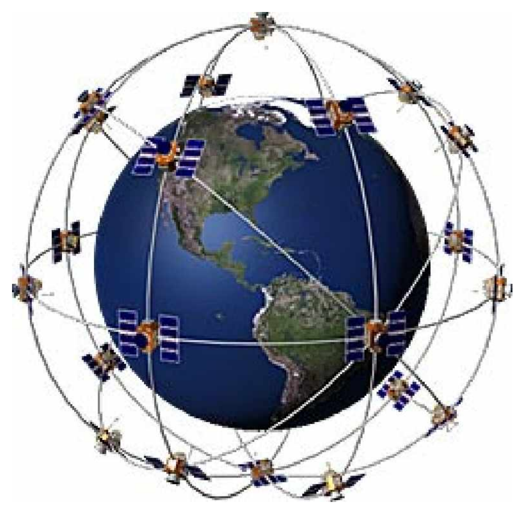
All other things being equal, a self-locating beacon theoretically provides an improved chance for a successful rescue than a beacon without self-location. What is not well-documented is how critical this has proven in actual emergencies, and what increased use of self-locating beacons would do to the success rate overall. There is much more that goes into the equation than simply alert time, actual response time can vary significantly such that it can partially negate any advantage. For an organization such as the U.S. Coast Guard whose aerial response can be launched in 25 minutes, typical for a "ready" helicopter, minutes can make a big difference. For other search and rescue services where launching any response can take hours, at best, the relative importance of 30 –60 minutes advantage over a conventional Doppler location is diminished, although the accuracy issue remains.

There are also potentially commensurate reductions in costs to Search and Rescue organizations prosecuting the rescue, and a theoretical lower risk to SAR personnel involved due to less time exposed to the inherently risky tasks involved.

GPS and GPS Limitations

(Portions of this overview have been adapted from GPS receiver manufacturer sources and operator's manuals and public domain materials on the subject.)

The ability of self-locating beacons to shorten rescue times is tempered by the fact that they derive their location information from a GPS receiver that is itself subject to a variety of limitations. This report shall cover these issues in enough detail to provide a basis for understanding the evaluation results and to allow a reader some perspective from which to judge the evaluation protocols and the results. The technical issues are significantly involved that readers are encouraged to gain additional knowledge of GPS operations and technology via other sources. It is assumed that the reader has at least a cursory understanding of GPS navigation.



Whether the GPS receiver is a chip and antenna integrated within the body of the beacon or is a separate GPS receiver connected to the beacon (external), the effectiveness of the receiver in deriving a location is determined by a combination of factors.

All contemporary GPS receivers are "parallel 12-channel" designs that have the capability to separately receive and integrate signals from up to 12 GPS satellites at once. Generally, the more satellites received, the more accurate the location provided. Typically, 12 satellites are in view at any one time from sea level locations, but, only 6-8 typically have a sufficiently strong signal for the receiver to lock on to the signal and make use of it. However, we have seen up to 11 satellites locked on in some instances in this evaluation.

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude). GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight and cannot pass around objects too dense to allow the signal to penetrate through. The signal will pass through clouds, glass, and plastic but will not go through most solid objects such as buildings and mountains or more than a thin layer of water.

A GPS signal contains three different bits of information; a pseudorandom code, ephemeris data, and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information and is not important for location purposes. Ephemeris data, which is constantly transmitted by each satellite, contains information about the status of the satellite (healthy or unhealthy), current date, and time. This part of the signal is essential for determining a position. The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system. This is useful for many purposes, but not essential to gain a location.

The ability of the receiver to receive GPS satellite transmissions is determined in part by the sensitivity of the antenna. Some antennas are better than others and this is an area where considerable progress has been made in recent years, both in miniaturizing the antenna and in improving its sensitivity. All other things being equal, smaller antennas will generally not perform as well as a larger antenna using the same level of technology, but with the rapid advance of antenna technology, size alone is not a reliable factor in determining performance. GPS antennas integrated within a beacon or handheld GPS are available in a variety of technologies, but package formats are limited to a flat plate or a stub mast. There is no independent documentation to suggest that either format is necessarily superior, too much depends on other technological issues. Suffice to say, the best GPS chip in the world will be handicapped if the antenna is compromised.

When a GPS receiver is integrated into a beacon, there is another issue that comes into play and can have a potentially detrimental affect on GPS performance, one that an independent receiver may not be affected by.

A GPS-equipped beacon contains all of the usual beacon electronics in very close proximity to the GPS receiver and antenna. Most electronics generate unintentional RF radiation or “radio-frequency noise.” This noise can interfere with the operation of an internal GPS receiver. Similar behavior can be observed in broadcast radio receivers placed next to computers (especially AM radios).

More critically, all of these beacons transmit a 121.5 MHz homing frequency that allows rescuers to use direction-finding equipment to home in on the beacon once they have arrived in the general area, particularly important when there is no GPS location provided or the survivors have moved or have been moved from the originally transmitted position. The GPS satellite transmission frequency (1575.42 MHz) is very nearly the 13th harmonic (or multiple) of 121.5 MHz. As such, some of the radio energy generated by creating and transmitting the 121.5 MHz homing signal can interfere with receiving the GPS signal. The GPS signal is very weak—so weak in fact that a mathematical trick known as "coding gain" is required for GPS receivers to even "hear" it. The specified minimum received signal strength of the GPS "Link1" (L1) frequency is -160 dBW (decibels referenced to 1 watt). That is 0.0000000000000001 watts; in scientific notation: 1 x 10^{-16} watts. The 121.5 MHz signal from the beacon is a minimum of 25 mW up to 100 mW or -10 dBw (a tenth of a watt), 0.1 watts, 1×10^{-1} watts. So the beacon's 121.5 MHz transmission is potentially 150 dB or 10^{15} times stronger than the weakest civilian GPS signal. For the non-mathematically inclined, that's 1 quadrillion times stronger.

However, it's not the beacon primary homing frequency we're (mostly) concerned with—it's the 13th harmonic of that signal, and harmonic energy tends to fall off rapidly. We did not disassemble any of the tested beacons to measure the strength of these harmonic signals. However, there could easily be a few million times (~60 dB) as much beacon energy being transmitted as the GPS signal being received at the same time. Engineers are faced with a difficult design problem to filter out the weak GPS signal from this overwhelmingly stronger transmission virtually on top of or next to the receiving GPS antenna.

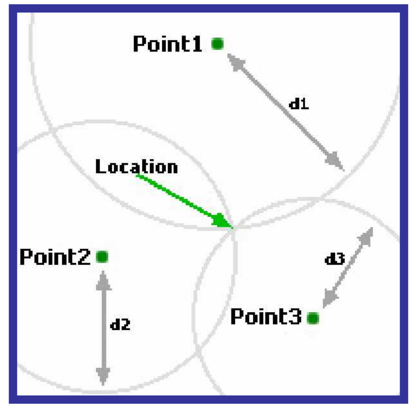
The final part of the GPS performance equation is the software. GPS chips generally come preprogrammed with basic software that takes 3 or more satellite signals and generates a location from them. If that's all there was to it, most GPS receivers would be pretty comparable. However, many, if not most, GPS receiver manufacturers tweak the software to one degree or another in order to gain some sort of process improvement or added capabilities. Depending upon how good a job they do, software can make a radical difference in GPS performance, for either better or worse.

ACR has recently made a point of touting its "FastACQ chip," included in the ACR GlobalFix EPIRB, which is marketing terminology referring to their proprietary software that they claim is designed to improve the speed of location acquisition. None of the other beacon manufacturers has acknowledged or made any public disclosure as to whether or not they tweak the GPS software in their integral GPS beacons.

Whether a beacon receives the GPS location information from an external GPS or an integral GPS chip, the longitude and latitude coordinates are included in the digital data stream sent to the satellite.

This location information is updated once every 20 minutes for beacons with internal GPS. If the location is not updated, after four hours the location data is removed from the transmission. Those beacons that rely upon an external GPS do not update GPS information unless the beacon is switched off and then on again, in accordance with COSPAS-SARSAT standards.

In order for GPS to derive a location, it must receive data from at least three satellites. This will allow it to achieve a 2-D (two dimensional) location providing longitude and latitude. The most common reason for this location to not be acquired under normal circumstances in non-urban areas is that the signal is being blocked by intervening material. As noted, the GPS signal is relatively weak and is blocked relatively easily.



High-density material such as rock, concrete, metal, and the like will prevent GPS signal reception.

Water is a very effective absorber of the GPS radio frequency. This means that the canopy of a tree with branches and leaves containing a high percentage of water can prove to be effective blockers of GPS signals if the foliage is dense and thick enough. So, too, is the human body. A hand held over a GPS receiving antenna will prevent reception of the GPS signal. Persons standing too close will have the same effect, particularly if surrounding the beacon, creating something of a canyon with a very limited view of the sky. The same situation can occur with a beacon at water level, floating or being held, when elevated swells or waves can obscure a significant portion of the sky for critical periods of time, to say nothing of the drenching a beacon may receive from waves, spray, or rain.

Regular users of GPS for navigation, particularly on land where many sources of blockage exist, have learned that they must be cognizant of their surroundings and may have to relocate the GPS receiver or antenna to allow for adequate reception. Under a moderately dense overhead canopy, sometimes even an inch or two of movement will make the difference between acquisition of a location or not.

Movement of the GPS antenna in combination with the chip and software can also have a detrimental effect on GPS performance with some systems exhibiting lesser capability to lock onto GPS satellite signals while in motion. Particularly in the case of integral GPS EPIRBs floating in the water, extreme motion can be evident due to the effects of water movement and this can be further exacerbated by the “jerking” effect caused by a tethered EPIRB and the vessel to which it is tethered moving in uncomplimentary fashion.

As we saw during our tests, the quality of the GPS receiver, as a packaged system of chip, antenna and software, can also significantly effect whether a location is acquired. In numerous instances we were able to acquire a location on some of our GPS receivers and not on others. That this is also an issue, to an even greater degree, with the integral GPS beacons is self-evident from the results.

Due to media coverage of the use of GPS by the military, which is not comparable to civilian GPS use, and the media coverage of which is also not necessarily always factually accurate, unrealistic portrayal of GPS capabilities in movies and TV programs, and day-to-day interface with higher performance GPS units used in boats, automobiles, aircraft and the like that are generally operating under favorable receiving conditions, it seems inevitable that the average consumer with limited or no GPS experience has an unrealistic expectation of what performance they can expect from GPS. This is especially true for the GPS receivers currently used in integral GPS beacons. Some existing advertising for these beacons appears to suggest a level of performance that may not exist, even among the best performing examples. The natural limitations to GPS acquiring a location are not well communicated to consumers who purchase or are looking to purchase a self-locating beacon. The desirability of optimizing conditions for GPS reception when using a self-locating beacon, especially one with integral GPS, is also not well-communicated to the end user.

Accuracy Limitations of GPS in Location Protocol Beacons

Users of GPS are used to seeing very accurate resolution from even the most rudimentary of current generation GPS receivers, typically down to a tenth of a second with an estimated accuracy of a few 10s of feet even without WAAS (with WAAS this accuracy improves even further). The GPS chips in these beacons are capable of such resolution, but the GPS location resolution and accuracy provided by these beacons is compromised by the COSPAS-SARSAT protocol specification for the data stream. This is an artifact of the original specifications for the hexadecimal "long" location protocol message that is limited to 30 characters.

The finest resolution available from a beacon transmission is in 4-second increments. At the equator, 1 second of latitude or longitude equals 101.3 feet. The distance in longitude is reduced as you increase latitude since the lines of longitude converge to zero at the poles. By way of example, at the approximately 37 degrees of latitude for the testing conducted in Santa Cruz, 1 second of longitude is equal to 81 feet. At the equator, a beacon transmission defines a square box 405.2 feet on each side. At Santa Cruz, a beacon transmission defines a rectangle 405.2 feet in the North-South direction by 324 feet in the East-West direction.

NOAA and others claim that accuracy is typically within 100 meters—328 feet—for self-locating beacons. It is therefore perfectly reasonable for a beacon right in the middle of one 4-second "box" to report itself as being in either that box or any of the eight adjoining boxes. In the worst case (involving a 100-meter GPS error in precisely the worst possible direction), the beacon will be found 615 feet away from the center of the box reported in the beacon transmission. McMurdo claims "positional accuracy to within typically 30 meters. "

McMurdo provided the following explanation that their "beacons determine their exact location based upon the GPS co-ordinates and round this up or down to the nearest 4 second grid co-ordinates in the box corners. Thus the worst case error is for an actual location in the middle of a box that might be reported as any one of the four corners of that box. If we use the numbers in your report for Santa Cruz then the worst case error to the middle of the box is 79 metres (259 feet). As we do not know which “side” of the box this position relates to, this error must be +/- 79 metres. If we now assume that, on average, the error will be half of this, then at Santa Cruz the typical error would be +/- 39.5 metres. In practise (sic) we assumed that typically a higher latitude would apply and thus used a smaller longitude box, thus we believe that “typically +/- 30 metres” is still a valid statement.”

The Foundation believes that McMurdo’s assumptions are flawed and thus the statement misleading.

McMurdo takes the position that half the time the beacon would be found within 30 meters of the reported position. In order to make that statement, McMurdo has to make certain assumptions, assumptions that we think are not necessarily valid.

First, McMurdo apparently assumes that the beacon is at a specific location that is further north than the approximately 37 degrees at Santa Cruz. Regardless of what location they assume, we reject this assumption as entirely valid for a product that is sold for use in any geographic region of the world, excepting any disclosure of this assumption to the consumer, which McMurdo does not make.

Moreover, even at the North or South Poles, the worst case (assuming millimeter precision GPS accuracy) is approximately 62 meters, and half the worst case is approximately 31 meters, which is still greater than 30 meters at the highest possible latitude.

McMurdo also assumes that the GPS system error is extremely small, which is not necessarily a valid assumption. McMurdo also assumes that the beacon was activated near the center of a “box,” which is not a valid or reasonable assumption at all.

Some significant percentage of the time, the GPS error of a beacon placed randomly in the box will overlap the side of a box, and that beacon can be expected to report itself as being in either of the two boxes. Likewise, the GPS error of a beacon will sometimes overlap a corner, and the reported position might be in any of four boxes.

If the beacon is in the box that it reports itself in, the average error will be about 40 meters. However, McMurdo is ignoring the very real likelihood that the beacon is in an adjacent box.

Appendix 9 includes a detailed analysis of this issue to explain why we believe that McMurdo’s contention that “typically +/- 30 metres” or the original in McMurdo’s literature of “positional accuracy to within typically 30 meters” is a misleading statement.

EPIRB vs. PLB

This evaluation tested both EPIRBs and PLBs. Both transmit a 5 Watt digital burst of approximately 0.5 seconds duration approximately every 50 seconds. This period is randomly distributed between 47.5 to 52.5 seconds to prevent multiple beacon transmissions from interfering with each other. Both transmit an equivalent digital message. However, there are notable differences between the two types of beacons. EPIRBs are meant to be carried on and deployed from a marine vessel; PLBs are meant to be carried by a person and deployed by an individual in distress. EPIRBs are intended to be used only in a marine environment; PLBs may be used on land or in a marine environment. As such, with the exception of the baseline tests, EPIRBs were tested only in the marine environment.

EPIRBs come in both automatically deployed or manually deployed models. Category I EPIRBs are activated either manually or automatically. Category I EPIRBs are housed in a bracket equipped with a hydrostatic release that releases the EPIRB when the vessel sinks. The EPIRB is activated when released and floats to the surface. An EPIRB thus released will float free unless retrieved by survivors in the water or in a survival craft. Category II EPIRBs are manual activation only units. Both categories of EPIRBs are designed to activate when they are immersed in water, regardless of the position of the manual switch.

EPIRBs must float with the antenna deployed and out of the water in the normal transmitting position. They are equipped with a strobe light that activates automatically when the beacon is switched on, and a means to tether them to a vessel or survival craft so they will float attached to the survival craft. They must operate for at least 48 hours at either -40°C to +55°C (Class 1) or -20°C to +55°C (Class 2). COSPAS-SARSAT standards assume that the body of water in which the EPIRB is floating will serve as the ground plane for the antenna.

PLBs are generally smaller because they require smaller batteries, being required to operate for only 24 hours at either -40°C to +55°C (Class 1) or -20°C to +55°C (Class 2). They are not required to be equipped with a strobe light. All are currently equipped with a tether of some sort, although this may just be a wrist tether. Category 1 PLBs must be buoyant; Category 2 PLBs are not buoyant. Category 1 PLBs are not required to float in a transmitting position—they simply are required not to sink, the objective being solely to help prevent loss if dropped into the water. They are not precluded from floating in a transmitting position. PLBs are manually activated only.

It has been noted that in real survival situations many EPIRBs are retrieved from the water after automatic release and activation or are retrieved from the vessel by survivors when they abandon ship into a life raft. In either case the EPIRB is then retained inside the life raft, rather than being floated in the water on the end of their very thin tether line, as designed. In some cases this appears to be the result of ignorance as to how to deploy the EPIRB as designed. In other situations, it appears that as their primary hope for rescue, survivors do not appear to be willing to trust their life to that thin tether, particularly in severe conditions. In a number of documented cases, the tether line was not securely tied off to the life raft and was separated from the life raft. Since they will tend to drift at different rates, they can quickly become separated. At least one life raft manufacturer, in recognition of this, provides an option for a secure pocket in the life raft to hold the EPIRB. (NOTE: Some aviation life rafts come equipped with an ELT that is secured semi-permanently in the raft, and some also activate the ELT automatically upon deployment of the raft.) In recognition of this reality, we tested EPIRBs both floating tethered to a vessel and retained inside a life raft.

PLBs were tested on land, held by persons floating in the water (or simulation of same) and in the life raft.

External vs. Integral GPS

The location protocol beacons tested obtain their GPS location via two dissimilar means that offer various advantages and disadvantages. The operation of beacons using an external GPS source and those with an internal, or integral, GPS receiver are markedly different and not always directly comparable.

Beacons using an external GPS source have generally been less expensive than those with an internal GPS receiver. Especially for a consumer who already owns a GPS receiver and for one who uses a GPS for navigation purposes, this can result in a more economical total purchase cost with similar distress signaling benefits.

Having an external GPS source requires that the owner/operator connect the GPS to the beacon. All current beacons require a physical connection. The ACR external GPS beacons evaluated come with a proprietary infrared adapter that terminates in two bare wires. This adapter provides a waterproof connection to the beacon as there is no physical connection between the interior and exterior of the beacon case, but the wires must be connected to an adapter to fit the external GPS.

On some units by other manufacturers that were not evaluated, the adapter is not included and must be purchased. On some units the connection is a plug and receptacle that may not be waterproof, not via an infrared connector.

There is no universal standard for the GPS data output connector used for this purpose; sometimes not even within a GPS manufacturer’s product line. As a result, the owner must acquire a GPS adapter from the manufacturer or elsewhere and either assemble their own interface cord or have one manufactured for them using the beacon’s adapter. In most cases, the GPS adapter is not waterproof or submersible, although most appear to be very water-resistant. The interface cord for our evaluation was provided by the ACR Electronics representative attending the evaluation who had personally assembled it.

External GPS receivers have the potential, at least when compared to the current generation of GPS enhanced beacons, of being more capable of acquiring a location under difficult conditions. This can be attributed to a combination of any or all of better receiver, software, and antenna.

EPIRBs using an external GPS source in most marine installations use the boat's own generally very capable high-performance GPS receiver that is permanently connected to the EPIRB held in its storage bracket. In such installations the GPS is generally equipped with a high-performance external GPS antenna that provides much-improved reception compared to the internal antennas on a handheld GPS receiver or within an integral GPS beacon. In such an installation, the EPIRB is constantly being updated with the latest GPS location and would be expected to have received a GPS location from the GPS prior to being activated and deployed. This would not be the case for an EPIRB in an abandon-ship bag or in a life raft survival equipment pack.

In situations where a user of a beacon, typically a PLB in this case, is going to be entering an area or circumstances where they know that it is unlikely that a GPS location can be acquired, an area with heavy overhead canopy, a narrow canyon, or where they might fall into a crevasse, for example, they can load a location into the beacon beforehand, possibly providing a nearby location for SAR to work with and the attendant advantages when they might otherwise not be able to do so. Note, that while the beacons tested retain this location in memory forever or until the beacon is activated and then deactivated again, the COSPAS-SARSAT standard has been changed since they were originally approved and any recently approved model beacons discard the location after four hours.

A beacon and an external GPS generally represent a bulkier and weightier package than a single integrated device. With an external GPS beacon, the user must contend with two devices and a connecting cord, at least with existing beacon and GPS interfaces. Deployment and activation can be more difficult when having to handle multiple devices. The survivor must know how to switch on and properly orient the GPS for satellite reception. In a situation where the owner or normal operator of the beacon is incapacitated or unavailable, and the person operating the distress signaling gear is not familiar with the gear, these issues can become a bigger liability.

Beacons using external GPS do not update their position unless manually switched off and on again while a GPS is still connected. Typically, the user isn't aware of this as an option as it is usually only explained in the operator's manual. Experience suggests that many owners do not read the operator's manual or review it only cursorily. This is not a disadvantage in inland use where survivors will typically remain in the same location until rescue, or at least until contact is made with SAR. It is a potential deficiency in marine use, but as noted in the following discussion of integrated GPS beacon advantages, this is of practical use in only a very limited number of SAR scenarios.

The primary advantage of an integral GPS beacon is in the packaging—everything is self-contained. This is an advantage especially for PLBs where size and weight typically are major considerations.

Another advantage is that there is no need for a user to be familiar with the operation of the GPS receiver, or how to connect the two devices together. Simply activating the beacon also activates the GPS. In general, operation of the beacon is easy and self-evident to a degree, although most beacons examined by the authors do not do a very good job of instructing the user in optimum operation with regards gaining a GPS location.

Beacons with integral GPS can update their position every 20 minutes. This is of little advantage for inland use where survivors will typically remain in the same location until rescue, or at least until contact is made with SAR. It is a potential advantage in maritime use in a minority of survival circumstances.

The value of the ability to update location under current search and rescue protocols used in the U.S. SAR community is limited, even in the maritime environment where movement due to wind, current, and waves is the norm. Current protocol is to provide the initial location to SAR forces who launch on that information. In the vast majority of circumstances in response to a GPS-enabled 406 MHz alert, SAR resources will arrive on scene within an hour or two. Unless a new location is significantly distant from the original, they will not be provided with it enroute. Typically, they find the survivor(s) within viewing distance of the original location as drift is generally slow enough that they will not have moved a significant distance in the interval, or SAR on scene can quickly determine the direction and speed of drift and can thereby locate the survivor(s).

If the survivor(s) is a person in the water in a PFD, rather than an easier-to-detect vessel or life raft, then the probability of detection is much lower and the value of updated location information becomes greater. If the SAR resource that first arrives on the scene does not promptly locate the survivors, they may contact their operations control and should receive an updated position at that time. Movement due to drift is more significant an issue in blue water conditions far from land, where the time to arrive on scene may be measured in hours or even days. Extreme conditions can also increase the rate of drift to a sometimes surprising degree. In such instances, updated location has the potential to be much more valuable.

It is also expected that the on-scene SAR resource will use their 121.5 MHz homing capability to locate the survivors upon arrival, if necessary. In some instances crews do not even turn on direction-finding equipment unless they fail to locate survivor(s) initially. The instances when this tool is useful with 406 MHz location protocol alerts are relatively few because the overall location accuracy is so good. However, in those cases where it is needed, there are a number of potential problems with this strategy, not the least of which being both the poor overall performance of 121.5 homing in some conditions, and the poor performance of some aircrews in use of existing direction-finding equipment to quickly locate 121.5 MHz transmission sources.

It is expected that the increased utilization of self-locating beacons will engender a change in strategy to provide enroute updates more readily and resultant potential for improved rescue response times in such scenarios. In addition, new direction-finding equipment has been introduced that directly receives and translates the location data, and provides improved directional guidance using the more robust 406 MHz data burst, which will provide on-scene communication directly from the beacon to SAR resources. This improved capability is just beginning to be put into service, but will eventually make its way into the majority of the SAR fleet. Once available, it will likely become a primary location tool as SAR resources approach the scene.

Integral GPS beacons are generally more expensive than those relying upon an external GPS. In many situations the ability of the internal GPS to acquire a location under poor reception conditions, at least that we have seen in current generation beacons, may not be as good as that available from a high quality external GPS. With packaging limitations, that may be the situation for some time to come, but it should not be considered inherently so.

Operation of the GPS receiver is a significant drain on the battery, as users of handheld GPS units have often discovered to their dismay when they have no spare batteries available. Manufacturers have developed proprietary operating schemes that minimize the operation of the GPS receiver, while at the same time theoretically providing adequate time to acquire a location. This is an effort to limit battery consumption, and thereby the size of the battery, which is a prime component that determines the overall size of the beacon, and to a lesser degree, the cost.

As COSPAS-SARSAT specifications allow the transmitted location to be updated no less than every 20 minutes, there is no need to operate the GPS continuously. Between operating periods, the GPS receiver is put into “sleep” mode to conserve power, waking up to check for location and, if necessary, update the location, every 20 minutes. The initial operating period of the GPS receiver may be longer than subsequent periods, although not necessarily so, to allow additional time to acquire and download the ephemeris data and almanac.

Some industry observers have suggested that the difficulty some integral GPS beacons may have in acquiring a location could be related to an initial operating period that is too short. In the Key West Test report’s summary (see Appendix 1), one suggestion is that ”beacons be designed to try to acquire GPS locations for time periods of at least [15] minutes.” The ACR beacon already complies with this suggestion. The Techtest beacon initially attempts to acquire for a total of four 5-minute periods alternating with 5-minute sleep periods. McMurdo has an initial period of 5 minutes duration. There is no way to determine solely by independent observation if the length of the initial GPS operational period is a contributor to any integral GPS beacon’s location performance deficit in this evaluation.

See Appendix 5 for operating schemes provided by the manufacturers.

A good argument can be made that the ideal self-locating beacon would offer both the option of using an external GPS when that is advantageous and would also have an internal GPS for situations when that is an advantage. Shortly after the completion of these field tests ACR Electronics announced the upcoming availability of a PLB that offers this capability.

Beacon Descriptions

The following pages include copies of the manufacturers' sales materials for the beacons tested:

GlobalFix™ 406

Product No. 2744 Cat II (Manually Deployed)
406 MHz EPIRB with Integral GPS
Model No.: RLB-35 Cat II

> FastACQ™ GPS engine acquires LAT/LON from a cold start better than normal GPS engines
> Patented proprietary electronics package provides greater frequency stability for most accurate position through the LEOSAR satellites
> FastACQ™ GPS is on for up to 25 minutes in the first 45 minutes of operation
> 100 m (110 yds) GPS position accuracy, optimum allowed by COSPAS-SARSAT
> Only EPIRB available that provides a GPS acquisition test, a full functional self test of internal circuitry, and battery voltage test
> High-impact polycarbonate case with non-tangling lanyard
> Universal Low Pro™$_2$ Category II EPIRB Bracket (P/N 9430) included; bulkhead and rail mounting options
> Class 1 battery for colder temperature operation; minimum 48 hrs @ -40°C (-40°F), 5 year replacement
> Automatically activated when out of bracket and in the water or manually activated
>Transmits on 406 MHz (COSPAS-SARSAT) with your registered, digitally-coded distress signal, and 121.5 MHz (SAR homing frequency)
> Audio/visual indicators of active transmission
> Floats upright with high visibility built-in strobe

Size: 17.5 x 4.75 x 3.5 in (44.4 x 12.1 x 8.9 cm)
Weight: 2.3 lbs (1.04 kg)

Material: High impact polycarbonate blend case/polyethylene bracket
Color: Hi-Viz Yellow/White bracket
Deployment: Manual
Operation: Lift switch up, slide left, push down fully breaking tab; water activated when out of bracket
Waterproof: 33 ft (10 m)
Accessories: 1096 Battery Replacement Kit
Certification: Approved by COSPAS-SARSAT, FCC, USCG; complies with GMDSS, European MED
Radiated Power: 5 watts ±2dB (406 MHz) 50 mW ±3 dB (121.5 MHz)
Battery Type: Lithium 5-year replacement life (11-year storage life)
Frequency: 406.028 MHz, 121.5 MHz
Carton Weight: 3.5 lbs (1.59 kg)
Carton Dimensions: 18.0 x 7.0 x 6.0 in (45.7 x 17.8 x 15.0 cm)
Units Per Carton: 1
Modulation: AM
Limited Warranty: 5 years
U.S. Patent No. 6,501,340

WORLD LEADER IN SAFETY AND SURVIVAL TECHNOLOGIES
ACR

ACR Electronics, Inc.
5757 Ravenswood Road
Fort Lauderdale, FL 33312, U.S.A.
Tel Worldwide: +1(954) 981-3333
Fax: +1(954) 983-5087
www.acrelectronics.com

A Chelton Group Company

RapidFix™ 406

Product No. 2777.5 Cat II (Manually Deployed)
406 MHz EPIRB with GPS Interface
Model No.: RLB-33 Cat II

> Improved GPS LED Infrared Interface (NMEA 0183) cable, visually confirm GPS download; GPS LAT/LON are sent on the very first burst, no waiting to acquire GPS coordinates

> Patented proprietary electronics package provides greater frequency stability for most accurate position through the LEOSAR satellites

> When GPS data is present, 100 m (110 yds) GPS position accuracy, optimum allowed by COSPAS-SARSAT

> World's smallest 406 MHz EPIRB that meets all regulations and is fully approved worldwide

> GPS confirmation test; a full functional self test of internal circuitry, and battery voltage test

> High-impact polycarbonate case with non-tangling lanyard

> Universal Low Pro$^{TM}{}_2$ Category II EPIRB Bracket (P/N 9430) included; bulkhead and rail mounting options

> Class 1 battery for colder temperature operation; minimum 48 hrs @ -40°C (-40°F), 5 year replacement

> Automatically activated when out of bracket and in the water or manually activated

>Transmits on 406 MHz (COSPAS-SARSAT) with your registered, digitally-coded distress signal, and 121.5 MHz (SAR homing frequency)

> Audio/visual indicators of active transmission

> Floats upright with high visibility built-in strobe

Size: 14.5 x 4.25 x 3.62 in (36.8 x 10.8 x 9.2 cm)
Weight: 1.9 lbs (.861 kg)

Material: High impact polycarbonate blend case/polyethylene bracket
Color: Hi-Viz Yellow/White bracket
Deployment: Manual
Operation: Lift switch up, slide left, push down fully breaking tab; water activated when out of bracket
Waterproof: 33 ft (10 m)
Accessories: 1096 Battery Replacement Kit
Certification: Approved by COSPAS-SARSAT, FCC, USCG; complies with GMDSS, European MED
Radiated Power: 5 watts ±2dB (406 MHz) 50 mW ±3 dB (121.5 MHz)
Battery Type: Lithium 5-year replacement life (11-year storage life)
Frequency: 406.028 MHz, 121.5 MHz
Carton Weight: 3.0 lbs (1.36 kg)
Carton Dimensions: 18.0 x 7.0 x 6.0 in (45.7 x 17.8 x 15.0 cm)
Units Per Carton: 1
Modulation: AM
Limited Warranty: 5 years
U.S. Patent No. 6,501,340

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Tel Worldwide: +1(954) 981-3333
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NEW

GyPSI™ 406 PLB

406 MHz Personal Locator Beacon with GPS Interface

Product No. 2793 FCC APPROVED
Product No. 2790 Approved for sale outside the United States

- > Transmits on 406 MHz via the COSPAS- SARSAT satellite system with your registered unique, digitally coded distress signal and 121.5 MHz (SAR homing frequency).
- > Recessed, waterproof GPS/programming interface (NMEA 0183) transmits GPS data for even faster response.
- > Small, lightweight unit can be easily carried in a pack or pocket; small enough to wear on deck by racers, crew, solo cruisers, kyakers, climbers, hikers, hunters, pilots or any outdoor enthusiast.
- > Single, three - position switch for simplicity. Red LED flashing indicates unit is "ON", Yellow LED flashing indicates test sequence in process, steady green LED indicates unit has passed full functional test.
- > Functional test for battery power, 406 MHz transmission, and GPS.
- > Flat, stainless steel antenna wraps compactly around bottom case for easy stowage; is easily positioned when needed.
- > Floats to avoid loss if dropped in water, waterproof to 3.3 ft (1 m).
- > Case and instruction label are oil, water and UV resistant, with non-corroding components.
- > Wrist lanyard ensures security when hand-held.
- > Can be stored between -50° C and +70°C (-58°F and +158°F).

Size:	1.9 x 6.5 x 3.8 in (4.8 x 16.5 x 9.5 cm)
Weight:	17.6 oz. (499 g)
Battery:	Lithium 5 year replaceable (11 year storage)
Material:	Fiber reinforced polycarbonate blend with resin tougheners
Color:	Hi-Viz Yellow/Blue
Deployment:	Manual
Operation:	Lift switch up, slide right, push forward breaking tab
Accessories:	RapidDitch-P carrying bag Included (P/N 2267)
Certification:	Approved by COSPAS -SARSAT; FCC approved
Limited Warranty:	5 years
Radiated Power:	5 watts ± 2dB (406 MHz) 50 mW ± 3dB (121.5 MHz)
Operational Life:	In excess of 24 hours @ -40°C (-40°F), longer in higher ambient temperature

RapidDitch-P Included

WORLD LEADER IN SAFETY AND SURVIVAL TECHNOLOGIES
ACR

ACR Electronics, Inc.
5757 Ravenswood Road
Fort Lauderdale, FL 33312, U.S.A.
Tel Worldwide: +1(954) 981-3333
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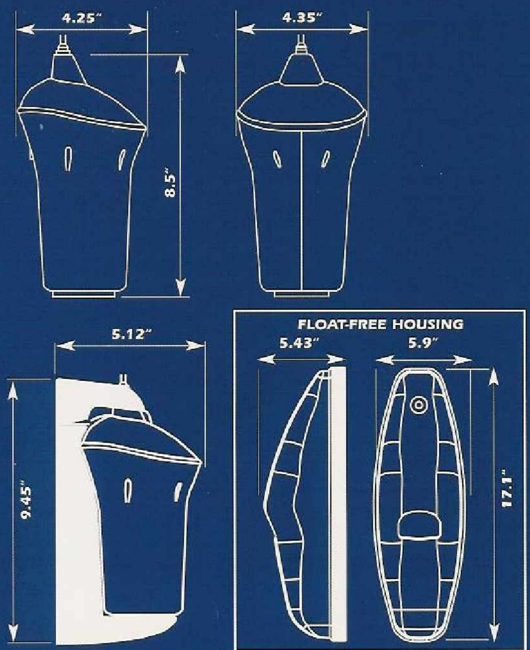
PRECISION
406 MHz GPS
EPIRB
The smallest, lightest, most powerful 406MHz GPS EPIRB on the face of the planet!
Pains-Wessex has broken new ground in developing technically advanced equipment for safety at sea with the new Precision 406 GPS EPIRB. Designed specifically to meet the needs of leisure boaters and commercial ship operators alike, the Precision 406 GPS features an internal 12 channel parallel GPS receiver within a compact 406 EPIRB.
mcmurdo PAINS WESSEX
USCG & FCC approved
Built-in 12 Channel GPS receiver
Transmits on the NEW clearer 406.028 MHz frequency (Only GPS EPIRB to do so)
Long life SIX YEAR battery (12 year useful life)
Once activated operates up to 60 HOURS (48 hours minimum requirement)
121.5MHz homing signal up to 40 Mile range
Pinpoints global position to within 100 feet
Alert time to rescue service approximately 3 minutes
Updates accurate latitude/longitude position every 20 minutes
Built-in self-test & diagnostic check capabilities
Smallest, lightest & most powerful GPS EPIRB available. Weight 1.6lbs, Height 8.25"
Available in Category 1 (Automatic) or Category 2 (Manual) deployment
5 year limited warranty
Using the latest Cospas Sarsat geo-stationary constellation, the Precision 406 GPS EPIRB provides an instant alert to the search and rescue services with the vessel's details including latitude and longitude.
mcmurdo PAINS WESSEX
PRECISION
406 GPS EPIRB
NOTICE TO PUBLIC
IF FOUND, DO NOT MOVE, REPORT POSITION TO COASTGUARD
GMDSS

technical specifications

PRECISION 406 MHz GPS EPIRB



General

Message formats	EPIRB National, Standard and User Location Protocol as applicable, plus EPIRB user protocols. Serialized, MMSI and radio call sign.
Programming	Via RS232 light pen and windows based PC
Temperature	Beacon: Manual deployment Operating -4°F to +131°F (Class 2) Storage -22°F to +131°F (Class 2) Float free mechanism: Operating -22°Fto +158°F (Class 2) Storage -58°F to +158°F
Battery life	6 years storage life from date of battery manufacture, then minimum of 48 hours operating time
Sealing depth	Waterproof to 33'
Weight	1.6lb (730g)
Auto case & EPIRB	4.9lb (2.2kg)

406MHz transmitter

Frequency	406.028MHz +/-1kHz
Output power	5 Watts +/- 2dB
Modulation	Biphase 1.1 +/- 0.1 radians

121.5MHz transmitter

Frequency	121.5MHz +/-3kHz
Output power	50mW ERP
Modulation	AM,up or down swept tone

Visual location

Intensity	0.75Cd Xenon discharge light
Flash rate	23 flashes per minute

Approvals

Complies with IMO resolutions A662(16), A694(17), A810(19)

IEC 1097-2
Cospas-Sarsat C.S.T.001 and T.007
European ETS-300-066
USA, RTCM, FCC Approved.
EU MED (Ship's Wheel) Approved, GPS

mcmurdo PAINS WESSEX

Emergency Position Indicating Radio Beacon (EPIRB)

The Precision 406 GPS EPIRB is the result of extensive research and development which brings together the expertise of McMurdo and the knowledge of Pains-Wessex, utilizing the award-winning design of the Rescue 406 EPIRB.

The Precision 406 GPS EPIRB features an integral 12 channel parallel GPS receiver within a compact 406 EPIRB. The benefits of the Precision's integral GPS is that position information is updated every 20 minutes providing an accurate position even when the EPIRB has been activated and is drifting in the sea.

Using the latest Cospas Sarsat satellite constellation, the McMurdo Pains-Wessex Precision 406 GPS EPIRB provides an instant EPIRB alert to the search and rescue services. The vessel's details, together with latitude and longitude, are signalled to rescue services thus avoiding lengthy searches.

As with all Mcmurdo Pains-Wessex commercial products the Precision 406 GPS EPIRB is fully compliant with international legislation and meets worldwide approval standards.

- High intensity xenon strobe light
- Global coverage with Cospas Sarsat polar orbiting satellites
- Geostationary coverage >75°N - 75°S
- Typical battery life 48 hours at - 4°F
- Transmits on new C-S frequency of 406.028MHz
- Comprehensive transmit fault indicator
- Handles all Cospas Sarsat EPIRB message formats (location and user protocols)
- Comprehensive transmit fault indicator
- 121.5 MHz homing transmitter indicator
- 406 MHz Transmit Indicator
- 121.5 MHz fault indicator
- 406 MHz fault indicator
- GPS position acquired indicator
- GPS position transmitted indicator
- Integral 12 channel parallel GPS receiver
- GPS cold start time to fix typically less than 5 minutes
- GPS transmitted position update rate every 20 minutes (as permitted by Cospas Sarsat)
- GPS reacquisition time, typically less than 60 seconds
- Positional accuracy better than ±197' (60m) typically 98.5' (30m)
- Time to alert, less than 5 minutes (via geostationary satellite)

Ordering information

Model	Category	Class	Deployment / Description	Part No.
Precision GPS EPIRB	2	2	Manual / c/w Bulkhead Bracket	82-514A
Precision GPS EPIRB	2	2	Manual / c/w Protective Housing	82-524A
Precision GPS EPIRB	1	2	Auto / c/w Float-Free Housing	82-504A
Protective Housing	-	-	Manual / w/o HRU	82-534A
Float-Free Housing	-	2	Auto / c/w HRU	82-544A
Bulkhead Bracket	-	-	Manual	82-276B

Other GMDSS equipment in the McMurdo Pains-Wessex Safety product Range includes Radios and SART

AUTHORIZED DEALER

REVERE SUPPLY CO., INC.

Exclusive US importer for McMurdo Pains Wessex Electronics

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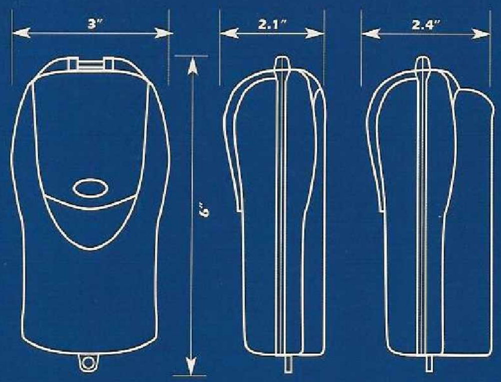
PAINS WESSEX
FASTFINDSeries
Personal Location Beacons
The only PLB with built-in GPS worldwide
The smallest and lightest PLB worldwide
The Fastfind and Fastfind Plus series of Personal Location Beacons are the very latest from McMurdo Pains Wessex designed to provide individuals with the highest chance of being found in an emergency.
In the event of an emergency an alert signal is transmitted to COSPAS-SARSAT satellites and forwarded to a rescue coordination center within approximately 3 minutes. The built-in GPS receiver will provide latitude and longitude coordinates to a position of within approximately 100 feet anywhere in the world.
Built-in GPS receiver
Global alert to COSPAS-SARSAT satellites
121.5MHz homing in frequency
Alert time typically within 3 minutes
Positional accuracy to within approximately 100 ft
Compact & stylish
Complete with lanyard and carry case
User replaceable battery packs (-4°F or -40°F)
Floats with -4F° battery pack
Accepts serialized or MMSI protocols
Simple three stage manual activation
The standard 406MHz Personal Location Beacon has all the features of the Fastfind Plus but without GPS. The 406MHz frequency provides and alert signal to rescue services within 90 minutes maximum, depending on satellite passes and gives a positional accuracy to within 3 miles. Once in the vicinity the 121.5MHz transmitter provides a signal for the rescue services to home-in on. This information is more than sufficient to enable rescue services to find an individual in distress.
These latest advanced products from McMurdo Pains Wessex have been designed to provide the very best chance of being found in an emergency for:
Professional & recreational boaters
Single handed boaters
Kayakers
Fishermen
Pilots
Hikers
Campers
Mountain climbers
Skiers
Hunters
Divers
FASTFIND
406
mcmurdo PAINS WESSEX
FASTFIND PLUS
1
2
3
Three stage activation
Transmitting

mcmurdo
PAINS WESSEX

technical specifications

Fastfind and Fastfind Plus



Profile with -4 battery pack

Profile with -40 battery pack

General	
Message formats	PLB National, Standard, and User Location Protocol as applicable, plus serial
user	(non-GPS version)
Programming	Via RS232 light pen and windows based PC
Temperature	Storage: -67°F to +158°F (Class 1) Operating: -40°F to +131°F (Class 1) With class 1 battery pack
	Storage: -22°F to +158°F (Class 2) Operating: -4°F to +131°F (Class 2) With class 2 battery pack
Battery life	5 years storage then 24 hours operation
Sealing	BSEN 60945 temporary immersion MIL-STD-810F method 500.4 15,000 feet altitude
Weight	Approx. 14oz with -40° battery pack Approx. 9oz with -4° battery pack
406MHz transmitters	
Frequency	406.028MHz +/-1kHz
Output power	5 Watts +/- 2dB
Modulation	Biphase L
121.5MHz transmitter	
Frequency	121.5MHz +/-3kHz
Output power	50mW
Modulation	AM,up or down swept tone
Approvals	
R & TTE Approved	
International Approvals to follow	

Accessories

Dive Canister

Direction Finder

Emergency Receiver

Fastfind and Fastfind Plus
Personal Location Beacons

The Fastfind and Fastfind Plus Personal Location Beacons feature the same advanced technology as found in the award winning Rescue and Precision 406 GPS EPIRBs. Designed using miniaturized components to fit into an aesthetically styled compact casing both versions employ a simple three stage manual operation and feature user replaceable battery packs, available in for use in temperatures of -4° and -40° Fahrenheit.

These latest advanced products from McMurdo Pains Wessex have been designed to provide all types of outdoorsmen with the very best chance of being found without delay in an emergency on land, on sea, or in the air.

- **Global coverage with Cospas-Sarsat polar orbiting satellites**
- **Geostationary coverage >75°N - 75°S**
- **Comprehensive indication of operation**
  - 121.5 MHz transmission
  - 406 MHz transmission
  - GPS acquisition and fix status
- **Integral 12 channel parallel GPS receiver**
- **GPS cold start time to fix typically less than 3 minutes**
- **GPS transmitted position update rate every 20 minutes (as permitted by Cospas-Sarsat)**
- **GPS reacquisition time, typically less than 60 seconds**
- **Positional accuracy typically 100 feet**
- **Time to alert, typically three minutes (via geostationary satellite)**

Carry case and lanyard

Carrying the Fastfind could not be simpler, both versions come equipped with a lanyard and carrying case to enable the user to keep the PLB safely attached at all times. A watertight canister is also available for diving.

HR Smith
Group of
Companies

Specmat Technologies Inc.
215 Dunavant Drive
Rockford, TN 37853
Tel: 865-609-1411
Fax: 865-609-1911
E-mail: spectinc01@aol.com
www.searchandrescue.com

Multi Function Personal Locator Beacons PLUS Embedded GPS

Series 500-27

Techtest Limited

Advanced test and measuring equipment

Multi Function Personal Locator Beacons PLUS Embedded GPS

Series 500-27

Features

- Simultaneous Transmissions.
- Beacon and Speech Modes and COSPAS/SARSAT coverage.
- Continuous transmission of GPS lat/long data on COSPAS/SARSAT data burst.
- Unique remotely programmable country code function for406.025MHz.
- Manual or automatic operation.
- Meets NATO STANAG 7007, latest issue. ED-62 CAA CAP 208 Chapter 10.
- Waterproof to 10 metres.
- Reprogrammable on aircraft.

The Series 500-27 Personal Locator Beacons are simple, compact lightweight units which can be used either manually or automatically via ejection seat harness. A fully embedded 12 channel GPS with data burst transmission on 406.025 MHz. Fully compatible with the majority of search and rescue equipment including the COSPAS/SARSAT satellite based survivor location equipment.

The PLB is a one piece unit with the transmission housed in a yellow pigmented or NATO green moulded thermoplastic case, which is designed such that the replaceable battery pack can be mounted within the overall package to form a smooth but non-slip hand portable unit. The design is such that easy replacement of the battery module (15 seconds) is possible during beacon operation. Full speech capability on 121.5 and 243 MHz together with an audible tone indicating live beacon transmissions with GPS lat/long position. The unit is designed to survive for up to ten years with the only maintenance being battery replacement every five years. The antenna (supplied) is capable of being attached directly to the PLB or remote through a cable assembly for operation in a dinghy.

Specification

Transmitter Signal

Frequency

The PLB transmits modulated homing signals on both 121.5 MHz (Civil), and 243.0 MHz (Military) distress frequencies, with characteristics in accordance with STANAG 7007. Together with 406.025 MHz in accordance with COSPAS/SARSAT.

Channel

Transmissions and reception on both frequencies are compatible with 25KHz channel spacing.

Modulation (121.5 and 243 MHz)

Continuous Swept Tone of at least 700Hz within the Sweep Range.

Sweep Range 1.6 KHz to 300Hz (i.e. downwards).

Sweep Rate 2-3 Hz

Amplitude Modulated with Rectangular Wave.

Modulation Depth – 67% minimum (80% typical).

Modulation (406.025 MHz)

0.5 Secs 5W pulse every 50 secs.

Phase modulation of +/- $\pi/3$ rad (peak)

Digital modulation to include (see C/S G.005 Iss. Rev 1, Section 3)

Bit Synchronisation

Frame Synchronisation

Protected Field

Emergency-Code/National Use Field

Long Message (optional)

GPS Receiver (Embedded)

Snap Start (advanced hot start)	2 sec
Hot Start (avg)	< 8 sec
Warm Start (avg)	< 40 sec
Cold Start (avg)	< 50 sec
Satellite Signal Reacquisition Time	100 ms
No of Channels	12
Correlation Points	960
Min Signal Level Tracked	-172 dBw
Power Consumption	110 mA
Receiver	L1 C/A Code
Protocols	NMEA V2.2, SIRF

GPS Antenna

Centre Frequency	1575.42 MHz
Bandwidth	2 MHz min (at -10dB point)
Gain	1 dBi min (elevation 90°)
VSWR (at fo)	2.0 : 1 max
Impedance (at fo)	50 ohm
Polarisation	RHCP

Power Output (121.5 and 243 MHz)

48 hours min.,100mW (+20dBm) at -20°C.

Power Output (406.025 MHz)

24 hours min., 5W (+37dBm +/- 2dBm) at -20°C.

Activation	Manual or Automatic
Dimensions	150 x 87.5 x 37.5 mm
Weight	650gm nominal
Colour	NATO green or yellow

Compliance

The PLB is compliant with the following specifications.

Civil

BS 3G 100 Series for general requirements for use in aircraft.

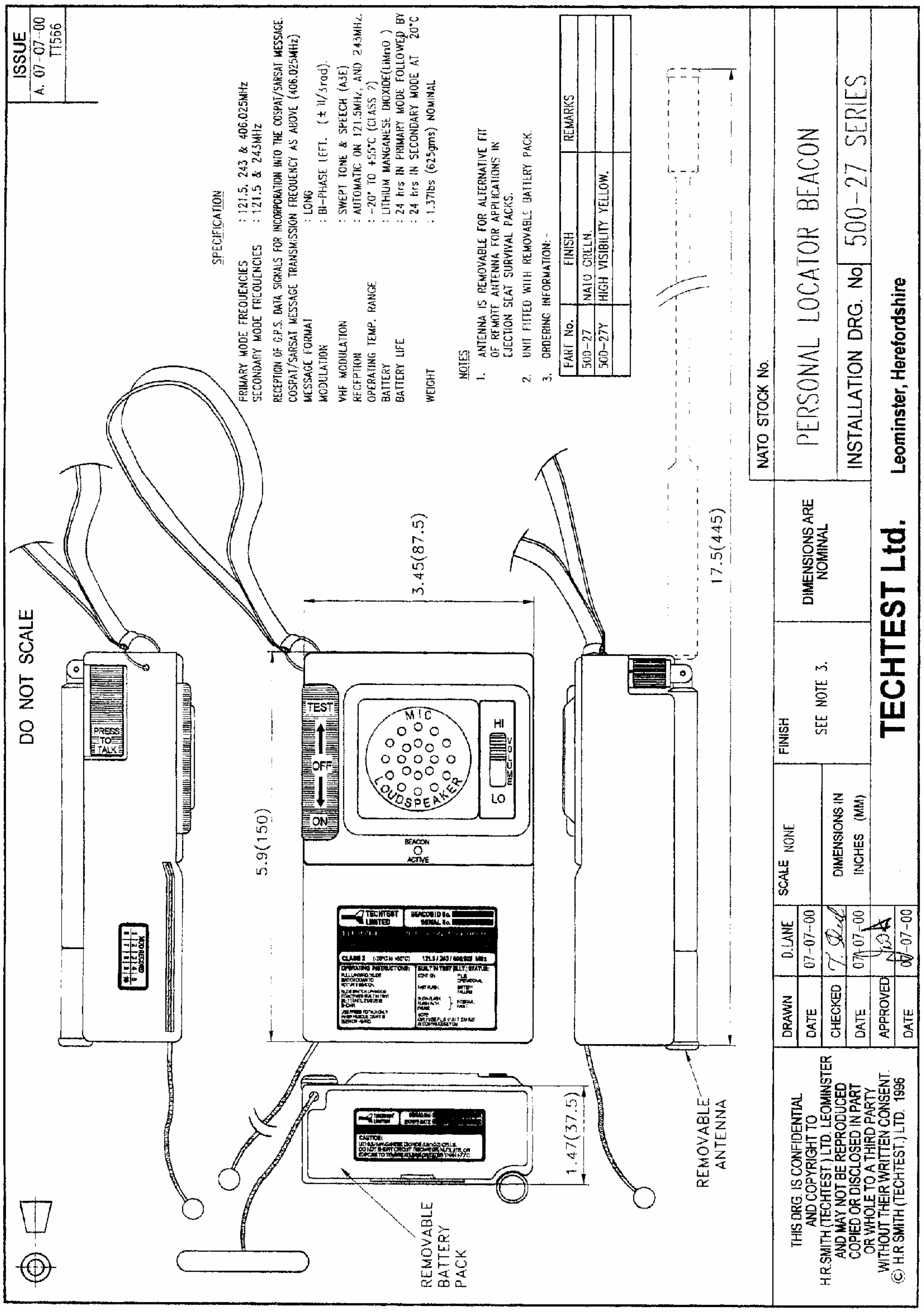
CAP 208 Aircraft Radio Equipment Issue 2 January 1991, Volume 1 Part 10 – Survival (ELTS). EUROCAE ED62 / RTCA DO-204 / RTCA DO-183 EUROCAE ED14C / RTCA DO-160C COSPAS/SARSAT.

Military

NATO – STANAG 7007 latest issue Personal Locator Beacon

Approvals

TSO C91a and C126. JTSO-2C91a and 2C126.


DO NOT SCALE
ISSUE
A. 07-07-00 TT566
SPECIFICATION
PRIMARY MODE FREQUENCIES : 121.5, 243 & 406.025MHz
SECONDARY MODE FREQUENCIES : 121.5 & 243MHz
RECEPTION OF G.P.S. DATA SIGNALS FOR INCORPORATION INTO THE COSPAT/SARSAT MESSAGE.
COSPAT/SARSAT MESSAGE TRANSMISSION FREQUENCY AS ABOVE (406.025MHz)
MESSAGE FORMAT : LONG
MODULATION : BI-PHASE LEFT. (± π/3rad).
VHF MODULATION : SWEPT TONE & SPEECH (A3E)
RECEPTION : AUTOMATIC ON 121.5MHz, AND 243MHz.
OPERATING TEMP. RANGE : -20° TO +55°C (CLASS 2)
BATTERY : LITHIUM MANGANESE DIOXIDE(LiMnO₂)
BATTERY LIFE : 24 hrs IN PRIMARY MODE FOLLOWED BY
: 24 hrs IN SECONDARY MODE AT 20°C
WEIGHT : 1.37lbs (625gms) NOMINAL
NOTES
1. ANTENNA IS REMOVABLE FOR ALTERNATIVE FIT OF REMOTE ANTENNA FOR APPLICATIONS IN EJECTION SEAT SURVIVAL PACKS.
2. UNIT FITTED WITH REMOVABLE BATTERY PACK.
3. ORDERING INFORMATION:-
PART No. | FINISH | REMARKS
500-27 | NATO GREEN |
500-27Y | HIGH VISIBILITY YELLOW. |
3.45(87.5)
17.5(445)
5.9(150)
1.47(37.5)
TEST
OFF
ON
MIC
LOUDSPEAKER
HI
LO
BEACON ACTIVE
PRESS TO TALK
REMOVABLE ANTENNA
REMOVABLE BATTERY PACK
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DRAWN D.LANE
DATE 07-07-00
CHECKED
DATE 07-07-00
APPROVED
DATE 07-07-00
SCALE NONE
DIMENSIONS IN INCHES (MM)
FINISH SEE NOTE 3.
DIMENSIONS ARE NOMINAL
NATO STOCK No.
PERSONAL LOCATOR BEACON
INSTALLATION DRG. No 500-27 SERIES
TECHTEST Ltd.
Leominster, Herefordshire

Laboratory Tests

Laboratory testing was conducted at Imanna Laboratory in Rockledge, Florida, the week of December 8, 2003. Imanna performs U.S. Coast Guard approval testing and other independent testing for the marine industry.
One reason that Imanna was selected was our belief that they had previously done testing for both ACR and McMurdo. We subsequently discovered that the so-called McMurdo testing was actually for Pains Wessex prior to its current ownership when it was a separate company not affiliated with McMurdo.

The laboratory testing was designed to attempt to provide data to support the field tests and to help answer the following questions that have been asked repeatedly by consumers, or raised by various industry members:

1. How do the 406 MHz and 121.5 MHzsignal strengths radiated from the beacon antenna in normal operational configuration compare in performance among beacons? Information provided by manufacturers only indicates the nominal required performance as specified by COSPAS-SARSAT as measured at the circuit board.

2. Does water on the beacon attenuate the distress signal, and if so, by how much? The physical case design of the McMurdo Fastfind line of PLBs has the likely potential in a wet marine activation or in a terrestrial activation if in the rain of retaining a small amount of water in the antenna storage well where the base of the antenna is secured in a manner that some industry members claim attenuates the signal from the antenna. While it was not anticipated that other PLB designs would show this potential attenuation problem if it exists in that they lack this specific design characteristic, all PLBs were tested under identical dynamic and static wet conditions in order to ensure fair and unbiased results. The other question related to this issue, if attenuation is found to exist, is whether or not it is of a degree as to adversely affect distress signaling performance.

Water filled antenna storage well of McMurdo Fastfind Plus PLB

3. Will the beacon batteries last for the prescribed period of time (24 hours @ -40º C for Class 1 PLBs, 24 hours @ -20º C for Class 2 PLBs) under worst-case conditions providing no worse than minimum allowable distress signal strength

for the full period? And, related to this, is there a drop-off in signal strength over time, and if so, how much?

Laboratory Tests Attendee List

Ritter represented the Foundation at the testing for the week, departing after the test fixtures and set-up for the battery run-down testing had been assembled and shown to maintain the required temperature overnight. The Techtest representative departed at the same time as Ritter. The ACR representative was present only during the first actual day of testing. At this point, McMurdo had not agreed to participate and was not eligible to attend. Imanna Laboratory personnel are not listed.

Doug Ritter – ETS Foundation
Bill Cox – ACR Electronics
Paul Salisbury – Techtest

Laboratory Tests Protocols

The following procedures were specified by Imanna and were incorporated into the original test protocols (see Appendix 2). They were modified as noted in accordance with the original protocols, which also provided for “test protocols subject to revision with concurrence of sponsors.”

To prevent inadvertent contact with the NOAA satellite, all tests with the units in operational configuration, will be conducted inside a sealed RF enclosure. For temperature tests, the thermal chamber will be relocated inside the RF enclosure.

The signal strength tests will be conducted inside a (sic) *RF enclosure, and final details of the test procedure will be documented at the time of test. The signal strength will be measured as a power radiating from the Unit Under Test (UUT) antenna as received by another antenna placed inside the RF enclosure. Care will be taken to minimize effects of standing waves inside the enclosure, and the final selection of test equipment will be based upon the engineering assessment of the conditions and desired parameters.*

The RF signal will be measured using a spectrum analyzer, and the results of the measurements will be recorded using the screen capture capabilities of the analyzer. The environmental conditions inside the RF enclosure will be normal lab air conditioning temperature and humidity, recorded at the time of test.

Test fixture for 40° measurements in RF screen room – McMurdo Fastfind Plus mounted

After consultation with NOAA technical representatives and others indicated that it would be prudent to make measurements from at least two positions relative to the antenna, a test fixture was developed that would allow the beacon to be angled vs. the receiving antenna to allow the RF signal capture to be made at 10 degrees and 40 degrees to the vertical antenna and a computer-controlled rotary positioner was used to rotate the test fixture in 10 degree increments. When further investigation of an anomaly was required, the rotation was reduced to lesser increments. A mounting fixture for each beacon was assembled that allowed for the beacon to be offset such that the antenna would be located at the center of rotation.

Test fixture for rain test

To determine the effects of water on the UUT, a plastic rain enclosure containing fresh water will be used to wet the unit and the antenna. The "simulated rain mist" will fall vertically on the UUT to simulate "real world" conditions in the open environment. Wetting will continue throughout the data collection activity. Care will be taken to prohibit signal attenuation or amplification by using the fixture. Before and after signal comparisons with a "dry" fixture will be taken to verify the test set-up. Signal strength will be recorded during the wetting to determine the effects to the transmitted signal. This test will be conducted in the RF enclosure, with the same care and procedures listed above for the radiated signal strength.

A standard salt-water solution was used as simulation of rain and spray conditions in an ocean operating environment. It was obvious from the rain test that the antenna well of the McMurdo beacon does not drain through the hole penetrating the well and used for coiling the antenna for packing quick enough to prevent the well from overflowing under any moderate level of rain, however it was also observed that with heaver rain, the larger rain drops falling in the antenna well would drive the majority of water from the well for intermittent periods, it was decided to also conduct a test with the water in the well in a static condition. It was filled to the maximum level allowed by the hole penetrating the well. Further investigation led to testing the effects of fully submerging the base of the antenna of all beacons in the water.

It is estimated that the battery tests will be determined on individual units serially to prevent signal interactions and simplify the data taking. It may be possible to correlate the radiated signal strength to the antenna input, and record directly from the unit; however, current plans are to measure the output via radiated signal from the antenna. Care will be taken to document the near-field effects of the test equipment, and take measures to minimize (or eliminate, if possible) the effects. If effects are significant, the effects may be reduced by placing the UUT inside a non-metal extension on the front of the chamber, and leaving the metal door off for the test. The temperature chamber has a range of -73°C to +150°C allowing a broad selection of test temperatures, should the *test conductor demand temperatures in addition to those low temperatures itemized in the test definition e-mail.*

> The modified temperature chamber proved inadequate to attain and maintain the temperature in the assembled foam test chamber attached to the temperature chamber. Liquid nitrogen and a thermally coupled valve were used to establish the required temperatures with liquid nitrogen injected as required to maintain the temperature required for the test. Care was taken to ensure that the liquid nitrogen would not be directed onto the beacons in the chamber.

The shipping boxes which were received were kept, unopened, until the day of testing was to commence. The representative of Equipped To Survive Foundation was present and assisted in the opening of the test article boxes. Each test article was taken from the shipping box, and all available information on the packaging or directly on the article that gave descriptive information about the device was recorded.

There were two instances where beacons exhibited anomalous performance. In the cold-temperature battery run-down test an ACR GyPSI failed after two hours. This was the same beacon used in the prior tests, including the water testing, even though the battery test was supposed to start with a fresh beacon. While it should not make any difference, this represented a lapse on the part of the laboratory in terms of test protocol and as such we might legitimately choose not to present this data. Because this represents an inherent design deficiency in all the beacons, the inability to assess the state of charge of their battery(ies), we have decided to include this, but caution readers that as a result of the laboratory error, this cannot be considered a valid test.

When a fresh beacon was tested, it passed with plenty of reserve. The short-lived beacon was sent to ACR for a failure analysis and they reported they could find nothing wrong, beyond the depleted battery. With a replacement battery installed it performed as expected in their own -40° battery run-down test. ACR offered the following as part of their failure analysis report to us:

> *The unit did not have the latest modification to the reed switches to minimize the possibility for inadvertent activation against external magnets, which was incorporated into production in early March 2004. The unit also did not have a seal on the switch to prevent it from being positioned in the up or test position prior to delivery, which was incorporated into production about six months ago.*
>
> *From the analysis and data reviewed we conclude that the unit was left in the self test routine for an extended period of time or it was inadvertently turned on at*

some time prior to the test at IMANNA resulting in reduced battery life at -40C. We are not sure how this happened. It is all we can surmise at this time.

A Techtest beacon failed part way through the rain and water testing when it was immersed in water over the top of the beacon. Subsequent investigation is reported to have discovered that there was a miscue in preparation of the beacons. The two test beacons had been prepped as they would be for typical internal company testing, which does not include fully RF welding the case together so as to enable easy access to the components during developmental testing. A second beacon survived the immersion and was used to complete the tests. It must be noted that this discrepancy falls outside the parameters of the test protocols and investigation and does not represent a legitimate failure.

Lab Tests Conclusions Submitted by Imanna

The following conclusions have been taken from the report submitted by Imanna Laboratories. A detailed report of test results is included in Appendix 4.

During the laboratory tests the need to be inside a sealed RF enclosure to prevent satellite contact causes some concern for the "near-field effects" of a transmitting beacon signal. The presence of the perturbations was considered to be acceptable if the measured data can be construed to be taken as "trend" or "comparative" data only. For this reason, the reader of this report is cautioned to view the recorded data as such and not place undue criticism on or faith in absolute numerical values. The data presented is to be viewed as investigatory trending, such as assessing the attenuation of the emitted signal with water contact as a possibility with an order of magnitude expression.

The laboratory data (with the exception of the battery life tests conducted at low temperature) was intended to be a help guide for future field tests that would more accurately determine the effectiveness of the various devices in contacting the satellite system and obtaining a position fix under real world conditions. An example of the discussion that would be appropriate for the lab test data is as follows: *If water contact has "significant" attenuation evidence in the lab tests, then it would be appropriate to investigate the more absolute effect during the field tests*. Hence, the lab test results are to be taken as road map guides for true field evaluations. The relative field strengths of the lab tests are important only in respect to being evidence of a condition that should be investigated in true operation conditions in the field tests.

With the aforementioned cautions in mind, the following conclusions are drawn from the lab test data:

- There appears to be a significant signal attenuation associated with saltwater contact and especially so, for units with an antenna well that can hold the water in contact with the base of the antenna for an extended length of time.

- Battery life appears to be better than the minimum required by the regulations, and better than manufacturer's claims, even in extreme cold conditions.

- Battery life may be compromised by test checks during long term storage and adverse environmental conditions in PLBs and EPIRBs just as in other battery powered devices.

- Some "real world" conditions such as rain and temperature can affect either the 406 MHz signal or the 121.5MHz signal and not necessarily in the same manner.

- A better set of laboratory tests is needed. While laboratory tests are included in the current regulations, the tests do not capture the actual antenna emissions to evaluate realistic performance radiating into the free air from the antenna itself. Current regulatory lab tests measure the input to the antenna and not radiation from the antenna under a set of conditions that would reveal real world operation in adverse conditions. Better laboratory tests or actual transmission tests under more realistic use conditions would better serve the industry by giving the trend in transmission signatures that appear to be available as evidenced in the simplistic laboratory tests conducted in this effort.

- Signal strengths in both RF bands appear to be consistent over an extended run period and not varying significantly in their magnitude as radiated from the antenna for the devices tested and with good battery power available.

- Some of the devices tested have signature patterns that do allow dips in the radiated signal coming from the antenna. These signal dips could be significant in SAR activities if the device is oriented in the direction that the dip would be toward the satellite or the SAR personnel.

  (Editor's Note: McMurdo has responded that because "the screened room used was not anechoically lined, you would expect to get reflections that would show up as dips in the antenna patterns.")

Field Tests

Evaluation Development, Conduct, and Methodology

It was initially the intention of the organizers to field test the beacons the week of December 15, 2003, immediately following conclusion of the laboratory testing. Difficulties coming to an understanding with NOAA for cooperation in the field testing resulted in postponement of field testing to January. One primary area of contention was that NOAA insisted that the beacons be test protocol coded. The operational portion of the COSPAS-SARSAT system ignores test protocol beacons for the most part, so there is no adverse impact on the system and there is no need for complicated interaction between various national SAR agencies to prevent any test alerts from inadvertently being treated as a real alert.

The sequestered off-the-shelf beacons could only be recoded by the manufacturer. This meant that it was necessary to gain manufacturer cooperation in order to test their beacons, giving a manufacturer *de facto* veto power over any testing conducted and allowing the manufacture to interface with the off-the-shelf beacons, potentially allowing tampering with the devices.

Customary consumer product testing protocol is to not alter the tested products in any manner, nor to allow manufacturers access to the products prior to testing, all to ensure that the products tested are the same as those consumers can themselves purchase. This is central to the entire concept of consumer product testing and deriving credible results from it. NOAA declined to cooperate if we did not use test protocol coded beacons, and noted the possibility of potentially ruinous FCC sanctions against the organizers if we used operationally coded beacons.

Heretofore this had not been an issue because: 1) the manufacturer has supplied the beacons to be tested and they are thus test protocol coded, as was the case in the Key West Test; 2) the quantities of beacons tested is so few as to not present a problem for NOAA; or 3) NOAA or another government agency is performing the testing.

Subsequently, as a result of our activities and queries related to developing this evaluation, NOAA has determined that there is no provision in U.S. regulations to accommodate active consumer testing of 406 MHz beacons without prior special approval of the FCC. This is a time-consuming process, at best, fraught with bureaucratic potholes. Even the use of test protocol coded beacons is not accommodated by the regulations. As a result, we were also forced to find a government sponsor to cooperate, NOAA declining to do so. This requirement was eventually fulfilled with recruitment and participation in the evaluation of the Protection and Survival Laboratory at the FAA Civil Aerospace Medical Institute.

Recoding of the beacons is accomplished via an infrared link hooked to a personal computer, and nominally does not involve any disassembly of the beacon. ACR was willing to send a computer and link with its representative and to do the recoding at the field test site with witnesses present, and did so do during the field test.

McMurdo declined to do the recoding onsite, citing as their primary reason various security concerns revolving around their proprietary software. McMurdo insisted that the recoding to test protocol could be done only at their factory in the U.K. This presented numerous difficulties, including how to maintain the chain of custody and the considerable expense involved in shipping the beacons and sending a representative to the U.K. for the recoding process.

Recoding ACR beacons at test site with evaluation participant witnesses present.

Organizers were faced with the following options:

1) Disregard NOAA cooperation, potentially eliminating access to satellite data, and risk sanction by testing the beacons with operational coding. This was very seriously considered and would have been undertaken as a last resort with appropriate warnings to COSPAS-SARSAT and SAR agencies; our belief being that this action would be defensible.

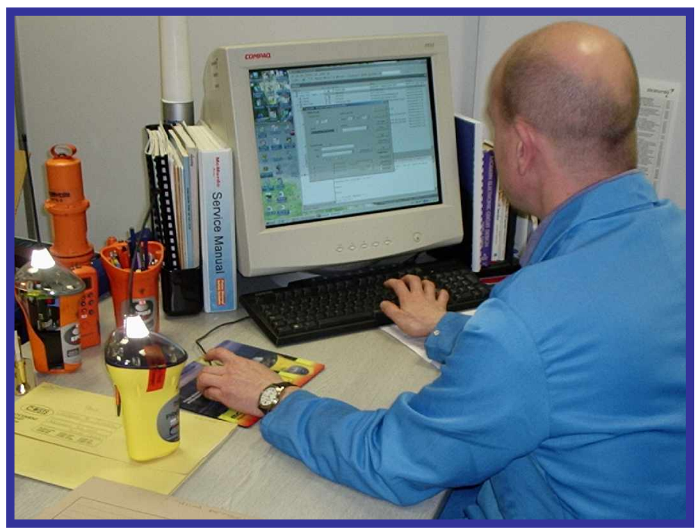
2) Conduct the tests, but not include the McMurdo beacons, letting their lack of cooperation speak for itself, however an observer might so interpret their actions, the least desirable option in the opinion of the primary sponsors.

3) Find some means to accommodate McMurdo's demand that was practical as well as more affordable, and that would maintain some reasonable chain of custody to ensure fairness and the credibility of the results.

Peter Forey of Sartech Engineering was considered as a possible agent for the organizers. He is very highly respected in the COSPAS-SARSAT community, sells his beacon test sets to all the manufacturers involved, and had already donated use of test sets for the field tests. The only potential hitch was that his company was also a dealer for McMurdo beacons, but not ACR or Techtest. ACR and Techtest were contacted and they both were willing to accept Forey to act on the organizer's behalf. Forey was approached and readily agreed to do so, although it would have to wait until after he returned from holiday vacation on January 2, 2004. McMurdo was then approached by Forey on behalf of the Foundation, and agreed that it was acceptable for Forey to accompany the beacons to the McMurdo facility and observe the re-coding process.

Shipping the beacons presented a variety of logistical challenges, as well as considerable expense. It was felt that it was desirable to apply tamper-evident seals to the beacons as added protection against tampering. The only practical way to ship the beacons within the time-frame available was via air freight. Aside from the normal expense of air freight, the lithium batteries in these beacons required that they be shipped as Dangerous Goods with added paperwork, special packaging, and added expense. West Marine has a corporate policy of not shipping Dangerous Goods via air due to the financial liability it presents.

In order to get the beacons shipped to the U.K., it was necessary for Ritter to fly to West Marine headquarters in Watsonville, California, USA, to pack and ship the beacons. Over the course of three days Ritter unpacked the beacons, applied the tamper-evident seals, repacked the beacons in their own packaging and then packed them in three larger boxes meeting Dangerous Goods shipping requirements. Ritter completed all the required paperwork and transported the goods to a FedEx Express World Service Center located in Soquel, California, where they were shipped to Forey. Due to uncertainty over the satisfaction of all the paperwork and labeling requirements, Ritter had to remain overnight in Watsonville and it was, indeed, necessary to return to FedEx the next day and revise some of the required Dangerous Goods documentation before the shipment could be processed.



Recoding McMurdo Beacons at McMurdo

The beacons were received at Sartech on December 22, 2003 without incident and on January 7, 2004 Forey took them to McMurdo and witnessed the recoding process, taking digital photos of the activities and reporting on the process via email (see Appendix 6), noting that “the beacons were not opened, and the reprogramming was done via the infrared port using an engineering version of the same software we use for programming here. The EPIRBs were tested live in a screened box with GPS data input from a repeater. They were tested for power, frequency, data content, and GPS lock. It was decided just to do a message read on the PLBs, as a full test would have required deployment and restowing of the antennas.” This means that the Fastfind PLBs received little more than a self-test with confirmation of the proper data sent using a test set.

McMurdo repackaged the beacons in new boxes, and Forey returned the beacons to Sartech. He then shipped the beacons back to the Foundation in care of West Marine via FedEx Express, having to comply with all Dangerous Goods shipping requirements, at the Foundation’s expense.

It must be emphasized that while it does not appear to have been the case and we have no reason to suspect it being so, it is incumbent upon the authors to note that there is no 100% assurance that a manufacturer did not tamper with the beacon software in the process of recoding the beacons. Despite Forey's presence at the McMurdo recoding and the presence of all the witnesses to the ACR recoding at the field tests, without the means to independently monitor and interpret the digital activity while the beacon is connected to the computer, we are limited to accessing the activity that was visible to the witnesses, which appeared straightforward and benign.

NOAA also advised us shortly before the originally scheduled December test date that they required that NOAA be provided a list of the Beacon I.D.s and other test information at least 30 days ahead of the test. In months of prior discussions, this requirement was not mentioned to the organizers and with some of the beacons being recoded locally at the test and the McMurdo beacons not being recoded until less than two weeks prior, it presented additional unexpected challenges. NOAA reconsidered this demand and accommodated the situation to provide enough flexibility to get the revised Beacon I.D.s that would be programmed into the beacons from the manufacturers sufficiently ahead of time for NOAA's purposes, and so that it would not cause another test delay.

Multiple beacons were required of each model to ensure that each test beacon started on equal terms, from what is known as a "cold start." This is based on the assumption that the beacon will likely not have been activated prior to use and thus will have no GPS information, ephemeris data or the almanac in memory, which could possibly shorten the time to acquiring a location. Before the GPS can derive a location, it must download from the satellite certain data. This takes a period of time and can theoretically significantly impact time to acquisition and even if acquisition is successfully accomplished in the time available. If that data has already been downloaded and held in a memory, it is likely that the GPS will acquire a location faster or acquire when it might not otherwise. Manufacturers claim that their beacons do not retain this data after being shut off, but as there is no way for us to independently confirm this, and there are technically ways in which it could be accomplished even with no power, the only way to ensure a cold start is to use a fresh, un-activated beacon for each test.

Note that while this is not an issue for the external GPS beacons, it was determined that fairness dictated that a fresh beacon be used for each test for these beacons as well. There was no practical way to arrange for the handheld Garmin eTrex GPS to be operated from a cold start for each test of the external GPS beacons. Timing for these beacons began with the activation of the GPS first, but as it was always a warm start, the location acquisition time when satellites were in view was minimal. For typical use of PLBs this would be a relatively likely scenario, as the GPS would be expected to have been used for navigation within a short period of time of its use to interface with the beacon. For external GPS EPIRBs mounted on a boat and permanently interfaced with the boat's GPS this would not be a factor at all.

For circumstances where this is not the case, for example when a GPS and external GPS EPIRB or PLB are stored in an abandon-ship bag, it can be expected that additional time will be required until location acquisition, the actual amount being dependent upon the GPS receiver's speed to acquisition from a cold start. Typically, this can vary from 4 to10 minutes, in the author's experience. This can be determined more precisely by experimentation or by reference to the GPS manufacturer's literature or published independent tests and this time should be used to derive a time to beacon location transmission from a cold start. In the case of the Garmin eTrex Legend reference GPS used in this evaluation, this would add "up to 5 minutes" according the manufacturer's literature.

Because ephemeris data is location- and time-dependent, we ensured that the test location was thousands of miles away from the factory or importer of the beacons to ensure that even if the beacons acquired and maintained in memory the ephemeris or almanac data from an original functional test, it would not be current and would need to be reacquired upon activation. Again, this was not expected to be an issue for a variety of practical reasons, including the extended time interval between when the manufacturer had possession of the beacons and the test, but this was an matter raised at the Key West Test where the location was close enough to one manufacturer's facility that it theoretically could have influenced the results. There is the theoretical possibility that the EPIRBs recoded and tested at McMurdo could retain a current almanac, which could provide an advantage, but if they did so, there was no evidence that it helped.

The field testing was conducted in and around Santa Cruz, California, USA. Potential terrestrial test sites were reconnoitered, with assistance from West Marine, weeks ahead of the originally scheduled December 2003 test dates during a visit to West Marine by Ritter. GPS reception at the various test locations was determined using the reference Garmin eTrex Legend portable handheld GPS receiver and additional GPS receivers that would be used during the actual testing. Specific sites were then selected that met the criteria established for the various test scenarios (see Appendix 2). Despite this effort, during the actual tests for partially obscured GPS satellite visibility, it was necessary to re-identify nearby sites in some instances to satisfy the intent of the test scenario.

On the Saturday prior to commencing the field tests, Ritter, ETS Foundation volunteers, and a West Marine representative met at West Marine's facility in Watsonville, California, USA. The boxes of sequestered ACR beacons from West Marine stock and the McMurdo beacons received back from Forey were retrieved from storage along with the beacons received the week prior from Techtest.

Beacons were unpacked, randomly selected, and assigned to a particular test scenario. In the case of the Techtest Beacons, the battery, which is not installed into the beacon for shipping, was installed. The Beacon I.D. of every beacon to be used in the testing was recorded from the label on the beacon. Each beacon was then labeled with its assigned scenario for quick identification at the test site. EPIRBs were labeled using waterproof tape applied to the body of the beacon. PLBs were labeled using a waterproof plastic tag secured to the beacon with a plastic cable tie. Each Beacon I.D., manufacturer, model, and assigned scenario was recorded on Data Sheets that would be used to manually record data during each scenario, as well as on a master list.

All Data Sheets were laser printed on Rite-In-The-Rain brand waterproof paper and were filled out with indelible ink due to the wet conditions that might be experienced during the testing. After this, each beacon was placed into a lockable bin secured with two padlocks. The only keys to the padlocks were retained by Ritter and the primary ETS Foundation volunteer. Within each bin, beacons were segregated by test scenario with dividers. The bins of beacons were themselves labeled with the scenarios for the beacons they contained. At the end of the day, the bins were loaded into the rented delivery cargo van along with the rest of the equipment and supplies for the testing, and the door was padlocked with the only keys retained by Ritter and the primary ETS Foundation volunteer. Bins were unlocked for removal of beacons for particular scenarios, then locked up again for security or were in full view of the participants and witnesses if unlocked for any longer period of time.

In order to ensure commonality of all the data recorded, all time data was recorded as UTC (Universal Coordinated Time, still commonly referred to as GMT, Greenwich Mean Time) with time synchronized using the time supplied from the GPS receivers.

Multiple sources for receiving and recording locally the 406 MHz beacon transmissions were used in order to ensure back-up capability.

Sartech Engineering Ltd (UK) provided two model TSR406 406 MHz receivers. These each included an antenna with attached coaxial lead, 12-volt power cord, and a cord to connect to a computer. There was no recording or interpretive program provided, the receivers simply output via a serial cable the 30-character hexadecimal code the beacon was transmitting. These were the first two production units of a prototype receiver that was used by COSPAS-SARSAT Secretariat representative Sergey Mikhailov at the Key West Test.

Bob Dubner of Dubner International wrote a data acquisition program that took the serial output from the receiver and translated it into plain English so that the Beacon ID and any GPS-derived location information transmitted could be read. This was displayed in real time on the computer display upon receipt of each data burst from a beacon, and was saved to diskette and to the hard drive. Also saved with this information was a date and time stamp from the computer, operator-inputted scenario information and any added comments. During the Maritime phase of the testing, the assigned operator’s bout of seasickness resulted in some operator inputted scenario information to be in error, but accurate time stamps allowed the data to be properly integrated. Four notebook personal computers were borrowed for the testing so that there would be back-ups. One computer failed to boot in the field on the fourth day, but the back-ups ensured adequate capabilities.

Because the computers either didn't have functional batteries or their batteries would not last for an entire day of testing, a man-portable Honda EU1000i Generator/Inverter was procured (purchased by the Foundation, used for the evaluation, then sold at a discount). This provided both 120-volt power for the computers and to charge camera batteries and 12-volt power for the Sartech receivers and to charge camera batteries.

For the terrestrial testing, the antennas were attached to a telescoping aluminum pole that provided adequate elevation, approximately 7-8 feet, for good reception under all testing conditions. For the maritime testing the antennas were secured to the mizzenmast. In testing prior to the evaluation we were able to receive a 406 MHz signal from over ¼mile away.

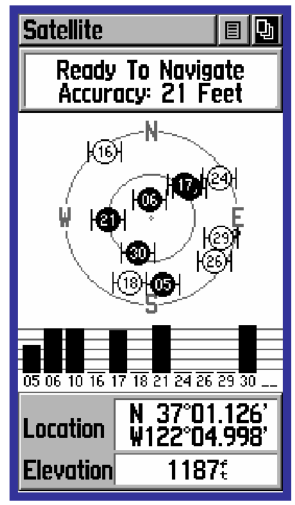
WS Technologies Inc. (Canada) provided two Model BT100A 406 Beacon Testers. These were prototype units that provided essentially all the functionality, as well as added data parameters, of the aforementioned Sartech receivers and computers together, integrated into a handheld Dell Personal Digital Assistant. The built-in antenna had a range of 10 meters. One unit could be fitted with a remote antenna with a range of approximately 50 meters. These units recorded data on Secure Digital memory cards and this data was then later transferred to a computer. Each data burst resulted in an HTML page of formatted data, saved with its date and time stamp. File names were coded to provide scenario, manufacturer, and model of the beacon and receiver I.D. Dubner wrote a program that extracted the data from the 1,501 HTML files and combined it with the date and time stamp and the decoded file name to output to a results database with fields equivalent to the other data recorded.

The ETS Foundation provided the GPS receiver required for those beacons that utilize an external GPS source and this served as the standard reference beacon as well. This was a Garmin model eTrex Legend (WAAS enabled) which was selected because 1) it is a WASS-enabled mid-range member of the most popular moderate-priced portable handheld GPS line sold in the U.S.; 2) it is the model GPS used as reference for the Key West Test; and 3) because the manufacturer of the beacons relying upon an external GPS, ACR Electronics, at various times has offered units from this line of handheld GPS as a package with their beacons, the ACR GyPSI 406 PLB and ACR SatFind 406 EPIRB. In addition, for the inland terrestrial testing we had Garmin GPSmap 165, Garmin 12 and Garmin V GPS receivers.

To record the number of satellites being received by the GPS and their signal strength, we used a waterproof Pentax OPTIO 33WR digital camera to photograph the GPS display. The waterproof camera could be safely taken on board the life raft during those maritime scenarios, without risk of damage. The camera also saved in the individual image metadata files the date and time the image was taken. While the camera has the capability to display the date and time stamp in the image itself, it was decided not to display this data due to the possibility that it might obscure critical data in the image. A waterproof Olympus Stylus 300 digital camera was available as back-up.

For data reduction purposes, these images were printed out with this included metadata date and time stamp as a caption using the "contact sheet" production capability of ACDsystems' ACDSee software to produce a reference that could be manually integrated into the results database. In some instances where poor lighting or reflections made the image indistinct, it was necessary to manually adjust the gamma of the image to view the display.

Typical image recorded showing GPS satellites, signal strength, lock-on and location.



Typical bitmapped recorded image from GPS

For the terrestrial testing, we also had an ETS volunteer who hooked up a laptop computer to a Garmin eTrex Legend GPS using the NMEA serial output and recorded a bitmap image of the display using G7ToWin software from Ron Henderson (**www.gpsinformation.org/ronh**) with coded file names providing scenario, manufacturer, and model of the beacon.

A candid digital photographic and digital video record of all beacon tests, including preparations involving the beacons, was made for documentary purposes. Images in this report have been taken from these photographs.

The draft field test protocols for this evaluation were initially based on those used in the Key West Test. They were then refined and additional tests added based on input from a variety of industry and government sources and the results of the laboratory tests.

For each scenario the following procedure was specified in the original test protocols (see Appendix 2). They were modified in the field as noted in accordance with the original protocols, which also provided for "test protocols subject to revision with concurrence of sponsors."

1. Record GPS hand-held derived position of testing site (using at least two different model WASS enabled GPS units) for each beacon tested. For beacons using external GPS, confirm that GPS location data is identical to reference beacons within ± 0.01 seconds of longitude and latitude. Satellite signal strength shall be recorded for all satellites. In the tests protocols below, the term "visible satellites" shall mean a satellite indication showing no less than 50% and a full acquisition indication on the GPS signal strength meter/graph.

It was determined that it was impossible to get all the GPS receivers to agree within the defined criteria on a consistent basis. It was decided to record the location displayed on the reference GPS, except in instances when it did not derive a location, then the location from the Garmin 12 or Garmin V was used. This is the same means used in the Key West Test. After consultation it was decided to amend the visible satellites to include those showing a filled-in black circle indicating that the receiver had achieved full reception of the critical ephemeris data from the GPS, regardless of the signal strength shown, which could be as low as 25% of the scale. This conforms to the criteria used in the Key West Test and by all GPS manufacturers.

2. Record environmental conditions at test site (weather, temperature, humidity, sea conditions, etc.) and record any substantial changes that occur during each individual beacon test.

We recorded sky and sea conditions. Sea conditions recorded were determined by one of the West Marine representatives with a claimed 40 years of yachting experience and were consistent with the observations of the experienced U.S. Coast Guard Rescue Swimmers.

3. Confirm each beacon ID prior to activation.

This was eliminated by dint of the assignment, labeling, and recording of this information prior to the field testing. It was confirmed that the beacon was labeled for the scenario and the correct data sheet was being used.

4. Record total number, identity and signal strength of GPS satellites “in-view” as indicated by GPS units (immediately prior to the each beacon activation and every 15 minutes until the beacon is deactivated).

5. Perform beacon self-test in accordance with manufacturer’s instructions, note any anomalies.

Some beacons had their self-test activated 2 or 3 times prior to beacon activation to confirm that both sets of local receivers were properly receiving the beacon’s transmission. In almost all the tests, the GEO satellites also received this self-test transmission.

6. All beacons will be placed in the same relative position for each particular test.

7. Activate beacon in accordance with manufacturer’s instructions.

In the case of beacons using an external GPS source, the external GPS was turned off and the activation sequence initiated by turning on the GPS co-located with the beacon. It was logistically impractical to achieve a full cold start of the

GPS, but this ensured that the GPS was not transmitting a location achieved under more favorable conditions than those of the beacons with integral GPS.

8. Record time of beacon activation or scenario change (time synchronized from GPS units).

In the case of beacons using an external GPS source, the time of initiation of the activation sequence was that of turning on the GPS co-located with the beacon.

9. Use the local beacon test set to confirm beacon ID is transmitted, record digital data received, timestamp.

10. Use the local beacon test set to confirm when GPS information is transmitted, record digital data received, time stamp.

11. Deactivate beacon once it is confirmed that GPS location has been transmitted and beacon has gone to "sleep" or after 35 minutes, whichever occurs first.

Since it was not possible to empirically identify if and when a beacon went into sleep mode, at the suggestion of the NOAA representative, and in conformity to the Key West Test protocols, the beacons were left on for five minutes after a GPS location encoded transmission was initially transmitted. This allowed the Geosynchronous Satellite to receive at least five bursts of data with the location information, just in case there was an anomaly that prevented the first burst from being received. We did have numerous examples where the first transmission received had an anomaly and provided only the coarse location. If a beacon did not transmit a location, it was left on for the maximum 35 minutes, based on the COSPAS-SARSAT requirement that the internal navigation device provide valid data within 30 minutes (COSPAS-SARSAT T.001 section 4.5.5.3), and allowing for some additional leeway to compensate for any timing or other issues. In all but one instance, excluding scenario Inland Golf where the beacons were purposely shielded from GPS initially, beacons that did not transmit a location during their initial active GPS acquisition phase did not thereafter acquire a location. On one occasion a beacon that did not initially transmit a location, did later acquire and transmit a location 27 minutes after activation.

To maintain consistency, accuracy and ensure independent recording of this critical data, most of the hand-written data recording was accomplished by a single West Marine representative with the NOAA representative filling in as needed. All data was recorded using a pen with waterproof indelible ink. The data sheets were stored in the integral storage space within the provided clipboard maintained in the possession of the recorder, and kept overnight in secure storage.

Test results recorded locally during the test were supplemented by beacon message data provided by NOAA via the New Zealand GEOLUT pointed at GOES West satellite and via various U.S. LEOLUTs for the LEO satellite data. This supplementary GEOLUT data was primarily used to provide confirmation of locally recorded data, and to confirm acquisition of the data by the satellite. LEOLUT data was used for determining performance of beacons in those scenarios where integrated system performance relying upon Doppler location in unconventional operating conditions was the primary purpose of the test. Dubner decoded the GEOLUT and LEOLUT data received from NOAA and incorporated it into the results database.

The GEO satellite data will continue to be analyzed with the goal of extracting additional useful information, but since this information is not central to the primary investigative purpose of this evaluation, publication of the evaluation is not being held up while awaiting any further analysis.

As a standard practice, tested devices are retained until well after publication of the report of an evaluation to ensure they are available in case of a challenge to the published results, or if questions arise regarding the devices tested. Two beacons were returned to their respective manufacturers for failure analysis. These beacons were selected for exceptional treatment in this regard because their failure was an anomaly, their performance inconsistent with the overall performance of that model beacon in the full evaluation. As such and because such performance anomalies are, in the experience of the authors, most often caused by production or assembly errors that can and should be corrected at the earliest opportunity, considering the life-threatening potential such failures can cause, an exception is made to standard practice. Poor performance on a consistent basis is not considered an anomaly, and is dealt with in the overall context of the evaluation.

Field Tests Schedule and Sequence

The field tests and operations were conducted in the following sequence:

January 17
Unpack all equipment and test for function.
Unpack, record and label all beacons.

January 18
Install test sets and equipment on board SV Willow and test for function.
Install gasoline-powered water pump and lines in RIB and test for function.
Visit Baseline and Inland test locations and review logistics.

January 19
Meeting, signing of confidentiality agreements and liability waivers.
Recoding of ACR beacons.
Baseline Scenario Alpha.

Baseline Scenario Bravo.
Baseline Scenario Charlie.
Maritime Scenario India.

January 20
Finished recoding of remaining ACR beacons.
Maritime Scenario Alpha.
Maritime Scenario Bravo.
Maritime Scenario Charlie.
Inland Scenario Hotel conducted on the beach concurrently, aborted due to personal emergency of ETS Volunteer.

Doug Ritter addresses assembled participants in January 19 meeting

January 21
Maritime Scenario Golf.
Maritime Scenario Hotel.
Maritime Scenario Delta.
Maritime Scenario Echo.
Maritime Scenario Foxtrot.
Inland Scenario Hotel conducted on the beach concurrently.

January 22
Inland Scenario Delta.
Inland Scenario Bravo.
Inland Scenario Alpha.

January 23
Inland Scenario India started and conducted concurrently.
Inland Scenario Foxtrot started and conducted concurrently.
Inland Scenario Charlie.
Inland Scenario Golf.

Field Tests Attendee List

Doug Ritter – ETS Foundation
Denis Inman – West Marine
Kevin Barber – West Marine
Phil Cowley – West Marine
Susan Altman – West Marine
Ruth Wood – Boat U.S. Foundation
Jerry McDown – FAA/CAMI
Tom Griffin – NOAA
Bill Street – WS Technologies
Kevin Holmes – WS Technologies
Bill Cox – ACR Electronics
Paul Salisbury – Techtest
MCPO Joseph Flythe – U.S. Coast Guard
SCPO Jeff Tunks – U.S. Coast Guard
Rick Lindstrom – ETS Foundation Videographer
Dave Higdon – ETS Foundation Photographer
Sue Ritter – ETS Foundation Volunteer
Dave Foster – ETS Foundation Volunteer
Neil Osborn – ETS Foundation Volunteer
Michael Adams – ETS Foundation Volunteer
Carl Ruhne – SV Willow

Field Test Results

What follows is a summary of the field test results. The field tests were separated into three fundamental types: Baseline, Inland, and Maritime. These were in line with the same basic types used in the Key West Test. The inland and maritime tests are considered the real-world tests. These represented simulation of use of the beacons in the natural environment under conditions that survivors might likely use them.

We do not consider the baseline tests to be appropriate to be combined in any statistical manner with the real-world scenarios (as was done in the Key West Test report), with the possible exception of Baseline Scenario Charlie (see following section). They were done to provide a baseline of performance under virtually ideal conditions, establishing a norm from which variation could be measured. It was anticipated that because of the nearly ideal conditions the beacons would all perform to COSPAS-SARSAT standards or better for these baseline tests.

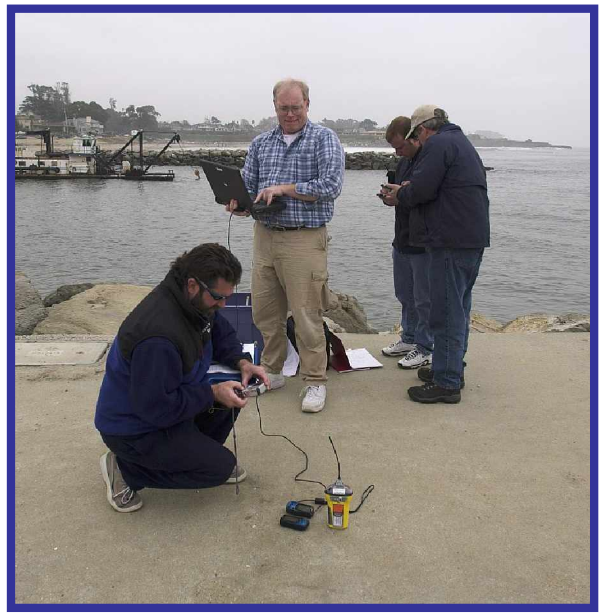
Baseline Scenarios

The original Baseline test protocols that served as the basis for the actual tests are included in italics. Any variances from the scenario outlined are reviewed in the individual scenario results.

Baseline Scenario Alpha

> *Individual Beacon Test (PLB and EPIRB). Cold Start. Activate one beacon of each model sequentially in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Priority 1*

The location of the Baseline Scenarios Alpha and Charlie tests was selected for having a full sky view and a horizon that was for the most part uninterrupted over most of the circumference of the site. The location was a jetty at the Santa Cruz Harbor entrance. Fully 220 degrees (approximately) of the horizon were uninterrupted ocean (Monterey Bay). An additional 50 degrees (approximately) was Twin Lakes State Beach on both sides and 20 degrees (approximately) was the open harbor itself. The remaining horizon was about 300 yards at the closest point running back sharply from there, an approximately 15-20 ft high cliff with personal residences on top.



Baseline Scenario Alpha – recording GPS readings prior to activation of McMurdo Precision EPIRB

The location of the Baseline Bravo relocation point was approximately 400 yards East on the beach with similar sky view but somewhat more restricted horizon except somewhat closer to the cliff and without the open harbor. Satellite visibility was comparable to the Baseline Alpha location.

In the most benign test, Baseline Alpha, with the exception of the McMurdo Fastfind Plus PLB, all the beacons transmitted location data within 4 minutes. The McMurdo Fastfind Plus PLB took 27 minutes to transmit a position. This is within the 30-minute COSPAS-SARSAT requirement, but significantly worse performance than the others tested.

The approximately 1 minute time to transmit a position for the external GPS source beacons would prove typical of these beacons throughout the testing. This is a function of the use of the warm start GPS and as noted elsewhere in the report, should be adjusted for an added cold start delay if that is the situation to be considered. In the case of the Garmin eTrex Legend reference GPS used, this would add “up to 5 minutes” according the manufacturer’s literature.

Baseline Alpha

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent Time[2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	7	20:56:01	N36°57'41.8" W122°00'10.0''	20:56:55	0:54	N36°57'40" W122°00'08"	Yes
ACR RapidFix 406 EPIRB[1]	6	20:47:48	N36°57'41.8" W122°00.100	20:48:40	0:52	N36°57'44" W122°00.08	Yes
ACR GlobalFix 406 GPS EPIRB	6	19:46:18	N36°57'41.8" W122°00'10.0"	19:47:49	1:31	N36°57'44" W122°00'12"	Yes
McMurdo Fastfind Plus 406 GPS PLB	6	19:09:22	N36°57'41.8" W122°00'10.0"	19:36:29	27:07	N36°57'44" W122°00'08"	Yes
McMurdo Precision 406 GPS EPIRB	6	18:57:40	N36°57'41.8" W122°00'10.0"	19:00:44	3:04	N36°57'44" W122°00'08"	Yes
Techtest 500-27 406 GPS PLB	7	20:34:29	N36°57'41.8" W122°00'10.0"	20:37:00	3:31	N36°57'40" W122°00'08"	Yes

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Baseline Scenario Bravo.

Updated Position Test (PLB and EPIRB). Beacons activated in Phase 1 will be transported while still active to an open area that is at least 300 meters from site in Phase 1, to check the "update" capability. The beacons will remain active until the updated position is observed to be transmitted, or 30 minutes has elapsed once the beacon is at the new site. Beacons using external GPS will be cycled off and on at the new site. Priority 1

Baseline Bravo tested the beacon's ability to update its location when moved or relocated. In an actual survival situation this is most likely in a maritime environment where wind, waves and current can cause a significant movement over time. The integral GPS beacons are limited to updating their location every 20 minutes, so each beacon was moved to the new location immediately after they completed Baseline Alpha so that they were in place at the new location well before the 20-minute point was reached. Transit time was approximately 10 minutes with the beacon held with the antenna vertical while in transit.

This is primarily a test of the integral GPS beacons. In the case of the external GPS beacons, they are prohibited by COSPAS-SARSAT specifications from updating the location, so we forced the issue by turning them off and then on again at the new location. Both external GPS source beacons acquired the new location promptly.

Of the integral GPS beacons, the ACR Globalfix 406 GPS EPIRB, Techtest 500-27 PLB and the McMurdo Precision 406 GPS EPIRB updated properly. The McMurdo Fastfind

Plus PLB did not update at the first 20-minute cycle and was allowed to run an additional 20-minute cycle. It failed to update the location and was shut down at that point. (See Appendix 5 for beacon operating schemes)

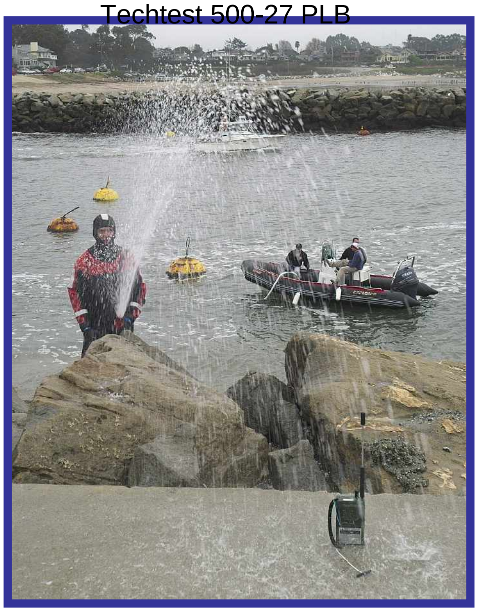
Baseline Bravo

Beacon	Sats in View	Revised Location Data Sent [2]	GEOS Updated Location Received[4]
ACR GyPSI 406 PLB[1]	6	Yes[1]	Yes
ACR RapidFix 406 EPIRB[1]	6	Yes[1]	Yes
ACR GlobalFix 406 GPS EPIRB	6	Yes	Yes
McMurdo Fastfind Plus 406 GPS PLB	7	No[3]	NA
McMurdo Precision 406 GPS EPIRB	6	Yes	Yes
Techtest 500-27 406 GPS PLB	6	Yes	Yes

[1] External GPS source - Shut off then activated again
[2] After 20 minutes, 1 cycle
[3] After 40 minutes, 2 cycles
[4] GEOS satellite data is preliminary and should not be considered definitive

Baseline Scenario Charlie.

Baseline Scenario Charlie
Techtest 500-27 PLB



While being sprayed with water to simulate heavy rainfall, activate one beacon (PLB and EPIRB) of each model sequentially in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Cold Start. Priority 2

Scenario Baseline Charlie was to determine what effect rain or a similar drenching would have on acquisition of a location, a person trapped in a river under a waterfall where there is a constant drenching with water, for example. It was suggested at the evaluation by a number of participants and observers that this scenario might more correctly be treated as a real-world inland scenario, at least with regards the PLBs. Upon review, we concluded that is a valid observation, and for purposes of statistical analysis we have included the Baseline Scenario Charlie tests of PLBs with the Inland results.

The RIB with water pump and an attached fire hose was located in the harbor channel adjacent to the jetty and a rescue swimmer used the hose to maintain a stream of water over the beacons that were set up on the edge of the jetty.

The use of saltwater to simulate rain was determined to be valid for our purposes as the primary purpose was to assess the effect on reception of the GPS signals and there is not a significant difference in attenuation of this signal between fresh and salt water.

One observer suggested that by his observation the volume of water that fell on the McMurdo Fastfind Plus PLB initially was greater than that which fell on the other beacons. In view of this beacon's failure to acquire a location, this was investigated. A review of video of the test found that the volume of water varied from time to time on all the beacons, but that it did not appear that this particular beacon experienced any notable difference in volume initially or overall during the course of its test sequence. A query to other independent ETS observers did not provide any concurrence with his observation. With regards to this beacon, the result was consistent with the performance of this model in a similar simulated rainfall test conducted as Maritime Scenario Hotel; in neither case was a location acquired.

Baseline Charlie

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent Time[2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	7	23:24:33	N36°57'41.7" W122v00'09.6"	23:25:26	0:53	N36°57'40" W122°00'08"	Yes
ACR RapidFix 406 EPIRB[1]	7	23:20:31	N36°57'41.7" W122°00'09.6"	23:21:30	0:59	N36°57'40" W122°00'08"	Yes
ACR GlobalFix 406 GPS EPIRB	6	23.00.21	N36°57'41.7" W122°00'09.6"	23:02:24	2:03	N36°57'44" W122°00'08"	Yes
McMurdo Fastfind Plus 406 GPS PLB	7	21:53:17	N36°57'41.7" W122°00'09.6"	No GPS	NA	No GPS	NA
McMurdo Precision 406 GPS EPIRB	7	21:41:23	N36°57'41.7" W122°00'09.6"	21:46:55	5:32	N36°57'44" W122°00'08"	Yes
Techtest 500-27 406 GPS PLB	7	22:39:04	N36°57'41.7" W122°00'09.6"	22:49:45	10:41	N36°57'40" W122°00'08"	Yes

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Inland Scenarios

The inland scenarios were designed to progressively increase the difficulty for the PLBs to obtain a GPS location by reduction in sky view and reduced horizon, thereby reducing the number of satellites visible to the beacons. This included scenarios where there were less than the three satellites minimum required for a 2-D GPS location showing on the Garmin eTrex, but where an adequate number of satellites were visible to the better-performing GPS receivers on hand, allowing a location to be acquired.

Time limits and difficulty obtaining fine differences in satellite visibility in the available natural conditions combined to reduce the evaluation's ability to define the point of demarcation between the likelihood that a particular beacon would acquire a location and when it would not based solely on satellite visibility under obscured overhead conditions. This does not adversely impact the overall conclusions, particularly when viewed in combination with the Baseline and Maritime testing results and in context of the Key West Test results, but does limit the conclusions that can be made vis-à-vis a particular beacon's susceptibility to marginal satellite visibility due to overhead obstructions, such as a forest canopy.

There are also a number of scenarios where no GPS location was expected and the purpose was to explore situations where either transmission to the GEO satellite was unlikely and any alert would have to come from receipt of transmission by a LEO satellite passing overhead and any location would be via Doppler from a LEO satellite or where the beacon was placed in a non-nominal position, as might realistically occur inadvertently in the real world to see if the GEO satellite would receive the transmission and if LEO satellites would receive the transmission and provide a location via Doppler. These scenarios were designed to provide some minimal real-world testing of situations that could be readily expected to occur in real life survival scenarios and for which the utility of the PLBs was in doubt on the part of consumers with conflicting answers from industry.

The original Inland test protocols that served as the basis for the actual tests are included in italics. Any variances from the scenario outlined are reviewed in the individual scenario results.

Inland Scenario Alpha

> *Activate each PLB model in an area with minimal obstructions (e.g., an open area with few trees and a surrounding tree line at least 25 meters away, but not more than 50 meters away to simulate operation in a typical moderate size forest clearing.), so that there is not a significant obstruction to the GPS satellites (at least 5 satellites visible as determined by handheld GPS). Cold Start. Priority 2*

Inland Scenario Delta

> *Activate each PLB model in an area with minimal overhead obstructions (e.g., an open area with few trees and a surrounding tree line at least 10 meters away, but not more than 15 meters away to simulate operation in a typical small forest clearing.), so that there is not a significant obstruction to the GPS satellites (at least 5 satellites visible as determined by handheld GPS). Cold Start. Priority 1*

Inland Scenarios Alpha and Delta represented use of the beacons in circumstances where it was felt that anyone familiar with typical GPS performance would normally expect the beacon to obtain and transmit a location, a clearing in a forest with a clear sky view overhead, but a restricted horizon due to the tree line.

Scenario Alpha was an attempt to duplicate the conditions that apparently resulted in a failure to acquire location that occurred during the media event in Vermont surrounding the July 1 legalization of PLBs in the continental U.S. Unfortunately, it proved difficult to exactly duplicate the site conditions from the Vermont scenario. This was primarily due to there not being as dense a tree line to restrict the horizon and the site being perched on top of a hill higher than all the surrounding terrain, as well as the meadow being somewhat larger than optimum. As such, this was not considered to be an effective duplication of the Vermont scenario, but it was a legitimate test in a not particularly demanding environment.

Inland Scenario Alpha large meadow – setting up for testing

For Scenario Inland Alpha the Techtest 500-27 did not acquire a location.

This failure of the Techtest beacon to acquire a location represented an anomalous performance that was surprising to all in attendance and the Techtest representative voiced his suspicion that the cause could be a disconnect between the GPS chip and the antenna due to a newly introduced connector in these beacons. We returned this beacon to Techtest and requested that Techtest report back to us if they could determine why the beacon had not derived a location when it would have normally been expected to based upon prior performance at the evaluation. Their investigation confirmed the suspicions the Techtest representative voiced at the evaluation, that “the reason for the lack of acquisition was the RF cable from the GPS antenna becoming detached from the GPS circuit board. As a result an engineering change has been put in place to stop this from happening again in the future.” Techtest provided us a copy of the engineering change, which would appear to have addressed this issue.

Inland Alpha

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	7	23:27:36	N37°01'13.0" W122°05'00.1"	23:28:50	1:14	N37°01'08" W122°04'60"	Yes
McMurdo Fastfind Plus 406 GPS PLB	5	00:14:56	N37°01'13.0" W122°05'00.1"	00:18:37	4:44	N37°01'08" W122°04'56"	Yes
Techtest 500-27 406 GPS PLB	7	23:36:26	N37°01'13.0" W122°05'00.1"	No GPS	NA	No GPS	NA
[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS [2] All times UTC [3] GEOS satellite data is preliminary and should not be considered definitive							

For Scenario Inland Delta, the McMurdo Fastfind Plus did not obtain a location.

Inland Scenario Delta – measuring the width of the clearing at its narrow point.

The original protocol specified 5 GPS satellites visible; during the test there were 4 satellites visible. Since this is in excess of the minimum of three required to obtain a 2-D location and adequate to obtain a 3-D location (including altitude), both theoretically and as indicated on the reference Garmin eTrex GPS receiver, this was determined to be a legitimate test of the desired real-world scenario. The clearing was 99 feet on one side and 128 feet long on the other, 56 feet wide at the narrowest and 81 feet wide at the widest with a moderately dense tree line estimated to be 20-30 feet high. As evidenced by the location acquired on the Garmin eTrex, this was not a demanding environment for even a relatively low performance GPS to obtain a location.

The Techtest beacon failed its self-test. Normal protocol would be to replace it with another unit, but at the suggestion of the manufacturer's representative the removable field-replaceable battery was exchanged with another unit and after passing the self-test, it was used for the test. A failure analysis revealed that the battery had passivated. The operator's manual for the beacon includes the following instructions:

> *After long periods of inactivity the high capacity battery will develop a passivation layer and therefore not provide full power for a few seconds. It may be necessary to repeat the built in test several times to develop full battery power and a successful test (all high capacity batteries develop a passivation layer which reduce self discharge and increases battery life.*

It should be noted that there is no such instruction on the beacon itself. Battery passivation is not mentioned in the other manufacturers' beacon manuals.

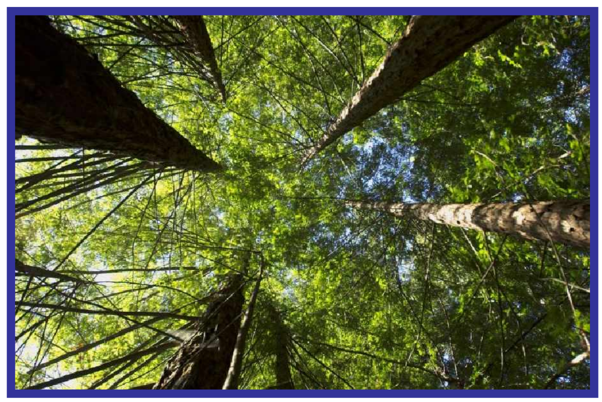
Inland Delta

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent[2]	Time Delta	Location Data Sent	GEOS Location Received[3]
ACR GyPSI 406 PLB[1]	4	17:10:04	N37°00'05.5 W121°54'31.4"	17:10:54	0:50	N37°00'04" W121°54'16"	Yes
McMurdo Fastfind Plus 406 GPS PLB	4	18:08:10	N37°00'03.8 W121°54'30.2"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	4	17:56:11	N37°00'03.0 W121°54'18.5"	17:58:42	2:31	N37°00'04" W121°54'16"	Yes

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Inland Scenario Bravo

Activate each PLB model in an area with moderate overhead obstruction (e.g., under a tree canopy) so that there is moderate obstruction to view of the GPS satellites (at least 3 satellites visible, but no more than 4 satellites visible as determined by handheld GPS). Cold Start. Record with photographs the obscuration of the sky from the canopy. Priority 1



Inland Scenario Bravo – sky view

Inland Scenario Charlie

Activate each PLB model in an area with significant overhead obstructions (e.g., under a heavy tree canopy) so that there is significant obstruction to the GPS satellites (1 satellite visible, but no more than 2 satellites visible as determined by handheld GPS). Cold Start. Record with photographs the obscuration of the sky from the canopy. Priority 1

For Inland Scenarios Bravo and Charlie the Garmin eTrex Legend was not able to reliably acquire a location. We were able to acquire location on the higher performance Garmin receivers. If we had an adapter cable to connect to the other Garmin receivers, the ACR GyPSI would have been able to transmit a location. Experienced GPS users of higher performance GPS receivers under these circumstances might be expected to believe their integral GPS PLB would be able to provide a location, when it would appear based on the tests that it would not.

Inland Bravo

Beacon	Sats in View [4]	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	4	18:26:15	N37°00'10.2" W121°54'32"	No GPS	NA	No GPS	NA
McMurdo Fastfind Plus 406 GPS PLB	4	19:12:21	N37°00'10.2" W121°54'32"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	4	18:35:31	N37°00'10.2" W121°54'32"	No GPS	NA	No GPS	NA

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive
[4] Satellite and Locations from Garmin V

Inland Charlie

Beacon	Sats in View [4]	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	5	21:05:00	N37°00'17.6" W121°54'25.8"	No GPS	NA	No GPS	NA
McMurdo Fastfind Plus 406 GPS PLB	5	20:22:54	N37°00'17.6" W121°54'25.8"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	5	19:45:01	N37°00'17.6" W121°54'25.8"	No GPS	NA	No GPS	NA

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive
[4] Satellite and Locations from Garmin 12

Inland Scenario Echo

Using the PLB beacons from a prior scenario, activate beacon under dense overhead canopy with zero GPS satellites visible. Activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds and they are separated by no less than 5 feet. Leave operating for multiple LEOSAT passes. Record scanner with audiotape and provide time stamps in audio to capture any inadvertent simultaneous transmissions. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 2

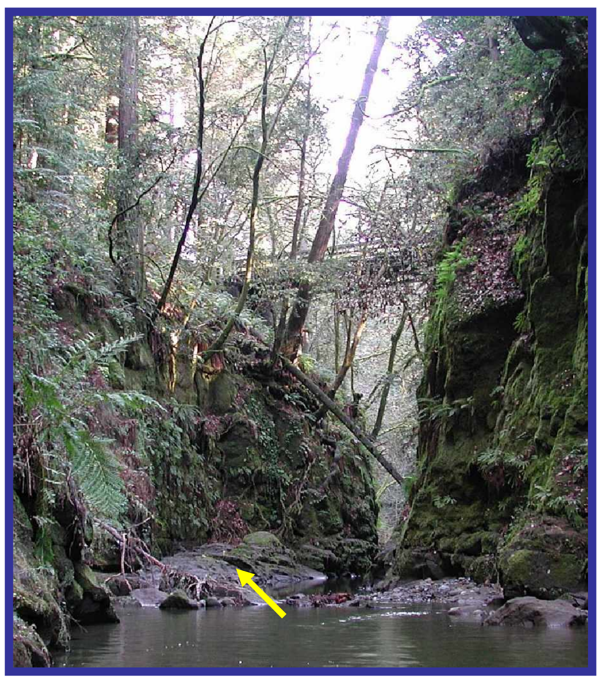
Inland Scenario Echo was not conducted

Inland Scenario Foxtrot

Using the PLB beacons from a prior scenario, activate beacon at the bottom of a narrow forested canyon no less than 8 meters deep, plus any trees lining the canyon, without regard to GPS satellites visibility. Activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds and they are separated by no less than 5 feet. Leave operating for multiple LEOSAT passes. Record scanner with audiotape and provide time stamps in audio to capture any inadvertent simultaneous transmissions. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 2

Inland Scenario Foxtrot was developed to assess the ability of the COSPAS-SARSAT system to receive an alert and derive a Doppler location in circumstances where the beacons had a very narrow and limited sky view, as when survivors are located in a narrow canyon. The location selected was within a narrow rock gorge through which flowed Aptos Creek. Estimated depth of the gorge where the beacons were placed was approximately 30-40 feet plus trees lining both sides. It was approximately 15-20 feet wide at the bottom and approximately 30-40 feet wide at the top at the point the PLBs were located. Only a single GPS satellite was viewable from the beacon location at the start of the scenario and two were visible at the close of this scenario on the reference Garmin eTrex GPS.

The only access to the selected location was by traveling up the creek approximately 100 yards, which ran from wall to wall of the gorge in places. Ritter and the U.S. Coast Guard rescue swimmers donned insulated waders and waded up the creek, which was approximately 3 feet deep at its deepest, to place the beacons on a rock bar. The beacons were turned on sequentially with a 15-second interval and after it was confirmed using the WS Technologies test set that there were no data burst collisions, the beacons were left in place for approximately 2.5 hours which allowed for 5 LEO satellite passes.



Inland Scenario Foxtrot – PLBs located on rock bar to left in photo (arrow).

By chance, the narrow view out of the gorge lined up almost perfectly with GOES West satellite and thus it was able to receive the transmissions and the unlocated alert was received from all three beacons for the duration of the test scenario.

On the first pass it appears the LEO satellite “saw” the McMurdo Fastfind Plus and Techtest 500-27, but did not generate a Doppler location. The second and subsequent LEO satellite passes did generate a Doppler location on both beacons. The ACR GyPSI, which was being constantly picked up by the GEO satellite, was either not received by the LEO satellite, considered unlikely by the experts we spoke with, or that data was missed in the data dump received from NOAA, or there was some other unexplained system failure. Due to resource constraints we were unable to gain more information on this discrepancy prior to publication. The inexplicable lack of LEO satellite data for this beacon is an anomaly that is being investigated by NOAA.

Inland Scenario Golf

Locate test site ensuring a clear line-of-sight to GOES East / West and no less than 4 available GPS satellites. Activate each PLB model while under metallic or other cover that ensures that no GPS satellites are visible to the beacon. After 20 minutes, remove cover and operate for another 20 minutes or until GPS coordinates are transmitted. This is a test of a circumstance where the beacon is initially activated by a survivor without due consideration of satellite visibility, under cover, and who subsequently moves to an area of better satellite visibility, either to be more visible for search aircraft or as a result of further consideration of the beacon operational limitations, taking the activated beacon with him/her. Cold Start. Priority 2, subject to beacon availability.

Inland Scenario Golf was developed to address a particular set of circumstances that might occur in a real-world survival scenario where the beacon is initially activated by a survivor without due consideration of satellite visibility and, not being able to receive the GPS satellite signal, does not acquire a location. The survivor later moves to an area of better satellite visibility, either to be more visible for search aircraft or as a result of further consideration of the beacon operational limitations, taking the activated beacon with them. This test was limited to only the integral GPS beacons because external GPS beacons do no provide for an automatic update of location so the test would not provide any meaningful data.

Inland Scenario Golf – covering Techtest PLB to prevent GPS acquisition

The test location was the beach next to the jetty used for the Baseline tests in order to ensure maximum GPS satellite visibility, having determined that the McMurdo might not acquire under any lesser level of satellite availability and desiring to give each beacon equal opportunity to perform. The beacon was activated under a plastic "blanket" coated with an aluminum metalized film (commonly referred to as a "space blanket") to prevent acquisition of the GPS signal. The blanket was supported by a piece of driftwood to ensure it did not touch the beacon or antenna. It was confirmed using the local test sets that the 406 MHz signal was being transmitted and that no location was acquired. After 20 minutes the blanket was removed to see if the beacon acquired a location. The Techtest 500-27 promptly acquired a location in 1 minute 15 seconds. The McMurdo Fastfind Plus did not acquire a location during the 35 minutes it was left on after being uncovered, encompassing at least two 20-minute update intervals. (See Appendix 5 for beacon operating schemes)

Inland Golf

Beacon	Sats in View	Start Time[2]	Uncovered Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta [4]	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	Not tested							
McMurdo Fastfind Plus 406 GPS PLB	8	22:41:00	23:01:00	N36°57'43.0" W122°00'11.4"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	8	22:12:30	22:32:30	N36°57'43.2" W122°00'11.3"	22:33:33	1:03	N36°57'40" W122°00'12"	Yes

[1] External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive
[4] Delta from time uncovered until data sent

Inland Scenario Hotel

Using the PLBs from prior phase, activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Each beacon shall be separated from the others by no less than 10 feet. Tip over each beacon so antenna is horizontal to the ground, but not touching the ground to simulate being inadvertently tipped over. All antennas shall point in the same direction. Leave operating in this position for as long as practical. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 3

Inland Scenario India

Using the PLBs from prior phase, activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Each beacon shall be separated from the others by no less than 10 feet. Tip over each beacon so antenna is horizontal to the ground with the antenna tip, but no other portion of the antenna touching the ground to simulate being inadvertently tipped over. All *antennas shall point in the same direction. Leave operating in this position for as long as practical. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 3*

Inland Scenario Hotel and India were developed to assess the ability of the COSPAS-SARSAT system to receive a GEO satellite alert and derive a Doppler location in circumstances where the beacon antenna was not vertically oriented, an abnormal configuration as would occur if it was tipped or blown over. The external GPS ACR GyPSI PLB would have transmitted a location if it had been connected to a GPS receiver and if it was received by the GEO satellite, then that is a presumed successful location acquisition. A lack of acquisition in this abnormal configuration would not be considered a technical failure, but success of any integral GPS beacon is noted as a useful GPS performance data point.

Inland Scenario Hotel was conducted on the beach next to the jetty where the Baseline Scenario Alpha tests were conducted. In this test the antenna was parallel to the ground, but did not touch the ground.

The beacons were turned on sequentially with a 15-second interval and the beacons were left in place for approximately 7 hours.

All beacons were immediately picked up by the GEO satellite a Doppler location from the LEO satellite was generated on the first LEO satellite pass.

Reviewing the GEO satellite data, there was no noticeable reduction in the C/No (Signal to Noise Ratio) levels compared to beacons transmitting in the normal orientation.

It was not anticipated that the tipped-over integral GPS beacons would acquire a location, but the Techtest did so and acquired a position in approximately 2 minutes on the second data burst.

Inland Scenario India – setting up beacons with antenna tips grounded

Inland Scenario India was conducted in the same small clearing as was Inland Scenario Delta with 4-5 GPS satellites visible. In this test the antenna tip was placed in contact with the ground.

The beacons were turned on sequentially with a 15-second interval and after it was confirmed that there were no data burst collisions, the beacons were left in place for approximately 2.5 hours which allowed for 5 LEO satellite passes.

It was not anticipated that the tipped-over integral GPS beacons would acquire a location, but the Techtest did so and acquired a position in approximately 3 minutes on the third data burst.

All beacons were immediately picked up by the GEO satellite and Doppler location from the LEO satellite was generated on the first LEO satellite pass.

Reviewing the GEO satellite data, there was a notable reduction in the C/No levels of the beacons with blade antennas compared to those same beacons transmitting in the normal orientation. In the normal orientation, typical C/No levels were in excess of 32. In this scenario the C/No levels were below 28 and as low as 25. The Techtest PLB evidenced a much smaller reduction in C/No levels on the order of 2-3 points.

Maritime Scenarios

The original maritime test protocols that served as the basis for the actual tests are included in italics. Any variances from the scenario outlined are reviewed in the individual scenario results.

For all the Maritime Scenarios the original protocols noted: *boat(s) will proceed offshore, to simulate conditions on open seas. As practical, effort will be made to seek out or simulate consistent non-stable conditions at sea.*

Two vessels were used for the maritime activities. The 46 ft. ketch SV Willow served as the “mother ship.” The computers and long range test sets were on the Willow with receiving antennas on the mizzenmast and cabin top. Depending upon the scenario, the Willow either stood off from where the beacons were being tested in or on the water or circled the test location clockwise with the receiver antennas facing the beacon being tested.

A 20 ft. Bombard RIB (Rigid Inflatable Boat) served as safety vessel and activities platform. It was manned by a West Marine representative, the two U.S. Coast Guard rescue swimmers and at times by the BoatU.S. Foundation representative.

Two weeks prior to the test an ETS volunteer met with a West Marine representative and picked up a 9,400 gallons per hour, gasoline engine-powered water pump that had been purchased by the Foundation and been shipped to West Marine. They measured the bow area of the RIB and he built a portable padded platform to fit in the bow area, mounting the water pump on the platform. The pump was equipped with a large intake suction hose and a 1.75-inch hose equipped with a standard adjustable fire hose nozzle to create simulated rain and spray.

For the beacon tests conducted on board the life raft, West Marine provided a new West Marine by Zodiac Offshore life raft with a removable insulated floor. The floor was removed as it is covered in an aluminum-coated material that is not typical of all life rafts. It was hoped that time might allow an additional test sequence to be conducted with the floor in place to determine what, if any, effect the metalized floor has on beacon performance in the life raft. Time was not available for that option.

The life raft was damaged accidentally when it was placed so as to be close to the exhaust of the water pump's engine, which resulted in the melt-through of the life raft's plastic storage canister and damage to the floor of the raft. After deployment and inflation, Ritter used life raft repair clamps in the life raft survival equipment pack to repair the leaking floor and the raft was bailed out prior to the beacon testing being conducted.

All Maritime Scenarios were conducted with the beacons activated individually, none were operated concurrently due to the difficulty in keeping track of local test set data.

The Maritime testing activities were adversely impacted by the unexpected consistent failure of the McMurdo beacons to obtain a location. While it was anticipated that a modest percentage of beacons would not acquire a location during the tests, the total failure of the McMurdo beacons to acquire a location resulted in considerable additional time being used than was expected, which resulted in some adjustments to the testing protocols in order to accomplish as much of the test objectives as possible in the time available. For safety and practical consideration, all testing had to be accomplished during daylight hours. As it was, we returned to the harbor the last day of Maritime testing after sundown.

This issue primarily manifested itself during the life raft related testing conducted during the latter part of the last day of Maritime testing. After consultation with participants and observers, it was concluded that a process of elimination would be used to accelerate the testing of beacons in the life raft. The life raft testing was a series of escalating more difficult scenarios, from an open raft, to a closed raft, to a closed raft being drenched with water. By this point in testing it had become apparent and obvious that beacons that did not succeed in acquiring a location under more benign conditions also did not do so as conditions become more challenging. Therefore, any beacon that failed to acquire a location in the life raft under a particular scenario would not be tested in the next, more challenging scenario. This is a well-established test protocol used in many product-testing evaluations and there were no objections to this change by those participating in or witnessing the evaluation. As neither McMurdo beacon nor the Techtest beacon acquired a location during the initial life raft test scenario, they were eliminated from the remaining life raft test scenarios. This allowed us to complete the life raft testing before sundown, which would have otherwise been impossible.

Test conditions were as desired the first day of Maritime testing with moderate swells and waves estimated at 8-10 feet that created considerable motion on the Willow (and subsequent bouts of sea-sickness among many participants) and noticeable gyrations of the beacons when in the water. The second day of Maritime testing was much less challenging and by afternoon when the life raft testing commenced the seas were estimated 2-foot swells with 6-inch wind clop which devolved into glassy surface conditions and virtually no movement in or on the water—very benign conditions. When reviewing the results, the environmental conditions should be taken into account.

Maritime Scenario Alpha

> *Activate each beacon model (PLB and EPIRB) in an upright position in the boat's cockpit. Cold Start. Priority 1*

The cockpit of the Willow was fitted with a full dodger (metal supported canvas and plastic covering) and it was feared that could potentially adversely influence the ability of the beacons to gain a location for Maritime Scenario Alpha. The test location was moved from the cockpit to the aft deck under the mizzen boom, approximating the structural interference experienced in a typical cockpit location with the mainsail boom overhead. One observer suggested that this was a less challenging environment because the beacons were higher than they would be if located in a cockpit below deck level and had a wider sky view as a result.

Maritime Scenario Alpha - aft deck of SV Willow, recording GPS satellites in view preparatory to activating McMurdo Fastfind Plus PLB

Two observers sat on both sides of the aft portion of the Willow, approximating the effect of a cockpit with a modest number of occupants, but being further from the beacon than they would typically be in an actual cockpit were it located centrally. The beacons were placed in the middle of the deck and activated in turn. On the ocean, there was a complete 180 degrees above and 360 degrees around sky view and no less than 4 satellites were visible at all times despite the structural and personnel impediments. The McMurdo Precision 406 GPS EPIRB and the McMurdo Fastfind 406 PLB failed to acquire a location, despite the reference Garmin eTrex GPS showing 5 and 7 satellites locked up, respectively.

Maritime Alpha

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	4	20:03:31	N36°53'55.5" W121°59'05.1"	20:04:30	0:59	N36°53'56" W121°59'08"	Yes
ACR RapidFix 406 EPIRB[1]	4	19:55:02	N36°54'15.3" W121°59'19.7"	19:56:20	1:18	N36°54'20" W121°59'24"	Yes
ACR GlobalFix 406 GPS EPIRB	6	19:00:53	N36°55'15.2" W122°02'16.9"	19:05:51	6:28	N36°55'16" W122°02'32"	Yes
McMurdo Fastfind Plus 406 GPS PLB	7	18:26:34	N36°55'12.7" W122°04'30.5"	No GPS	NA	No GPS	NA
McMurdo Precision 406 GPS EPIRB	5	17:52:22	N36°55'24.7" W122°02'29.9"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	6	19:28:00	N36°54'42.8" W122°00'02.8"	19:43:07	16:14	N36°54'40" W121°59'56"	Yes

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Maritime Scenario Bravo

Each EPIRB model will be activated and set afloat, attached with its tether to a life raft, RIB or otherwise moored away from the mother vessel. If possible to ensure separation by at least 20 feet, activate multiple beacons such that each beacon transmits approximately every 15 seconds. Cold Start. Priority 1

Maritime Scenario Bravo – gyrations of McMurdo Precision EPIRB tethered to RIB

Maritime Scenario Charlie

While being sprayed with water to simulate heavy rainfall, each EPIRB model will be activated and set afloat, attached with its tether to a life raft or RIB. Cold Start. Priority 2

The Maritime Bravo and Charlie scenarios were conducted with the EPIRBs tethered to the RIB using their integral tethers. For the Maritime Bravo scenario, the McMurdo Precision 406 GPS EPIRB failed to acquire a location.

For Maritime Charlie scenario, the water pump and spray nozzle was used to simulate moderate rainfall or drenching spray/waves. The two integral GPS beacons, the ACR GlobalFix 406 GPS EPIRB and the McMurdo Precision 406 GPS EPIRB failed to acquire a location. The external GPS EPIRB, the ACR Rapidfix did transmit a location in the approximate 1 minute timeframe expected, however the external GPS was not itself being showered with water when it was turned on to load the position into the EPIRB, invalidating that test with regards a direct comparison to the internal GPS EPIRBs.

Maritime Scenario Charlie – Simulated rainfall / spray drenching ACR GlobalFix EPIRB

However, it should be noted that in many, if not most, mounted marine installations the external GPS used is the boat’s own generally very robust GPS unit that is permanently connected to the EPIRB held in its storage bracket. In such an installation the EPIRB would be expected to have received a GPS location from the GPS prior to being activated and deployed, so in most cases it would provide a location under these exact same circumstances. This represents one of the advantages of an external GPS source for an EPIRB when full advantage is taken of this capability.

Maritime Bravo

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR RapidFix 406 EPIRB[1]	6	21:42:20	N36°52'03.4" W121°58'34.9"	21:43:15	1:16	N36°52'08" W121°58'36"	Yes
ACR GlobalFix 406 GPS EPIRB	6	21:26:52	N36°52'18.4" W121°58'36.1"	21:31:02	4:25	N36°52'20" W121°58'36"	Yes
McMurdo Precision 406 GPS EPIRB	6	21:47:22	N36°52'55.9" W121°58'43.4"	NO GPS	NA	NO GPS	NA

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Maritime Charlie

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR RapidFix 406 EPIRB[1]	6	00:00:01	N36°51'00.4" W122°01'110"	00:00:58	0:57	N36°51'00" W122°01'12"	Yes
ACR GlobalFix 406 GPS EPIRB	6	23:19:00	N36°51'28.0" W122°00'26.6"	NO GPS	NA	NO GPS	NA
McMurdo Precision 406 GPS EPIRB	6	22:15:30	N36°52'01.5" W121°59'54.2"	NO GPS	NA	NO GPS	NA

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Maritime Scenario Delta

Each beacon (PLB and EPIRB) will be secured inside a life raft with the antenna vertical and activated with the canopy partially closed as initially erected providing partial sky obscuration. Record and photograph obscuration. As best as possible, ensure equal or nearly equal satellite visibility to all the beacons. Cold Start. Priority 1

Maritime Scenario Echo

Each beacon (PLB and EPIRB) used will be secured inside a life raft with the antenna vertical and activated with the canopy fully closed to simulate activation in adverse weather conditions. Cold Start. Priority 1

Maritime Scenario Foxtrot

Each beacon (PLB and EPIRB) used will be secured inside a life raft with the antenna vertical and activated with the canopy fully closed and while simulating heavy rain on the canopy to simulate activation in adverse weather conditions. Cold Start if possible, otherwise use beacon from previous day. Priority 2

Maritime Scenario Delta – arrangement of life raft occupants in raft with McMurdo Precision EPIRB in center (typical) preparatory to starting testing.

For Maritime Scenarios Delta, Echo and Foxtrot, the testing was conducted inside a six-person double tube West Marine by Zodiac offshore life raft. The insulated floor with its metalized covering was removed. The raft was boarded by six individuals including the 2 manufacturers' representatives, 2 sponsor representatives, a WS Technologies engineer with test set, and Ritter. All occupants were wearing survival dry suits and insulated undergarments due to the cold water (approximately 49 degrees F) conditions. To compensate for the removal of the insulated floor, each was provided a 0.5-inch thick, 12 x 12-inch piece of closed cell foam for use as insulation under their posterior. Occupants arrayed themselves inside the life raft without explicit direction resulting in three persons seated at either end of the "boat shaped" raft. This inadvertently provided the maximum uninterrupted horizon around the raft with bodies squeezed into both ends and the major portion of the center section having unimpeded views of the horizon and sky though the canopy, entries, and inflated buoyancy tubes. This represents the optimum conditions in the life raft in terms of available horizon and sky view, providing the beacons the maximum opportunity to acquire a GPS location.

In an actual survival situation, the occupants would likely have quickly rearranged themselves across the raft in staggered positions with a slightly larger cumulative obstruction of the horizon due to not being squeezed tightly together, some being located closer to the beacons and the angle to horizon thus being steeper and the ability to raise their legs in a manner that might add more obstruction.

The life raft's mooring line was secured to the Willow, which proceeded to steer a course of 150 degrees magnetic at dead slow speed in order to ensure that each beacon received an approximate equivalent GPS satellite constellation vis-à-vis the artificial horizon produced by the bodies in the life raft surrounding the beacon. This addressed an issue raised after the Key West Test that the beacons were not treated equally in this respect.

For Maritime Scenario Delta through Foxtrot the beacons were activated in the center of the raft amongst the occupants' feet with the antenna vertical and the GPS antenna oriented towards the sky. By this point the seas were mild with only two to three foot swells with lengthy fetch and about 6-inch wind chop, which decreased to two foot swells with virtually glassy surface conditions by the end of the three scenario test sequence. Movement of the raft in the water, with the exception of the forward movement due to the Willow's slow progress, was minimal.

The McMurdo Precision 406 GPS EPIRB, McMurdo Fastfind Plus 406 GPS PLB and Techtest 500-27 PLB failed to acquire a location.

ACR GlobalFix on laying on side in life raft

After completion of Maritime Scenario Delta, the ACR representative requested he be allowed to test the GlobalFix EPIRB with it laying on its side with the antenna horizontal. This was a test that was originally part of the test protocols, based on real world reports of survivors who simply laid the EPIRB down on the floor of the raft, but which was dropped later in development of the evaluation due to time constraints. It was discussed briefly and nobody expressed any objections, but it was decreed that the test would be discontinued if location was not obtained within five minutes due to the lateness of the hour. Note that the beacon tested was not a fresh beacon with a confirmed cold start for the GPS, but the one used previously for Maritime Scenario Delta. Laid on its side with the antenna pointing sideways in the raft, approximately 240 degrees magnetic, the ACR GlobalFix EPIRB obtained location in XX minutes, virtually identical to the times recorded when vertical.

Maritime Delta

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent[2]	Time Delta	Location Data Sent	GEOS Location Received[3]
ACR GyPSI 406 PLB[1]	8	22:48:00	N36°53'54.2" W121°59'22.4"	22:49:00	1:00	N36°53'56" W121°59'24"	Yes
ACR RapidFix 406 EPIRB[1]	8	22:14:01	N36°54'55.8" W121°59'54.4"	22:15:03	1:00	N36°54'56" W121°59'56"	Yes
ACR GlobalFix 406 GPS EPIRB	7	22:39:02	N36°54'08.3" W121°59'30.0"	22:41:08	1:58	N36°54'08" W121°59'28"	Yes
McMurdo Fastfind Plus 406 GPS PLB	7	23:09:00	N36°53'27.8" W121°59'05.4"	NO GPS	NA	NO GPS	NA
McMurdo Precision 406 GPS EPIRB	7	21:36:00	N36°56'02.2" W122°00'34.7"	NO GPS	NA	NO GPS	NA
Techtest 500-27 406 GPS PLB	8	22:22:00	N36°54'19.6" W121°59'34.3"	NO GPS	NA	NO GPS	NA

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

For the next scenario, the canopy entries were closed up, as would be the case in poor weather or more extreme conditions and the test repeated using the beacon that succeeded in the previous open canopy test. The external GPS beacons were not tested again, to save time, as the external GPS receiver had no difficulty acquiring a location and their transmission of location data is entirely dependent upon that.

Maritime Echo

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent[2]	Time Delta	Location Data Sent	GEOS Location Received[3]
ACR GyPSI 406 PLB[1]	Not tested - external GPS acquired location which is equivalent to successful acquisition of location						
ACR RapidFix 406 EPIRB[1]	Not tested - external GPS acquired location which is equivalent to successful acquisition of location						
ACR GlobalFix 406 GPS EPIRB	11	00:37:45	N36°51'54.9" W121°58'17.2"	00:39:14	1:29	N36°51'56" W121°58'20"	Yes
McMurdo Fastfind Plus 406 GPS PLB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						
McMurdo Precision 406 GPS EPIRB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						
Techtest 500-27 406 GPS PLB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

For the final test utilizing the life raft, the RIB pulled alongside and used the water pump to spray the canopy down with water to simulate moderate rainfall or spray on the canopy. The first attempt to do so resulted in intermittent coverage, so the test was repeated with adjustments to the flow and this resulted in more even coverage over the whole of the canopy. The external GPS beacons were not tested again, to save time, as the external GPS receiver had no difficulty acquiring a location and their transmission of location data is entirely dependent upon that.

Maritime Foxtrot

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	Not tested - external GPS acquired location which is equivalent to successful acquisition of location						
ACR RapidFix 406 EPIRB[1]	Not tested - external GPS acquired location which is equivalent to successful acquisition of location						
ACR GlobalFix 406 GPS EPIRB	11	00:52:33	N36°51'55" W121°58'12"	00:54:13	1:40	N36°51'52" W121°58'12"	Yes
McMurdo Fastfind Plus 406 GPS PLB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						
McMurdo Precision 406 GPS EPIRB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						
Techtest 500-27 406 GPS PLB	Eliminated due to failure to acquire in previous scenario – Presumptive failure to acquire location						

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Maritime Scenario Golf

Person in PFD (and/or survival suit depending upon water temperature) will enter water, activate each PLB, then dunk PLB in water and without draining any water from any cavities that might naturally retain water, hold it on top of chest to simulate a typical man overboard situation in moderate to severe weather and sea conditions where the beacon is regularly drenched with water. Cold Start. Priority 1

For Maritime Scenario Golf a U.S. Coast Guard rescue swimmer dressed in regulation dry suit with thermal undergarments, facemask, and snorkel and personal floatation survival vest entered the water and was secured to the RIB with a tether manned by the other rescue swimmer. Due to the high concentration of great white sharks in the Monterey Bay, the swimmers were being extremely cautious and the RIB was within 10 yards of the swimmer at all times. A separate lookout was maintained on board Willow while the swimmer was in the water. The swimmer activated each PLB while in the water, dunked it as directed and then held it clear of the water for the duration of the test. In order to allow the swimmer to readily turn his head and look underwater to clear the immediate area, instead of holding the PLB on his chest, it was held aloft. During this test sea conditions were moderate with swells and waves three feet. The McMurdo Fastfind Plus 406 PLB failed to acquire a location.

Maritime Scenario Golf – USCG Rescue Swimmer in water with McMurdo Fastfind Plus

Maritime Golf

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	8	17:40:56	N36°55'36.0" W122°03'25.9"	17:41:53	0:57	N36°55'36" W122°03'20"	Yes
McMurdo Fastfind Plus 406 GPS PLB	6-8	15:52:00	N36°35'34.9" W122°03'38.0"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	7	18:30:50	N36°55'52.4" W122°04'28.4"	18.32.41	1:51	N36°55'28" W122°04'16"	Yes

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Maritime Scenario Hotel

Person in PFD (and/or survival suit depending upon water temperature) will enter water and while being sprayed with water to simulate heavy rainfall, will activate each PLB, holding it on top of chest to simulate a typical man overboard situation in adverse weather conditions with heavy rain. Cold Start. Priority 1

Maritime Scenario Hotel – ACR GyPSI PLB

For Maritime Scenario Hotel the swimmers determined that conditions would evolve to the point that there was significantly increased likelihood of sharks attack due to the added attraction of the water spray hitting the surface of the water. The swimmers rigged one of their inflatable PFDs so that is would remain stable in the water and attached the PLBs to it in a manner that allowed the GPS antenna to present itself to the sky view and keep the transmitting antenna vertical. The PFD was tethered to the RIB and the water pump was used to spray the beacon to simulate moderate rainfall or drenching spray/waves. The McMurdo Fastfind Plus 406 PLB failed to acquire a location.

Maritime Hotel

Beacon	Sats in View	Start Time[2]	Local GPS Location	Location Data Sent [2]	Time Delta	Location Data Sent	GEOS Location Received [3]
ACR GyPSI 406 PLB[1]	6	20:15:00	N36°55"22.4" W122°04"10.0"	20:15:44	0:44	N36°55'20" W122°04'12"	Yes
McMurdo Fastfind Plus 406 GPS PLB	7-8	19:04:36	N36°55"62.1" W122°04"58.2"	No GPS	NA	No GPS	NA
Techtest 500-27 406 GPS PLB	5-8	19:48:36	N36°55."45.40" W.122°04"44.4"	19:55:21	7:00	N36°55:20" W122°04'24"	Yes

[1]External GPS source Garmin eTrex Legend – Add "up to 5 minutes" to acquisition time for a GPS cold start with this GPS
[2] All times UTC
[3] GEOS satellite data is preliminary and should not be considered definitive

Added Maritime Scenario for McMurdo EPIRB

Benign sea conditions shortly before added test of McMurdo Precision EPIRB.

After the conclusion of tests conducted in the life raft, while the test personnel were disembarked from the raft to the RIB and then to the Willow and the life raft recovered and stowed on the RIB, just prior to departing for the harbor, it was determined that it would be a potentially useful data point to try a McMurdo Precision 406 GPS EPIRB, which to that point had failed to acquire on the water, in what were as nearly ideal conditions for EPIRB deployment as possible. Sea conditions at this time were 1 to 2-foot swells with a nearly glassy smooth surface. Immediately prior to deployment of the EPIRB, the Garmin eTrex GPS in the life raft recorded 11 satellites visible. The EPIRB would be left to drift free until it either acquired a location or everyone was disembarked and the raft stowed and we had to depart for shore. Using the EPIRB from Baseline Scenario Alpha, two days prior, the EPIRB was activated and tossed into the water from the stern of the Willow and allowed to float free. The EPIRB was visibly very stable in the seaway with little movement of the antenna. The McMurdo Precision 406 GPS EPIRB acquired a location in 4:23.

Maritime Scenario India

> *Using a stable pool of water, while restraining beacon in water with base of antenna submerged, but with water covering no more than 1/2 inch over top of beacon case, activate each PLB to simulate a typical man overboard situation in adverse weather conditions where beacon is partially submerged continuously due to wave action or survival equipment or survivor performance deficiencies. Priority 2*

Maritime Scenario India was conducted on the jetty after completion of the baseline testing. An 8-foot diameter plastic pool 18 inches deep was set up and filled to a depth of approximately 8 inches with seawater using the pump from the RIB and the fire hose. Each PLB in turn was placed in the pool with approximately 0.5 inch of water covering the body with the antenna vertical. This ensured the base of the antenna, as well as any GPS antenna, was well immersed in the water. Height was adjusted by shimming under the beacon. The Category 1 beacons that would float were secured with Velcro straps to a brick. This was not a test of the GPS capability because the GPS receivers are not capable of receiving a GPS signal through that amount of water.

Maritime Scenario India – measuring 121.5 signal strength of McMurdo Fastfind Plus with base of the antenna submerged.

This test was added after the laboratory tests suggested that the 121.5 MHz signal was significantly attenuated in some beacons by submergence of the base of the antenna in the water (see Laboratory Testing,). The WS Technologies test set had the capability of measuring the 121.5 RF output as a percentage of the receiver's maximum capabilities. This does not allow for direct measurements, and no attempt should be made to compare the individual beacon performance against each other, but will show up any order of magnitude differences for a particular beacon. As such we were only able to determine a relative relationship between unsubmerged and submerged performance of each beacon individually. Both PLBs with blade antennas, the ACR GyPSI and McMurdo Fastfind Plus, evidenced an extreme reduction in 121.5 MHz signal strength with the base of the antenna submerged. This correlated with the laboratory test experience.

The Techtest did not evidence an order of magnitude reduction in signal strength. This may be able to be attributed to the that fact that unlike the simple blade antennas of the McMurdo and ACR PLBs, the Techtest is equipped with a conventional triple frequency 50 ohm telescoping antenna with the 121.5/243 MHz section on the tip.

Maritime India

Beacon	Antenna Type	Power Reading Dry @ Distance	Power Reading Wet @ Distance
ACR GyPSI 406 PLB	Blade	32%@ 3.28 ft.	14% at 1 inch
McMurdo Fastfind Plus 406 GPS PLB	Blade	34% @ 3.28 ft.	0.5% @ 2 inches
Techtest 500-27 406 GPS PLB	Triple frequency 50 ohm telescoping antenna	45% @ 3.28 ft.	26% @ 2 ft.

Conclusions

The authors of this evaluation are of the opinion that the following conclusions can be drawn from the data and experience collected during this evaluation, and general observations of the use of these beacons during this evaluation and elsewhere:

1. The self-locating performance deficits of some location protocol distress beacons that this evaluation has documented should not be interpreted as an indictment in any manner of the COSPAS-SARSAT Satellite Distress Alerting System or 406 MHz distress beacons in general. This system has proven to be an extremely reliable and effective means of distress alerting that has saved thousands of lives worldwide since its inception. Even if some of the beacons evaluated in this report have not reliably provided self-location data, they appear to provide the minimum acceptable level of distress alerting and Doppler locating performance expected from conventional, non-location protocol 406 MHz emergency beacons.

2. Assuming that all the beacons in this evaluation conformed to COSPAS-SARSAT specifications as represented, it appears self-evident that the COSPAS-SARSAT standards covering location performance of location protocol beacons with integral location means do not adequately predict the performance of these location protocol beacons in the real world.

3. Based on the test results, which proved to be consistent with previous de-identified testing conducted by the U.S. government at which the principal author was present, users of the McMurdo self-locating beacons tested may expect to find that GPS-derived location may not be transmitted unless environmental conditions are generally benign and the beacon is stable, and unless there is a largely uninterrupted sky view covering most of 180 degrees above and 360 degrees around the beacon location. This level of performance appears to be inconsistent with that portrayed in McMurdo's advertising and product literature and consumers' reasonable expectations.

4. Based on the test results, users of the ACR and Techtest self-locating beacons tested may expect to find that under most moderate environmental conditions a GPS-derived location will be reliably transmitted.

5. Consumer expectations regarding the performance of integral GPS beacons may be shaped by their personal experience with handheld GPS receivers, which can prove to be an unreliable comparison. Users of the popular-priced Garmin eTtrex class of GPS receivers can expect the ACR beacons to perform comparably, meeting their experiential expectations. They can expect that the Techtest beacon will perform comparably in all but the most challenging circumstances. However, McMurdo beacons are likely to fail to acquire a location in circumstances where the Garmin eTrex class GPS typically provides a location, but with only a minimum number of satellites in view and locked on (3 or 4 satellites). None of the beacons tested are

likely to reliably acquire a location when a higher performance GPS receiver, such as the Garmin 12 or Garmin V, acquires a location with only 3 satellites in view and locked on. A consumer's experience using this class of handheld GPS is less likely to be indicative of a beacon's acquisition performance.

6. Location performance of beacons relying upon an external GPS source is entirely dependent upon the performance of that external source. With these beacons, if the external GPS gains a location, it will be transmitted. The evaluation showed marked differences in performance between handheld GPS receivers. In every instance where the standard reference external Garmin eTrex GPS source failed to acquire a location, had the beacon been interfaced with the better GPS on hand, they would have been able to transmit a location.

7. PLBs with blade antennas appear to provide significantly compromised 121.5 MHz performance when the base of the antenna is submerged in water. In situations where this occurs for an extended period of time while a direction finding (DF) search is in process, the beacon may not provide a useable signal for homing purposes under such circumstances.

8. On the basis of the laboratory tests, submerging the base of the PLBs' antenna in water appears to result in orders of magnitude attenuation of the 406 MHz signal. This could compromise the ability of the PLB to reach the COSPAS-SARSAT geostationary satellite. In the maritime field test of this condition, only the Techtest with its conventional 50 ohm telescoping antenna transmitted an alert to the COSPAS-SARSAT geostationary satellite (no GPS location was acquired nor was one expected because the GPS antenna was submerged). It is postulated that this attenuation under these conditions could potentially be a factor in preventing transmission to the COSPAS-SARSAT geostationary satellites and especially so in circumstances where environmental conditions are more detrimental to RF transmissions. It is postulated that this would not be expected to prevent transmission to the low earth orbit satellites under any likely circumstances where they would otherwise be successfully received.

9. A design such as that used in the McMurdo Fastfind that can retain water at the base of the antenna appears to compromise the performance of the antenna when that occurs, but based on the limited capability laboratory tests conducted it does not appear to attenuate the performance to the extent that complete submersion does, provided the beacon is otherwise kept dry. In the maritime field tests under these conditions, (antenna well filled) the Fastfind was able to communicate an alert to the COSPAS-SARSAT geostationary satellite (no location was acquired in this test). It is postulated that this attenuation under these conditions (antenna well filled) could potentially be a factor in preventing transmission to the COSPAS-SARSAT geostationary satellites in circumstances where environmental conditions are more detrimental to RF transmissions. It is postulated that this would not be expected to prevent transmission to the low earth orbit satellites under any likely circumstances where they would otherwise be successfully received.

10. Results from the gorge test suggests that Doppler location can be achieved even with a very limited sky view, though it may take multiple LEO satellite passes. Further investigation to establish practical limits is worthy of consideration.

11. Should the PLB be tipped over such that the antenna is oriented in an abnormal position instead of the nominal vertical position, there appears to be minimal impact on the capability of the beacon to communicate with the COSPAS-SARSAT geostationary satellite.

12. In the instance where the tip of antenna was grounded, the transmission power of the PLBs with a blade antenna was significantly less than normal while the Techtest with its telescoping antenna evidenced only a small reduction. In neither case did it prevent the satisfactory transmission of the alert via the COSPAS-SARSAT geostationary satellite. While GPS location acquisition was not specifically being tested in these scenarios, it should be noted that of the integral GPS PLBs, only the Techtest acquired a GPS location when tipped over, which it did in both scenarios tested, in two different locations, including one location in which the McMurdo did not acquire a GPS location under normal conditions.

13. Alert transmission time via COSPAS-SARSAT geostationary satellite appears to meet expectations of 3 minutes or less in most circumstances, but it extended to 5-7 minutes in some scenarios tested when the initial location transmitted was not adequately strong and thus only a “coarse” instead of “fine” location was received, which is of more limited value. It should be noted that claims that the “alert time is typically 3 minutes or less” may be misleading to many consumers who would not be knowledgeable enough to differentiate an alert from an alert with a fine location, nor does that take into account the added delay that can occur between the first transmission received and actual transmission of the alert to the Mission Coordination Center.

14. Battery life for the PLBs tested appears to exceed that required by the COSPAS-SARSAT specifications and that promised by the manufacturers.

15. In the opinion of the authors, those beacons that more often than not provided a location validated the functionality and desirability of this capability as a means of enhancing survivors’ chances of rescue. While neither a panacea, nor without notable limitations, the current state of the art in Location Protocol 406 MHz Distress Beacons appears to be capable of improving the likelihood of a successful rescue by potentially shortening response times in many likely survival scenarios. The location information generally will allow for quicker dispatch of SAR resources and the more accurate location, compared to a Doppler-derived location, reduces the search area with resultant likelihood of quicker detection of survivors when SAR resources arrive on scene. Consumers seeking a survivability advantage would do well to consider self-locating beacons as an option.

16. As noted in this report, both means of supplying location, an external GPS source or an integral GPS source, offer advantages and disadvantages. In the opinion of the authors, a beacon that incorporated both capabilities would provide the best potential for optimum performance under any particular set of circumstances, although the operator would have to have a certain level of knowledge and additional equipment, a high performance GPS receiver and interface means, to make best use of this option.

17. The performance deficits identified in this evaluation are proof that consumers cannot rely solely on regulatory means to ensure adequate performance and that independent real world testing is essential to ensure that consumers are protected and have the information required to make a knowledgeable purchase decision. Failure to enable this sort of consumer testing can unnecessarily imperil the lives of consumers relying upon these beacons and represents an unconscionable breach of the government's fiduciary duty to its citizens.

Recommendations

The authors of this evaluation are of the opinion that the following recommendations are appropriate to make based on the data and experience collected during this evaluation, and general observations of the use of these beacons during this evaluation and elsewhere. Some of these recommendations are Location Protocol Beacon specific; some are more generic in nature and apply to any relevant beacons:

1. The self-locating performance deficits of some location protocol distress beacons that this evaluation has documented, together with similar performance deficits exhibited during prior tests should elicit a strong response from regulatory and specification-setting bodies to ensure that the self-locating distress beacons consumers have purchased, or may purchase in the future, will perform to reasonable expectations in actual survival circumstances in the real world.

2. Advertising and promotion for self-locating beacons should realistically portray the performance consumers can expect in real-world conditions. Advertising and promotion that leads to unrealistic expectations on the part of consumers is not only potentially detrimental to the health and welfare of consumers of these products, but failure to live up to unrealistic expectations can adversely affect public confidence in, and support for, the COSPAS-SARSAT distress alerting system. Advertising and promotion that leads to unrealistic expectations on the part of consumers should elicit a strong response from regulatory bodies.

3. COSPAS-SARSAT standards for self-locating performance should be revised with all possible haste to more accurately reflect and test for real-world operational performance. The current standard is manifestly inadequate.

4. COSPAS-SARSAT standards should be amended to require fully functional self-test for GPS location acquisition of any included GPS receiver. The existing beacon self-test fully functionally checks the transmitter circuitry, including sending a test burst. If such a capability was required of the included GPS capability, a failure such as was experienced with the Techtest beacon caused by a faulty internal connection between the GPS antenna and the GPS chip would be identified during the self-test. Ideally, such a self-test should include transmission of the location so that with the proper equipment to receive and decode the self-test data burst, the accuracy of the GPS location can also be checked against a known position, though this will require more significant changes to COSPAS-SARSAT standards to accommodate such a change in the self-test transmission, which should be the ultimate goal. If digital display or artificial voice capability is incorporated, the self-test should include the readout of the full GPS location to at least 1 second resolution, not the artificially reduced accuracy of the transmitted location.

5. COSPAS-SARSAT should investigate establishment of standards for performance based on actual transmitted power radiated from the antenna and consider the effects of likely immersion in water in a dynamic survival circumstance on transmission performance.

6. COSPAS-SARSAT should revise or provide an alternative to the existing location protocol long message format to allow for transmission of location data resolution to at least 1 second . The current rounding of the location data deprives the search and rescue system of improved location resolution that already inherently exists within the GPS capability, but which cannot be taken advantage of due to the artificial limitations of the existing protocols. Improved resolution can only serve to improve chances for a successful rescue.

7. The COSPAS-SARSAT standard for location accuracy should be revised to require a greater degree of accuracy. Considering the current state of the art in GPS technology, and other similar technological options for location information existent or planned, the standard is unnecessarily and counterproductively low, as even very inexpensive GPS receivers provide data which is orders of magnitude better than the current 5 kilometers standard.

8. The beacon manufacturing industry or an appropriate independent standards setting body should develop voluntary objective performance standards and ratings for which cost-effective tests can be conducted that which will accurately predict and represent the level of self-location performance consumers can expect from a particular beacon under particular defined real-world conditions of reduced GPS satellite reception on both land and in the marine environment.

9. Operating instructions on or attached to the beacon should be improved. This is particularly critical in the case of the PLBs. None of the beacons' operating instructions were deemed to be very clear, particularly with regards to any external GPS interface or the self-test procedures, although the basic operation of turning on

the beacon was generally self-evident. In the opinion of the authors, operational instructions should be given the highest priority space on the beacon and should be as large and as distinct as possible. Marketing and cosmetic appearance considerations should not override the desirability of presenting essential operating instructions in the most effective manner possible when lifesaving is the aim.

10. Manufacturers should provide better operating instructions on or attached to the beacon that would guide a user to more readily identify a failure to acquire a location, and which would guide the user in maximizing self-locating performance when such opportunities exist and would be prudent for the user.

11. Operating instructions on or attached to the beacon should emphasize the importance of GPS antenna orientation when this is an inherent design factor for optimum performance, the importance of not blocking the antenna with the body or body parts, and for marine operations, the importance of keeping the GPS antenna clear of the water if possible. The location and preferred orientation of the GPS antenna should be clearly marked. In instances where the GPS antenna might likely be covered by a survivor's hand(s) while being held in a foreseeable manner or by foreseeable means of securing the beacon to a person or object under foreseeable survival circumstances, a warning against doing so should be clearly displayed.

12. Beacon design should seek to avoid the retention of water in such a manner that it adversely affects the performance of the transmitting antenna or the GPS receiving antenna. In a beacon such as the McMurdo Fastfind where the design inherently can retain water under wet operating conditions, operating instructions on the beacon should clearly warn users to avoid retention of water if possible in order to maximize alerting performance.

13. For beacons equipped with antennas that are subject to significant attenuation of the 406 MHz signal and/or 121.5 MHz homing signal when the base of the antenna is submerged, instructions on or attached to the beacon should instruct the operator to keep the antenna clear of the water if possible. Manufacturers should consider this potential shortcoming when designing beacons so as to reduce or eliminate it as a possible operational deficiency.

14. Airborne search and rescue operators should be encouraged to accelerate the replacement of outdated direction-finding equipment limited to 121.5/243 MHz with direction finding equipment that will also operate on 406 MHz and that will automatically decode the data burst for direct reading by SAR resources on scene. Industry should be encouraged to develop inexpensive, compact handheld 406 MHz direction-finding and decoding equipment that can be fielded by volunteer search and rescue operators and local fire and rescue agencies with limited budgets.

15. In recognition that EPIRBs will be often be used inside a survival craft or on the deck of a vessel, COSPAS-SARSAT standards should be revised to ensure satisfactory

operation of an EPIRB under operational conditions when not immersed in water acting as its ground plane.

16. In recognition that EPIRBs will be often be used inside a survival craft or on the deck of a vessel, instructions on or attached to the beacon should not assume deployment only in the water and should clearly include instructions for optimal use of the beacon inside a survival craft or on the deck of a vessel, emphasizing maintaining a vertical orientation of the antenna.

17. In recognition that EPIRBs will be often be used inside an enclosed survival craft or occupied space, standards or regulations requiring a strobe light should provide for the optional termination of the strobe light by the operator.

18. In the case of beacons that rely upon an external GPS, in accompanying literature manufacturers should stress the effect of GPS receiver performance on the self-locating capability of the beacon and the difference it can make, so that consumers can make a knowledgeable purchase decision as to what GPS receiver to interface with.

19. In the case of beacons that rely upon an external GPS, COSPAS-SARSAT specifications should be revised to allow for updating of position information. On such beacons where this capability does not exist, instructions on or attached to the beacon should explain this limitation to the user and provide instructions on how to update the location when it is desirable to do so.

20. Manufacturers should investigate a practical means by which the beacon can provide the owner an indication of the state of charge of a beacon's battery.

21. Government agencies and regulatory bodies involved in operation and regulation of these beacons and the COSPAS-SARSAT system should establish an ongoing means to study the actual effects of alerts with self-location information on the outcome of distress situations with regular public reports that can be compared to alerts lacking self-location information.

22. There is an obvious and urgent need for government agencies involved in operation and regulation of these beacons and the COSPAS-SARSAT system to develop a more expedient means by which real world testing of these beacons can be conducted with a minimum of bureaucratic interference and hurdles. It should be possible for any legitimate organization representing consumer interests to schedule a test of beacons on relatively short notice. For relatively small numbers of beacons, the use of operationally coded beacons should be facilitated, as the need to use test protocol-coded beacons is a very substantial impediment to the independent testing of these beacons.

23. Delay in receiving system performance data (satellite data) is detrimental to the expedient and effective testing of 406 MHz emergency beacons with the potential for

devastating data loss and resultant invalidation of testing that, at best, is difficult and expensive to organize. It should be a priority for the government agencies involved to enable these same testing organizations to receive immediate automated feedback, perhaps via the Internet, of the system performance.

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Appendices

1. Key West Test Report
2. Original Field Test Protocols
3. Original Field Test Schedule
4. Imanna Laboratories Test Report
5. Beacon Operating Schemes
6. Forey McMurdo Recoding Report
7. U.S. Coast Guard Fastfind Test Report
8. McMurdo Ltd. Response
9. Analysis of McMurdo 30 Meter Statement
10. McMurdo Email Regarding Participation

Appendix 1

Key West Test Report

Appendix 2

Original Field Test Protocols

Beacon Test Protocols
Revised January 2, 2004

General

Prior to commencing the below tests, verify and record the ID of every beacon to be used in the testing; clearly label all beacons for quick ID at the test site. Secure and seal all beacons to ensure and maintain chain of custody. Beacons will be selected at random from the beacon pool of each model for any particular test scenario.

Input beacon IDs and other relevant data into field data recorder(s).

All field data will be recorded both digitally and on paper as back-up. Digital data will be recorded on CD or other non-volatile memory after each test sequence.

Two each of the following local test sets (a total of four) will be employed in order to provide back-up and cross-check:

Sartech Engineering Ltd TSR406 (the prototype of which was used by COSPAS-SARSAT representative Sergey Mikhailov at the Key West test)

WS Technologies Inc. Model BT100A 406 Beacon Tester
Bill Street (email: bill@wst-inc.ca)
WS Technologies Inc.
201-1960 Springfield Road
Kelowna, BC
Canada V1Y 5V7
250-860-7277

A candid photographic and video record of all beacon tests, including preparations, will be made for documentary purposes. Back-up video and photographic equipment shall be available on site to ensure substantially continuous record.

The ETS Foundation will provide the GPS units required for those beacons that utilize an external GPS source. This will be a Garmin model Etrex Legend (WAAS enabled) as being representative of typical GPS units being used for this purpose based on a survey conducted by ETS in October, 2003.

West Marine will provide a West Marine by Zodiac Offshore life raft with a removable insulated floor. The floor will be removed as is contains aluminum-coated material that is not typical of most life rafts. If time and resources allow, additional test sequence may be conducted with the floor in place to determine what, if any, effect the metalized floor has on beacon performance in the life raft.

Test protocols subject to revision with concurrence of sponsors.

Tests have been given priorities of 1, 2 and 3 - High to Low and lower priority tests will be conducted only if circumstances and time permit.

For reasons of safety and security, all on site participants and observers shall immediately comply with any reasonable request of the evaluation organizer. A liability waiver and confidentiality agreement provided by the organizer must be signed by all participants and observers. U.S. government employees are exempted from the liability waiver requirement.

Field Tests

The following procedures apply, unless alternate procedures are specified for a given phase:

1. Record GPS hand-held derived position of testing site (using at least two different model WASS enabled GPS units) for each beacon tested. For beacons using external GPS, confirm that GPS location data is identical to reference beacons within ± 0.01 seconds of longitude and latitude. Satellite signal strength shall be recorded for all satellites. In the tests protocols below, the term "visible satellites" shall mean a satellite indication showing no less than 50% and a full acquisition indication on the GPS signal strength meter/graph.

2. Record environmental conditions at test site (weather, temperature, humidity, sea conditions, etc.) and record any substantial changes that occur during each individual beacon test

3. Confirm each beacon ID prior to activation

4. Record total number, identity and signal strength of GPS satellites "in-view" as indicated by GPS units (immediately prior to the each beacon activation and every 15 minutes until the beacon is deactivated)

5. Perform beacon self-test in accordance with manufacturer's instructions, note any anomalies

6. All beacons will be placed in the same relative position for each particular test

7. Activate beacon in accordance with manufacturer's instructions

8. Record time of beacon activation or scenario change (time synchronized from GPS units)

9. Use the local beacon test set to confirm beacon ID is transmitted, record digital data received, timestamp.

10. Use the local beacon test set to confirm when GPS information is transmitted, record digital data received, time stamp.

11. Deactivate beacon once it is confirmed that GPS location has been transmitted and beacon has gone to "sleep" or after 35 minutes, whichever occurs first.

Phase 1: Baseline Scenario Alpha. Individual Beacon Test (PLB and EPIRB). Cold Start. Activate one beacon of each model sequentially in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Priority 1

Phase 2: Baseline Scenario Bravo. Updated Position Test (PLB and EPIRB). Beacons activated in Phase 1 will be transported while still active to an open area that is at least 300 meters from site in Phase 1, to check the "update" capability. The beacons will remain active until the updated position is observed to be transmitted, or 30 minutes has elapsed once the beacon is at the new site. Beacons using external GPS will be cycled off and on at the new site. Priority 1

Phase 3: Baseline Scenario Charlie. While being sprayed with water to simulate heavy rainfall, activate one beacon (PLB and EPIRB) of each model sequentially in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Cold Start. Priority 2

Phase 4: Inland Scenario Alpha. Activate each PLB model in an area with minimal obstructions (e.g., an open area with few trees and a surrounding tree line at least 25 meters away, but not more than 50 meters away to simulate operation in a typical moderate size forest clearing.), so that there is not a significant obstruction to the GPS satellites (at least 5 satellites visible as determined by handheld GPS). Cold Start. Priority 2

Phase 5: Inland Scenario Bravo. Activate each PLB model in an area with moderate overhead obstruction (e.g., under a tree canopy) so that there is moderate obstruction to view of the GPS satellites (at least 3 satellites visible, but no more than 4 satellites visible as determined by handheld GPS). Cold Start. Record with photographs the obscuration of the sky from the canopy. Priority 1

Phase 6: Inland Scenario Charlie. Activate each PLB model in an area with significant overhead obstructions (e.g., under a heavy tree canopy) so that there is significant obstruction to the GPS satellites (1 satellite visible, but no more than 2 satellites visible as determined by handheld GPS). Cold Start. Record with photographs the obscuration of the sky from the canopy. Priority 1

Phase 7: Inland Scenario Delta. Activate each PLB model in an area with minimal overhead obstructions (e.g., an open area with few trees and a surrounding tree line at least 10 meters away, but not more than 15 meters away to simulate operation in a typical small forest clearing.), so that there is not a significant obstruction to the GPS satellites (at least 5 satellites visible as determined by handheld GPS). Cold Start. Priority 1

Phase 8: Inland Scenario Echo. Using the PLB beacons from a prior scenario, activate beacon under dense overhead canopy with zero GPS satellites visible. Activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds and they are separated by no less than 5 feet. Leave operating for multiple LEOSAT passes. Record scanner with audiotape and provide time stamps in audio to capture any inadvertent simultaneous transmissions. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 2

Phase 9: Inland Scenario Foxtrot. Using the PLB beacons from a prior scenario, activate beacon at the bottom of a narrow forested canyon no less than 8 meters deep, plus any trees lining the canyon, without regard to GPS satellites visibility. Activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds and they are separated by no less than 5 feet. Leave operating for multiple LEOSAT passes. Record scanner with audiotape and provide time stamps in audio to capture any inadvertent simultaneous transmissions. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 2

Phase 10: Inland Scenario Golf: Locate test site ensuring a clear line-of-sight to GOES East / West and no less than 4 available GPS satellites. Activate each PLB model while under metallic or other cover that ensures that no GPS satellites are visible to the beacon. After 20 minutes, remove cover and operate for another 20 minutes or until GPS coordinates are transmitted. This is a test of a circumstance where the beacon is initially activated by a survivor without due consideration of satellite visibility, under cover, and who subsequently moves to an area of better satellite visibility, either to be more visible for search aircraft or as a result of further consideration of the beacon operational limitations, taking the activated beacon with him/her. Cold Start. Priority 2, subject to beacon availability.

Phase 11: Inland Scenario Hotel. Using the PLBs from prior phase, activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Each beacon shall be separated from the others by no less than 10 feet. Tip over each beacon so antenna is horizontal to the ground, but not touching the ground to simulate being inadvertently tipped over. All antennas shall point in the same direction. Leave operating in this position for as long as practical. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 3

Phase 12: Inland Scenario India. Using the PLBs from prior phase, activate one beacon of each model sequentially such that each beacon transmits approximately every 10-15 seconds in an open area at the test site, ensuring a clear line-of-sight to GOES East / West and no less than 6 available GPS satellites. Each beacon shall be separated from the others by no less than 10 feet. Tip over each beacon so antenna is horizontal to the ground with the antenna tip, but no other portion of the antenna touching the ground to simulate being inadvertently tipped over. All antennas shall point in the same direction. Leave operating in this position for as long as practical. This is primarily a test of the 406 MHz distress signal, not the GPS location capability. Priority 3

Additional Inland Scenarios may be considered based on available resources.

For the Maritime Scenarios the boat(s) will proceed offshore, to simulate conditions on open seas. As practical, effort will be made to seek out or simulate consistent non-stable conditions at sea.

Phase 13: Maritime Scenario Alpha. Activate each beacon model (PLB and EPIRB) in an upright position in the boat's cockpit. Cold Start. Priority 1

Phase 14. Maritime Scenario Bravo. Each EPIRB model will be activated and set afloat, attached with its tether to a life raft, RIB or otherwise moored away from the mother vessel. If possible to ensure separation by at least 20 feet, activate multiple beacons such that each beacon transmits approximately every 15 seconds. Cold Start. Priority 1

Phase 15. Maritime Scenario Charlie. While being sprayed with water to simulate heavy rainfall, each EPIRB model will be activated and set afloat, attached with its tether to a life raft or RIB. Cold Start. Priority 2

Phase 16. Maritime Scenario Delta. Each beacon (PLB and EPIRB) will be secured inside a life raft with the antenna vertical and activated with the canopy partially closed as initially erected providing partial sky obscuration. Record and photograph obscuration. A beast as possible, ensure equal or nearly equal satellite visibility to all the beacons. Cold Start. Priority 1

Phase 17. Maritime Scenario Echo. Each beacon (PLB and EPIRB) used will be secured inside a life raft with the antenna vertical and activated with the canopy fully closed to simulate activation in adverse weather conditions. Cold Start. Priority 1

Phase 18. Maritime Scenario Foxtrot. Each beacon (PLB and EPIRB) used will be secured inside a life raft with the antenna vertical and activated with the canopy fully closed and while simulating heavy rain on the canopy to simulate activation in adverse weather conditions. Cold Start if possible, otherwise use beacon from previous day. Priority 2

Phase 19: Maritime Scenario Golf. Person in PFD (and/or survival suit depending upon water temperature) will enter water, activate each PLB, then dunk PLB in water and without draining any water from any cavities that might naturally retain water, hold it on top of chest to simulate a typical man overboard situation in moderate to severe weather and sea conditions where the beacon is regularly drenched with water. Cold Start. Priority 1

Phase 20: Maritime Scenario Hotel. Person in PFD (and/or survival suit depending upon water temperature) will enter water and while being sprayed with water to simulate heavy rainfall, will activate each PLB, holding it on top of chest to simulate a typical man overboard situation in adverse weather conditions with heavy rain. Cold Start. Priority 1

Phase 21: Maritime Scenario India. Using a stable pool of water, while restraining beacon in water with base of antenna submerged, but with water covering no more than 1/2 inch over top of beacon case, activate each PLB to simulate a typical man overboard situation in adverse weather conditions where beacon is partially submerged continuously due to wave action or survival equipment or survivor performance deficiencies. Priority 2

Additional Maritime Scenarios may be considered based on available resources. If time and resources allow, additional test sequence may be conducted with the life raft insulated floor in place to determine what, if any, effect the metalized floor has on beacon performance (406 MHz only, not GPS) in the life raft.

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Appendix 3

Original Field Test Schedule

Tentative Schedule
(updated January 5, 2004)

Schedule will be adjusted as necessary depending on how testing progresses. Starting times are preliminary and may be changed according to circumstances. Tests have been prioritized and higher priority tests will be conducted first with lower priority tests conducted as time allows.

Friday, Jan. 16

Doug Ritter arrives Bay Area (meets/picks up Dave Higdon at OAK)

Saturday, Jan 17

0800: DR and Higdon pick up Panel Van from Ryder

1000: Meet West Marine Representative at West Marine, Watsonville
- Unpack, assign and label all beacons for test phases, measure activation offset for each model beacon.
- Test all shipped gear
- Load all gear for transport
  - Doug Ritter
  - West Marine Representative (TBA)
  - Dave Foster
  - Dave Higdon
  - Other participants welcome

Run logistics errands as necessary
- Pick up Air Pots at Alexis Party Rental

Test Fire Pump if time allows

Dinner on own

Sunday, Jan 18

0800: Meet at Santa Cruz Harbor and review logistics and installation of test sets and equipment into RIB and SV Willow, test all gear and installation as necessary (may require brief trip out of harbor)
- Doug Ritter
- Carl Ruhne
- Bill Street
- Kevin Holmes
- Dave Foster
- West Marine Representative(s) (TBA)
- Phil Cowley (West Marine)
- Other participants welcome

Run logistics errands as necessary

After Harbor set-up completed, if time allows, drive to terrestrial test sites and review logistics for each.

1800: Kick-off Dinner – All participants welcome. Location and Details TBA

Monday, Jan 19

TBA before operations underway: Denis Inman picks up lunches

0730: General Meeting – Seacliff meeting room
Introductions
Administrative details and handouts
Issue Harbor Parking Permits to car pool drivers
Sign and witness Waivers and NDAs
Witness re-coding of ACR beacons

0800: Logistics and RIB crew departs for Santa Cruz Lighthouse Jetty and unloads and sets up equipment (RIB crew to ready RIB and fire pump or remove pump from RIB and transport to Jetty, depending upon conditions)

0900: Depart for Santa Cruz Lighthouse Jetty and harbor

0930: Testing commences: Baseline tests, Inland Hotel, Maritime India

If sufficient time remains in the afternoon to conduct Inland Alpha, drive to site and conduct testing.

Dinner on own

Tuesday, Jan. 20

TBA before operations underway: Denis Inman picks up lunches

0730: Logistics crew arrives boats and loads equipment

0800: Meet at Santa Cruz Harbor, Board Boat, Safety Brief

0830: Cast off lines; depart for test site offshore

0930: Arrive test site and commence maritime testing

1800: Depart test site for harbor

1900: Arrive Dock – Dinner on own

Wednesday, Jan. 21

TBA before operations underway: Denis Inman picks up lunches

0730: Logistics crew arrives boats and loads equipment

0800: Meet at Santa Cruz Harbor

0830: Cast off lines; depart for test site offshore

0930: Arrive test site and commence maritime testing

1800: Depart test site for harbor

1900: Arrive Dock – Dinner on own

Thursday, Jan. 22

TBA before operations underway: Denis Inman picks up lunches

0730: Logistics crew arrives Forest of Nisene Marks State Park test site and unloads and sets up equipment

0800: Meet at Forest of Nisene Marks State Park test site

0830: Testing commences

If sufficient time remains in the afternoon to conduct Inland Alpha, drive to site and conduct testing.

Dinner on own

Friday, Jan. 23

TBA before operations underway: Denis Inman picks up lunches

0730: Logistics crew arrives Forest of Nisene Marks State Park test site and unloads and sets up equipment

0800: Meet at Forest of Nisene Marks State Park test site

0830: Testing commences

If sufficient time remains in the afternoon to conduct Inland Alpha, drive to site and conduct testing.

1900: Wrap-up Dinner – All participants welcome. Location and Details TBA

Saturday, Jan. 24

0800: Meet at West Marine, Watsonville
    Unload van and pack all gear for shipping.
    Doug Ritter
    Dave Foster
    West Marine Representative (TBA)

1500: Depart for Bay Area

1700: Latest drop off of van at Ryder

TBA: Doug departs Bay Area

Appendix 4

Imanna Laboratories Test Report

INTERMODAL MATERIÉL AND NAUTICAL/NUCLEAR ANALYSIS
IMANNA LABORATORY INC.

CERTIFICATION TEST

515 Gus Hipp Blvd.
Rockledge, Florida 32955-4810
Telephone (321) 632-2008
http://www.imanna.com

Post Office Box 560933
Rockledge, Florida 32956-0933
FAX (321) 690-3360
E-mail: imanna@yourlink.net

TEST REPORT 16335-1
COMPARATIVE EVALUATIONS
OF
VARIOUS PLB AND EPIRB UNITS
FOR PURPOSES OF
INTERPRETING AND SUPPORTING
FIELD TEST EVALUATION DATA
AND
FOR DETERMINATION OF BATTERY
LIFE AT MINIMUM RATED
OPERATING TEMPERATURE

CUSTOMER:

EQUIPPED TO SURVIVE FOUNDATION
2211 W. ROCKROSE PLACE
CHANDLER, AZ 85248-4208

MANUFACTURER OF TEST ARTICLE: VARIOUS

REPORT NO.: 16335-1
IMANNA JOB NO.: 16335
CUSTOMER P.O. NO.: LETTER
CONTRACT: N/A

DATE: March 9, 2004

PAGES IN 48

STATE OF FLORIDA

ROBERT L. WHITE being duly sworn, deposes and says: The information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

Robert L. White

SUBSCRIBED and sworn to before me this 19th day of March, 2004

David H. Hudgins

David H. Hudgins
Commission # DD 010632
Expires May 3, 2005
Bonded Thru
Atlantic Bonding Co., Inc.

Imanna shall have no liability for damages of any kind to person or property, including special or consequential damages resulting from Imanna's providing the service covered by the report.

IMANNA LABORATORY, Inc.
TEST BY

Robert L. White
PROJ. MANAGER

TABLE OF CONTENTS

1. TEST ARTICLE

   Several samples of Personal Locator Beacons (PLB) and Emergency Position radio Indicating Beacons (EPIRB) were received for test. The beacons received are as listed below:

PLBs – Personal Locator Beacons

"McMurdo Fast Find 406MHz **P**ersonal **L**ocator **B**eacon"

Serial# 530-194 UID# 2DD6C1443F81FE0
Serial# 530-321 UID# 2DD6C1543F81FE0
Serial# 530-330 UID# 2DD6C14F3F81FE0
Serial# 530-349 UID# 2DD6C13B3F81FE0

"ACR 406MHz **P**ersonal **L**ocator **B**eacon w/GPS Interface"

Serial# 2419 UID# 2DCE3692E6FFBFF
Serial# 2420 UID# 2DCE3692E8FFBFF
Serial# 2431 UID# 2DCE3692FEFFBFF
Serial# 2449 UID# 2DCE369322FFBFF

"TechTest Ltd – ELT" (Emergency Locator Transmitter)

Model# 500-27 Serial# 446
Model# 500-27 Serial# 447

EPIRBs – Emergency Position Radio Indicating Beacons

"ACR GlobalFix 406 EPIRB with integral GPS"

Serial# 2435 UID# 2DCC3F9306FFBFF
Serial# 2444 UID# 2DCC3F9318FFBFF
Serial# 2463 UID# 2DCC3F933EFFBFF
Serial# 2467 UID# 2DCC3F9346FFBFF

"ACR RapidFix 406MHz EPIRB with GPS interface"

Serial# 8103 UID# 2DCC363F4EFFBFF
Serial# 8130 UID# 2DCC363F84FFBFF
Serial# 8138 UID# 2DCC363F94FFBFF
Serial# 8141 UID# 2DCC363F9AFFBFF

"McMurdo Precision 406 EPIRB with Integral 12-channel GPS Receiver"

Serial# 33-1070 UID# 2DD42F083F81FE0
Serial# 33-1079 UID# 2DD42F0D3F81FE0
Serial# 33-1090 UID# 2DD42F14BF81FE0
Serial# 33-1094 UID# 2DD42F13BF81FE0

Figure 1 View of test articles received.

2. <u>TEST DEFINITION</u>

General

Prior to commencing the below tests, verify and record the ID of every beacon to be used in the testing; clearly label all beacons for quick ID at the test site. Secure and seal all beacons to ensure and maintain chain of custody. Beacons will be selected at random from the beacon pool of each model for any particular test scenario.

Test protocols subject to revision with concurrence of sponsors.

For reasons of safety and security, all on site participants and observers shall immediately comply with any reasonable request of the evaluation organizer. A liability waiver and confidentiality agreement provided by the organizer must be signed by all participants and observers. U.S. government employees are exempted from the liability waiver requirement.

LABORATORY TEST PROTOCOL DETAILS

The following details are intended to supplement the general test protocol listed in Doug Ritter's November 6, 2003 e-mail. To prevent inadvertent contact with the NOAA satellite, all tests with the units in operational configuration, will be conducted inside a sealed RF enclosure. For temperature tests, the thermal chamber will be relocated inside the RF enclosure.

The signal strength tests will be conducted inside a RF enclosure, and final details of the test procedure will be documented at the time of test. The signal strength will be measured as a power radiating from the Unit Under Test (UUT) antenna as received by another antenna placed inside the RF enclosure. Care will be taken to minimize effects of standing waves inside the enclosure, and the final selection of test equipment will be based upon the engineering assessment of the conditions and desired parameters. An assortment of antennae and equipment is available to select from in real time to obtain the most appropriate and accurate test data; however, selection must be made at the time of test. Final selection criteria will be documented along with the selection rationale. The RF signal will be measured using a spectrum analyzer, and the results of the measurements will be recorded using the screen capture capabilities of the analyzer. The environmental conditions inside the RF enclosure will be normal lab air conditioning temperature and humidity, recorded at the time of test.

To determine the effects of water on the UUT, a plastic rain enclosure containing fresh water will be used to wet the unit and the antenna. The “simulated rain mist” will fall vertically on the UUT to simulate “real world” conditions in the open environment. Wetting will continue throughout the data collection activity. Care will be taken to prohibit signal attenuation or amplification by using the fixture. Before and after signal comparisons with a “dry” fixture will be taken to verify the test set-up. Signal strength will be recorded during the wetting to determine the effects to the transmitted signal. This test will be conducted in the RF enclosure, with the same care and procedures listed above for the radiated signal strength.

It is estimated that the battery tests will be determined on individual units serially to prevent signal interactions and simplify the data taking. It may be possible to correlate the radiated signal strength to the antenna input, and record directly from the unit; however, current plans are to measure the output via radiated signal from the antenna. Care will be taken to document the near-field effects of the test equipment, and take measures to minimize (or eliminate, if possible) the effects. If effects are significant, the effects may be reduced by placing the UUT inside a non-metal extension on the front of the chamber, and leaving the metal door off for the test. The temperature chamber has a range of -73°C to +150°C allowing a broad selection of test temperatures, should the test conductor demand temperatures in addition to those low temperatures itemized in the test definition e-mail.

3. PROCEDURES

The beacons are to be tested in accordance with the following test definition described above. The procedures follow general laboratory accepted procedures with specific considerations for the uniqueness of the test article. Care was taken to prevent data alterations occurring as a result of the test environment and test article fixturing. All test set-ups were identical for every test article experiencing the same test to prevent differences from test article to test article. All tests that required activation of the test article were performed inside the RF screen room to prevent satellite contact.

4. RECEIVING INSPECTION

General information of the receiving inspection is given here. A video tape of the receiving inspection was taken for detail observations if needed for future discussions.

The shipping boxes which were received were kept, unopened, until the day of testing was to commence. The representative of Equipped To Survive was present and assisted in the opening of the test article boxes. Each test article was taken from the shipping box and all available information on the packaging or directly on the article that gave descriptive information about the device was recorded.

The following information was recorded for the test articles received:

McMurdo PLB Fast Find Plus

1) Identification number – 530-194
   Open the battery cover to find the beacon number – 2DD6C1443F81FE0
2) Identification number – 530-330
   Open the battery cover to find the beacon number – 2DD6C14F3F81FE0
3) Identification number – 530-321
   Open the battery cover to find the beacon number – 2DD6C1543F81FE0
4) Identification number – 530-349
   Open the battery cover to find the beacon number – 2DD6C13B3F81FE0

Techtest LTD – ELT PLB

1) Serial Number – 446
   Installed O-Ring and battery on the unit and taped lanyard to prevent inadvertent turn-on
2) Serial Number – 447
   Installed O-Ring and battery on the unit and taped lanyard to prevent inadvertent turn-on

ACR 406 mHz PLB with GPS interface

1) Serial number -- 2431
   Beacon ID – 2DCE3692FEFFBFF
2) Serial number – 2419
   Beacon ID – 2DCE3692E6FFBFF
3) Serial number – 2449
   Beacon ID – 2DCE369322FFBFF
4) Serial number – 2420
   Beacon ID – 2DCE3692E8FFBFF

ACR EPIRB – GLOBAL FIX with integral GPS

1) Serial number – 2435
   ID – 2DCC3F9306FFBFF
2) Serial number – 2467
   ID – 2DCC3F9346FFBFF
3) Serial number – 2463
   ID – 2DCC3F933EFFBFF
4) Serial number – 2444

ID – 2DCC3F9318FFBFF

ACR RAPIX FIX 406 EPIRB with GPS interface

1) Serial number – 8103

   ID – 2DCC363F4EFFBFF

2) Serial number – 8141

   ID – 2DCC363F9AFFBFF

3) Serial number – 8130

   ID – 2DCC363F84FFBFF

4) Serial number – 8138

   ID – 2DCC363F94FFBFF

McMurdo PRECISION 406 EPIRB with Integral 12-channel GPS receiver

1) Serial Number 33-1079

   Serialized Number 0024090

   User ID – 2DD42F0D3F81FEO

2) Serial Number 33-1090

   Serialized Number 0024105

   User ID – 2DD42F14BF81FEO

3) Serial Number 33-1070

   Serialized Number 0024080

   User ID – 2DD42F083F81FEO

4) Serial Number 33-1094

   Serialized Number 0024103

   User ID – 2DD42F13BF81FEO

5. RESULTS

Radiated Emissions with UUT dry

McMurdo PRECISION 406 EPIRB with Integral 12-channel GPS receiver

The field strength around the unit appeared generally consistent except for points at approximately 135 to 195 degrees from the initial starting position.

The dip in radiated emissions appeared in both the 406 and 121.5 MHz frequencies at the same rotational point in the 10 degree source position.

The dip in radiated emissions was not as pronounced at the 40 degree source position.

At the 40 degree source position, the 121.5 MHz frequency appeared to be consistent at all rotational angles.

McMurdo Fastfind Plus 406 PLB

The field strength around the unit appeared generally consistent except for points at approximately 135 ± 30 degrees from the initial starting position. A detailed investigation was conducted to verify the initial indication. The detailed investigation showed that the signal did dip in the suspect region.

The dip in radiated emissions appeared in both the 406 and 121.5 MHz frequencies at the same rotational point in the 10 degree source position.

The reduction in field strength was approximately 20 dBµV and was centered at approximately 140 degrees of rotation from the initial starting position.

The dip in radiated emissions was not as pronounced at the 40 degree source position.

ACR GlobalFix 406 EPIRB with integral GPS

The field strength around the unit appeared generally consistent at both the 10 degree source position and the 40 degree source position.

The field strength appeared to be somewhat higher at the 40 degree source position over the 10 degree source position.

The increase in field strength at the 40 degree source position was evident in both the 121.5 and the 406 MHz bands.

ACR RapidFix 406 MHz EPIRB with GPS interface

The field strength around the unit appeared generally consistent except for points at approximately 90 and 315 degrees from the initial starting position.

The dip in radiated emissions appeared to be more pronounced in the 406 MHz band than in the 121.5 MHz frequency at the same rotational point in the 10 degree source position.

The dip in radiated emissions was not as pronounced at the 40 degree source position.

At the 40 degree source position, the 406 and 121.5 MHz signal strength appeared to be consistent at all rotational angles.

ACR 406 MHz PLB with GPS interface

The field strength around the unit appeared generally consistent except for points at approximately 135 and 315 degrees from the initial starting position.

The dip in radiated emissions appeared to be more pronounced in the 406 MHz band than in the 121.5 MHz frequency at the same rotational point in the 10 degree source position.

The dip in radiated emissions was not as pronounced at the 40 degree source position.

At the 40 degree source position, the 406 and 121.5 MHz signal strength appeared to be consistent at all rotational angles.

Techtest Limited ELT

The field strength around the unit appeared generally consistent except for points at approximately 0 and 315 degrees from the initial starting position in the 406 MHz signal.

The field strength around the unit appeared generally consistent except for points at approximately 45 to 90 degrees from the initial starting position in the 121.5 MHz signal.

The dip in radiated emissions appeared to be fairly consistent in the 406 MHz band and in the 121.5 MHz frequency but occurred at different rotational points in the 10 degree source position.

The dip in radiated emissions was not as pronounced at the 40 degree source position.

At the 40 degree source position, the 406 and 121.5 MHz signal strength appeared to be much more consistent at all rotational angles.

Rain Test using 2.8% Salt Solution as the rain drops

McMurdo Fastfind Plus 406 PLB

The radiated signal strength diminished with water in the antenna well.

The radiated strength attenuation was not as pronounced when the water splashed in the well keeping the level of the liquid lower than the depth of the well

The radiated signal strength attenuated more when the unit was placed in water so the UUT was immersed in two inches of water.

The unit was placed in the horizontal position for the body, but with the antenna vertical for all portions of the rain test.

All measurements taken with the unit wetted were lower than the baseline measurement taken with the unit dry before the test.

The signal attenuation was pronounced in both the 406 MHz and the 121.5 MHz bands when the unit was wetted.

The lowest readings were measured when the unit was immersed in two inches of saltwater.

ACR 406 MHz PLB with GPS interface

The radiated signal strength diminished with saltwater wetting of the UUT.

The radiated signal strength attenuated more when the unit was placed in water so the UUT was immersed in 1.75 inches of water than when immersed in 2 inches of water.

All measurements taken with the unit wetted were lower than the baseline measurement taken with the unit dry before the test.

The signal attenuation was pronounced in the 406 MHz; however, the signal strength for the 121.5 MHz band was higher when the unit was wetted than the baseline measurement taken with the UUT dry.

The lowest readings for the 121.5 MHz band were measured when the unit was immersed in two inches of saltwater.

Techtest Limited ELT

The radiated signal strength attenuated more when the unit was placed in water so the UUT was immersed in two inches of water.

The radiated signal strength was higher with the UUT vertical than when the UUT was horizontal.

The signal attenuation was pronounced in both the 406 MHz and the 121.5 MHz bands when the unit was wetted.

The lowest readings for both the 406 MHz and the 121.5 MHz bands were measured when the unit was immersed in two inches of saltwater and was horizontal.

Cold Test for Battery life (-20°C)

McMurdo Fastfind Plus 406 PLB

The unit operated at a fairly consistent signal out put for 38 hours of continuous operation at the cold temperature.
The signal level did not vary significantly over the run period except when the battery voltage dropped drastically at the end of the 38 hours.
Both the 121.5 MHz and the 406 MHz signal remained level during the run period.
Both the 121.5 MHz and the 406 MHz signals decayed at the same time.

ACR 406 MHz PLB with GPS interface

The unit operated at a fairly consistent signal out put for 44 hours of continuous operation at the cold temperature.
The signal level did not vary significantly over the 44-hour run period except when the battery voltage began to drop drastically at the end of the 44 hours.
The UUT had a reducing signal level for the 45th and 46th hours before it completely diminished after 47 hours of continuous operation at the -20°C temperature.
Both the 121.5 MHz and the 406 MHz signal remained level during the run period.
Both the 121.5 MHz and the 406 MHz signals decayed at the same time.

Techtest Limited ELT

The unit was placed in the cold temperature following the rain test and found to operate for only 2 hours.
The manufacturer's representative that was present indicated that the battery that was in the unit was deteriorated from previous tests and ordered a new replacement battery. The replacement battery was installed on the original UUT and the cold test was re-initiated.
The unit with the replacement battery operated at a fairly consistent signal out put for 27 hours of continuous operation at the cold temperature.
The signal level did not vary significantly over the run period except when the battery voltage dropped drastically at the end of the 27 hours.
The UUT had a reducing signal level for the 28th and 29th hours before it completely diminished after 29 hours of continuous operation at the -20°C temperature.
Both the 121.5 MHz and the 406 MHz signal remained level during the run period for the first 17 hours of operation. The 121.5 MHz signal began showing a decrease in output at the 18th hour.
The 121.5 MHz signal showed the same reduced level from the 18th hour until the 28th hour.
Both the 121.5 MHz and the 406 MHz signals stopped emitting from the UUT at the same time.

Cold Test for Battery life (-40°C)

ACR 406 MHz PLB with GPS interface

This unit was advertised on the unit as having a -40°C lower temperature limit. The unit was tested at the labeled temperature for this test.

After a 2-hour preconditioning period at -40°C, the unit was turned on and operated in the -40°C ambient environment. The unit showed a good signal strength during the first hour of operation, then began to show decreasing signal strength over the next hour of operation at the cold temperature. At the end of the second hour of operation, the signal strength was approximately half of the signal strength at the beginning of the run period. At the end of the second hour, the unit showed no signal output in the 406 MHz or the 121.5 MHz bands.

It is to be noted that this particular unit was exposed to the rain test prior to starting the cold temperature test, and the exposure may have contributed to the premature failure at -40°C. The section below describes the results on an identical unit that was not exposed to the rain test prior to performing the cold temperature operation test.

ACR 406 MHz PLB with GPS interface (second unit test)

This unit is identical to the unit described as tested above. Based on the premature signal depletion, this second unit was selected from the items received and tested to determine if it responded in the same fashion as the first unit tested.

This unit was advertised on the unit as having a -40°C lower temperature limit. The unit was tested at the labeled temperature for this test.

The unit operated at a fairly consistent signal out put for 44 hours of continuous operation at the cold temperature of -40°C.

The signal level did not vary significantly over the 44-hour run period except when the battery voltage began to drop drastically at the end of the 44 hours.

The UUT had a reducing signal level for the 45th and 46th hours before it completely diminished after 47 hours of continuous operation at the -40°C temperature.

Both the 121.5 MHz and the 406 MHz signal remained level during the run period.

Both the 121.5 MHz and the 406 MHz signals decayed at the same time.

6. CONCLUSIONS

During the laboratory tests the need to be inside a sealed RF enclosure to prevent satellite contact causes some concern for the "near-field effects" of a transmitting beacon signal. The presence of the perturbations was considered to be acceptable if the measured data can be construed as "trend" or "comparative" data only. For this reason, the reader of this report is cautioned to view the recorded data for comparative purposes only and not place undue criticism on or faith in absolute numerical values. The data presented is to be viewed as investigatory trending, such as assessing the attenuation of the emitted signal with water contact as a possibility with an order of magnitude expression. The reader is reminded that scaling is important in reading the collected data that is presented herein. A 3dbµV loss is representative of a decrease in radiated power of ½ the original signal, and for every additional 3dbµV loss the power is again halved. Notes and color coding is provided on the data sheets as a reminder of this. The signal variance that was measured in the RF enclosure may well be attributed to the "near-field effects" in the small measurement distance and irrelevant in field tests.

The laboratory data (with the exception of the battery life tests conducted at low temperature) was intended to be a help guide for future field tests that would more accurately determine the effectiveness of the various devices in contacting the satellite system and obtaining a position fix under real world conditions. An example of the discussion that would be appropriate for the lab test data is as follows: *If water contact has "significant" attenuation evidence in the lab tests, then it would be appropriate to investigate the more absolute effect during the field tests*. Hence, the lab test results are to be taken as road map guides for true field evaluations. The relative field strengths of the lab tests are important only in respect to being evidence of a condition that should be investigated in true operation conditions in the field tests.

With the aforementioned cautions in mind, the following conclusions are drawn from the lab test data:

- There appears to be a significant signal attenuation associated with saltwater contact and especially so, for units with an antenna well that can hold the water in contact with the base of the antenna for an extended length of time.
- Battery life appears to be better than the minimum required by the regulations, and better than manufacturer's claims, even in extreme cold conditions.
- Battery life may be compromised by test checks during long term storage and adverse environmental conditions in PLBs and EPIRBs just as in other battery powered devices.
- Some "real world" conditions such as rain and temperature can affect either the 406 MHz signal or the 121.5MHz signal and not necessarily in the same manner.
- A better set of laboratory tests is needed. While laboratory tests are included in the current regulations, the tests do not capture the actual antenna emissions to evaluate realistic performance radiating into the free air from the antenna itself. Current regulatory lab tests measure the input to the antenna and not radiation from the antenna under a set of conditions that would reveal real world operation in adverse conditions. Better laboratory tests or actual transmission tests under more realistic use conditions would better serve the industry by giving the trend in transmission signatures that appear to be available as evidenced in the simplistic laboratory tests conducted in this effort.
- Signal strengths in both RF bands appear to be consistent over an extended run period and not varying significantly in their magnitude as radiated from the antenna for the devices tested and with good battery power available.
- Some of the devices tested have signature patterns that do allow dips in the radiated signal coming from the antenna. These signal dips could be significant in SAR activities if the device is oriented in the direction that the dip would be toward the satellite or the SAR personnel.

APPENDIX A
SUPPORTING DATA
FOR
McMURDO UNITS
FOR DRY OPERATION TEST

UUT: **MCMURDO**
MODEL: **Precision 406 / GPS EPRIB**
SERIAL: **Serial# 33-1094 UID# 2DD42F13BF81FE0**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10-11/2003**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	0	109.2	10	119.2	52.0	10	62.0
10	45	108.0	10	118.0	52.8	10	62.8
10	90	99.6	10	109.6	50.2	10	60.2
10	135	109.7	10	119.7	44.0	10	54.0
10	180	112.1	10	122.1	47.1	10	57.1
10	225	111.3	10	121.3	50.0	10	60.0
10	270	106.7	10	116.7	50.2	10	60.2
10	315	99.8	10	109.8	50.3	10	60.3
40	0	109.9	10	119.9	67.8	10	77.8
40	45	110.4	10	120.4	67.8	10	77.8
40	90	110.0	10	120.0	68.8	10	78.8
40	135	107.1	10	117.1	69.1	10	79.1
40	180	102.5	10	112.5	69.6	10	79.6
40	225	98.9	10	108.9	69.6	10	79.6
40	270	101.1	10	111.1	69.0	10	79.0
40	315	108.1	10	118.1	68.3	10	78.3

Data verified by: C.E. Herhold, NCE

UUT: **MCMURDO**
MODEL: **Fastfind Plus 406 PLB** (Personal Locator Beacon)
SERIAL: **Serial# 530-321 UID# 2DD6C1543F81FE0**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10-11/2003**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	0	100.8	10	110.8	49.4	10	59.4
10	45	103.0	10	113.0	49.8	10	59.8
10	90	102.9	10	112.9	46.4	10	56.4
10	135	102.0	10	112.0	** 26.2	10	36.2
10	180	102.6	10	112.6	45.2	10	55.2
10	225	103.0	10	113.0	48.5	10	58.5
10	270	103.2	10	113.2	43.9	10	53.9
10	315	101.5	10	111.5	40.5	10	50.5
40	0	111.3	10	121.3	56.1	10	66.1
40	45	110.7	10	120.7	54.1	10	64.1
40	90	112.8	10	122.8	46.9	10	56.9
40	135	115.4	10	125.4	42.6	10	52.6
40	180	116.2	10	126.2	46.7	10	56.7
40	225	115.0	10	125.0	40.1	10	50.1
40	270	112.3	10	122.3	48.1	10	58.1
40	315	112.0	10	122.0	54.6	10	64.6

** Low value at this measurement point confirmed and investigated further with a detailed scan.
NOTE:This color represents a drop to 1/2 of original radiated power (1 order of magnitude)
NOTE:This color represents a drop of 7 orders of magnitude in radiated power
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 orders of magnitude in radiated power
Data verified by: C. E. Herhold, NCE

UUT: **MCMURDO**
MODEL: **Fastfind 406 PLB** (Personal Locator Beacon)
SERIAL: **Serial# 530-321 UID# 2DD6C1543F81FE0**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
NOTES: **DETAILED MEASUREMENTS AROUND ** DATA POINT NOTED ABOVE.**
DATE: **12/11/03**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	90	- - -	- - -	- - -	46.1	10	56.1
10	95	- - -	- - -	- - -	45.4	10	55.4
10	100	- - -	- - -	- - -	44.7	10	54.7
10	105	- - -	- - -	- - -	43.9	10	53.9
10	110	- - -	- - -	- - -	42.7	10	52.7
10	115	- - -	- - -	- - -	41.4	10	51.4
10	120	- - -	- - -	- - -	39.6	10	49.6
10	125	- - -	- - -	- - -	37.4	10	47.4
10	130	- - -	- - -	- - -	34.5	10	44.5
10	135	- - -	- - -	- - -	29.8	10	39.8
10	140	- - -	- - -	- - -	## 16.7	10	26.7
10	145	- - -	- - -	- - -	26.8	10	36.8
10	150	- - -	- - -	- - -	33.0	10	43.0
10	155	- - -	- - -	- - -	36.3	10	46.3
10	160	- - -	- - -	- - -	39.3	10	49.3
10	165	- - -	- - -	- - -	41.3	10	51.3
10	170	- - -	- - -	- - -	42.8	10	52.8
10	175	- - -	- - -	- - -	43.9	10	53.9
10	180	- - -	- - -	- - -	45.1	10	55.1

This anomaly was observed under conditions noted above, not in an open field.
NOTE:This color represents a drop to 1/2 of original radiated power (1 order of magnitude)
NOTE:This color represents a drop of 7 orders of magnitude in radiated power
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 orders of magnitude in radiated power
NOTE: This color represents a drop on nearly 10 orders of magnitude in radiated power
Data verified by: C. E. Herhold, NCE

APPENDIX B
SUPPORTING DATA
FOR
McMURDO RAIN TEST

UUT: **McMurdo**
MODEL: **FastFind 406 PLB** (Personal Locator Beacon)
SERIAL: **Serial# 530-321 UID# 2DD6C1543F81FE0**
TEST: Radiated Emissions measurements for comparative evaluations.
Emergency transmitters are subjected to simulated rain under controlled conditions.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **RAIN TEST (2.8% SALT SOLUTION)**
DATE: **12/11/03**

	EUT (Body) Position	Meas'ment Count	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
A	Horizontal	Base Line	108.3	10	118.3	42.0	10	52.0
	Horizontal	DSH-R 1	99.6	10	109.6	39.0	10	49.0
	Horizontal	2	99.8	10	109.8	38.6	10	48.6
	Horizontal	3	99.1	10	109.1	38.9	10	48.9
	Horizontal	4	99.8	10	109.8	38.5	10	48.5
	Horizontal	5	98.7	10	108.7	38.8	10	48.8
	Horizontal	6	101.0	10	111.0	40.1	10	50.1
	Horizontal	WSH-R 1	97.6	10	107.6	37.2	10	47.2
	Horizontal	2	98.0	10	108.0	36.9	10	46.9
	Horizontal	3	97.8	10	107.8	37.0	10	47.0
	Horizontal	4	98.4	10	108.4	36.9	10	46.9
B →	Horizontal	5	97.6	10	107.6	36.6	10	46.6
	Horizontal	AWF-RS 1	94.1	10	104.1	38.1	10	48.1
	Horizontal	2	94.0	10	104.0	37.7	10	47.7
	Horizontal	3	94.0	10	104.0	38.0	10	48.0
	Horizontal	4	94.0	10	104.0	37.9	10	47.9
	Horizontal	WSH-R2 1	98.3	10	108.3	35.5	10	45.5
	Horizontal	2	98.7	10	108.7	35.9	10	45.9
	Horizontal	3	100.6	10	110.6	35.8	10	45.8
	Horizontal	4	98.8	10	108.8	36.0	10	46.0
	Horizontal	IMMH 1	86.7	10	96.7	7.3	10	17.3
	Horizontal	2	86.6	10	96.6	7.3	10	17.3
	Horizontal	3	86.6	10	96.6	7.3	10	17.3
	Horizontal	4	86.6	10	96.6	4.1	10	14.1
	Horizontal	5	86.6	10	96.6	6.3	10	16.3

A Dry Baseline data prior to test. For this test series; the UUT body is *Horizontal* , its antenna is *Vertical* .
DSH-R Dry-Start in Rain. UUT is Horizontal. Consecutive (follow-on) measurements show trend if any.
WSH-R Wet-Start in Rain. UUT is Horizontal. Consecutive measurements show trend if any.
B Up to this instant, rain has been driving water out of the antenna well.
AWF-RS Antenna Well Filled, Rain Stopped.
WSH-R2 Wet-Start in Rain. UUT is Horizontal. Rain no longer driving antenna well empty.
IMMH UUT is IMMersed in two inches of water and Horizontal. Consecutive measurements show trend if any.

NOTE:This color represents a drop to 1/2 of original radiated power (1 order of magnitude)
NOTE:This color represents a drop of 7 orders of magnitude in radiated power
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 to 4 orders of magnitude in radiated power
NOTE: This color represents a drop on nearly 10 orders of magnitude in radiated power
NOTE: This color represents an 11 to 12 order of magnitude drop in radiated power

Data verified by: C.E. Herhold, NCE

APPENDIX C
SUPPORTING DATA
FOR
McMURDO COLD TEST

UUT: **MCMURDO**
MODEL: **Fastfind 406 PLB** (Personal Locator Beacon)
SERIAL: **Serial# 530-321 UID# 2DD6C1543F81FE0**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -20°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -20°C**
DATE: **12/12-14/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
12-Dec	8PM	122.4	10	132.4	50.6	10	60.6
12-Dec	9PM	122.5	10	132.5	52.2	10	62.2
12-Dec	10PM	122.9	10	132.9	52.4	10	62.4
12-Dec	11PM	123.0	10	133.0	52.1	10	62.1
12-Dec	12AM	123.1	10	133.1	52.8	10	62.8
13-Dec	1AM	123.1	10	133.1	53.6	10	63.6
13-Dec	2AM	122.9	10	132.9	54.5	10	64.5
13-Dec	3AM	122.9	10	132.9	54.9	10	64.9
13-Dec	4AM	122.9	10	132.9	55.8	10	65.8
13-Dec	5AM	123.0	10	133.0	56.1	10	66.1
13-Dec	6AM	122.9	10	132.9	56.7	10	66.7
13-Dec	7AM	122.7	10	132.7	56.6	10	66.6
13-Dec	8AM	122.8	10	132.8	56.4	10	66.4
13-Dec	9AM	123.0	10	133.0	57.1	10	67.1
13-Dec	10AM	122.9	10	132.9	57.4	10	67.4
13-Dec	11AM	123.0	10	133.0	57.5	10	67.5
13-Dec	12PM	122.3	10	132.3	58.8	10	68.8
13-Dec	1PM	122.0	10	132.0	59.2	10	69.2
13-Dec	2PM	122.0	10	132.0	59.0	10	69.0
13-Dec	3PM	122.2	10	132.2	59.7	10	69.7
13-Dec	4PM	122.3	10	132.3	59.8	10	69.8
13-Dec	5PM	122.3	10	132.3	59.6	10	69.6
13-Dec	6PM	122.3	10	132.3	59.5	10	69.5
13-Dec	7PM	122.2	10	132.2	59.4	10	69.4
13-Dec	8PM	122.2	10	132.2	59.6	10	69.6
13-Dec	9PM	122.1	10	132.1	59.9	10	69.9
13-Dec	10PM	121.6	10	131.6	59.5	10	69.5
13-Dec	11PM	121.6	10	131.6	59.6	10	69.6

Data verified by: C. E. Herhold, NCE

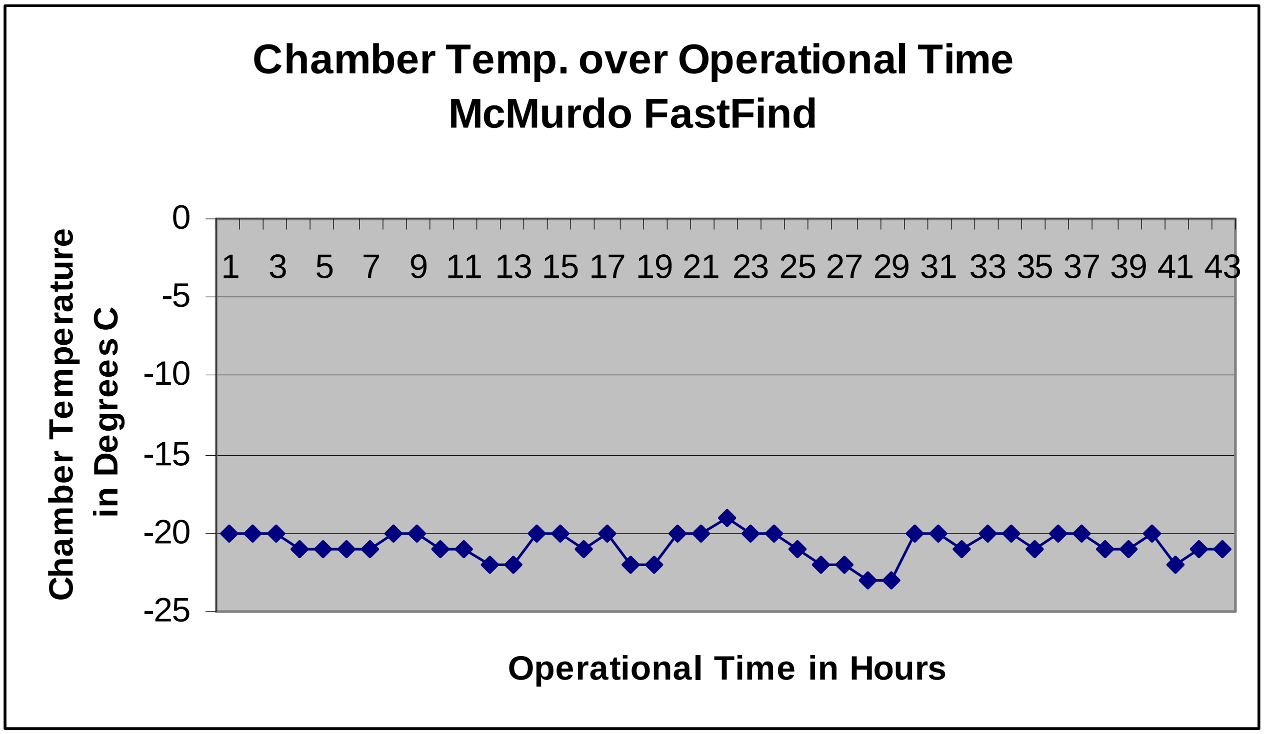
UUT: **MCMURDO**
MODEL: **FAST FIND**
SERIAL: **Serial# 530-321 UID# 2DD6C1543F81FE0**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -20°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -20°C**
DATE: **12/12-14/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
14-Dec	12AM	121.4	10	131.4	59.5	10	69.5
14-Dec	1AM	121.1	10	131.1	59.8	10	69.8
14-Dec	2AM	118.8	10	128.8	60.2	10	70.2
14-Dec	3AM	118.8	10	128.8	60.1	10	70.1
14-Dec	4AM	118.6	10	128.6	59.7	10	69.7
14-Dec	5AM	118.2	10	128.2	59.0	10	69.0
14-Dec	6AM	117.8	10	128.2	57.2	10	67.2
14-Dec	7AM	117.6	10	127.8	56.6	10	66.6
14-Dec	8AM	118.2	10	127.6	52.8	10	62.8
14-Dec	9AM	117.2	10	128.2	46.6	10	56.6
14-Dec	10AM	116.2	10	127.2	37.8	10	47.8
14-Dec	11AM	No Signal			No Signal		

Data verified by: C. E. Herhold, NCE

APPENDIX D
SUPPORTING DATA

TEMPERATURE CHAMBER
TEMPERATURE PLOTS
DURING COLD TEST
McMURDO


Chamber Temp. over Operational Time
McMurdo FastFind
0
-5
-10
-15
-20
-25
Chamber Temperature in Degrees C
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
Operational Time in Hours

APPENDIX E
SUPPORTING DATA
FOR ACR DRY TEST

UUT: **ACR**
MODEL: **GlobalFix 406 EPRIB with integral GPS**
SERIAL: **Serial # 2463 UID# 2DCC3F933EFFBFF**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10/03**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	0	106.7	10	116.7	38.7	10	48.7
10	45	105.9	10	115.9	40.3	10	50.3
10	90	105.4	10	115.4	42.0	10	52.0
10	135	105.7	10	115.7	44.6	10	54.6
10	180	107.1	10	117.1	46.2	10	56.2
10	225	108.1	10	118.1	46.2	10	56.2
10	270	108.4	10	118.4	43.9	10	53.9
10	315	107.7	10	117.7	39.8	10	49.8
40	0	110.6	10	120.6	59.0	10	69.0
40	45	112.3	10	122.3	58.7	10	68.7
40	90	113.3	10	123.3	58.5	10	68.5
40	135	113.0	10	123.0	58.2	10	68.2
40	180	111.2	10	121.2	58.2	10	68.2
40	225	110.1	10	120.1	58.1	10	68.1
40	270	109.7	10	119.7	58.2	10	68.2
40	315	109.6	10	119.6	58.4	10	68.4

NOTE: This color represents a drop of 2 to 3 orders of magnitude in radiated power from maximum

Data verified by: C.E. Herhold, NCE

Figure 2 Typical set-up for dry data test

UUT: **ACR**
MODEL: **RapidFix 406 MHz EPRIB with GPS interface**
SERIAL: **Serial# 8138 UID# 2DCC363F94FFBFF**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10-11/2003**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	0	109.9	10	119.9	32.6	10	42.6
10	45	110.6	10	120.6	35.9	10	45.9
10	90	99.9	10	109.9	35.6	10	45.6
10	135	106.5	10	116.5	30.8	10	40.8
10	180	112.1	10	122.1	26.5	10	36.5
10	225	112.9	10	122.9	29.1	10	39.1
10	270	109.9	10	119.9	32.2	10	42.2
10	315	91.0	10	101.0	32.7	10	42.7
40	0	115.4	10	125.4	57.8	10	67.8
40	45	115.3	10	125.3	57.7	10	67.7
40	90	117.1	10	127.1	57.7	10	67.7
40	135	119.5	10	129.5	57.9	10	67.9
40	180	121.4	10	131.4	58.0	10	68.0
40	225	121.6	10	131.6	58.0	10	68.0
40	270	120.5	10	130.5	57.8	10	67.8
40	315	118.2	10	128.2	57.8	10	67.8

NOTE:This color represents a drop of 1 order of magnitude in radiated power
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 to 4 orders of magnitude in radiated power
NOTE: This color represents a drop on nearly 7 orders of magnitude in radiated power

Data verified by: C.E. Herhold, NCE

UUT: **ACR**
MODEL: **406MHz PLB** (Personal Locator Beacon with GPS interface)
SERIAL: **Serial# 2419 UID# 2DCE3692E6FFBFF**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10-11/2003**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
10	0	108.4	10	118.4	44.6	10	54.6
10	45	111.0	10	121.0	38.9	10	48.9
10	90	108.8	10	118.8	35.2	10	45.2
10	135	106.6	10	116.6	44.4	10	54.4
10	180	109.9	10	119.9	44.2	10	54.2
10	225	110.3	10	120.3	36.5	10	46.5
10	270	107.2	10	117.2	39.4	10	49.4
10	315	102.8	10	112.8	44.4	10	54.4
40	0	112.8	10	122.8	53.5	10	63.5
40	45	113.8	10	123.8	49.3	10	59.3
40	90	115.0	10	125.0	46.0	10	56.0
40	135	115.8	10	125.8	47.4	10	57.4
40	180	115.5	10	125.5	52.6	10	62.6
40	225	114.6	10	124.6	56.8	10	66.8
40	270	113.7	10	123.7	58.5	10	68.5
40	315	113.1	10	123.1	57.3	10	67.3

NOTE:This color represents a drop to 1/2 of original radiated power (1 order of magnitude)
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 to 4 orders of magnitude in radiated power
Data verified by: C.E. Herhold, NCE

APPENDIX F
SUPPORTING DATA
FOR ACR RAIN TEST

UUT: **ACR**
MODEL: **406MHz PLB** (Personal Locator Beacon with GPS interface)
SERIAL: **Serial# 2419 UID# 2DCE3692E6FFBFF**
TEST: Radiated Emissions measurements for comparative evaluations.
Emergency transmitters are subjected to simulated rain under controlled conditions.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **RAIN TEST (2.8% SALT SOLUTION)**
DATE: **12/11/03**

	EUT Position	Meas'ment Count	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
A	Vertical	Base Line	101.5	10	111.5	47.2	10	57.2
B	Horizontal	Base Line	103.4	10	113.4	48.4	10	58.4
	Vertical	DSV-R 1	104.3	10	114.3	50.0	10	60.0
	Vertical	2	102.6	10	112.6	51.1	10	61.1
	Vertical	WSV-R 1	97.1	10	107.1	54.5	10	64.5
	Vertical	2	96.1	10	106.1	54.8	10	64.8
	Vertical	3	95.8	10	105.8	55.9	10	65.9
	Vertical	4	95.8	10	105.8	55.8	10	65.8
	Vertical	5	96.1	10	106.1	56.3	10	66.3
	Vertical	~8th	96.7	10	106.7	54.6	10	64.6
	Vertical	~9th	96.7	10	106.7	54.6	10	64.6
	Horizontal	IMMD 1	78.0	10	88.0	35.7	10	45.7
	Horizontal	2	77.9	10	87.9	35.5	10	45.5
	Horizontal	3	77.9	10	87.9	35.5	10	45.5
	Horizontal	IMMH 1	86.2	10	96.2	35.5	10	45.5
	Horizontal	2	86.2	10	96.2	32.7	10	42.7
	Horizontal	3	86.2	10	96.2	32.6	10	42.6

A & B Dry baseline data prior to start of test.
DSV-R Dry-Start in Rain. UUT is Vertical. Consecutive (follow-on) measurements show trend if any.
WSV-R Wet-Start in Rain. UUT is Vertical. Consecutive measurements show trend if any.
IMMD UUT is Horizontal with antenna hinge is IMMersed in water. Depth is approximately 1-3/4 inches.
IMMH UUT is IMMersed in two inches of water and Horizontal. Consecutive measurements show trend if any.

NOTE:This color represents a drop to 1/2 of original radiated power (1 order of magnitude)
NOTE:This color represents a drop of 7 to 8 orders of magnitude in radiated power
NOTE: This color represents a drop of 2 orders of magnitude in radiated power
NOTE: This color represents a drop of 3 to 4 orders of magnitude in radiated power
NOTE: This color represents a drop of 5 orders of magnitude in radiated power

Data verified by: C.E. Herhold, NCE

APPENDIX G
SUPPORTING DATA
FOR
ACR COLD DATA TEST

UUT: **ACR**
MODEL: **406MHz PLB** (Personal Locator Beacon with GPS interface)
SERIAL: **Serial # 2431 UID# 2DCE3692FEFFBFF**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -40°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -40°C**
DATE: **12/15/03**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
15-Dec	7:30PM	86.2	10	96.2	53.2	10	63.2
15-Dec	8:30PM	39.6	10	49.6	23.2	10	33.2
15-Dec	9:30PM	No Signal			No Signal		

Notes: This UUT was subjected to earlier (rain) test; a possible cause for its premature failure at -40°C.
An identical model ACR unit was substituted and the test was re-started.

Data verified by: C. E. Herhold, NCE

UUT: **ACR**
MODEL: **406MHz PLB** (Personal Locator Beacon with GPS interface)
SERIAL: **Serial # 2420 UID# 2DCE3692E8FFBFF**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -40°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -40°C**
DATE: **12/16-18/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
16-Dec	9:30AM	125.2	10	135.2	67.2	10	77.2
16-Dec	10:30AM	123.6	10	133.6	65.7	10	75.7
16-Dec	11:30AM	123.0	10	133.0	65.3	10	75.3
16-Dec	12:30PM	123.2	10	133.2	64.2	10	74.2
16-Dec	1:30PM	125.3	10	135.3	64.0	10	74.0
16-Dec	2:30PM	124.1	10	134.1	64.8	10	74.8
16-Dec	3:30PM	122.1	10	132.1	62.0	10	72.0
16-Dec	4:30PM	115.8	10	125.8	57.3	10	67.3
16-Dec	5:30PM	115.7	10	125.7	56.6	10	66.6
16-Dec	6:30PM	116.1	10	126.1	57.5	10	67.5
16-Dec	7:30PM	117.9	10	127.9	63.4	10	73.4
16-Dec	8:30PM	117.8	10	127.8	63.5	10	73.5
16-Dec	9:30PM	117.2	10	127.2	63.4	10	73.4
16-Dec	10:30PM	117.9	10	127.9	63.2	10	73.2
16-Dec	11:30PM	118.0	10	128.0	63.2	10	73.2
17-Dec	12:30AM	118.4	10	128.4	63.7	10	73.7
17-Dec	1:30AM	118.3	10	128.3	63.5	10	73.5
17-Dec	2:30AM	118.3	10	128.3	63.5	10	73.5
17-Dec	3:30AM	118.5	10	128.5	63.6	10	73.6
17-Dec	4:30AM	118.7	10	128.7	63.1	10	73.1
17-Dec	5:30AM	118.7	10	128.7	63.6	10	73.6
17-Dec	6:30AM	118.3	10	128.3	63.4	10	73.4
17-Dec	7:30AM	117.9	10	127.9	63.8	10	73.8
17-Dec	8:30AM	117.9	10	127.9	63.8	10	73.8
17-Dec	9:30AM	118.1	10	128.1	64.6	10	74.6
17-Dec	10:30AM	117.7	10	127.7	64.9	10	74.9
17-Dec	11:30AM	118.0	10	128.0	64.7	10	74.7
17-Dec	12:30PM	118.1	10	128.1	62.8	10	72.8

Data verified by: C. E. Herhold, NCE

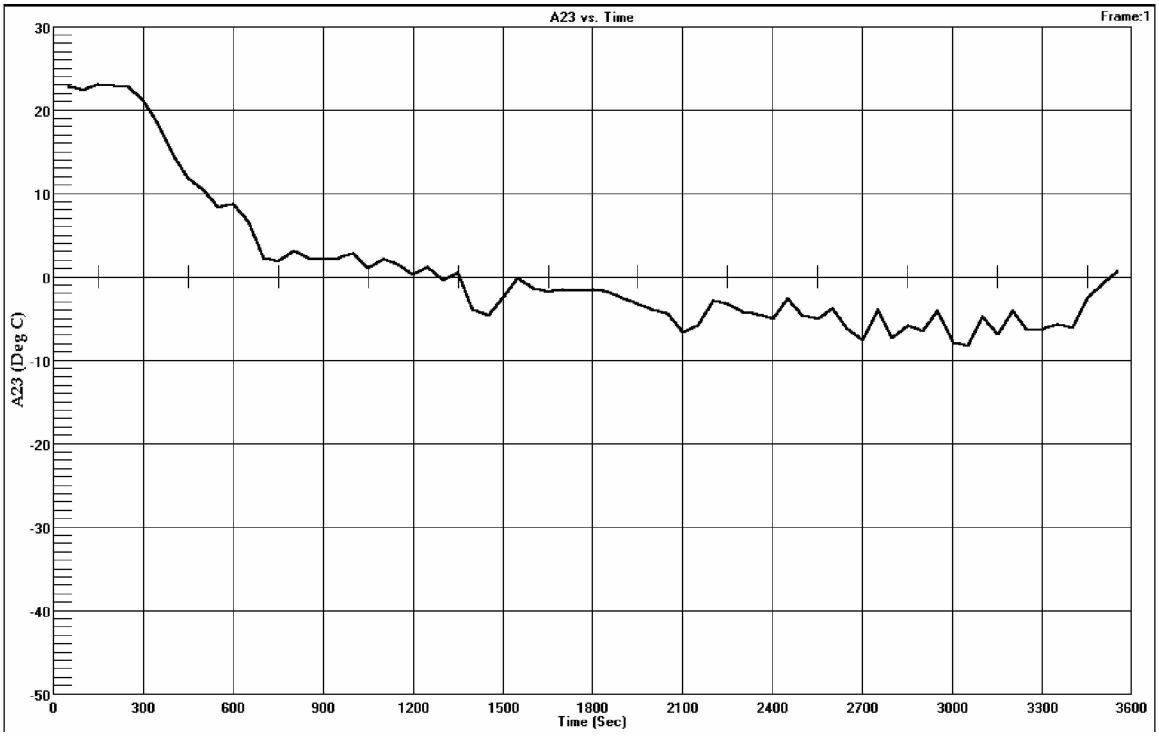
UUT: **ACR**
MODEL: **406MHz PLB** (Personal Locator Beacon with GPS interface)
SERIAL: **Serial # 2420 UID# 2DCE3692E8FFBFF**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -40°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -40°C**
DATE: **12/16-19/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.5MHz Spectrum Analyzer dBuV	External Atten dB	121.5MHz Measured Level dBuV
17-Dec	1:30PM	117.7	10	127.7	62.7	10	72.7
17-Dec	2:30PM	117.7	10	127.7	63.5	10	73.5
17-Dec	3:30PM	118.7	10	128.7	63.7	10	73.7
17-Dec	4:30PM	116.4	10	126.4	64.9	10	74.9
17-Dec	5:30PM	119.7	10	129.7	66.6	10	76.6
17-Dec	6:30PM	120.3	10	130.3	66.1	10	76.1
17-Dec	7:30PM	120.7	10	130.7	65.7	10	75.7
17-Dec	8:30PM	120.7	10	130.7	65.3	10	75.3
17-Dec	9:30PM	120.8	10	130.8	65.0	10	75.0
17-Dec	10:30PM	120.9	10	130.9	64.8	10	74.8
17-Dec	11:30PM	120.8	10	130.8	64.8	10	74.8
18-Dec	12:30AM	120.2	10	130.2	65.7	10	75.7
18-Dec	1:30AM	120.5	10	130.5	66.0	10	76.0
18-Dec	2:30AM	120.0	10	130.0	65.3	10	75.3
18-Dec	3:30AM	120.5	10	130.5	65.6	10	75.6
18-Dec	4:30AM	120.3	10	130.3	66.0	10	76.0
18-Dec	5:30AM	120.4	10	130.4	65.4	10	75.4
18-Dec	6:30AM	81.3	10	91.3	42.1	10	52.1
18-Dec	7:30AM	54.2	10	64.2	33.4	10	43.4
18-Dec	8:30AM	No Signal			No Signal		

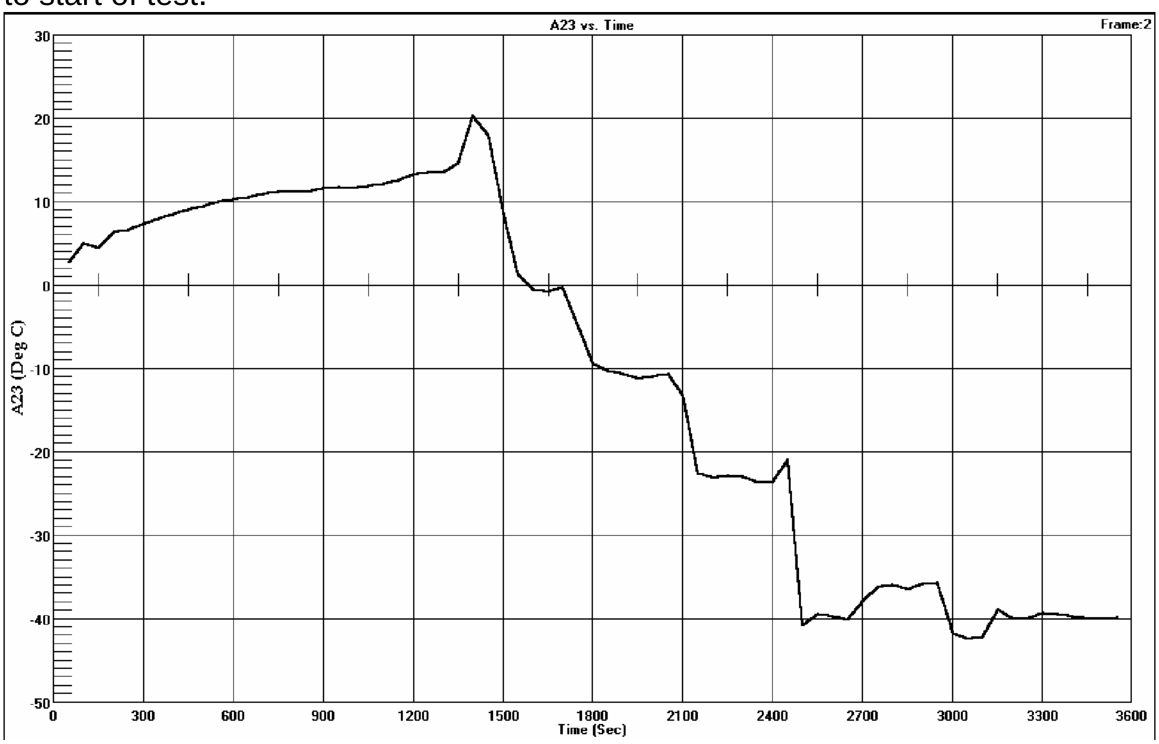
Data verified by: C. E. Herhold, NCE

APPENDIX H
SUPPORTING DATA

THERMAL CHAMBER
TEMPERATURE PLOTS
FOR
FIRST ACR UNIT
(UNIT FAILED AFTER 2 HOURS OF OPERATION)

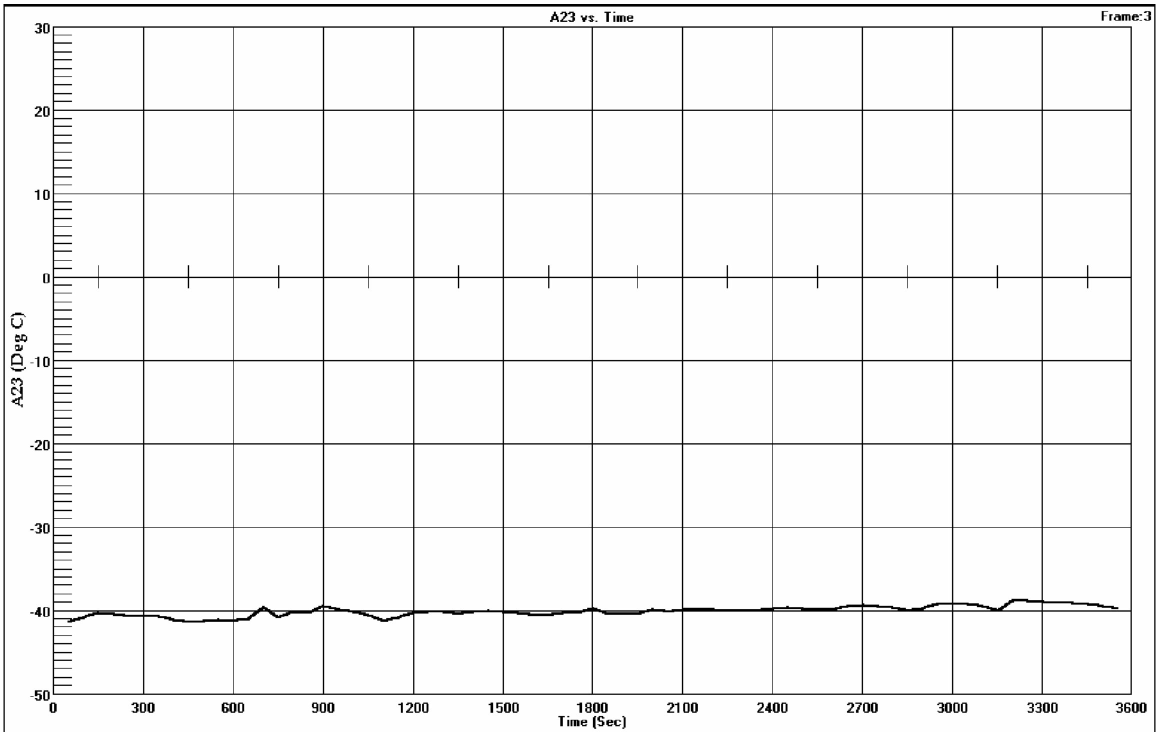


All frames are in sequence. Each frame represents one hour. The first frames show ambient conditions and ramping down to -40°C for the initial pre-soak with the EUT de-energized prior to start of test.

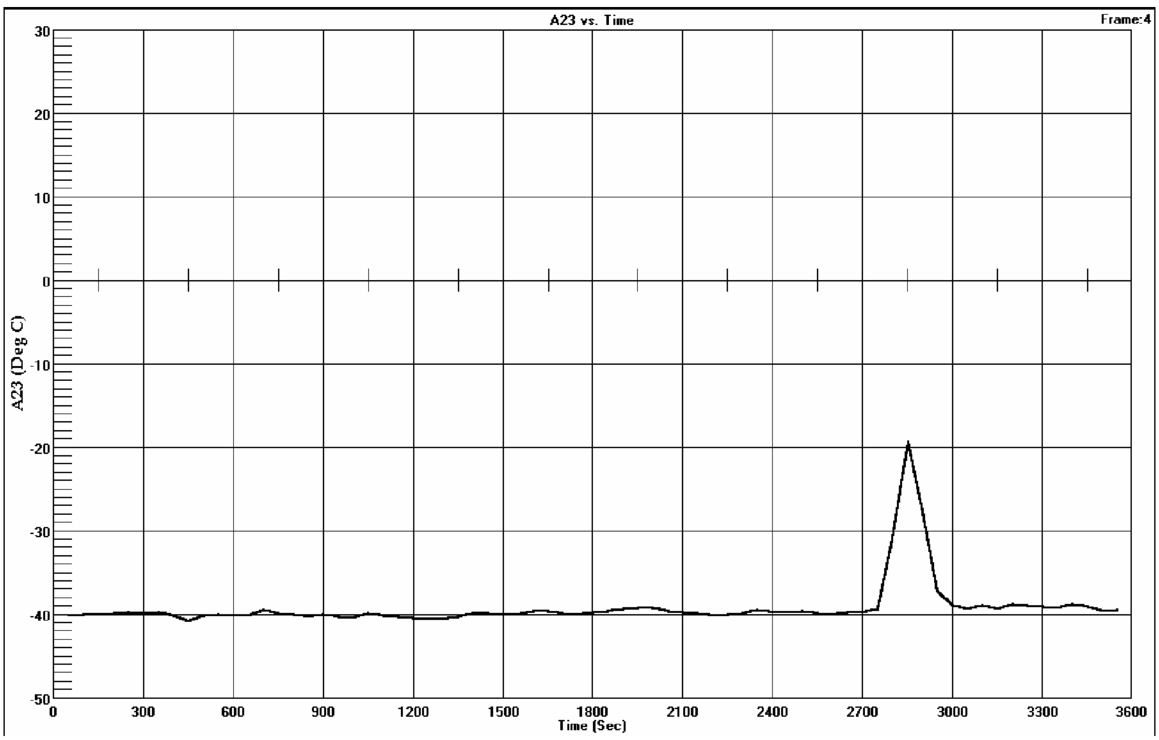


4:40PM

The Equipment Under Test (EUT), the ACR PLB Serial # 2431 will be soaked at -40°C for two hours prior to start of test.

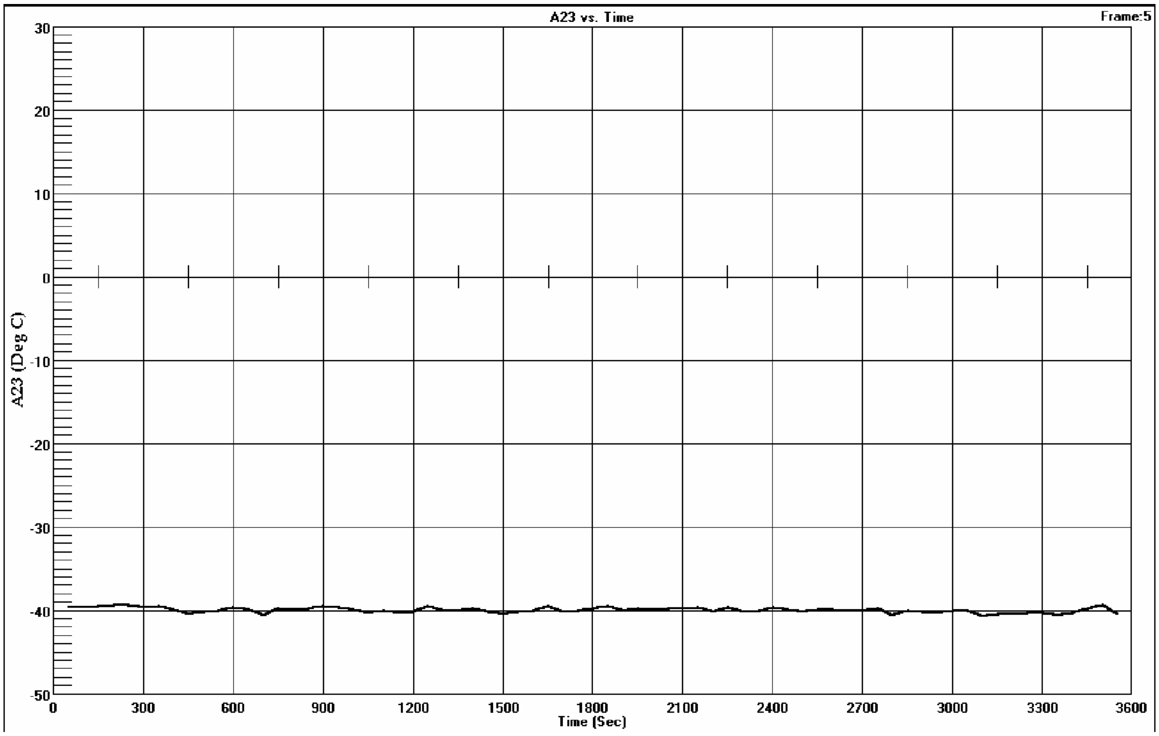


5:40PM

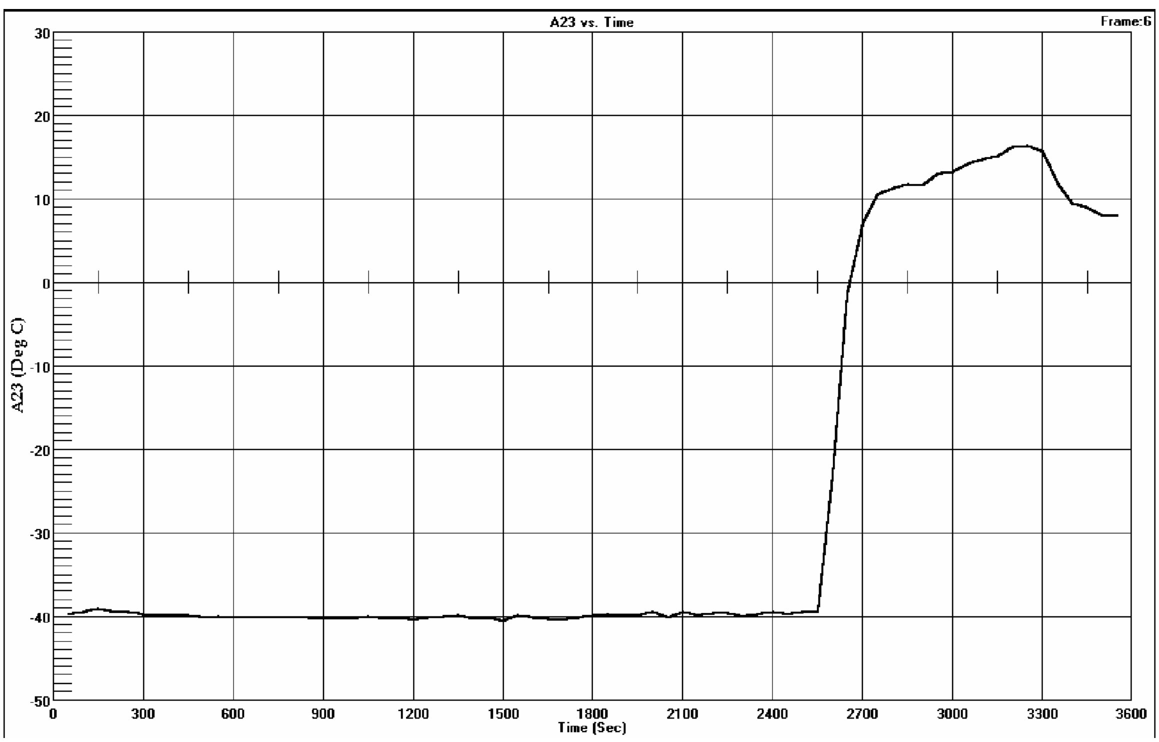


6:40PM

After two hours soak at -40°C, EUT removed from test chamber at 2750, energized and returned to chamber for test run. Temperature spike indicates opening of chamber for access to EUT. Test started on Frame 4 at 3000 seconds or 7:30PM 12/15/2003.



7:40PM

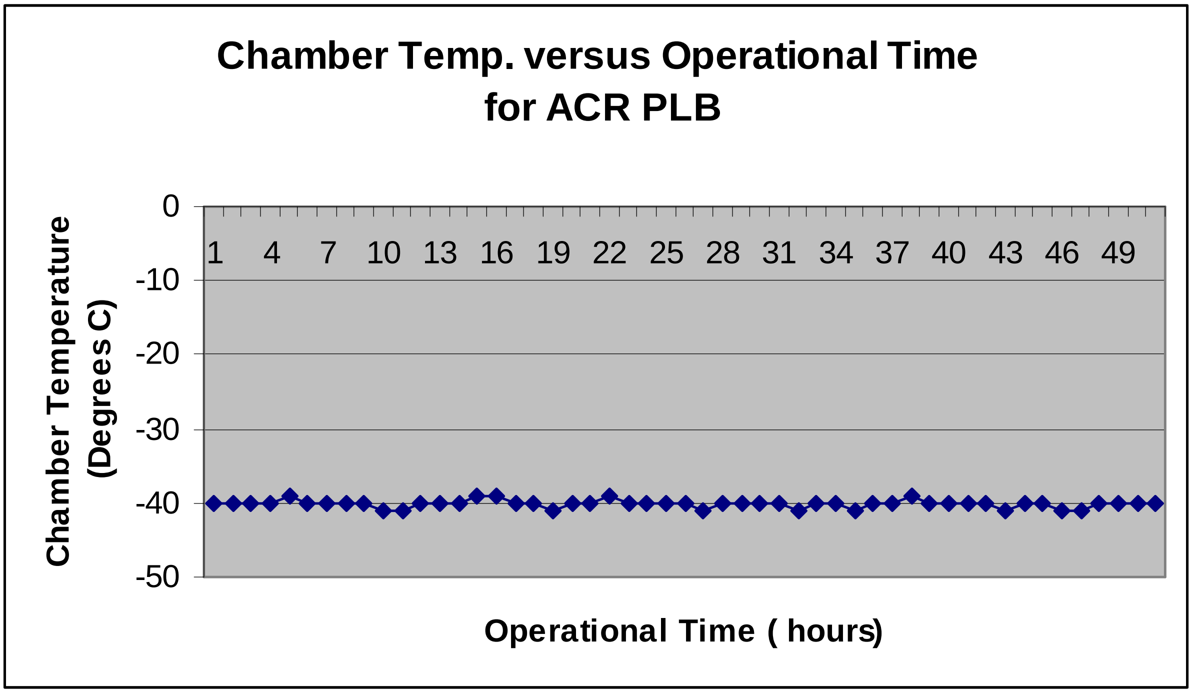


8:40PM

The EUT has ceased to function. The test is terminated. EUT removed from test chamber and refrigeration turned off.

APPENDIX I
SUPPORTING DATA

THERMAL CHAMBER
TEMPERATURE PLOTS
FOR SECOND ACR COLD TEST UNIT


Chamber Temp. versus Operational Time
for ACR PLB
Chamber Temperature (Degrees C)
0
-10
-20
-30
-40
-50
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49
Operational Time (hours)

APPENDIX J
SUPPORTING DATA
FOR
TECH TEST LIMITED
DRY TEST

UUT: **Techtest Limited** - Emergency Locating Transmitter (ELT)
MODEL: **500-27**
SERIAL: **446**
TEST: Radiated Emissions measurements for comparative evaluations; observation of radiated field strength at two elevations as UUT is rotated 360° at a 1 meter distance.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **DRY DATA**
DATE: **12/10/03**

Source Position Degrees	Rotation Degrees	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.65MHz Spectrum Analyzer dBuV	External Atten dB	121.65MHz Measured Level dBuV
10	0	97.6	10	107.6	45.3	10	55.3
10	45	102.5	10	112.5	40.0	10	50.0
10	90	104.0	10	114.0	43.1	10	53.1
10	135	104.8	10	114.8	52.8	10	62.8
10	180	105.1	10	115.1	51.6	10	61.6
10	225	104.5	10	114.5	53.6	10	63.6
10	270	101.7	10	111.7	56.0	10	66.0
10	315	92.1	10	102.1	55.1	10	65.1
40	0	107.8	10	117.8	50.4	10	60.4
40	45	106.1	10	116.1	53.3	10	63.3
40	90	106.4	10	116.4	53.8	10	63.8
40	135	108.7	10	118.7	52.1	10	62.1
40	180	111.6	10	121.6	48.0	10	58.0
40	225	112.9	10	122.9	44.1	10	54.1
40	270	112.2	10	122.2	43.1	10	53.1
40	315	110.3	10	120.3	43.8	10	53.8

Data verified by: C.E. Herhold, NCE

APPENDIX K
SUPPORTING DATA
FOR
TECHTEST LIMITED
RAIN TEST

UUT: **Techtest Limited** - Emergency Locating Transmitter (ELT)
MODEL: **500-27**
SERIAL: **446**
TEST: Radiated Emissions measurements for comparative evaluations.
Emergency transmitters are subjected to simulated rain under controlled conditions.
PICKUP: Broadband Antenna, Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **RAIN TEST (2.8% SALT SOLUTION)**
DATE: **12/11/03**

	EUT Position	Meas'ment Count	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.65MHz Spectrum Analyzer dBuV	External Atten dB	121.65MHz Measured Level dBuV
A	Vertical	Base Line	107.5	10	117.5	61.0	10	71.0
B	Horizontal	Base Line	100.8	10	110.8	52.0	10	62.0
	Horizontal	WSH-R 1	108.6	10	118.6	54.8	10	64.8
	Horizontal	2	108.0	10	118.0	54.4	10	64.4
	Horizontal	3	107.9	10	117.9	54.4	10	64.4
	Horizontal	4	107.6	10	117.6	55.1	10	65.1
	Horizontal	5	107.6	10	117.6	53.7	10	63.7
	Vertical	DSV-R 1	113.5	10	123.5	64.6	10	74.6
	Vertical	2	112.9	10	122.9	64.5	10	74.5
	Vertical	3	113.4	10	123.4	64.7	10	74.7
	Vertical	4	113.6	10	123.6	63.3	10	73.3
C →	Vertical	5	113.4	10	123.4	63.7	10	73.7
	Horizontal	WSH-R 1	105.4	10	115.4	54.3	10	64.3
	Horizontal	2	105.4	10	115.4	52.8	10	62.8
	Horizontal	3	105.2	10	115.2	53.1	10	63.1
	Horizontal	4	105.3	10	115.3	53.6	10	63.6
	Horizontal	5	105.2	10	115.2	53.5	10	63.5
	Horizontal	IMMH 1	87.8	10	97.8	29.9	10	39.9
	Horizontal	2	87.6	10	97.6	30.0	10	40.0
	Horizontal	3	87.6	10	97.6	30.0	10	40.0
	Horizontal	4	87.6	10	97.6	30.0	10	40.0
	Horizontal	5	87.6	10	97.6	30.1	10	40.1

A & B Dry baseline data prior to start of test.
C Problem with Serial# 446 at this instant. Substituted #447 unit and retained #446 battery pack; continued with test
WSH-R Wet-Start in Rain. UUT is Horizontal. Consecutive (follow-on) measurements show trend if any.
DSV-R Dry-Start in Rain. UUT is Vertical. Consecutive measurements show trend if any.
IMMH UUT is IMMersed in two inches of water and Horizontal. Consecutive measurements show trend if any.

Data verified by: C.E. Herhold, NCE

APPENDIX L
SUPPORTING DATA
FOR
TECHTEST LIMITED
COLD DATA TEST

UUT: **Techtest Limited** - Emergency Locating Transmitter (ELT)
MODEL: **500-27**
SERIAL: **496**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -20°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -20°C**
DATE: **12/29-30/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.65MHz Spectrum Analyzer dBuV	External Atten dB	121.65MHz Measured Level dBuV
30-Dec	8PM	75.0	10	85.0	12.7	10	22.7
30-Dec	9PM	50.9	10	60.9	10.2	10	20.2
30-Dec	10PM	No Signal			No Signal		

Note: 406MHz Signal degraded by 31dB from 7PM to 8PM indicating end of battery life.

Data verified by: C. E. Herhold, NCE

NOTE: Following the premature failure of the unit, it was determined by the manufacturer's representative that the battery supplied should be replace with another battery due to prior testing on the original battery. The following data is data taken from this same unit with the newly supplied battery from the manufacturer.

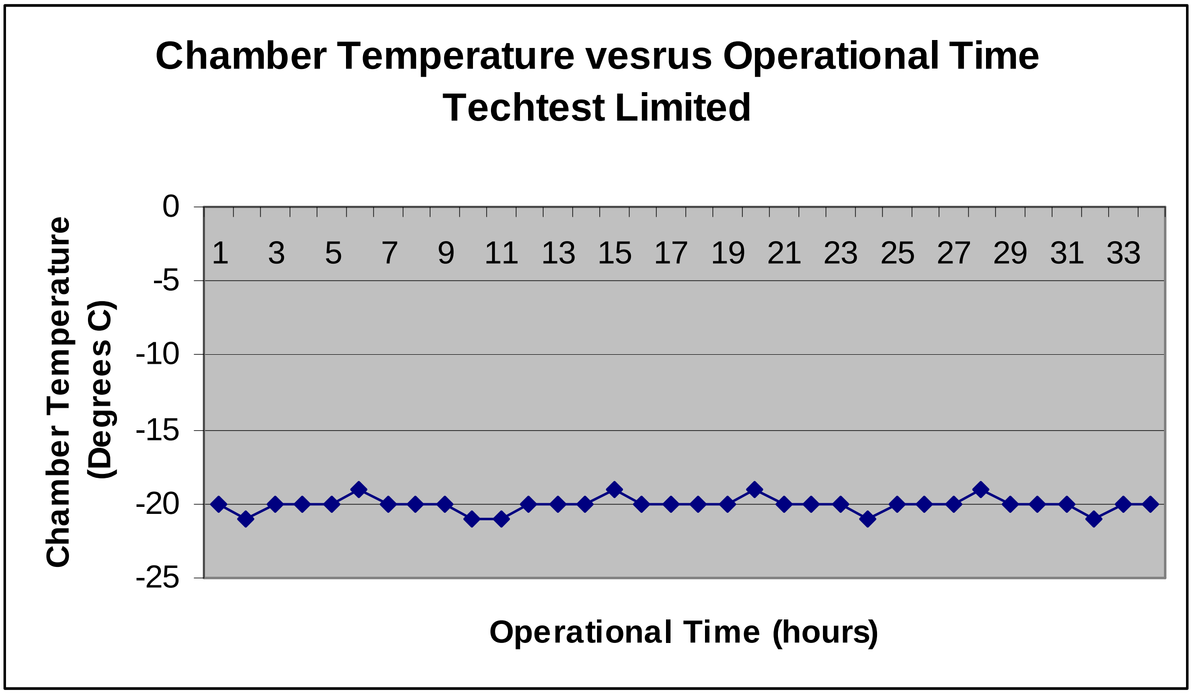
UUT: **Techtest Limited** - Emergency Locating Transmitter (ELT)
MODEL: **500-27**
SERIAL: **496**
TEST: Measured Battery Life at specified temperature.
PICKUP: Broadband Antenna , Polarization = Vertical
CONDITIONS: Peak Data obtained in Screen Room at 1 meter for reference only.
NOTES: **UUT PRE-CONDITIONED AT -20°C FOR 2 HOURS PRIOR TO START OF TEST.**
NOTES: **COLD DATA, TEST TEMP -20°C**
DATE: **12/29-30/2003**

Date	Time	406MHz Spectrum Analyzer dBuV	External Atten dB	406MHz Measured Level dBuV	121.65MHz Spectrum Analyzer dBuV	External Atten dB	121.65MHz Measured Level dBuV
29-Dec	4PM	110.1	10	120.1	20.0	10	30.0
29-Dec	5PM	109.4	10	119.4	20.3	10	30.3
29-Dec	6PM	109.6	10	119.6	19.8	10	29.8
29-Dec	7PM	109.5	10	119.5	19.7	10	29.7
29-Dec	8PM	109.6	10	119.6	19.5	10	29.5
29-Dec	9PM	109.6	10	119.6	19.9	10	29.9
29-Dec	10PM	109.5	10	119.5	19.9	10	29.9
29-Dec	11PM	109.5	10	119.5	20.9	10	30.9
30-Dec	12AM	109.4	10	119.4	19.9	10	29.9
30-Dec	1AM	109.4	10	119.4	20.1	10	30.1
30-Dec	2AM	109.6	10	119.6	20.5	10	30.5
30-Dec	3AM	109.5	10	119.5	20.1	10	30.1
30-Dec	4AM	109.5	10	119.5	19.9	10	29.9
30-Dec	5AM	109.5	10	119.5	19.7	10	29.7
30-Dec	6AM	109.5	10	119.5	20.1	10	30.1
30-Dec	7AM	109.5	10	119.5	20.4	10	30.4
30-Dec	8AM	109.4	10	119.4	20.7	10	30.7
30-Dec	9AM	109.4	10	119.4	19.5	10	29.5
30-Dec	10AM	109.3	10	119.3	13.1	10	23.1
30-Dec	11AM	109.3	10	119.3	12.9	10	22.9
30-Dec	12PM	109.3	10	119.3	12.9	10	22.9
30-Dec	1PM	109.2	10	119.2	12.9	10	22.9
30-Dec	2PM	108.4	10	118.4	13.1	10	23.1
30-Dec	3PM	108.4	10	118.4	12.9	10	22.9
30-Dec	4PM	108.5	10	118.5	13.4	10	23.4
30-Dec	5PM	108.2	10	118.2	12.9	10	22.9
30-Dec	6PM	108.2	10	118.2	13.1	10	23.1
30-Dec	7PM	106.1	10	116.1	13.3	10	23.3

Data verified by: C. E. Herhold, NCE

APPENDIX M
SUPPORTING DATA

THERMAL CHAMBER
TEMPERATURE PLOTS
FOR
TECH TEST LIMITED
COLD DATA TEST


Chamber Temperature vesrus Operational Time
Techtest Limited
Chamber Temperature (Degrees C)
0
-5
-10
-15
-20
-25
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
Operational Time (hours)

Appendix 5

Beacon Operating Schemes

26 March 2004

Mr. Doug Ritter
Equipped To Survive Foundation

At activation the ACR GlobalFix™ begins warming the oscillator and forming a message. In the process of doing so it looks to the GPS receiver to see if data is collected and continues doing so for 100 seconds. If GPS data is available, and it generally is, it grabs it and forms the 406 message and sends the GPS data on the first burst. Then the GPS shuts down and waits 20 minutes before attempting to reacquire.

If no GPS data is available at 100 seconds the GlobalFix™ sends its first 406 transmission using default position data and the GPS continues to attempt to acquire data for up to 15 minutes. When it does acquire data the data is incorporated into the next 406 transmission. If at 15 minutes no data has been acquired we assume that there is something preventing the GPS from acquiring and we shut down to preserve battery capacity.

We turn the GPS receiver back on in 20 minutes, the minimum time interval allowed by Cospas-Sarsat, and attempt to re-acquire data as above for up to 10 minutes. Our logic is that we should be able to re-acquire within a minute and if we cannot acquire in 10 minutes then we never will under the current conditions and we shut down to conserve the battery. At this point we have had the GPS receiver on for up to 25 of the first 45 minutes of operation. We consider the first 45 minutes the most crucial time for the GPS receiver to perform as this is when the greatest time saving benefit of having a GPS occurs.

In 20 minutes we turn the GPS receiver back on and attempt to re-acquire for up to 5 minutes. At this point we settle into a pattern of turning the GPS receiver on for up to a maximum of 5 minutes per on period and then turning it off to conserve battery power as allowed by Cospas-Sarsat.

Our scheme is designed to allocate as much of the available battery to GPS acquisition during the earlier minutes of the emergency in an effort to get the vital GPS data incorporated into the alert message at a time when it can do the most good.

The GyPSI™ and RapidFix™ GPS Interface beacons wake up and look for GPS data from an external GNSS data source ever 4 seconds from the moment they are built and for as long as there is no data in memory. If data is available from an external source it is downloaded via the NMEA 0183 compatible optical interface into the beacon's memory where it is held for use in an emergency. Once data is loaded into memory, the beacon will "sleep" for 20 minutes before attempting to update its position data.

It will continue to look for a connection to a valid data source and will download new data every 20 minutes for the rest of its life unless the data is dumped, at which point it will revert back to a 4 second cycle of checking to see if it is connected to a valid data source. Upon activation the most current position data is incorporated into the message string and

ACR Electronics, Inc.
5757 Ravenswood Road, Fort Lauderdale, FL 33312-6645
+1(954)981-3333, Fax : +1(954)983-5087, e-mail: info@acrelectronics.com, www.acrelectronics.com

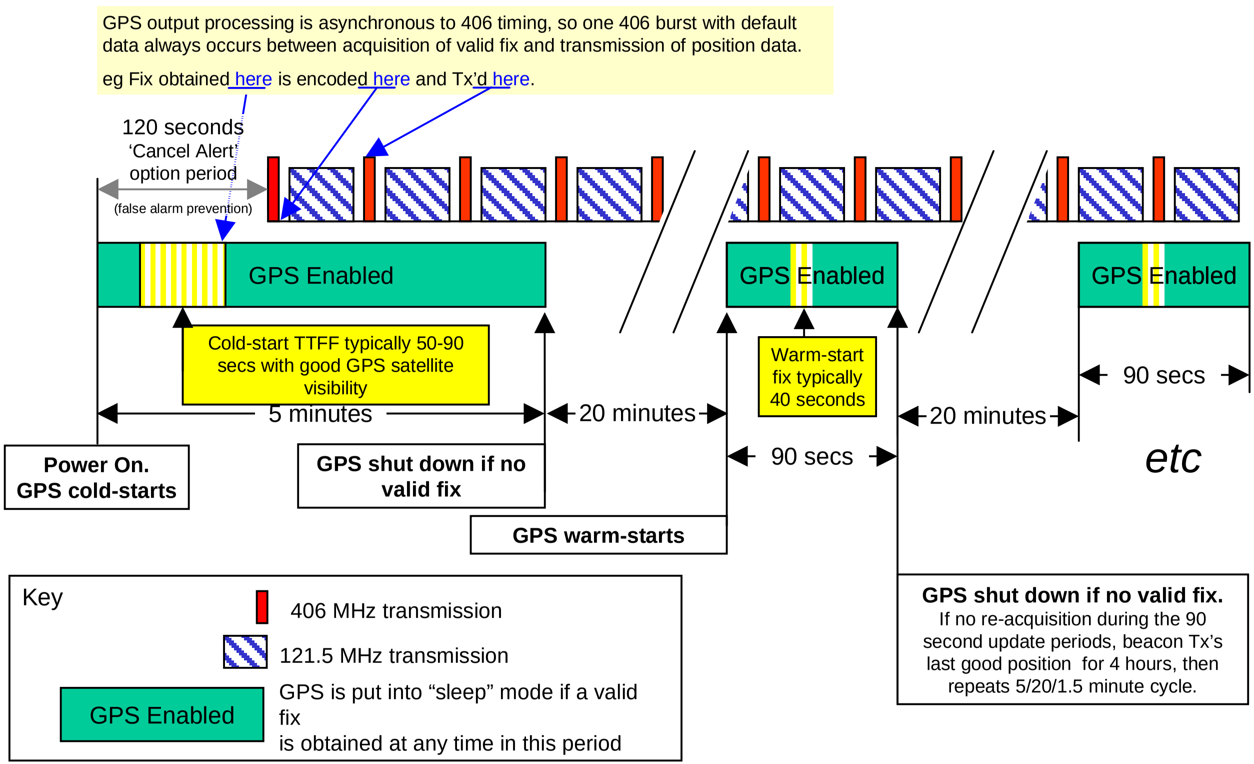
is transmitted on the first burst insuring that your alert message is routed to the closest appropriate response agency.

These interface beacons make no attempt to update position data once they are activated. The logic is that the initial position is transmitted through the system and provides SAR with enough information to route your emergency message to the closest appropriate response agency in the least amount of time.

Like a regular 406 EPIRB the position is updated via Doppler shift with each satellite pass. Search and Rescue forces have locate the beacon once they enter the search area by homing on the 121.5 MHz homing signal produced by the EPIRB. The emphasis with the GyPSI™ and RapidFix™ is on reliably providing positional data through GEOSAR on the first burst every time regardless of external conditions.

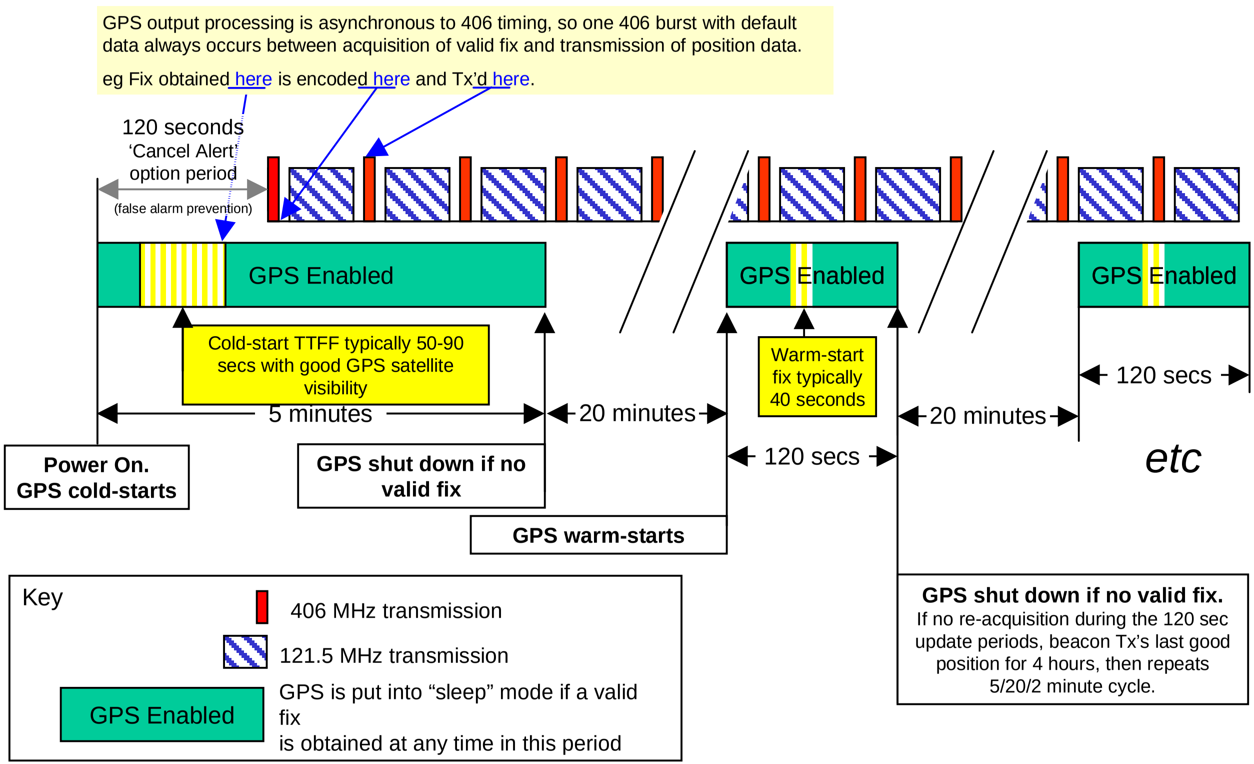
FASTFIND PLUS PLB - GPS TIMING

GPS strategy is optimized to ensure that maximum power is always available for the primary beacon functions (406 MHz & 121.5 MHz transmitters).



G4/PRECISION EPIRB - GPS TIMING

GPS strategy is optimized to ensure that maximum power is always available for the primary beacon functions (406 MHz & 121.5 MHz transmitters).



From: "H.R.Smith" <street@hr-smith.com>
To: "'Doug Ritter'" <dritter@equipped.org>
Subject: THE SERIES 500-27 PLB
Date: Mon, 29 Mar 2004 16:57:28 +0100

TO: Doug Ritter
DATE: 29th March 2004

SUBJECT: THE SERIES 500-27 PLB

The Series 500-27 Personal Locator Beacons are simple, compact lightweight units which can be used either manually or automatically via ejection seat harness.

The 500-27 Series of Beacons offers the facility to determine a GPS position and transmit it as part of the 406.025 MHz message.

The PLB is a one piece unit with the transmitter housed in a yellow pigmented or NATO green moulded thermoplastic case, which is designed such that the replaceable battery pack mounted within the overall package to form a smooth but non-slip hand portable unit. The design is such that easy replacement of the battery module (15 seconds) is possible during beacon operation.

The unit is designed to survive for up to ten years with the only maintenance being battery replacement every five years.

The 500-27 PLB is switched on by pulling the lanyard or slide switch down. The beacon will then transmit on the distress frequencies 121.5, 243 and 406.025 MHz for a period of at least 24 hours at minus 20C and a further 24 hours on 121.5 and 243 MHz or until the unit is switched off. All the transmissions are verified by audible and visual indications.

The 500-27 Series PLB has a built in GPS receiver which is able to determine the beacons position and relay this data onto the 406 MHz message data burst.

At initial switch on the GPS receiver is activated in order that it can determine its position. This will generally occur in less than 50 seconds. However, this is dependant upon satellite visibility during this period. All but the first two 121.5 MHz and 243 MHz transmissions are suppressed between 50 and 200 seconds in order to allow uninterrupted signal reception from the GPS.

After approx 30seconds the first 406.025 MHz data burst is transmitted. If after 50 seconds the beacon has acquired at least one satellite it will continue searching for a GPS resolution and transmissions on 121.5 / 243 MHz will continue to be suppressed.

However, should no satellite signal be received to a severely restricted field of view the PLB will revert to beacon mode and transmit on 121.5 / 243 MHz.

If the GPS receiver has determined the position of the beacon, the data is added to the message (usually long) and the beacon provides a visual indication of GPS acquisition. For the duration that the beacon is acquiring a GPS position there is an internal lamp which flashes every one quarter second. This lamp extinguishes in the event of a loss in GPS reception or the beacon is switched off. If an immediate GPS position is not apparent the beacon will continue to attempt to acquire GPS position at 5 minute intervals for 4 attempts after which attempts are made at 20 minute intervals. Similarly, if the beacon acquires a GPS position it is updated once every 20 minutes such that the operator can be tracked if moving.

If a beacon is deployed within a short distance of one or more other beacons then only one of the beacons will transmit the 121.5 / 243 MHz distress signals. The 500-27 is designed to automatically receive transmissions from other beacons and in the event of such a signal being received will suppress 121.5 / 243 MHz transmissions. However, it should be noted that the 406.025 MHz data transmission will continue irrespective of the beacons state of operation. This feature helps prevent multiple beacon location problems which can provide some concern to SAR crews.

In addition, the facility exists for two way speech communication on 121.5 / 243 MHz with other beacons of this type and search aircraft.

The antenna has an impedance of 50ohms and has the capability of being removed from the beacon thus allowing the use of any antenna with the same impedance and frequency of operation.

Appendix 6

Forey McMurdo Recoding Report

From: "Peter Forey" <pforey@sartech.com>
To: "Doug Ritter" <dritter@equipped.org>
Subject: EPIRB Reprogramming
Date: Wed, 7 Jan 2004 18:56:04 -0000
Message-ID: <001101c3d54f$e6c308e0$1500a8c0@sartech.co.uk>
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary="----=_NextPart_000_0012_01C3D54F.E6C308E0"
X-Priority: 3 (Normal)
X-MSMail-Priority: Normal
X-Mailer: Microsoft Outlook, Build 10.0.2627
Importance: Normal
X-MimeOLE: Produced By Microsoft MimeOLE V6.00.2800.1165
X-Spam-Processed: sartech.com, Wed, 07 Jan 2004 18:56:20 +0000
(not processed: message size (11055063) exceeds max size (25600))
X-MDRemoteIP: 192.168.0.21
X-Return-Path: pforey@sartech.com
X-MDaemon-Deliver-To: dritter@equipped.org
X-RCPT-TO: <dritter@equipped.org>
Status: U
X-UIDL: 322610490

Hi Doug,

Have just returned from McMurdo. All went well there, and the beacons are now back at Sartech ready for packing & shipping tomorrow. Attached is a summary of the programming data which accords with what was requested. I can confirm that the beacons were not opened, and the reprogramming was done via the infrared port using an engineering version of the same software we use for programming here.

The EPIRBs were tested live in a screened box with GPS data input from a repeater. They were tested for power, frequency, data content, and GPS lock.

It was decided just to do a message read on the PLBs, as a full test would have required deployment and restowing of the antennas.

The PLBs were repacked in new cartons, as they have changed a more compact and easy to use carton design.

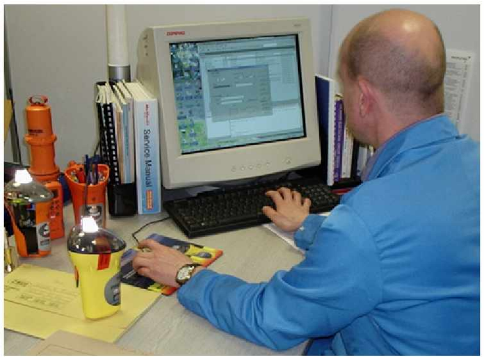
I have attached some pictures taken during the procedure.

Best regards,

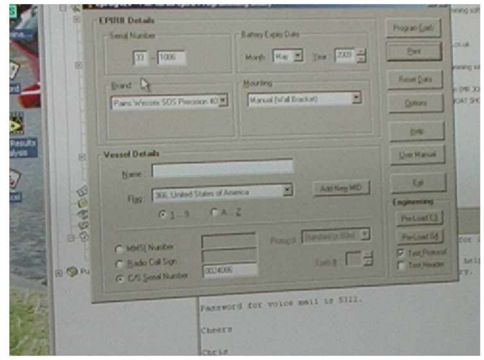
SARTECH ENGINEERING

Peter Forey 80 Brighton Road
Lower Kingswood
Surrey KT20 6SY
United Kingdom
pforey@sartech.com
tel:
fax:
mobile: +44 1737 832237
+44 1737 833903
+44 7050 186734

McMurdo Beacon Recoding – January 7, 2004 – Photos by Peter Forey

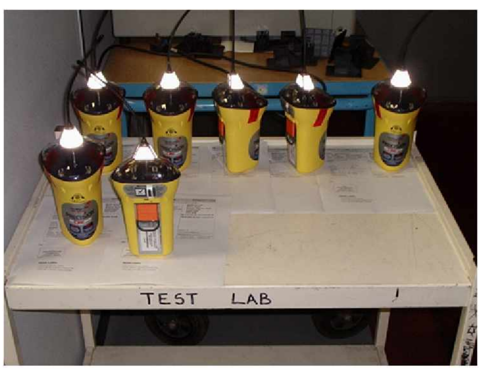


Entering programming data



EPIRB programming screen

Optical programming of EPIRB



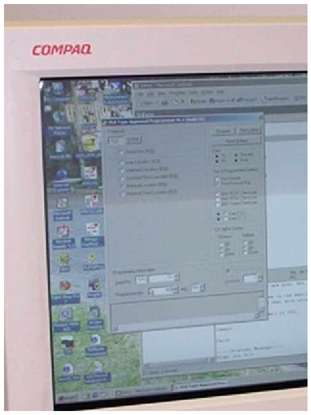
EPIRBs ready for testing

EPIRB testing (screened box on right)

Decoding and power measurements on EPIRB

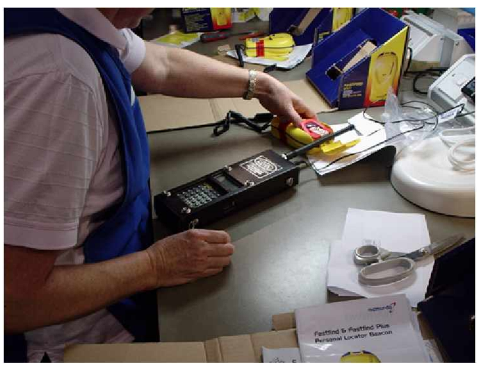
EPIRB warning label affixed

McMurdo Beacon Recoding – January 7, 2004 – Photos by Peter Forey

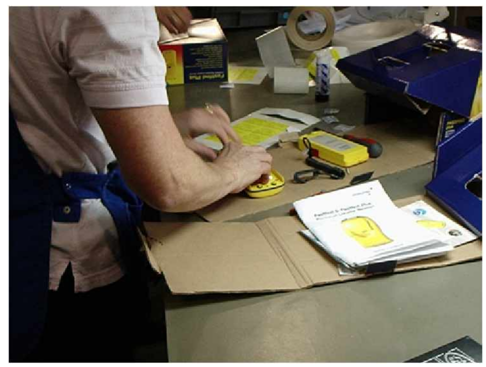


Test 123

Optical programming of PLB



Reading PLB message



Relabelling PLB

PLB warning label

Appendix 7 - U.S. Coast Guard Fastfind Test Report

Appendix 7

U.S. Coast Guard Fastfind Test Report

Coast Guard Test Plan
McMurdo Fast Find PLB

Background:

Starting in FY2002, the Coast Guard began the purchase of over 5000 McMurdo Fast Find PLBs to outfit individual boat crewmembers with an electronic means of signaling distress. On July 1st of 2003, PLBs became legal for use in the U.S. by the general public.

As a result of recent studies of PLBs and their performance under simulated field conditions, Coast Guard personnel in the field have raised questions as to the functional performance of the McMurdo Fast Find PLBs were they required in an actual emergency. In an effort to answer these doubts, Commandant (G-OCS) and (G-OPR) commissioned an analysis of the signal strength of the Fast Find PLB when operated under simulated field conditions where the unit was exposed to water. The findings of this study raised further questions as to the performance in the field. In summary, the findings indicated that the beacons radiated power is extremely degraded by the presence of water in the antenna well. The findings did not indicate if the power degradation would prevent a SARSAT system alert. While this clearly is not desirable for use in the maritime environment, it is important to note that despite this power degradation, the PLBs used in this testing created alerts that were relayed through the system.

Purpose:

This test will evaluate the beacons performance in the actual environmental conditions a Coast Guard boat crew encounters when signaling distress using their PLBs. A second portion of the test will evaluate the battery life of the PLB when operating in the maritime environment. The method of measurement will be to compile all data received by the U.S. SARSAT Mission Control Center (US MCC) from alerts/position information for the activated beacons. The resulting data will be compared against the manufacturers advertised performance of "Alert time within 90 minutes ", "Positional accuracy within 3 nautical miles" and 24 hours battery life. The resulting report should clearly establish if the McMurdo Fast Find PLBs are an appropriate piece of survival equipment for use by Coast Guard boat crews.

Methodology:

LCDR Jay Dell of Commandant (G-OPR) and CWO Kirk Neprud of Commandant (G-OCS) will coordinate the testing. As the Coast Guard's liaison to the SARSAT program, LCDR Dell will be responsible for providing the necessary registration information on the beacons being tested to the USMCC to ensure system-wide awareness of the planned testing and filtering of the alerts generated. In addition, he will work with the MCC staff to compile the resulting alert and position data to evaluate the performance of the beacons after testing is complete. CWO Neprud will provide PLBs for the test, coordinate testing with the selected field unit, ensure test procedures are understood and activation times/test locations are documented.
Test One: *Boat Crew Activation.* Three crewmembers will be provided with a PLB (one test encoded and two operational PLBs) with fresh batteries that has not been previously activated. Each

crewmember will enter the water and activate their PLB. The PLBs shall be activated at approximately 30-second intervals. The test duration will be two hours (of beacon activation). As part of the simulation, the crew may use a flotation device such as a life ring, surfboard or similar floating object to simulate debris used for floatation or partial removal from the water. During the period of immersion/activation, one crewmember with an operational beacon shall keep the PLB and antenna well as dry as possible and the beacon antenna pointed skyward by using whatever means available. The other two crewmembers shall activate their PLBs and then do nothing to protect them from the water but will ensure that they remain secured to their SAR vest by tether line. Over the course of the tests, all three crewmembers shall remain together to simulate a crew staying together in the debris field or near the partially submerged hull of a boat. After a period exceeding two hours of activation, the PLBs will be secured and the crewmembers removed from the water.

Test Two: *Beacon Operational Longevity:* This test will evaluate the battery life/longevity of a PLB activated in the maritime environment. As a control for this test, a test-encoded beacon will be activated and placed on the ground or pier for a period of 24 hours. Simultaneously, a beacon from the Coast Guard operational inventory will be activated, placed in the water and secured to a fixed object (such as a dayboard or piling) with a 8-10' lanyard. The location of the beacon should allow for mild to moderate wave/wake action, tidal change and allow for a clear view of the sky regardless of what direction the beacon drifts from the fixed object. Additionally, the beacon should be a location where its unobstructed floatation can be verified by the unit once every two hours for a 24-hour period. If the beacon either sinks or appears to have stopped functioning the time period should be noted. At the conclusion of the 24-hour period both beacons will be secured.

At the completion of both tests, the selected unit will provide an email report to LCDR Dell containing the activation times and locations of each of the beacons used in the two tests. This information will be used to compare to the data compiled by the USMCC on the beacon alerts actually received.

Report:

At the conclusion of the test, LCDR Dell and CWO Neprud will generate a written report that will detail the performance of each of the four beacons against the advertised performance criteria provided by the manufacturer. The conclusions of the report should clearly indicate if the units procured by the Coast Guard meet the criteria advertised by the manufacturer in the operating environment we may use them in. If so, this should inspire confidence in the personal survival equipment provided to our boat crews. If the units fail to perform as expected, the Coast Guard should have clear grounds to demand investigation and action by the manufacturer.

Beacon 1

McMurdo Pains Wessex FastFind Evaluation

Training Beacon Number: ADDE489C0000005

Date: 4 November 2003

2-Hour Duration Test

Crewmember Name: SN Leonardo Aspuru

This beacon will be activated by the crewmember and left to transmit without interference. The crewmember will ensure that the beacon remains tethered to the equipment vest.

Time of Activation: 10:08:23

Time Out of Water: 12:10:00

Time of Deactivation: 12:45:00

Comments:

Start LAT: 26 06.94
LON: 080:03:97

End LAT: 26 08.68
LON: 80 04.94

Post tested good.

Dell's Notes:

Site ID: 64650

Start Time: 1508

Received GEO unlocated at CHMCC 1717

No first pass data

No composite received.

Beacon 2

McMurdo Pains Wessex FastFind Evaluation

Training Beacon Number: ADDE489C0800005

Date: 4 and 5 November 2003

24-Hour Duration Test, Ground or Pier

This beacon will be activated and set out on the ground or on a pier and left to transmit for 24 hours.

Time of Activation: 4 November 2003 at 09:19:33

Time of Deactivation: 5 November 2003 at 09:19:35

Comments:

Post tested good.

Dell's Notes:

Site ID: 64644

Start Time: 1419

Received GEO unlocated at 1422

Received first pass at 1438

Received Composite at 1515
LAT: 26-05.1N
LON: 080-06.8W

Beacon 3

McMurdo Pains Wessex FastFind Evaluation

Operational Beacon Number: ADCE893844046D

Date: 4 November 2003

2-Hour Duration Test

Crewmember Name: SN Miguel Calderon

This beacon will be activated by the crewmember and the crewmember will make every effort to keep the beacon as dry as possible. The crewmember will ensure the antenna and antenna well are keep dry by lightly shaking excess water from the well or wiping excess water from the antenna surface. The crewmember will also ensure the antenna stays upright and pointed skyward by keeping the beacon attached as high on the body as possible ensuring the beacon remains tethered to the equipment vest.

Time of Activation: 10:09:45

Time Out of Water: 12:10:00

Time of Deactivation: 12:45:00

Comments:

Start LAT: 26 06.94
LON: 080:03:97

End LAT: 26 08.68
LON: 80 04.94

First alert in 3 minutes, composite solution in 8 minutes.

Post tested good.

Dell's Notes:

Site ID: 64647

Start Time: 1508

Received LEO unlocated at 1512

Received first pass at 1516

Received Composite at 1524
LAT: 26-07.1N
LON: 080-07.1W

Beacon 4

McMurdo Pains Wessex FastFind Evaluation

Operational Beacon Number: ADCE089E784006D

Date: 4 November 2003

2-Hour Duration Test

Crewmember Name: MK3 Jerry Suarez

This beacon will be activated by the crewmember and left to transmit without interference. The crewmember will ensure that the beacon remains tethered to the equipment vest.

Time of Activation: 10:08:55

Time Out of Water: 12:10:00

Time of Deactivation: 12:45:00

Comments:

Start LAT: 26 06.94
LON: 080:03:97

End LAT: 26:08:68
LON: 80:04:94

Post tested good.

Dell's Notes:

Site ID: 64649

Start Time: 1508

Received GEO unlocated at 1537 (1514)

Received first pass at 1734

No composite received.

Beacon 5

McMurdo Pains Wessex FastFind Evaluation

Operational Beacon Number: ADCE0892384046D

Date: 4 and 5 November 2003

24-Hour Duration Test, In-Water, Secured in Location

This beacon will be tethered to a fixed location and allowed to float free on an 8-10 foot long tether. The beacon will be activated and left to transmit for 24 hours.

Time of Activation: 4 November 2003 at 09:34:04

Time in Water: 4 November 2003 at 09:37:09

Time Out of Water: 5 November 2003 09:38:15

Time of Deactivation: 5 November 2003 at 09:39:33

Comments:

Fixed location LAT: 26 05.38
LON: 80 06.81

At time of removal from water the audible tone indication was working but no visual indication of 406 or 121.5 transmissions occurred for a 3-minute duration. The unit was deactivated with no visual indication occurring. The beacon was reactivated 1 minute after test termination to check for tone and visual indications, tone was working, the 121.5 red LED came on and stayed on until the beacon was secured, the green 406 LED never illuminated.

Post tested good with both tone and visual indicators working correctly.

Dell's Notes:

Site ID: 64645

Start Time: 1430

Received GEO unlocated at 1437

Received first pass at 1524

Received Composite at 1702
LAT: 26-05.0N
LON: 080-06.7W

R 261734Z NOV 03 ZUI ASN-A00330000161
FM COMDT COGARD WASHINGTON DC//G-OC//
TO ALCOAST
BT
UNCLAS //N10470//
ALCOAST 518/03
COMDTNOTE 10470
SUBJ: PERSONAL EPIRB TEST RESULTS AND CONFIGURATION CHANGE FOR MCMURDO PAINS WESSEX FASTFIND
A. COMDT COGARD WASHINGTON DC R091744Z MAY 02 ALCOAST 239/02
B. RESCUE AND SURVIVAL SYSTEMS MANUAL, COMDTINST M10470.10E
1. OVER THE PAST TWO YEARS, NUMEROUS INQUIRIES, COMMENTS AND CONCERNS CENTERING ON RELIABILITY OF THE MCMURDO PAINS WESSEX FASTFIND PERSONAL EPIRB (PEPIRB), REQUIRED FOR USE BY REF A, PROMPTED AN OPERATIONAL TESTING SCENARIO. THIS SCENARIO WAS DEVELOPED TO DETERMINE IF THE PEPIRB MEETS THE PERFORMANCE CRITERIA INDICATED BY THE RADIO TECHNICAL COMMISSION FOR MARITIME SERVICES (RTCM) PAPER 5-97/SC110STD AND THE MANUFACTURERS PRODUCT LITERATURE. THE PEPIRB TEST SCENARIO WAS DEVELOPED BY COMMANDANT G-OPR AND G-OCS IN COORDINATION WITH THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATIONS (NOAA) MISSION COORDINATION CENTER (MCC) IN SUITLAND, MARYLAND TO TEST THREE SPECIFIC CAPABILITIES OF THE PEPIRB:
A. ALERT THE COSPAS/SARSAT SYSTEM WITHIN 90 MINUTES OF ACTIVATION.
B. PRODUCE A CALCULATED COMPOSITE POSITION OF THE PEPIRB WITHIN 3 NAUTICAL MILES OF ACTUAL DISTRESS LOCATION.
C. OPERATE CONTINUOUSLY FOR 24-HOURS AFTER ACTIVATION.
2. FIVE PEPIRBS WERE SELECTED FOR THIS TESTING AND ALL FIVE PASSED EACH OF THE REQUIRED CAPABILITIES. THREE PEPIRBS WERE WORN IN INFLATABLE PFDS BY BOAT CREW MEMBERS AND WERE EVALUATED DURING A 2-HOUR DURATION IN-WATER TEST. TWO CREW MEMBERS WERE INSTRUCTED TO ACTIVATE THEIR PEPIRB AND ALLOW IT TO FLOAT FREE ON THE TETHER LINE. THE THIRD CREW MEMBER WAS INSTRUCTED TO ACTIVATE THE PEPIRB AND ENSURE THE PEPIRB STAYED ATTACHED TO THE VELCRO PATCH ON THE BOAT CREW MEMBERS HELMET. IN ADDITION TWO PEPIRBS WERE USED TO DETERMINE THE 24-HOUR OPERATING DURATION. ONE PEPIRB WAS ACTIVATED AND ALLOWED TO TRANSMIT UNDISTURBED FROM THE TOP OF A SIGN POLE. THE SECOND IN-WATER PEPIRB WAS TETHERED TO A DAY BOARD AND ALLOWED TO TRANSMIT AND FLOAT FREE.
3. ALL FIVE PEPIRBS SUCCESSFULLY ALERTED THE COSPAS/SARSAT SYSTEM BY TRANSMITTING THEIR SPECIFIC HEXADECIMAL IDENTIFICATION CODE TO THE NOAA MCC WITHIN 16 MINUTES OF ACTIVATION. WERE THIS NOT A TEST, AN ALERT MESSAGE WOULD FORWARD AUTOMATICALLY TO THE APPROPRIATE COAST GUARD RESCUE COORDINATION CENTER (RCC) IDENTIFYING THE SPECIFIC PEPIRB ACTIVATION. WITH PROPER REGISTRATION AND TIMELY OPERATIONS AND POSITION REPORTING, THIS ALERT IS SUFFICIENT TO ENSURE DISTRESS ALERTING FOR COAST GUARD BOAT CREW MEMBERS.
4. BOTH 24-HOUR PEPIRB TESTS GENERATED A COMPOSITE POSITION FOR

THEIR LOCATION, THE DRY PEPIRB AT 51 MINUTES AND THE IN-WATER PEPIRB AT 139 MINUTES. THESE POSITIONS WERE ACCURATE WELL WITHIN THE 3 NAUTICAL MILE TEST REQUIREMENTS AND BOTH PEPIRBS OPERATED IN EXCESS OF 24-HOURS.

5. THE PEPIRB ATTACHED TO THE BOAT CREW MEMBERS HELMET WAS THE ONLY ONE OF THE 2-HOUR DURATION IN-WATER TESTS TO PROVIDE SUFFICIENT TRANSMISSION OF DATA TO OBTAIN A COMPOSITE SOLUTION DURING THE TEST PERIOD. THE TWO PEPIRBS THAT WERE TETHERED TO THE CREW MEMBERS AND LEFT TO FLOAT FREE DID NOT GENERATE A COMPOSITE POSITION UNTIL AFTER THE 2-HOUR TEST WAS COMPLETE. DURING THE 2-HOUR IN-WATER TEST SCENARIO, THE TWO PEPIRBS THAT DID NOT GENERATE A COMPOSITE POSITION WERE OFTEN OBSTRUCTED BY THE CREW MEMBERS FOR SIGNIFICANT PORTIONS OF THE 2-HOUR TEST. MOST OF THE TIME THESE TWO PEPIRBS WERE NOT VISIBLE TO THE TEST OBSERVERS. THE TEST OBSERVERS INDICATED THAT THE TETHER LINES WERE NOT LONG ENOUGH TO ALLOW THE PEPIRB TO FLOAT AWAY AND FREE OF THE CREW MEMBER. WHILE THESE TWO PEPIRBS DID TRANSMIT THE HEXADECIMAL IDENTIFICATION CODE PERIODICALLY, DUE TO OBSTRUCTION BY THE CREW MEMBER, THE BURST TRANSMISSION SIGNAL WAS DEGRADED ENOUGH TO PREVENT THE COSPAS/SARSAT SYSTEM FROM GENERATING A COMPOSITE POSITION.

6. LESSONS LEARNED FROM THIS TESTING:

A. WHILE ALLOWED TO FLOAT FREE THE PEPIRB CASE IS SUBMERGED IN IT'S NORMAL FLOATING ATTITUDE. IN THIS ATTITUDE, WATER FLOODS THE ANTENNA STORAGE WELL. WHEN ANY AMOUNT OF WATER IS ALLOWED TO COLLECT IN THE ANTENNA STORAGE WELL THE SIGNAL IS DEGRADED AND MAY PREVENT THE COSPAS/SARSAT SYSTEM FROM RECEIVING THE TRANSMITTED SIGNAL. AFTER ACTIVATION, BOAT CREW MEMBERS SHALL MAKE EVERY EFFORT TO KEEP THE PEPIRB OUT OF THE WATER, THE ANTENNA AND ANTENNA STORAGE WELL AS DRY AS POSSIBLE AND THE PEPIRB ORIENTED SO THAT THE ANTENNA HAS AN UNOBSTRUCTED VIEW OF THE SKY. THIS CAN BE ACHIEVED BY ATTACHING THE PEPIRB TO THE HELMET, HOOD OR SURVIVAL VEST/PFD AND ROUTINELY CHECKING TO ENSURE WATER HAS NOT COLLECTED IN THE ANTENNA WELL.

B. CORRECT PEPIRB REGISTRATION WITH NOAA IS CRITICAL. SINCE ALL FIVE PEPIRBS TRANSMITTED THEIR HEXADECIMAL IDENTIFICATION CODE, THE MCC WOULD HAVE CONTACTED THE COAST GUARD UNIT IDENTIFIED AS THE EMERGENCY POINT OF CONTACT, AND THE RCC WOULD HAVE RECEIVED THE AUTOMATIC NOTIFICATION FROM THE COSPAS/SARSAT SYSTEM. WITH LAST KNOWN POSITION INFORMATION TYPICALLY TRANSMITTED DURING OPERATIONS AND POSITION REPORTING FROM OUR BOATS, THE UNIT WOULD KNOW WHERE TO SEARCH. PEPIRB REGISTRATION CAN NOW BE DONE ON LINE AT: HTTP://WWW.BEACONREGISTRATION.NOAA.GOV.

C. VELCRO HOOK TAPE AFFIXED TO THE BACK OF THE PEPIRB ALLOWS THE CREW MEMBER TO ATTACH THE PEPIRB TO THE HELMET OR HOOD AND TRANSMIT THE 406 MHZ SIGNAL UNOBSTRUCTED.

7. MAKE THE FOLLOWING CONFIGURATION CHANGE TO ALL IN SERVICE AND IN STOCK PEPIRBS AND NEW PEPIRBS RECEIVED FROM THE MANUFACTURER: ATTACH A 2-INCH BY 2-INCH PIECE OF VELCRO HOOK TAPE TO THE PEPIRB

BATTERY. DO NOT COVER THE BATTERY EXPIRATION DATE. SELF-ADHESIVE VELCRO HOOK TAPE IS AVAILABLE FROM NUMEROUS SOURCES INCLUDING BURCH FABRICS, 4200 BROCKTON DRIVE, GRAND RAPIDS, MI, 49572, TELEPHONE (800) 543-0441.

8. CONFIGURATION CHANGES TO INFLATABLE PFDS FOR INSTALLING VELCRO PILE TAPE WILL BE DIRECTED IN A FUTURE ALCOAST.

9. AS A RESULT OF THIS TESTING AND AS AN ADDED MEASURE OF SAFETY FOR OUR BOAT CREWS, G-OCS WILL CONSIDER THE INSTALLATION OF 406 MHZ EPIRBS ON COAST GUARD BOATS AT UPCOMING CONFIGURATION CONTROL BOARDS FOR THE MLB AND UTB. SPECIFIC INFORMATION REGARDING STANDARD CONFIGURATION, INSTALLATION AND FUNDING WILL BE FORTHCOMING UNDER SEPCOR UPON APPROVAL.

10. MAINTAIN A COPY OF THIS ALCOAST IN THE FRONT OF REF B PENDING PROMULGATION OF THE NEXT REVISION.

11. INTERNET RELEASE NOT AUTHORIZED.

12. RELEASED BY RADM JAMES C. OLSON, DIRECTOR OF OPERATIONS CAPABILITY.

BT

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Appendix 8

McMurdo Ltd. Review of Draft Report
&
ETS Foundation Response

mcmurdo

7 April, 2004

Mr D Ritter
ETS Foundation
2211 West Rockrose Place
Chandler
Arizona 85248
USA

Dear Doug,

Re: McMurdo Response to Trials Report

We have studied your Report carefully and are very concerned with regard to the outcome of your trials.

We have serious concerns about a) the conclusions you draw and b) the resultant allegations you make regarding our products.

We feel other manufacturers have been provided with opportunities to correct and comment on their products during the tests. Something we were not given the opportunity to do. I will detail our concerns in this letter but would insist that you do not proceed with publishing your Report until you have satisfactorily dealt with each of the following points.

Summary

Our products perform to specification and have been proven to work in real-life scenarios, both during actual emergencies and trials. We cannot understand why they performed as they did under your tests. We have a number of hypotheses, but will require more time to research these before we can report back to you. **As such, it is imperative you delay publishing your Report.** In our opinion, it presents a misleading and potentially inaccurate/flawed view of McMurdo products that could result in widespread trade and customer concerns with a potentially serious impact on our business.

McMurdo/Ritter Test Beacon Functionality

All EPIRBs and PLBs are tested prior to shipment in keeping with our standard manufacturing and testing procedures for all equipment, manufactured and sold by McMurdo / Pains Wessex Ltd.

The EPIRBs and PLBs used for this trial were tested to those standard operating procedures prior to shipment to our distributor, and obtained GPS lock within 2 to 3 minutes.

Furthermore the EPIRBs were re-tested at re-programming in the presence of your witness, Peter Forey, and again achieved GPS lock. These beacons worked when they left our factory. We do not understand why they performed as they did when tested by you.

McMurdo Beacon Test

It is imperative that McMurdo is given the opportunity to study the test beacons and comment prior to your Report publication, as were the other manufacturers when their beacons failed. We can have them collected today and request that you make them available to us immediately.

Successful McMurdo Global Studies

When independently tested elsewhere in the world, our products worked. They worked at the Key West trials on 17th through 20th March 2003. They worked at the USAF trials in Vermont on 1st July 2003. They worked in Australia at trials conducted on the 18th through 20th February 2002. They worked during testing conducted in the United Kingdom. They have been proven to work on a regular basis during other tests we regularly run for our products. As such, we cannot understand why our products failed to meet our usual high standards in your trials.

Competitor Product Failures

We find it incredible that throughout your tests, and in your draft Report, you allowed major failures in competitor products to go virtually unchallenged as well as allowing in-test modification/repair. Example: the ACR battery failure. Example: the Techtest RF cable becoming unplugged. These are major failures that would have been catastrophic in a real emergency. In a real emergency these products would have failed. In a real emergency, despite your test findings, the McMurdo products would have alerted through the COSPAS SARSAT satellite system. Techtest were also allowed to comment with regard to the RF welding on their beacons. This factor alone makes your test findings biased and even more imperative that we can examine our own equipment. We need a level playing-field and be afforded the same opportunities as our competitors.

Attendance at Tests

As you are aware, McMurdo was unable to attend the tests. We dislike the journalistic-style "selective" use of text from our correspondence you used in your draft Report. The text you chose gives the misleading impression that we were not committed to finding a way to participate in the tests. We were. We worked diligently to try to achieve approval to attend the tests, but the personal liability waiver you insisted one of our employees sign, before allowing him to attend the test, made it impossible. As a responsible employer we did not feel one of our employees should be forced to sign a legally binding document that released yourself and numerous third parties from any liability and denied him the right to pursue anyone through the courts should any harm come to him during his attendance at the trials.

Completeness of Tests

As you are aware, your trials omitted certain other manufacturers and their products. We do not understand why we were put under considerable pressure to commit to very onerous legal documents, whilst also being advised you would continue testing "irrespective" of our involvement. Why were your tests not comprehensive? What was your reason for your aggressive stance towards McMurdo when you allowed other manufacturers to be completely absent from your tests?

Way forward

We do not understand why our products performed as they did in your tests. We therefore do not understand your test results. Until we do, we cannot accept your Report's findings. We recommend three specific action items:

1. Delay publication of the Report until we have researched/you have dealt with the points made in this letter.
2. Return the test beacons to McMurdo so we can examine them at our own facility.
3. Confirm that McMurdo will be offered the same opportunity to "manage" any failures as was offered to ACR and Techtest

I will call you later today, but you can also reach me on +44 (0) 23 9262 3903

With best regards,

Yours sincerely,

C P HOFFMAN
Technical Director
For and on behalf of McMurdo Limited

Ref: CPH/2246/ad

Cc West Marine

McMurdo Limited
Silver Point, Airport Service Road,
Portsmouth PO3 5PB
United Kingdom

Telephone: +44(0)23 9262 3900
Facsimile: +44(0)23 9262 3996
www.mcmurdo.co.uk

mcmurdo

7 April, 2004

Mr D Ritter
ETS Foundation
2211 West Rockrose Place
Chandler
Arizona 85248
USA

Dear Doug,

McMurdo Detailed Response to the Draft Report on

Evaluation of 406 MHz Location Protocol Distress Beacons
April XX, 2004

Produced by
Equipped To Survive Foundation

This letter supports our previous letter of 7th April 2004, Ref: CPH/2246/ad and contains our detailed comments on your draft report.

Page 2 Final Paragraph and Page 3 Third Paragraph

Only one test was carried out on one beacon for each scenario, statistically this is not enough to draw conclusions, given the variables noted on page 3. McMurdo's own tests show that it is possible to carry out one or two tests and get results that are not representative of the population and variables, such as GPS satellite positions. Multiple tests are required in order to be able to draw any firm conclusions.

Pages 8 and 73

In the Maritime results table, there are a number of boxes filled in, where no tests were carried out (see footnotes 2 and 4). The table infers that the ACR beacons would have passed and the McMurdo and Techtest beacons would have failed. Due to the variables in the system as noted in page 3 of the report, you cannot draw these conclusions. It is patently unfair to infer a success in one case and a failure in another, the criteria used in the tables should be the same for all manufacturers in all cases. We would recommend that all boxes with footnotes 2 and 4 in them be modified to read "Not Tested".

Registered in England No. 746603
Registered Office: 1650 Parkway,
Whiteley, Fareham, Hants, PO15 7AH
VAT NO GB 421 1393 92

Member of Chemring Group PLC

McMurdo Limited
Silver Point, Airport Service Road,
Portsmouth PO3 5PB
United Kingdom

Telephone: +44(0)23 9262 3900
Facsimile: +44(0)23 9262 3996
www.mcmurdo.co.uk

mcmurdo

Pages 9, 43 and 64

In the Inland results table, Techtest were given a "Success" for the result in the Small Clearing. Clearly this was a failure, in the real world you do not have the opportunity to "swap out" a beacon if it is not working, whatever the reason. Failures such as this (and the ACR failure noted on page 43) are indicative of the quality of the beacons being supplied by that manufacturer and thus represent a real world indication of the likely performance of those beacons and accordingly such results should be factored into the overall conclusions and results, not dismissed.

Page 9

Again in the Inland results table, all beacons "Failed" to acquire GPS under the forest canopy. It is possible for a reader of this report to infer from this that the beacons failed to provide a distress alert, which from the detailed results, we believe not to be true. We believe that it is important that we maintain peoples confidence in the overall Cospas-Sarsat system and as such would recommend that a footnote be added to all such results to indicate that these beacons still transmitted a distress alert to the satellites. This comment also applies to all other cases where beacons failed to acquire GPS location.

Page 9

Finally in the Inland results table, Laying the beacons on the side, assumes a Success for the ACR beacon based upon footnote 7. Unless the Garmin was also laid on its side and switched on to see if it acquired GPS position under these conditions, then these results should not be reported as a success. It is recommended that all of the results for the GOES satellites be simply annotated as a "success" and footnote 7 and the word "Unlocated" be removed. Along the same lines, the result for the ACR beacon with LEO data (footnote 8) should be identified as a failure, unless the comments related to page 8 above are adopted.

Page 10 Final Paragraph and Page 11 Fourth Paragraph

These paragraphs infer that the USCG tests at Key West were a failure, in fact the results of the tests as detailed in Appendix 1 of your report, clearly indicate that in 77.4% of all cases GPS position was encoded into the beacon messages. This clearly indicates that the trials were a success and that GPS enabled beacons represent a worthwhile investment. The McMurdo beacons in the Key West trials achieved a success rate of 64.7% for the EPIRB and 55.0% for the PLB which contrasts sharply with the results in these trials and indicates some anomaly which to date we do not understand and needs further investigation.

Registered in England No. 746603
Registered Office: 1650 Parkway,
Whiteley, Fareham, Hants, PO15 7AH
VAT NO GB 421 1393 92

Member of Chemring Group PLC

McMurdo Limited
Silver Point, Airport Service Road,
Portsmouth PO3 5PB
United Kingdom

Telephone: +44(0)23 9262 3900
Facsimile: +44(0)23 9262 3996
www.mcmurdo.co.uk

mcmurdo

Page 12

The third paragraph talks about the AFRCC event in Vermont and infers that one beacon at that event failed to acquire GPS signals. We believe that it should be made clear that this was NOT one of the beacons that were tested in your trials.

Page 12 Fourth Paragraph

We believe that this paragraph should be deleted in its entirety as it infers that the system may not work. As we understand matters, in all cases all beacons provided a distress alert and location via Doppler and as such would have enabled a rescue to take place, thus this paragraph is misleading.

Page 14 Fourth Paragraph

While the quote from an email to Doug Ritter by Chris Hoffman is factually correct, this is only an extract of that email and in our opinion is being used out of context. We request that either this quote is deleted, or that the entire email is included (especially the previous paragraph in the email) such that the quote can be read in context.

Page 23 Final Paragraph

This paragraph is, we believe, misleading, McMurdo beacons determine their exact location based upon the GPS co-ordinates and round this up or down to the nearest 4 second grid co-ordinates in the box corners. Thus the worst case error is for an actual location in the middle of a box that might be reported as any one of the four corners of that box. If we use the numbers in your report for Santa Cruz then the worst case error to the middle of the box is 79 metres (259 feet). As we do not know which "side" of the box this position relates to, this error must be +/- 79 metres. If we now assume that, on average, the error will be half of this, then at Santa Cruz the typical error would be +/- 39.5 metres. In practise we assumed that typically a higher latitude would apply and thus used a smaller longitude box, thus we believe that "typically +/- 30 metres" is still a valid statement.

Page 40

The first paragraph states that McMurdo have been customers of Imanna, to the best of our knowledge McMurdo have never been a customer of Imanna. A long time ago, Pains Wessex may have used Imanna, but this was well before the companies were owned by the same organisation, Chemring. We believe that this statement thus creates a false impression endorsing Imanna that is not true from McMurdo's perspective and thus our name should be deleted here.

Registered in England No. 746603
Registered Office: 1650 Parkway,
Whiteley, Fareham, Hants, PO15 7AH
VAT NO GB 421 1393 92

MEMBER OF CHEMRING GROUP PLC

McMurdo Limited
Silver Point, Airport Service Road,
Portsmouth PO3 5PB
United Kingdom

Telephone: +44(0)23 9262 3900
Facsimile: +44(0)23 9262 3996
www.mcmurdo.co.uk

mcmurdo

Page 40 Point 2

This implies a deficiency in the McMurdo design which we believe was not borne out in either the Imanna testing or the field tests, as our beacons always got a signal to the satellites. The statements in point 9 on page 87 better reflect the true situation and we believe that the words on page 40 should be modified accordingly.

Pages 43 and 64

As previously stated both ACR and Techtest were allowed to remove beacons and investigate failures with their beacons, we believe that in the light of the much better trials results from Key West, McMurdo were not offered the same chance to investigate why their beacons did not perform as well in these trials as they did at Key West. This seems to be an unfair stance and thus does not give us the opportunity to adequately respond.

Page 45 Last bullet point

We disagree with this conclusion / statement, based upon the fact that the screened room used was not anechoically lined, you would expect to get reflections that would show up as dips in the antenna patterns.

Page 48

In the fourth paragraph you infer that McMurdo may have tampered with its beacons during the re-coding process in the factory. We strongly object to the inference herein that we tampered with our beacons in any way and require this inference removed from the report.

I look forward to your comments in due course.

Yours sincerely,

C P HOFFMAN
Technical Director

Registered in England No. 746603
Registered Office: 1650 Parkway,
Whiteley, Fareham, Hants, PO15 7AH
VAT NO GB 421 1393 92

MEMBER OF CHEMRING GROUP PLC

April 12, 2004

Mr. Chris Hoffman
McMurdo Limited
Silver Point, Airport Service Road
Portsmouth PO3 5PB
United Kingdom
(via email)

Dear Chris,

I am responding to your two letters dated April 7, 2004, which you sent in response to the draft Report you were provided for review in conformity with our Agreement.

In accordance with the Agreement, the Foundation is not required to respond to McMurdo's comments or implement any of McMurdo's suggested corrections. We have attempted to be as accommodating to all parties of interest as possible, and in this regard have, as detailed below, made some modifications to the Report based upon McMurdo's comments. We also elected to specifically address McMurdo's comments by this response and are willing to consider McMurdo's further comments within the time frame described.

In summary, The Foundation has made every effort herein to address all of the issues raised in your letters. In some instances we have modified the report, as noted below. In other instances, we believe that McMurdo's position is not justified or that the Report is accurate and no changes are warranted.

The Foundation understands McMurdo's desire to receive the test beacons back for analysis as soon as possible. As you are aware, our agreement allows us 60 days after publication of the report to do so. Unfortunately, as a result of McMurdo's response and its threatening tone, our lawyer has advised me that we have no alternative but to retain these beacons until such time as the Foundation is assured that any potential issues between McMurdo and the Foundation are resolved. It is anything but an ideal situation, but my hands are tied as a result of McMurdo's response.

As I am sure McMurdo is aware, this testing came about because of our interest and the interest of many third parties from industry, government and elsewhere in the performance of beacons with self-location capability. In particular, there was substantial and widespread concern after the Key West Test about the performance of these beacons. As McMurdo is aware and as detailed in the Report, these concerns were so great that many of these third party entities made substantial contributions, both financially and of other valuable resources to facilitate the testing.

The focus of these tests was upon the self-locating performance of beacons. McMurdo was well aware that this would be the focus of the testing. However, it appears from some of the comments and complaints made that McMurdo has failed to respect that this was the focus of the field tests, with the specific exceptions noted in the test protocols. The Foundation took pains to ensure that this was clearly stated and were equally as clear about those few tests that evaluated other capabilities. Some of these other issues that McMurdo has raised are generally not relevant or germane to our investigation, as we have explained in detail below.

Several of McMurdo's claims allege bias in the testing and presentation of the test results. As detailed below, the Foundation believes such allegations are unfounded. In short, bias is not evident simply because the results of the testing reveal that certain beacons performed better or worse than others in various situations or because the apparent poor performance of McMurdo's beacons in Key West was a factor for development of this investigation and evaluation.

In fact, before the testing occurred, there were four possible outcomes, two of which would have been entirely positive for McMurdo and one of which would have been neutral. We might have found that Key West was an anomaly and McMurdo's beacons performed no worse or no better than others or what might be reasonably expected. We might have found that McMurdo's beacons performed better than others or exceeded reasonable expectations. We might have inconclusive results that failed to answer the questions raised at Key West. We might have found that McMurdo's beacons did not perform on par with others or as might be reasonably expected.

The other issues investigated that revolved around McMurdo's beacon design were the result of what the Foundation has been hearing from consumers who have been told various things by sellers in the marketplace and didn't know who to believe. They look to the Foundation to provide unbiased and independent answers. Once again, there were the same possible outcomes.

The Foundation went to considerable, one might even say extraordinary, expense and effort to ensure that all beacons were treated fairly and, in fact, provided McMurdo beacons extra opportunities on a number of occasions in an effort to ensure that there could be no legitimate complaint of bias made with regards to its beacons. For example, the McMurdo PLB was given extra time to gain a relocation in the Baseline Scenario Bravo test and the McMurdo EPIRB was given a unique opportunity to acquire in the Maritime testing. If anyone had any reasons to complain of bias, it would have been the other manufacturers.

The Foundation has difficulty understanding McMurdo's portrayal of our requirement that all participants sign a personal liability waiver as being unreasonable or the allegation that such would cause you to require that McMurdo's employee "sign a legally binding document that released yourself and numerous third parties from any liability and denied him the right to pursue anyone through the courts should any harm come to him during his attendance at the trials." In fact, the draft agreement which was provided to McMurdo was specifically tailored to exclude from the waiver any "gross negligence or intentional conduct" on our part. Further, the use of this sort of waiver is common and usual in business in the U.S. Notably; EVERY other participant was willing to sign the waiver. Ultimately, McMurdo decided to move forward with the testing rather than further discuss the waiver issue. As such, we reject the legitimacy of your claim that our actions in this regard prevented you from sending an observer.

Our and the many third parties' concerns and interest with regards to this central issue of location performance are borne out by McMurdo's admissions in its response. One substantial concern is that consumers are being charged a premium for beacons with self-locating performance and that representations are being made that the self-locating beacons provide improved locating performance. Consumers and other third parties thus expect to receive performance based upon these representations for which they are paying a higher price.

Contrary to these expectations, it appears that from McMurdo's own comments McMurdo believes that there is nothing wrong with its beacons even if the self-locating performance is suspect, at best, because the beacons would have sooner or later allowed for a Doppler location to be provided. It would logically follow that McMurdo believes that there is no added benefit to GPS-enabled location information being transmitted in the initial GEO alert or in the initial LEO alert and that any time saved as a result in effecting a rescue would not alter the outcome. McMurdo seems to be arguing that self-location has no value and as long as a Doppler location is provided, that's all that's required.

Of concern from McMurdo's own response is that it appears that McMurdo is selling a device with a purported capability that McMurdo believes to be essentially of no value for a considerable premium over a device that lacks this capability.

The Foundation is puzzled as to how you can possibly portray our treatment of McMurdo prior to the testing compared with how we treated any other manufacturer as illustrating an exceptionally aggressive stance that was in some manner unfair or discriminatory to McMurdo, or that the Foundation did not include some manufacturers in the evaluation, making the evaluation less than comprehensive or somehow unfair to McMurdo. ACR and McMurdo are the only companies of which we are aware that were then, or currently are widely marketing GPS-enabled EPIRBs and PLBs to the general consumer in the United States. Since West Marine was a sponsor and a dealer for both companies, it was convenient for us to secure these beacons from their stock, as noted in the report.

In an effort to make the evaluation as comprehensive as possible, the Foundation invited both Microwave Monolithics and SERPE-IESM to participate. This was done even though they did not then offer their beacons for sale to the general consumer in the U.S. because they have continually expressed their intent to do so "in the near future." Since we obviously could have no access to their beacons in stock, nor could we purchase them from a dealer, it was quite impossible for us to test their beacons if they chose not to participate. I lobbied Dr. Chen especially hard to participate and we spent considerable time and extra effort in making the attempt, not unlike the effort put into encouraging McMurdo's participation, but in the end our responses to his issues that had developed as a result of his unfortunate Key West Test experience with his reportedly mis-coded beacons were apparently unsatisfactory. At that point, there was little the Foundation could do.

ACR readily agreed to participate and signed the agreement with which they were presented, the same one originally presented to McMurdo, with only the most minor technical changes. Techtest came to us asking to participate and signed the same agreement originally presented to McMurdo with no changes whatsoever. There was no need to take an "aggressive stance" in the least with these companies. No company was forced to sign the agreement and McMurdo could have chosen not to do so. The fact that the Foundation bent over backwards to enable McMurdo's participation is testament to our desire to have as many manufacturers on board as possible and to make every reasonable effort to accomplish that, and I believe a credit to our effort. Irrespective of whatever other beacons were tested, what is salient is that McMurdo's beacons were given every equitable opportunity to perform.

As such we reject McMurdo's portrayal of our solicitation of McMurdo to participate in the evaluation as revealing any bias or unfairness or that the fact that certain companies declined to participate makes the testing somehow less than comprehensive or unfair.

Now, to address each of McMurdo's detailed issues (McMurdo's comments in italics):

Page 2 Final Paragraph and Page 3 Third Paragraph

Only one test was carried out on one beacon for each scenario, statistically this is not enough to draw conclusions, given the variables noted on page 3. McMurdo's own tests show that it is possible to carry out one or two tests and get results that are not representative of the population and variables, such as GPS satellite positions. Multiple tests are required in order to be able to draw any firm conclusions.

McMurdo was well aware of the fact that the Foundation would be testing single beacons per protocol and that any conclusions drawn would necessarily be drawn on that basis. McMurdo expressed no dissatisfaction prior to the testing and agreed to participate, after strenuous and protracted negotiations over many issues McMurdo took exception with, without any mention of concern in this regard. It is our opinion and belief that the testing was suitably structured to provide valid results, even given these limitations. We reject McMurdo's assertion that this limitation does not allow us to "draw any firm conclusions."

We forthrightly disclose and discuss this limitation fully in the Evaluation Limitations and Considerations section prior to presentation of any substantive portion of the report in order that the reader can make an independent judgment as to the appropriateness of our assumptions in this regard, and thus, the validity of the opinions expressed in the Conclusions and the Recommendations sections of the report.

Pages 8 and 73

In the Maritime results table, there are a number of boxes filled in, where no tests were carried out (see footnotes 2 and 4). The table infers that the ACR beacons would have passed and the McMurdo and Techtest beacons would have failed. Due to the variables in *the system as noted in page 3 of the report, you cannot draw these conclusions. It is patently unfair to infer a success in one case and a failure in another, the criteria used in the tables should be the same for all manufacturers in all cases. We would recommend that all boxes with footnotes 2 and 4 in them be modified to read "Not Tested".*

The methodology the Foundation used is well founded and accepted procedure in product testing, as outlined in the report.

With regards McMurdo's assertions, the presumption of success on the part of the ACR PLB is entirely valid because the external GPS beacons in our tests, and experience, always transmit a position when the GPS has acquired a location. The only theoretical chance that they might not do so would be if something occurred to prevent transmission of the data between the GPS receiver and the beacon or reception of the data by the beacon. Since we have not seen this occur in all our combined experience when the components are properly assembled, we believe this is a highly unlikely occurrence. Moreover, the most likely failure point would be the adapter cord which had performed successfully immediately prior to the tests in question and subsequently worked for the remainder of the evaluation.

With regards McMurdo's beacons, the Foundation believe that the results of the testing overall make this a very logical and reasonable presumption, even aside from the fact that this is a well founded and accepted procedure in product testing, as outlined in the report. We reject McMurdo's assertion that we "cannot draw these conclusions."

The footnotes make clear the circumstances and assumptions. In order to ensure there is no confusion, we have changed to subject text to "Presumptive Success" and "Presumptive Fail."

Pages 9, 43 and 64

In the Inland results table, Techtest were given a "Success" for the result in the Small Clearing. Clearly this was a failure, in the real world you do not have the opportunity to "swap out" a beacon if it is not working, whatever the reason. Failures such as this (and the ACR failure noted on page 43) are indicative of the quality of the beacons being supplied by that manufacturer and thus represent a real world indication of the likely performance of those beacons and accordingly such results should be factored into the overall conclusions and results, not dismissed.

The primary purpose of the evaluation was to determine the "locating" performance of the beacons. As such, the Foundation early on determined to self-test all beacons prior to activation, per the published protocols, and to replace them if they didn't pass. For the purposes of our testing, a self-test failure was not considered a failure. In the case of the Techtest with its easily replaceable battery and the technical representative present noting the possible cause being battery related, it seemed at the time that the best response to the self-test failure was to replace the battery and allow the beacon itself to be tested.

As it turned out, the battery “failure” was not a failure at all, but an apparently anticipated event according to the beacon operating manual. We note in the report with the fact that this is not well documented on the beacon itself and no instruction for remedy is included on the beacon, a deficiency in our opinion. Had we been more familiar with this issue and had more time we might have performed the suggested field battery treatment which would be expected to have resulted in the same success. We believe the footnoted explanation along with the further discussion in the body of the report is satisfactory.

We reject McMurdo’s assertion that “clearly this was a failure” for the reasons noted above.

With regards the anomalous ACR battery run down laboratory test result, the Foundation would be entirely within accepted standard procedures to have not included this test result at all since is occurred in circumstances outside of the predetermined test protocols in that this was not a fresh beacon. It should never have been used in that test in the first place and any results were, as a result, invalid.

We debated at length as to whether or not we should include it. It was determined to include it as it points out a particular failure mode that all these beacons are susceptible to since there is no practical way to determine the actual charge status of the lithium battery(ies).

We reject McMurdo’s assertion that “clearly this was a failure” for the reasons noted above. We have amended the text to more clearly explain the invalid nature of the test result and our reasons for including this result in the report. We have added a recommendation that manufactures investigate ways in which the consumer can be better assured that the battery in their beacon is fully charged.

Page 9

Again in the Inland results table, all beacons “Failed” to acquire GPS under the forest canopy. It is possible for a reader of this report to infer from this that the beacons failed to provide a distress alert, which from the detailed results, we believe not to be true. We believe that it is important that we maintain peoples confidence in the overall Cospas-Sarsat system and as such would recommend that a footnote be added to all such results to indicate that these beacons still transmitted a distress alert to the satellites. This comment also applies to all other cases where beacons failed to acquire GPS location.

The Foundation shares McMurdo’s concerns that confidence in the COSPAS-SARSAT system and 406 MHz beacons in general not be adversely affected by this report. We have gone to great lengths to make it clear that these beacons were primarily tested for GPS acquisition and state in the Introduction and again in the Conclusions that all the beacons ”appear to provide the minimum acceptable level of distress alerting and Doppler locating performance expected from conventional, non-location protocol 406 MHz emergency beacons."

In order to err on the side of prudence in this regard, we have added a line prior to presentation of the summary tables that says: "Please note that the terms "success" and "fail" in these tables refers to the acquisition of a GPS-derived location and is not indicative of the alerting performance of the beacons."

Page 9

*Finally in the Inland results table, Laying the beacons on the side, assumes a Success for the ACR beacon based upon footnote 7. Unless the Garmin was also laid on its side and switched on to see if it acquired GPS position under these conditions, then these results should not be reported as a success. It is recommended that all of the results for the GOES satellites be simply annotated as a "success" and footnote 7 and the word "Unlocated" be removed. Along the same lines, the result for the ACR beacon with LEO data (footnote 8) should be identified as a failure, unless the comments related to page 8 above are adopte*d.

The referenced test of beacons with the antenna horizontal to the ground was a test of the beacon being inadvertently positioned on its side, either purposely due to ignorance, or more likely, as if accidentally knocked over. In the case of the ACR PLB under discussion, if it were connected to a GPS so as to provide a location it is not rational to assume that the GPS operator would purposely place the GPS receiver on its side prior to attempting to gain a GPS location. Once the GPS location has been received in the conventional manner, typically while being held in their hand or placed on the ground where they are inherently stable, this position is automatically transferred to the ACR beacon irrespective of its orientation. Thus, in our opinion this is a valid observation and we reject McMurdo's contention that the GPS need be laid on its side for the test to be valid.

With regards the ACR PLB performance in the gorge, this is where we stand today, an unexplained anomaly. We would label it a LEO Satellite Doppler failure if we could ascertain that it indeed did fail as a result of the beacon's failure to perform in some manner, but that is not clear because nobody we have spoken with so far can explain how its transmission was received by a satellite 22,300 miles away, but not one approximately 600 miles away. We suspect a system failure and NOAA is looking into this. As such we reject McMurdo's contention that this represents a beacon failure and we believe that "no data" is an appropriate table listing in conjunction with the explanatory footnote.

Page 10 Final Paragraph and Page 11 Fourth Paragraph

These paragraphs infer that the USCG tests at Key West were a failure, in fact the results of the tests as detailed in Appendix 1 of your report, clearly indicate that in 77.4% of all cases GPS position was encoded into the beacon messages. This clearly indicates that the trials were a success and that GPS enabled beacons represent a worthwhile investment. The McMurdo beacons in the Key West trials achieved a success rate of 64.7% for the EPIRB *and 55.0% for the PLB which contrasts sharply with the results in these trials and indicates some anomaly which to date we do not understand and needs further investigation.*

The Key West Test report statistics are flawed, as noted in the report, because they combined the baseline results with the operational testing. McMurdo's own computations with regards to performance of the McMurdo beacons is similarly flawed. If the baseline scenarios are removed from the statistics, the picture changes dramatically. While the overall operational scenario success rate for McMurdo's beacons in Key West was somewhat better than the Foundation saw in our evaluation, it was still extraordinarily poor, in our opinion. Had it not been so noticeably poor, there would not have been such a high interest in the industry to conduct another test of the beacons, and I would never have gone through the extraordinary effort and expense that was required to conduct this independent evaluation.

We reject McMurdo's contention that the apparent overall success of the Key West Tests, combining both baseline and operational scenarios, has any bearing on McMurdo's specific beacons or that the actual failure rate in the operational testing of McMurdo's beacons in Key West was so significantly different as to suggest some anomaly in the results of our own evaluation.

We reject McMurdo's implication that anything in our discussion of the Key West Test or our own evaluation suggests that GPS-enabled beacons may not be a worthwhile investment. We have quite clearly stated our opinion in the Conclusions that GPS-enabled beacons may be a worthwhile investment, that "those beacons that more often than not provided a location validated the functionality and desirability of this capability as a means of enhancing survivors' chances of rescue."

Page 12

The third paragraph talks about the AFRCC event in Vermont and infers that one beacon at that event failed to acquire GPS signals. We believe that it should be made clear that this was NOT one of the beacons that were tested in your trials.

Given that this was anecdotal information, the author or a representative was not present, and it is not essential to the report, we have removed this reference from the report.

Page 12 Fourth Paragraph

We believe that this paragraph should be deleted in its entirety as it infers that the system may not work. As we understand matters, in all cases all beacons provided a distress alert and location via Doppler and as such would have enabled a rescue to take place, thus this paragraph is misleading.

Please see our previous comments regarding this subject.

We reject McMurdo's contention that this paragraph "infers that the system may not work."

Page 14 Fourth Paragraph

While the quote from an email to Doug Ritter by Chris Hoffman is factually correct, this is only an extract of that email and in our opinion is being used out of context. We request that either this quote is deleted, or that the entire email is included (especially the previous paragraph in the email) such that the quote can be read in context.

The Foundation doesn't feel that this quote is taken out of context given the subject matter under discussion, primarily why McMurdo chose not to have a representative at the tests, but in consideration of McMurdo's expressed concerns, and it not adversely affecting the report in any manner other than to add some more pages, we have added the full text of the email to the Appendices and provided a reference.

Page 23 Final Paragraph

This paragraph is, we believe, misleading, McMurdo beacons determine their exact location based upon the GPS co-ordinates and round this up or down to the nearest 4 second grid co-ordinates in the box corners. Thus the worst case error is for an actual location in the middle of a box that might be reported as any one of the four corners of that box. If we use the numbers in your report for Santa Cruz then the worst case error to the middle of the box is 79 metres (259 feet). As we do not know which "side" of the box this position relates to, this error must be +/- 79 metres. If we now assume that, on average, the error will be half of this, then at Santa Cruz the typical error would be +/- 39.5 metres. In practise we assumed that typically a higher latitude would apply and thus used a smaller longitude box, thus we believe that "typically +/- 30 metres" is still a valid statement.

Thank you for more fully explaining your derivation of this statement. It does serve to support The Foundation's belief that McMurdo's assumptions are flawed and thus the statement misleading.

McMurdo takes the position that half the time the beacon would be found within 30 meters of the reported position. In order to make that statement, McMurdo has to make certain assumptions, assumptions that we think are not necessarily valid.

First, McMurdo apparently assumes that the beacon is at a specific location that is further north than the approximately 37 degrees at Santa Cruz. We reject this assumption as entirely valid for a product that is sold for use in any geographic region of the world, excepting any disclosure of this assumption to the consumer, which McMurdo does not make.

Moreover, even at the North or South Poles, the worst case (assuming millimeter GPS accuracy) is approximately 62 meters, and half the worst case is approximately 31 meters, which is still greater than 30 meters.

McMurdo also assumes that the GPS system error is extremely small, which is not necessarily a valid assumption.

McMurdo also assumes that the beacon was activated near the center of a "box," which is not a valid or reasonable assumption at all.

Some significant percentage of the time, the GPS error of a beacon placed randomly in the box will overlap the side of a box, and that beacon can be expected to report itself as being in either of the two boxes. Likewise, the GPS error of a beacon will sometimes overlap a corner, and the reported position might be in any of four boxes.

If the beacon is in the box that it reports itself in, the average error will be about 40 meters. However, McMurdo is ignoring the very real likelihood that the beacon is in an adjacent box.

Please see the attached analysis of this issue that was developed by Bob Dubner to explain why we reject McMurdo's contention that "typically +/- 30 metres" or the original in McMurdo's literature of "positional accuracy to within typically 30 meters" is a valid statement. In order to provide the reader more complete information, we intend to delete the final sentence of that paragraph and include this further information provided about how McMurdo have come to that statement as well as our detailed concerns as to its validity as enumerated above into the report in an appropriate manner, and to incorporate Dubner's analysis as an Appendix, all so that the reader can determine for themselves the validity of McMurdo's claim.

Page 40

The first paragraph states that McMurdo have been customers of Imanna, to the best of our knowledge McMurdo have never been a customer of Imanna. A long time ago, Pains Wessex may have used Imanna, but this was well before the companies were owned by the same organisation, Chemring. We believe that this statement thus creates a false impression endorsing Imanna that is not true from McMurdo's perspective and thus our name should be deleted here.

The Foundation agrees this may give a mistaken impression. We also believe that the fact that this actual relationship wasn't totally clear to us at the point we selected Immana as the independent laboratory is relevant. It had some bearing on why they were selected, regardless of the miscommunication. We have rewritten this so that the point is clear and to ensure that there is no implication that McMurdo has endorsed Imanna.

Page 40 Point 2

This implies a deficiency in the McMurdo design which we believe was not borne out in either the Imanna testing or the field tests, as our beacons always got a signal to the satellites.

The statements in point 9 on page 87 better reflect the true situation and we believe that the words on page 40 should be modified accordingly.

The Foundation rejects McMurdo's contention that this is any way "implies a deficiency in the McMurdo design." This simply states the issue being investigated, which is a fact beyond dispute. As noted previously, this was an issue being investigated as a result of conflicting claims in the marketplace. It is presented in this report in essentially the same language as was used in the draft test protocols of which McMurdo was aware prior to agreeing to participate in the evaluation and about which McMurdo raised no issue.

Pages 43 and 64

As previously stated both ACR and Techtest were allowed to remove beacons and investigate failures with their beacons, we believe that in the light of the much better trials results from Key West, McMurdo were not offered the same chance to investigate why their beacons did not perform as well in these trials as they did at Key West.   This seems to be an unfair stance and thus does not give us the opportunity to adequately respond.

McMurdo's comments regarding Techtest and ACR being allowed to "manage" the results, accusations of bias on our part and unfair treatment in this regard are without foundation, as previously noted. As was clearly explained in the report, the failure analysis these companies were asked to carry out was simply the result of their beacons behaving in an anomalous manner. When their beacons failed to acquire in circumstances where it might well have not been expected, they were not given the any more opportunity than McMurdo to examine their beacons. The failure of McMurdo's beacons to acquire does not represent any anomalous performance based on our experience. As noted above, we don't believe there is a substantial difference in performance of McMurdo's beacons between Key West and our evaluation. McMurdo's beacons acquired when conditions were optimum and didn't otherwise. We view that as simply poor performance in line with our experience based on Key West. Not being an anomaly, no special failure analysis was in order.

In the case of the Techtest beacon sealing incident, these were specially built for the testing and it took only a phone call to determine what miscommunication had occurred that resulted in this unexpected result. We simply reported the incident and since these beacons in particular were not production units, their performance in this regard could not be considered as indicative of what might be expected. Moreover, this was not the performance criterion being investigated and thus it would have been entirely appropriate to not even mention it, but we felt it proper to do so in our effort to operate in a fully transparent fashion. This is almost exactly the scenario Dr. Chen found himself in at Key West that resulted in the limited retest of his beacons by NOAA and the U.S. Coast Guard. None of which was mentioned in their report, please note.

Page 45 Last bullet point

We disagree with this conclusion / statement, based upon the fact that the screened room used was not anechoically lined, you would expect to get reflections that would show up as dips in the antenna patterns.

This report from the independent lab is what it is and it would be inappropriate to change it. Imanna noted this limitation in the preface and we do not include this issue in our own Conclusions due to our concerns in this regard. We will add an Editor's note to the above effect, attributed to McMurdo, following this statement.

Page 48

In the fourth paragraph you infer that McMurdo may have tampered with its beacons during the re-coding process in the factory. We strongly object to the inference herein that we tampered with our beacons in any way and require this inference removed from the report.

The Foundation infers no such thing and we reject McMurdo's allegation and demand. All it says is that we cannot guarantee this did not occur, which is a simple fact that applies equally to both ACR and McMurdo. Were we not to include this note, we would be guilty of not being thorough and forthright in our report. We are very careful to clearly make the point that we have no information to suggest it did occur.

I trust that the above addresses all McMurdo's concerns. The simple fact of the matter is that no matter how you slice it, on the water McMurdo's beacons had a 100% failure rate in the planned scenarios. Regardless of any other results, that in and of itself is an abysmal performance by any standard. Irrespective of any other results or experience the Foundation possesses, this performance supports the opinions expressed in the Conclusions and Recommendations. Combined with the McMurdo beacons' notably poor performance evidenced at Key West in the operational scenarios, which was part of the instigation for this investigation and evaluation in the first place, there is even more support for the opinions expressed in the Conclusions and Recommendations.

The publication of this report is overdue and the threatening nature of McMurdo's response has upset our schedule due to the need to get the lawyers more deeply involved, causing us considerable delay. If you care to make a response to this letter, I must have it no later than 9:00 AM Eastern Daylight Saving Time on Wednesday morning. I realize this is a short deadline, but I also don't believe there's much left to discuss. The Foundation has more than fulfilled our obligations, ethically and legally, to treat McMurdo fairly and equitably in all respects.

Sincerely,

<signature>

Doug Ritter
Executive Director

Appendix 9

Analysis of McMurdo 30 Meter Statement

To: Doug Ritter
From: Bob Dubner
Re: Analysis of McMurdo 30 Meter Statement

Doug – here is the statement you received from McMurdo:

> *McMurdo beacons determine their exact location based upon the GPS co-ordinates and round this up or down to the nearest 4 second grid co-ordinates in the box corners. Thus the worst case error is for an actual location in the middle of a box that might be reported as any one of the four corners of that box. If we use the numbers in your report for Santa Cruz then the worst case error to the middle of the box is 79 metres (259 feet). As we do not know which "side" of the box this position relates to, this error must be +/- 79 metres. If we now assume that, on average, the error will be half of this, then at Santa Cruz the typical error would be +/- 39.5 metres. In practise we assumed that typically a higher latitude would apply and thus used a smaller longitude box, thus we believe that "typically +/- 30 metres" is still a valid statement.*

There are a number of things in that statement that can be questioned.

McMurdo beacons determine their exact location based upon the GPS co-ordinates and round this up or down to the nearest 4 second grid co-ordinates in the box corners.

This isn't quite right. A beacon calculates a position based on GPS signals. That position is not the "exact location," because there is always some uncertainty due to the limitations of the GPS system. Those uncertainties are exacerbated by the beacon location protocols.

Thus the worst case error is for an actual location in the middle of a box that might be reported as any one of the four corners of that box. If we use the numbers in your report for Santa Cruz then the worst case error to the middle of the box is 79 metres (259 feet).

That statement is true if and only if the beacon really is inside of the box that it believes it is in. Because of the uncertainties of the GPS system, a beacon can properly report itself as being in one of the adjacent boxes, in which case the error grows larger.

If we now assume that, on average, the error will be half of this, then at Santa Cruz the typical error would be +/- 39.5 metres. In practise we assumed that typically a higher latitude would apply and thus used a smaller longitude box, thus we believe that "typically +/- 30 metres" is still a valid statement.

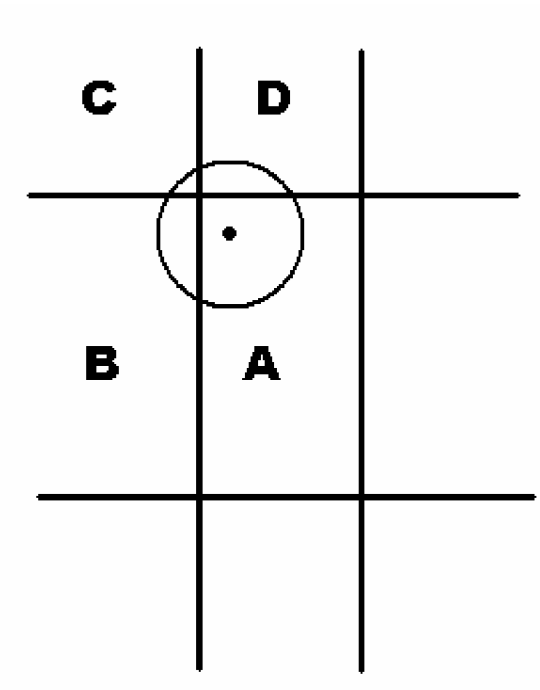
As just discussed, the 39.5 figure is based on the beacon actually being inside the box it thinks it is in, an assumption which isn't always true. But even when it is true, the 30 meter figure is not defensible, even at higher latitudes. The long North-South side of the box is always 123.5 meters, so the worst case error can't be less than 61.8 meters, and the typical value of half that can never be less than 30.9 meters – and that only at the North or South

poles. At latitude 45, to use an example, the in-box error is going to average 37.8 meters; "30 meters" is a definite exaggeration even in that case.

(Technically, saying that the error is "+/-" some distance is also a mistake. The issue here isn't coordinates; the issue is how far away from its reported position the searchers will find a beacon. It can't be "negative 27" meters away. But that's not really important here.)

But, as has been repeatedly mentioned, beacons will not always report the correct box.

GPS always has some uncertainty associated with it. When a GPS receiver says you are at a set of coordinates, all you can count on is that the reported coordinates are *near* where you are. The uncertainty can be treated like the area inside a circle:



The beacon is located at the dot. The circle around it represents the GPS uncertainty. At latitude 37, the narrow side of the box is about 98.8 meters long, so this figure shows a GPS uncertainty of about 50 meters – which is a perfectly ordinary real-world figure.

The beacon, of course, is actually in box A, where the worst-case distance from the beacon to the center of the box is the oft-mentioned 79 meters.

But, the beacon can read the GPS signals, and decide that it is any of the boxes A, B, C, or D, depending on what the GPS satellites are doing at that moment.

Consider, for example, the case where the beacon decides that it is in box C. The distance between the beacon and the center of box C is more than 79 meters.

And that's why 79 meters cannot be considered to be the worst case – because it isn't.

The worst case will typically occur when the beacon in Box A is in a position where the GPS uncertainty circle just barely overlaps the corner of box C. The resulting distance is the diagonal distance of 79 meters *plus* the GSP error. COSAPS-SARSAT regards an error of 100 meters as ordinary, thus the worst case error is 179 meters.

Rather than attempt to work out the mathematics of the actual typical distance a beacon will be found from the center of the box it reports itself to be in, a computer program was written. The program places a beacon at 1,600 equally spaced positions inside a box. It then draws a circle around the beacon at the radius of the GPS error.

It then calculates the coordinates of 100 equally spaced points around the circumference of that circle, and figures out which box would thus be reported by the beacon.

It then calculates the distance from the actual beacon position to the center of the reported box. The average of those 160,000 samples is then calculated. The worst-case distance is also tracked:

Here are the results for latitude 37 degrees

GPS Error (meters)	Average distance from beacon to the center of the reported box	Worst-case distance	Percentage of the time the distance is within 30 meters
0	43.3	79.0	22.6
10	44.1	88.5	22.6
20	46.4	98.0	22.6
30	50.3	108.2	21.7
40	55.4	117.7	19.4
50	62.0	127.4	15.5
60	69.8	137.8	10.9
70	77.8	148.2	6.7
80	86.6	156.7	3.2
90	95.8	167.5	1.0
100	105.0	177.2	0.1

It should be emphasized that these distances derive from the inherent limitations of the GPS and SARSAT beacon systems; they are the distances that would result if the beacons were working perfectly.

Because one of the claims at issue is McMurdo's statement that they achieve "positional accuracy to within typically 30 meters," the program also reported how many of those points were within that distance. It can be seen that the data doesn't really support that claim.

Appendix 10

McMurdo Email Regarding Participation

From: Chris Hoffman <chrishoffman@mcmurdo.co.uk>
To: 'Doug Ritter' <dritter@equipped.org>
Cc: Barry Sims <barrysims@mcmurdo.co.uk>, Gary Mullins <garymullins@mcmurdo.co.uk>, Helen Marsh <HelenM@chemring.co.uk>, Kevin Robertson <kevinrobertson@mcmurdo.co.uk>, Scott Weide <sweide@weidemiller.com>, 406 Beacon Test Sponsors <406beacontestsponsors@equipped.org>, James Chandler <JamesC@mcmpw.com>
Subject: RE: Next Weeks Trials
Date: Thu, 15 Jan 2004 13:04:23 -0000

Dear Doug

I am as disappointed as you that we have not been able to resolve the outstanding legal issues between our parent company Chemring and Equipped to Survive. We have been scratching our heads to find a way to enable us still to participate but at the same time overcome the legal issues.

I believe that the biggest stumbling block is the Personal Liability Waiver, with the Confidentiality Agreement being a secondary issue. I have spoken to our parent company and they still will not let us sign the waiver, I guess that USA and UK laws and liabilities, which I don't for a minute purport to understand, are different enough to create the problems.

So how does this sound as a way forward, we have very nearly agreed the Main Agreement between us and are almost in a position where we would be happy to sign this, if we could sort out the last outstanding minor legal issue. However nobody from McMurdo would attend the trials as a witness as I am sure that you already have enough "experts" and independent witnesses to cover anything that needs doing anyway. This then removes the issues with the Personal Liability Waiver and Confidentiality Agreement.

If you could advise if this is acceptable then Helen and Scott could sort out the agreement today maybe and we could be signed up and on board.

Assuming that this is acceptable then, I look forward to receiving any feedback that you feel able to provide as well as a preview copy of the report. If I can be of any further assistance, please let me know.

Best Regards

Chris Hoffman

Chris Hoffman
McMurdo Limited

-----Original Message-----
From: Doug Ritter [mailto:dritter@equipped.org]
Sent: 14 January 2004 01:03
To: Chris Hoffman
Cc: Barry Sims; Gary Mullins; Helen Marsh; Kevin Robertson; Scott Weide; 406 Beacon Test Sponsors
Subject: Re: Next Weeks Trials
Importance: High

Chris,

I am disappointed that you have waited until this late date to respond, and to do so while offering virtually nothing in the way of compromise after we have bent over backwards to address your stated concerns is only more disappointing. Your assessment of the situation is wildly optimistic and without any foundation, in my opinion. While I suppose there is always hope the lawyers will work something out in the short time remaining, and we would welcome your participation, if you are not willing to meet us halfway there's nothing much that can to be done.

Yes, we have received back the test coded beacons, thank you.

Regards,

At 12:27 AM 1/14/2004 +0000, Chris Hoffman wrote:

Dear Doug

I believe that we are close to having an agreement in place that is acceptable to our parent company and thus would allow us to send someone over to attend your trials next week. Helen will be responding formally to Scott, but I thought that I would give you a heads up of where we have got to.

Main Agreement

If we can get the additions that you made to Clause 14 last time taken back out then I think we are pretty much happy with this.

Confidentiality Agreement

There are a few minor changes that we would like to make to this, but I do not think that they are contentious.

Personal Liability Waiver

This is currently our only real outstanding issue, we have been advised that our employees should not sign up to this Waiver in its current form, thus if you are going to insist that the person who attends signs, then we will either have to agree a revised waiver with you this week or our "engineer" will not be able to attend.

As I said Helen will be responding formally on these points and any others she may have, but I thought that you would like to know where we are, as time is running short for next week now.

I trust that the Lab tests before Christmas went well and that you have received our beacons back from Peter Forey programmed in test mode.

Best Regards

Chris Hoffman

Chris Hoffman
McMurdo Limited