

McMurdo Trials Report

406 MHz EPIRB and PLB GPS Beacons in Operational Scenarios

Abstract

This report investigates the position-locating and reporting performance of 406 MHz GPS-equipped beacons in a variety of operational scenarios, both at sea and on land as appropriate.

The beacons which were tested included current production models and versions incorporating planned modifications.

The report concludes that the modified beacons performed faultlessly under all conditions.

Limitation

Satellite coverage at the time an alert is transmitted and obstructions, both overhead and on the horizon, may affect whether and how soon an alert signal is received by the appropriate satellite. Although McMurdo believes that the test results described in this Report fairly represent the performance of its EPIRB and PLB beacons, the results of other tests may vary from those described in this Report and will depend on the factors described above.

Further Information

For more information and additional copies of this Report, contact:

Kevin Robertson, Sales and Marketing Director
McMurdo Limited
Silver Point, Airport Service Road, Portsmouth PO3 5PB, United Kingdom
Telephone: +44 (0)23 9262 3905
Fax: +44 (0)23 9262 3998
Email: kevinrobertson@mcmurdo.co.uk

Copyright

This Report and its content are protected by U.S. and international copyright laws and treaties. This Report and its content are for noncommercial use only. You agree to comply with all copyright laws in your use of this Report and to prevent any unauthorized copying of this Report and its content. The copyright and all related intellectual property rights in all material provided is owned by McMurdo. You agree to use the Report solely for the lawful use and benefit of yourself or your organization, and not for resale or other transfer to, or use by or for the benefit of, any other person or entity. You agree to not copy, reproduce, recompile, decompile, use, distribute, publish, display, perform, modify, upload to, create derivative works from, transmit or in any way exploit any part of the Report for commercial purposes or in any manner that could compete with the business of McMurdo, except that you may make copies of the Report for your own use or use within your organization that is non-commercial and does not compete with the business of McMurdo, provided that all copies retain all copyright and other proprietary notices.

You acquire no rights or licenses in or to the Report or the materials contained therein other than the limited right to use the Report in accordance with these terms.

Contents

Synopsis.....	1
Executive Summary	1
Summary of Baseline Testing.....	2
Summary of Maritime Testing.....	3
Summary of Inland Testing.....	4
Introductory Statement.....	5
Field Test Results.....	6
Santa Cruz, USA – Land Tests	6
Baseline Scenarios	6
Baseline Scenario Alpha.....	6
Baseline Scenario Bravo.....	8
Baseline Scenario Charlie.....	8
Inland Scenarios	9
Inland Scenario Alpha.....	9
Inland Scenario Bravo.....	10
Inland Scenario Charlie.....	11
Inland Scenario Delta.....	12
Inland Scenario Echo.....	12
Inland Scenario Foxtrot.....	13
Inland Scenario Golf.....	16
Inland Scenario Hotel.....	17
Inland Scenario India	17
United Kingdom - Maritime Tests	18
Introduction.....	20
Baseline Scenarios	20
Baseline Scenario Alpha.....	20
Baseline Scenario Bravo.....	21
Baseline Scenario Charlie.....	21
Maritime Scenarios	22
Maritime Scenario Alpha.....	22
Maritime Scenario Bravo.....	23
Maritime Scenario Charlie.....	24
Maritime Scenario Delta.....	24
Maritime Scenario Echo.....	25
Maritime Scenario Foxtrot.....	26
Maritime Scenario Golf.....	27
Maritime Scenario Hotel.....	28
Maritime Scenario India	28
Modifications to existing design.....	29
GPS module firmware.....	29
Beacon Firmware.....	29
Beacon Hardware	29
Independent Witnesses.....	30
Field Tests Attendees	30
Acknowledgements	30
Acronyms and Abbreviations.....	31
Trade Marks	31

Synopsis

The upgraded units tested performed perfectly with a 100% pass rate in all the planned scenarios. Some units even performed in areas where the GPS receivers struggled to determine a position.

Executive Summary

This programme of work and evaluation was initiated in response to a sequence of independent testing of GPS enabled distress beacons, carried out by the Equipped to Survive Foundation, in and around Santa Cruz, California, USA, in January 2004. The ETS Foundation test plan covered a comprehensive range of operational scenarios. In the subsequent test report that the ETS Foundation published, it reported that the McMurdo GPS enabled distress beacons generally failed to acquire a GPS position and subsequently transmit position encoded data on the 406MHz international distress frequency. *It must be stressed that at no point did the ETS Foundation question the validity or efficacy of the doppler locating ability, or the 406 MHz transmitter capability, of the beacons under scrutiny.*

McMurdo Ltd responded expressing concern over the reported results. Other independent tests have taken place in Europe, Australia and the USA in the past, the results of which did not corroborate the findings of the ETS Foundation.

McMurdo Ltd takes such critical reports seriously and in response embarked on a programme to bring forward a planned technology upgrade programme, and to implement and operationally test upgraded beacons in the presence of independent witnesses.

It was decided to attempt to replicate the ETS Foundation trials as closely as possible to avoid controversy in any interpretation of the results. Because of the unique topography of the Santa Cruz area it was decided to conduct the land trials at the same locations used in the original trials. Since the ETS Foundation reported the GPS location of all the test sites, replication was easy. It was not considered advantageous to conduct the sea trials in California as the satellite coverage at sea in the UK is much the same as in California. The largest variability in any trial at sea is the weather and sea state. It was also decided to trial more than one beacon in any given scenario to gain some further statistical data. Beacons to be used in the trials were taken directly from production stock, in much the same way that industry standard quality sampling is done. No 'special' beacons were produced with modifications or enhancements other than those described in this report.

The 'original' build standard beacons were not altered in any way. The only intervention was that the antenna was disconnected and the outputs of the two distress transmitters were terminated into 50R loads. This allowed evaluation of the GPS performance, by noting the time taken for the Green 'GPS Fix' LED to illuminate, without making a transmission to the LEO or GEO satellites. The 'upgraded' beacons included the changes detailed in the "Modifications to existing design" section of this report, which are the same as those being offered free of charge to customers, and thus are representative of the ongoing build standard.

The tabulated results following summarise the trial results achieved in Santa Cruz, USA, (at locations used by the ETS Foundation), and in the UK for the upgraded Fastfind Plus 406 MHz PLB and the G4/Precision 406 MHz GPS EPIRB, both with internal GPS.

All trials with upgraded beacons used fully operational beacons transmitting on both 406 MHz and 121.5 MHz as they would in real life emergencies. The planned number of tests in the UK using multiple beacons in each scenario had to be reduced due to Air Traffic Control (ATC) concerns over the number of 121.5 MHz alerts being received by overflying

commercial passenger aircraft. However, at least one test was carried out in each maritime scenario.

Several tests with the 'original' build standard PLB beacons were conducted on land in the USA; the results of these tests are included in the body of this report. These tests have been omitted from this summary in order to improve clarity and avoid confusion. As McMurdo will be upgrading all products, it is only the results from the upgraded beacons as detailed here which are of importance. Because of the ATC requirement to limit the number of live transmissions during the UK sea trials, and because of the difficulty in detecting from a distance the activation of the green "GPS fix" LED, no comparison of the 'original' build standard EPIRBs were conducted during the sea trials.

Summary of Baseline Testing

USA	Number of satellites in view on Garmin eTrex Success or failure to acquire a GPS position Time to acquire a GPS position (minutes and seconds)					
Baseline Scenario Description	PLB 1	PLB 2	PLB 3	PLB 4	PLB 5	PLB 6
On jetty with clear view of the sky to the horizon	9 Success 0:48	Not tested	7 Success 1:23	Not tested	7 Success 1:16	Not tested
Relocation to beach with clear view of the sky to the horizon	7/8 Success < 40 secs*	Not tested	7/8 Success < 40 secs*	Not tested	7/8 Success < 40 secs*	Not tested

*Exact time not recorded

UK	PLB 1	EPIRB 1
On marina pontoon with clear view of the sky to the horizon, sprayed with water to simulate heavy rain.	7 Success 1:03	7 Success 1:05

Summary of Maritime Testing

UK	Beacon ID			
	Number of satellites in view on Garmin eTrex Success or failure to acquire a GPS position Time to acquire a GPS position (minutes and seconds)			
Maritime Scenario Description	Conditions	PLB	EPIRB	EPIRB
On deck of vessel at stern.	Clear sky, sea-state 0.5m to 0.7m swell	PLB 4 5 Success 1:56	EPIRB 4 5 Success 2:17	
Floating in sea, tethered with lanyard	Clear sky, sea-state 0.5m to 1m swell. choppy, 'white horses'		EPIRB 5 5 Success 2:03	
Floating in sea, tethered with lanyard, simulated rainfall.	Clear sky, sea-state 0.5m to 1m swell. choppy, 'white horses'		EPIRB 3 5 Success 4:02	EPIRB 4 5 Success 1:29
Held on swimmer's chest floating in the sea.	Clear sky, sea-state 0.5m to 0.7m swell	PLB 5 5 Success 3:30		
Held by swimmer floating in the sea, simulated rainfall	Clear sky, sea-state 0.5m to 0.7m swell	PLB 1 5 Success 1:59		
In 8-person liferaft, canopy closed	Floating in marina harbour	PLB 6 4 Success 1:07	EPIRB 6 4 Success 0:52	
In 8-person liferaft, canopy closed, sprayed to simulate rainfall	Floating in marina harbour	PLB 6 5 Success 1:02	EPIRB 6 5 Success 0:54	



Fastfind Plus PLB under heavy spray



Floating G4 EPIRB under spray

Summary of Inland Testing

USA	Number of satellites in view on Garmin eTrex Success or failure to acquire a GPS position Time to acquire a GPS position (minutes and seconds)					
Inland Scenario Description	PLB 1	PLB 2	PLB 3	PLB 4	PLB 5	PLB 6
Large meadow, tree-line 25 to 50 m away	Not Tested	7/8 Success 1:04	Not Tested	7 Success 1:04	Not Tested	7/8 Success 1:03
Small clearing in forest. Tall tree line 10m away	Not Tested	4 Success 1:21	Not Tested	3 Success 1:07	Not Tested	3 Success 1:32
Hidden from GPS satellites for initial start-up period. Cover removed to allow GPS acquisition at up-date time.	6 Success 1:13	Not Tested	7 Success 1:01	Not Tested	6 Success 1:16	Not Tested
Under redwood canopy, intermittent GPS reception	Not Tested	1 / 2 Failure§ No fix	Not Tested	1 / 3 Success§ 7:06	Not Tested	1 / 3 Success§ 3:29
In deep high-sided ravine. 1 satellite visible on Garmin	Not Tested	1 Failure§ No fix	Not Tested	1 Failure§ No fix	Not Tested	1 Success§ 10:08

§In previous ETS Foundation trials all beacons failed in these scenarios, thus these results have been excluded from the analysis. However, a 50% pass rate is considered very good under these conditions.



Obstructed view under trees during Inland Scenario Bravo/ Charlie



Fastfind Plus PLB on the ground under cover of redwood trees. The satellite coverage monitored on the two Garmin receivers varied between 1 and 3 satellites throughout the test.

Introductory Statement

This programme of work and evaluation was initiated in response to a sequence of independent testing of GPS enabled distress beacons, carried out by the Equipped to Survive Foundation, in and around Santa Cruz, California, USA, in January 2004. The ETS Foundation test plan covered a comprehensive range of operational scenarios. In the subsequent test report that the ETS Foundation published, they reported that the McMurdo GPS enabled distress beacons generally failed to acquire a GPS position and subsequently transmit position encoded data on the 406MHz international distress frequency. *It must be stressed that at no point did the ETS Foundation question the validity or efficacy of the doppler locating ability, or the 406 MHz transmitter capability, of the beacons under scrutiny.*

McMurdo Ltd responded expressing concern over the reported results. Other independent tests have taken place in Europe, Australia and the USA in the past, the results of which did not corroborate the findings of the ETS Foundation.

McMurdo Ltd takes such critical reports seriously and in response embarked on a programme to bring forward a planned technology upgrade programme, and to implement and operationally test upgraded beacons in the presence of independent witnesses.

It was decided to attempt to replicate the ETS Foundation trials as closely as possible to avoid controversy in any interpretation of the results. Because of the unique topography of the Santa Cruz area it was decided to conduct the land trials at the same locations used in the original trial. Since the ETS Foundation reported the GPS location of all the test sites, replication was easy. It was not considered advantageous to conduct the sea trials in California as the satellite coverage at sea in the UK is much the same as in California. The largest variability in any trial at sea is the weather and sea state. It was also decided to trial more than one beacon in any given scenario to gain some further statistical data. Beacons to be used in the trials were taken directly from production stock, in much the same way that industry standard quality sampling is done. No 'special' beacons were produced with modifications or enhancements other than those described in this report.

The 'original' build standard beacons were not altered in any way. The only intervention was that the antenna was disconnected and the outputs of the two distress transmitters were terminated into 50R loads. This allowed evaluation of the GPS performance, by noting the time taken for the Green 'GPS Fix' LED to illuminate, without making a transmission to the LEO or GEO satellites. The 'upgraded' beacons included the changes detailed in the "Modifications to existing design" section of this report, which are the same as those being offered free of charge to customers, and thus are representative of the ongoing build standard.

Field Test Results

The field tests were separated into three distinct types: Baseline, Inland and Maritime, as per the ETS Foundation test plan.

The results obtained during the Santa Cruz trials and the United Kingdom based trials are detailed separately. The text in italics is extracted from the McMurdo Test Plan which was devised to replicate the ETS Foundation tests as closely as possible.

Santa Cruz, USA – Land Tests

Both upgraded and current production build standard PLBs were tested in all the phases. In addition a 'test' beacon was operated in each phase. This beacon had both transmitters disabled and had access to the GPS interface connector, enabling all data from the internal GPS module to be logged by PC. This enabled *full* evaluation of the GPS module performance under each scenario, both during the test sequences and later back in the UK. The original build standard PLBs are identified in these tests as P4/0, P5/0 and P6/0. The upgraded PLBs are identified in these tests as PU1, PU2, PU3, PU4, PU5 and PU6. All tests were independently witnessed by Peter Forey of Sartech Engineering. In addition Chuck Hawley of West Marine witnessed the bulk of the land testing.

Baseline Scenarios

All the baseline tests took place in Santa Cruz on May 17, 2004.

Note: Chuck Hawley was *not* present during the baseline phases.

Baseline Scenario Alpha

Individual Beacon Test: Activate 3 PLBs sequentially in a wide open area on the shoreline (e.g., a beach or pier) with a clear view all around and no less than 6 available GPS satellites. Record with photographs pictures of the area and the GPS Receiver screens.

The site was the same used by the ETS Foundation trials - a long concrete jetty leading to a lighthouse at Santa Cruz yacht harbour. This site has a good all round view of the sky right down to the horizon with typically six to seven strong satellites present throughout the tests.



Baseline Scenario Alpha, concrete jetty at Santa Cruz yacht harbour
Setting up the beacon message logging equipment prior to activation of a Fastfind Plus PLB



Determining satellite coverage with a Garmin eTrex Legend

Three original build standard PLBs (transmitting into dummy loads, not to the satellite) and 3 upgraded PLBs were activated sequentially. **All** the beacons achieved a GPS fix in typically 1 to 2 minutes and transmissions from the three upgraded beacons were received by the GEO.

Garmin eTrex GPS Position: N36° 57' 42 0" W 122° 00' 10.2"

Weather Conditions: Good, clear, slight wind.

Beacon ID	Local Time	Sats in View	Time To First Fix	Time to transmit location	Location transmitted	GEO Location Received
P4/0	09:27	8	2:00	N/A	N/A	N/A
P5/0	09:27	8	2:01	N/A	N/A	N/A
P6/0	09:27	8	1:35	N/A	N/A	N/A
PU1	09:58	9	0:48	2:50	N 36° 57' 44" W 122° 00' 08"	Yes
PU3	10:53	7	1:23	2:50	N 36° 57' 44" W 122° 00' 08"	Yes
PU5	10:58	7	1:16	2:50	N 36° 57' 44" W 122° 00' 08"	Yes

Note: In this and all subsequent scenarios, it should be noted that the COSPAS-SARSAT system is only capable of resolving positions in steps of ±4 seconds. Thus there is generally a small variance between the Garmin GPS reported position and that transmitted by the beacon under test.

Baseline Scenario Bravo

Updated Position Test. 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 45 minutes has elapsed once the beacon is at the new site.

This test checked the ability of the PLB to update its GPS position when moved. Again the test replicated the original ETSF trial as closely as possible with the beacons being moved a few hundred meters down the beach, east of the activation point on the jetty. (It was not possible to include the unmodified beacons in this trial as the 406MHz transmission was terminated internally, preventing the reading of the data encoded in this transmission).

All three upgraded beacons updated their GPS position correctly and transmitted the encoded position data to the LEOs and GEO, taking less than 40 seconds to derive the new position.

Weather Conditions: Good, clear, slight wind



Baseline Scenario Alpha activation point visible in background with lighthouse at end of concrete jetty.

Beacon ID	Sats in View	Time to update position	Location transmitted	GEO Location Received
PU1	7/8	< 40 secs*	N 36° 57' 48" W 122° 00' 32"	Yes
PU3	7/8	< 40 secs*	N 36° 57' 48" W 122° 00' 32"	Yes
PU5	7/8	< 40 secs*	N 36° 57' 48" W 122° 00' 32"	Yes

*Exact time not recorded

Baseline Scenario Charlie

Conducted as part of the Sea trials Baseline Scenarios, please refer to the United Kingdom Maritime trials section of this report.

Inland Scenarios

This sequence of tests was carried out around the Santa Cruz area on May 18, 2004.

Inland Scenario Alpha

Activate 3 PLBs 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). Record with photographs the area and the GPS Receiver screens.

Locating the exact ETS Foundation test site from the declared GPS position proved elusive. A large meadow with a surrounding tree line that appeared to match the described scenario was located slightly further North than expected.



Setting up equipment at Inland scenario Alpha

All the beacons achieved a GPS fix in around a minute and transmissions from the three upgraded beacons were received by the GEO.

Garmin eTrex GPS Position:

N37° 01' 21.5" W 122° 05' 03.3"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
P4/0	12:15	7	1:10	N/A	N/A	N/A
P5/0	12:18	7/8	0:59	N/A	N/A	N/A
P6/0	12:21	7	1:10	N/A	N/A	N/A
PU2	12:01	7/8	1:04	2:50	N 37° 01' 28" W 122° 05' 08"	Yes
PU4	12:05	7	1:04	2:50	N 37° 01' 24" W 122° 05' 04"	Yes
PU6	12:09	7/8	1:03	2:50	N 37° 01' 24" W 122° 05' 04"	Yes



Five strong satellite signals displayed on Garmin eTrex Legend (7 visible).

Inland Scenario Bravo

Test not required as previous test proved GPS will not acquire in this scenario.

Inland Scenario Charlie

Despite the intention not to test units in this scenario because of the difficulty of getting a GPS fix under these conditions (the previous ETSF trial showed GPS will not acquire in this scenario), it was decided to test the units to gauge their performance.

Tests were carried out in the Nisene Marks State Park. This used to be a former commercial logging area and is heavily forested, mainly with Redwood, Douglas Fir, Tanoak and Madrone trees.

An area was identified that closely matched that of the ETSF trial but again was at a slightly different position to that reported. This was at the centre of a group of tall Redwood trees with steep hill slopes with tree coverage on three sides, the remaining side descending down into a ravine.

The foliage coverage was fairly heavy with sunlight breaking through as the branches moved in the wind. This was also evident on the Garmin GPS receivers with both showing fluctuating GPS satellite coverage of between 1 and 3 satellites throughout the trial.



Obstructed view under trees during Inland Scenario Bravo/ Charlie



Fastfind Plus PLB on the ground under cover of redwood trees. The satellite coverage monitored on the two Garmin receivers varied between 1 and 3 satellites throughout the test.

Three upgraded PLBs were tested with two obtaining GPS lock under these difficult conditions. (No beacons obtained GPS lock in this scenario in the previous ETSF trials.)

Garmin eTrex GPS Position: N 37° 00' 6.0" W 121° 54' 19.8"

Beacon ID	Local Time	Sats in View	TTF	Time to transmit location	Location transmitted	GEO Location Received
PU2	14:09	1/2	No fix	N/A	N/A	N/A
PU4	14:38	1/3	7:06	7:50	Not recorded	NOAA data not provided
PU6	14:52	2/3	3:29	4:30	N 37° 00' 4" W 121° 54' 16"	NOAA data not provided

Inland Scenario Delta

Activate 3 PLBs in an area with minimal overhead obstructions (e.g., an open area with few trees and a surrounding tree line 5 to 10 meters away, to simulate operation in a typical small forest clearing.), so that there is a little (some) obstruction to the GPS satellites (ideally 4 satellites visible, but no more 5 satellites visible as determined by handheld GPS). Record with photographs the obstruction of the sky by the canopy and the GPS Receiver screens.

This was carried out in another location in Nisene Marks State Park. The site was a small grassy area with tall trees all around obscuring the horizon up to about 30° to 40°. The PLBs were placed around 10m from this tree line at its closest point.



Tall tree obstruction in Scenario Delta



Three strong satellites signals displayed on Garmin eTrex Legend

The number of satellites visible during this phase varied between 3 and 4 as satellites rose above the obstruction of the tree line.

All the upgraded PLBs achieved a GPS lock in less than 2 minutes.

Garmin eTrex GPS Position : N 37° 00' 3.4" W 121° 54' 18.8"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
P4/0	09:27	4	No fix	N/A	N/A	N/A
P5/0	09:45	4	1:19	N/A	N/A	N/A
P6/0	10:15	3	2:16	N/A	N/A	N/A
PU2	09:33	4	1:21	2:50	N 37° 00' 00" W 121° 54' 16"	Yes
PU4	10:05	3	1:07	2:50	N 37° 00' 00" W 121° 54' 16"	Yes
PU6	10:23	3	1:32	2:50	N 37° 00' 00" W 121° 54' 16"	Yes

Inland Scenario Echo

Test not required as previous test proved GPS will not acquire in this scenario.

Inland Scenario Foxtrot

Due to the success achieved in Inland Scenario Charlie, it was decided to proceed with scenario Foxtrot, as time was available. The ETSF test described this scenario thus: *“Using the PLB beacons from a prior scenario, activate beacons 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.”*

The area selected was believed to be close to that used in the ETS Foundation tests. It had very steep wooded hillsides with high obstruction of the sky up to around 50°. A section of Aptos Creek flows over rocks at the bottom of the ravine.



Fastfind Plus PLB next to creek at the bottom of the ravine

A total of 3 PLBs were activated on the ground at the bottom of the ravine.

No location was recorded on the Garmin eTrex as it could not see enough satellites to determine a position. (No beacons obtained GPS lock in this scenario in the ETSF trials.)

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU2	15:33	1/3	No lock	N/A	N/A	N/A
PU4	15:50	1	No lock	N/A	N/A	N/A
PU6	15:50	1	5:18	6:10	N 37° 00' 00" W 121° 54' 20"	Yes

It was decided to determine if the PLB that got a fix would continue to perform floating in the creek itself. It was switched off and given enough time for internal voltages to discharge so a GPS cold-start was guaranteed.



View looking down into the Aptos Creek ravine from the bridge above



Detail from previous photo showing the PLB being placed into Aptos creek at the bottom of the ravine.



Fastfind Plus PLB floating in Aptos creek at bottom of ravine. Only one satellite is displayed on the adjacent Garmin eTrex

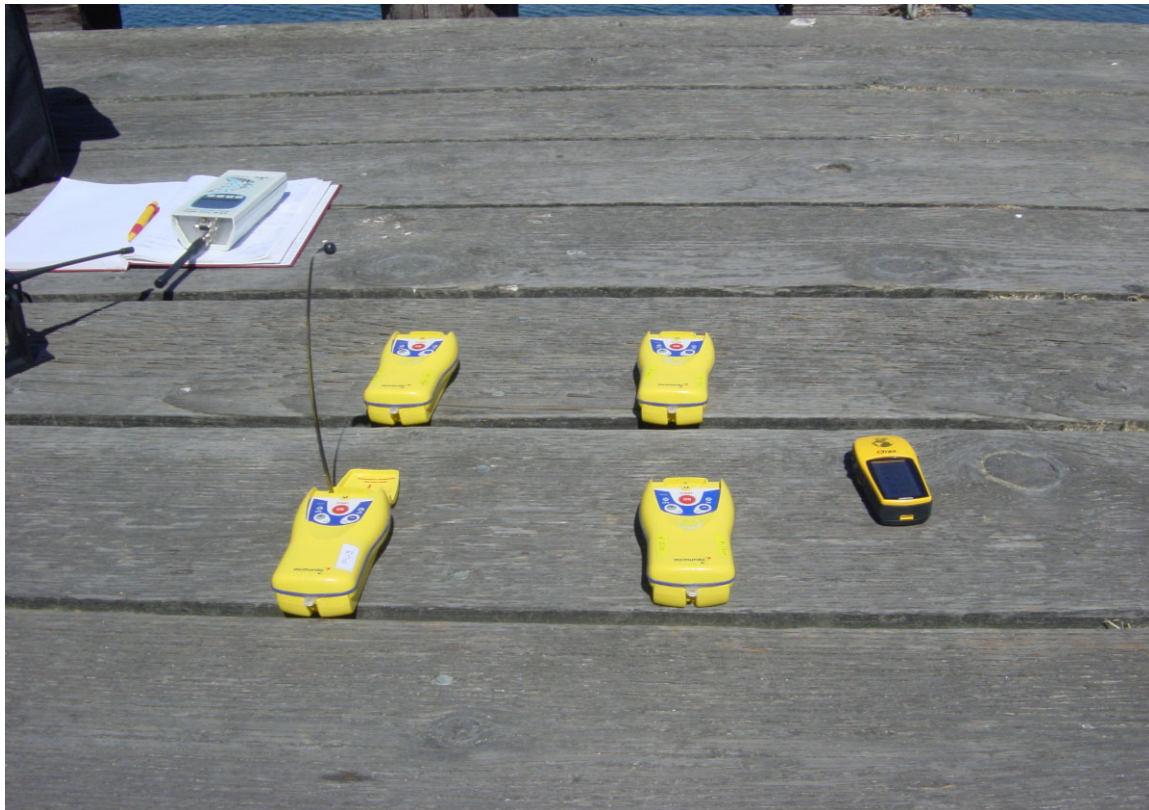
The Fastfind Plus PLB was activated at 16:10 local time and achieved a GPS fix in 10 minutes and 8 seconds! During the entire time, no more than one satellite was visible on the adjacent Garmin GPS receiver.

Inland Scenario Golf

At a test site next to that used for Baseline Scenario Bravo, ensuring a clear line-of-sight to GOES East / West and no less than 4 available GPS satellites. Activate the 3 PLBs used in Baseline Scenario Bravo 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 45 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.

The initial plan was to trial these units on the Santa Cruz yacht harbour beach with units being shielded by a metallised survival blanket. Unfortunately a strong coastal wind made it impossible to keep the blanket in place without tearing it.

The test location was moved to a wooden pier a few hundred yards away in Santa Cruz yacht harbour. The screening blanket was cut into strips and layers of the material were wrapped around the GPS antenna area for each PLB. They were then placed face down (completely obscuring the GPS antenna) on the wooden pier and activated. (It was confirmed by the 406MHz transmission monitoring receivers that no position encoded data was being transmitted).



*Screening foil removed from Fastfind Plus PLBs after 20 minutes activation
(Note: the three 'original' beacons in this picture do not have antennas fitted)*

When the foil was removed just before the next GPS receiver activation period, in all but one instance (an 'original' beacon) a GPS position was determined in just over one minute.

Garmin eTrex GPS Position :

N36° 57' 50.7" W 122° 00' 9.3"

Beacon ID	Local Time	Sats in View	TTFF (from next activation)	Time to transmit location (from GPS activation)	Location transmitted	GEO Location Received
P4/0	15:09	7	No lock	N/A	N/A	N/A
P5/0	15:09	7	1:06	N/A	N/A	N/A
P6/0	15:09	7	1:13	N/A	N/A	N/A
PU1	15:57	6	1:13	2:30	N 36° 57' 52" W 122° 00' 08"	Yes
PU3	15:09	7	1:01	2:30	N 36° 57' 52" W 122° 00' 08"	Yes
PU5	15:57	6	1:16	2:30	N 36° 57' 52" W 122° 00' 08"	Yes



Garmin eTrex on wooden pier, showing 7 satellites visible.

Inland Scenario Hotel

Test not required as test is not a GPS acquisition test.

Inland Scenario India

Test not required as test is not a GPS acquisition test.

United Kingdom - Maritime Tests

All maritime tests took place in the United Kingdom between June 29 and 30, 2004.

During development of the upgrade, the need to trial modified G4 beacons under varying sea states proved difficult. Most development evaluation was done in agitation vessels in an attempt to reproduce a consistent sea-state. However any opportunity to evaluate performance at sea in rough conditions was taken, as this would reveal the suitability of the proposed modification. Many days were spent conducting trials at sea but the weather was generally moderate to benign.

An opportunity arose to evaluate the improved floatation scheme and upgraded firmware under real-world storm conditions. Earlier in June, local sea conditions reached force 6 to 7. 'Voyager', a 36-foot catamaran with an experienced crew, became available for McMurdo's use. Six upgraded EPIRBs were made available for trials at sea; these had their transmitters connected to dummy loads to avoid generating alerts.

'Voyager' sailed from Littlehampton and about 3 miles out encountered a swell of 2 to 3m. Beacons were dropped into the sea on extended lanyards and observed and photographed. As the day progressed the sea state increased, exceeding 3m at times. The stability was judged to be excellent even when 'riding' large waves.

In all 6 units were trialled a total of 4 times, with the average TTFF being less than 4 minutes. 5 satellites were visible on a Garmin eTrex.



G4 being launched from 'Voyager' on a lanyard



G4 riding the waves. Note the upright position allowing maximum view of the sky

Although not part of the official witnessed trials, these results are included as they provide further evidence of the performance of the upgraded beacons.

Introduction

In the following scenarios, it was hoped to test multiple beacons, as per the Santa Cruz trials, but after consultation with the UK ARCC, it was agreed to limit the number and duration of transmissions to ease the logistics burden on them. (Although the beacons were coded for a 406 test protocol, the 121.5MHz transmission is treated as a genuine distress alert, resulting in multiple reports to the ARCC from overflying commercial aircraft relayed via Air Traffic Control).

Baseline Scenarios

These took place at Sparkes Marina, Hayling Island, Hampshire (South coast of England).

Baseline Scenario Alpha

Individual Beacon Test. Activate at least one and if possible / permitted 3 PLBs and at least one and if possible 3 EPIRBs sequentially in a wide open area on the shoreline (e.g., a beach or pier) with a clear view all around, especially towards GOES East and no less than 6 available GPS satellites. Record with photographs the area and the GPS Receiver screens.

The test site was a pontoon in the yacht harbour with clear views to the NE with some obstruction to the South from the vessels moored in the marina.

Both a Fastfind Plus PLB and G4 EPIRB determined a GPS position in less than 2 minutes.



Activation of a Fastfind Plus PLB on a pontoon at Sparkes Marina. There are 7 satellites clearly visible on the Garmin eTrex.

Garmin eTrex GPS Position:

N 50° 47' 12" W 0° 56' 33"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU1	09:15	6	1:28	2:50	N 50° 47' 12" W 0° 56' 28"	Yes
EPIRB 1	09:35	8	1:45	2:50	N 50° 47' 12" W 0° 56' 28"	Yes

Baseline Scenario Bravo

Test not required as Equipped to Survive Foundation trials proved EPIRB met this requirement.

Baseline Scenario Charlie

While being sprayed with water to simulate heavy rainfall, activate at least one and if possible 3 PLBs and at least one and if possible 3 EPIRBs sequentially in an open area at the test site, ensuring a clear line-of-sight to GOES East and no less than 6 available GPS satellites.

These tests were carried out on another pontoon in the main harbour area with clear views out into the harbour. The rainfall was simulated with a hose directly over each beacon simulating heavy rain. Despite the heavy spray, a GPS position was determined in just over a minute.



Fastfind Plus PLB under heavy spray



G4 EPIRB under heavy spray

Garmin eTrex GPS Position :

N 50° 47' 07" W 0° 56' 35"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU1	11:32	7	1:03	2:50	N 50° 47' 08" W 0° 56' 32"	Yes
EPIRB 1	11:38	7	1:08	2:50	N 50° 47' 08" W 0° 56' 32"	Yes

Maritime Scenarios

A 24 foot work boat, 'Patience' was made available to McMurdo by her owner, Nigel Roper. He also generously offered to captain the boat for us.

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

Maritime Scenario Alpha

Activate at least one and if possible 3 PLBs and at least one and if possible 3 EPIRBs sequentially in an upright position on the deck at the stern of the boat.



Activation of G4 EPIRB at stern of boat

'Patience' sailed from Sparkes Marina and headed about three miles out to an area between Medmery Bank and East Wittering. The sea state was good with a swell between 0.5 to 0.7m and a light wind. No anchor was deployed so the vessel drifted with the current during the tests.

Each beacon was activated sequentially at the stern of the vessel where 5 satellites were visible on the Garmin receiver.

Garmin eTrex GPS Position:

N 50° 43' 06" W 0° 51' 52"
drifting to N 50° 43' 09" W 0° 51' 45"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU4	12:46	5	1:56	2:50	N 50° 43' 08" W 0° 51' 56"	Yes
EPIRB 4	12:52	5	2:17	3:40	N 50° 43' 08" W 0° 51' 48"	Yes

Maritime Scenario Bravo

At least one and if possible 3 EPIRBs will be activated and set afloat sequentially, attached by the tether (which may be extended to provide separation between the boat and EPIRB) to the boat.



G4 EPIRB floating at sea restrained on its lanyard

During this phase the sea state was increasing with the swell approaching 1 to 1.5m with foaming on the wave crests.

An EPIRB was thrown in, tethered to the vessel by a lanyard. As expected from the known good performance in storm conditions, the stability was exemplary and the beacon rapidly acquired a GPS position.

Garmin eTrex GPS Position:

N 50° 43' 06" W 0° 52' 13"
drifting to N 50° 43' 08" W 0° 51' 58"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
EPIRB 5	13:38	5	2:03	3:40	N 50° 43' 04" W 0° 52' 12"	Yes

Maritime Scenario Charlie

While being sprayed with water to simulate heavy rainfall, at least one and if possible 3 EPIRBs will be sequentially activated and set afloat, attached by their tether to the boat.

A bilge pump and hose attachment were used to spray seawater directly over the top of the EPIRB whilst it was restrained close to the stern of the boat. (This worsened the conditions with the boat blocking the sky view of the GPS antenna.) Permission was granted to trial two beacons consecutively in this phase. Both achieved GPS lock.



Floating G4 EPIRB under spray.

Garmin eTrex GPS Position:

N 50° 43' 06'' W 0° 52' 13''
drifting to N 50° 43' 15'' W 0° 51' 38''

Beacon ID	Local Time	Sats in View	TTF	Time to transmit location	Location transmitted	GEO Location Received
EPIRB 3	13:46	5	4:02	5:20	N 50° 43' 08'' W 0° 52' 00''	UKMCC data not available
EPIRB 4	14:03	5	1:29	2:50	N 50° 43' 16'' W 0° 51' 40''	Yes

Maritime Scenario Delta

At least one and if possible 3 PLBs and at least one and if possible 3 EPIRBs will be secured inside a 6/8 man offshore life raft with the antenna vertical and will be activated sequentially with the canopy partially closed as initially erected providing partial sky obstruction. Record and photograph obstruction.

This phase was not carried out as it was agreed to proceed immediately with the more stringent Scenario Echo.

Maritime Scenario Echo

The canopy of the life raft will now be closed to simulate activation in adverse weather conditions and the Maritime Scenario Delta test phase above shall be repeated on at least one and if possible 3 PLBs and at least one and if possible 3 EPIRBs.



Activation of EPIRB inside 8 person closed liferaft

It was not possible to launch an 8 person liferaft safely from a 24 foot boat so it was decided to carry out these tests in the sea within the Marina.

A check on the satellite coverage within the liferaft, revealed that by putting the Garmin receiver on the floor, only 1 or 2 satellites were faintly visible. This is due to masking of the GPS satellites by the eight bodies. As the Garmin was raised from floor level, as expected, more satellites were visible with 4 being visible at about knee level. This seemed a reasonable compromise on how someone could choose to activate a beacon within a liferaft.

A PLB and an EPIRB were sequentially activated, both achieving lock in around a minute. An unmodified EPIRB was added into the trial and also easily acquired lock.

McMurdo’s general advice is to activate the EPIRB floating outside the liferaft on the lanyard; however it is appreciated that users may wish to retain the beacon within view. Ways to improve the advice to users will be considered.

Garmin eTrex GPS Position N 50° 47’ 07” W 0° 56’ 35”

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU6	09:51	4	1:07	2:50	N 50° 47’ 08” W 0° 56’ 32”	Yes
EPIRB 6	09:59	4	0:52	2:50	N 50° 47’ 08” W 0° 56’ 32”	Yes
EPIRB E12/O†	10:25	4	1:02	N/A	N/A	N/A

† Unmodified EPIRB with disabled transmitter.

Maritime Scenario Foxtrot

With the canopy of the life raft still closed and while simulating heavy rain on the canopy to simulate activation in adverse weather conditions repeat the Maritime Scenario Delta test phase again on at least one and if possible 3 PLBs and at least one and if possible 3 EPIRBs.



Three hoses being played on the closed liferaft to simulate heavy rain

The beacons were reactivated after 30 minutes off time, with the heavy rain being simulated with three hoses being played over as much of the surface of the liferaft canopy as possible. GPS lock was achieved in a virtually identical time to the dry scenario.

Garmin eTrex GPS Position : N 50° 47' 07" W 0° 56' 35"

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU6	10:30	4	1:02	2:50	N 50° 47' 08" W 0° 56' 32"	Yes
EPIRB 6	10:39	4	0:52	2:50	N 50° 47' 08" W 0° 56' 32"	Yes

Maritime Scenario Golf

A person in a PFD and Dry suit will enter the water and activate a PLB, then dunk the PLB in the water and without draining any water from any cavities that might naturally retain water, hold it (or affix it) on top of their chest to simulate a typical man overboard situation in moderate to severe weather and sea conditions where the beacon may regularly be drenched with water. If conditions permit, repeat the test with a further 2 PLBs.



Swimmer holding Fastfind Plus PLB on chest

This test phase was conducted at sea between Medmery Bank and East Wittering. The swimmer had to be tethered to the boat as although the sea swell was only around 0.5m, the current was strong. The PLB was dunked in the sea and held flat on the swimmer’s chest to retain the water in the antenna stowage cavity.

Garmin eTrex GPS Position: N 50° 42’ 48” W 0° 52’ 02” drifting

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU5	12:15	5	3:30	4:30	N 50° 42’ 52” W 0° 52’ 12”	Yes

Maritime Scenario Hotel

While the person in the PFD is in the water they shall repeat the Maritime Scenario Golf test above while being sprayed with water to simulate heavy rainfall, to simulate a typical man overboard situation in adverse weather conditions with heavy rain. If conditions permit, repeat the test with a further 2 PLBs.



Swimmer and Fastfind Plus PLB under simulated heavy rain

A bilge pump and hose arrangement was used to douse the PLB heavily in seawater spray. The time taken to acquire a GPS solution was virtually the same as when the PLB was held on the swimmer’s chest.

Garmin eTrex GPS Position: N 50° 42’ 51” W 0° 52’ 14”
drifting N 50° 42’ 58” W 0° 52’ 06”

Beacon ID	Local Time	Sats in View	TTFB	Time to transmit location	Location transmitted	GEO Location Received
PU1	12:24	4	1:59	2:50	N 50° 42’ 56” W 0° 52’ 04”	Yes

Maritime Scenario India

Test not required as test is not a GPS acquisition test.

Modifications to existing design

GPS module firmware

McMurdo has worked closely with the designers of the GPS module that is fitted in the Fastfind Plus and G4 beacons. As a result, a number of new settings have been incorporated as a firmware 'update' to the GPS module. These settings provide a faster cold-start TTFF under non-optimal GPS conditions.

Beacon Firmware

The GPS activation timing strategy has been revised, primarily in accordance with the recommendations of Cospas-Sarsat in communications JC-17/5/16 and JC-18/5/23; (*"It is suggested that beacons be designed to try to acquire GPS locations for time periods of at least [15] minutes."*)

During the design of the beacons, the unpredictability of deployment conditions and GPS conditions was taken into account by adopting a long term GPS strategy within the beacons. While this strategy optimises the probability of GPS acquisition over the operating life of the beacon, user feedback has shown that, with Selective Availability turned off, users expect GPS-derived location information to be available within a few minutes of beacon activation. The revised strategy also places greater emphasis on acquiring a GPS position during the early part of beacon deployment, as requested by end-user feedback.

Beacon Hardware

The G4 sealing gasket has been re-designed to incorporate a float chamber. This adds extra stability to the beacon under rough sea states. The additional stability affords the GPS antenna a more consistent view of the whole sky, allowing faster GPS position acquisition.

The Fastfind PLB antenna has had a short rubber overmoulded section added at its base to reduce any effect on radiated power caused by the user deploying the beacon with the antenna base immersed in water.

Additional case labelling has been introduced to advise the user not to cover the identified GPS antenna area.

Independent Witnesses

Chuck Hawley is the Vice President of Product Development of West Marine. West Marine are one of the world's largest suppliers of boating equipment, and retail both McMurdo and ACR 406MHz beacons. Mr Hawley attended most of the USA land based trials.

Peter Forey is the Managing Director of Sartech Engineering Limited. Sartech Engineering are joint designers of a range of EPIRB and SART test equipment. They also distribute 406MHz beacons manufactured by ACR Electronics, Jotron, McMurdo and SERPE-IESM. Mr Forey attended all the trials.

Field Tests Attendees

Santa Cruz Land Trials:

Chuck Hawley	Vice President of Product Development, West Marine.
Peter Forey	Managing Director, Sartech Engineering Limited.
Gary Mullins	Managing Director, McMurdo
Richard Read	Electronics Design Engineer, McMurdo

U.K. Sea Trials:

Rory Davis	Sales and Marketing Manager, McMurdo
Peter Forey	Managing Director, Sartech Engineering Limited.
Robin George	Marine Electronics Development Supervisor, McMurdo
Chris Mears	Mechanical Engineering Manager, McMurdo
Richard Read	Electronics Design Engineer, McMurdo
Nigel Roper	Captain of the 'Patience'.

McMurdo Volunteers to make the Life Raft numbers up to 8 persons:

Justine Heeley	Sales and Marketing Manager
Tom Pirie	Design Draughtsman
Philip Stubbs	Mechanical Design Engineer
Stephen Pike	Mechanical Design Engineer

Acknowledgements

McMurdo are grateful for the assistance of NOAA, the UKMCC, and the ARCC who granted permission for the trial to take place and provided the processed data from the LEO and GEO satellites.

Although not a named or participating witness to the trials, McMurdo wish to express their thanks to Nigel Roper of Hayling Island, UK, for the use and captaincy of his boat 'Patience', during the maritime testing phase.

Acronyms and Abbreviations

ARCC	Aeronautical Rescue Co-ordination Centre
ATC	Air Traffic Control
EPIRB	Electronic Position Indicating Radio Beacon
ETSF	Equipped To Survive Foundation
GEO	Geostationary Earth Orbit
GOES	Geostationary Operational Environmental Satellites
GPS	Global Positioning System
LEO	Low Earth Orbiting
N/A	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
PLB	Personal Locator Beacon
SV	Satellite Vehicle
TTFE	Time To First Fix
UK	United Kingdom
UKMCC	United Kingdom Cospas-Sarsat Mission Control Centre

Trade Marks

Garmin eTrex and Garmin eTrex Legend are trademarks of Garmin Limited.

McMurdo Limited

Silver Point, Airport Service Road, Portsmouth PO3 5PB, United Kingdom

Telephone: +44 (0)23 9262 3900

Fax: +44 (0)23 9262 3998

Email: sales@mcmurdo.co.uk

Webpage: www.mcmurdo.co.uk