MARITIME SURVIVOR LOCATING DEVICES

CREWSAFE V100
VHF DSC LOCATOR BEACON

This white paper describes the Crewsafe V100 VHF DSC Locator Beacon – a Maritime Survivor Locating Device (MSLD).

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Acronyms used in the Report

ACMA	Australian Communications and Media Authority
AMSA	Australian Maritime Safety Authority
DSC	Digital Selective Calling – technology used to automate calling on terrestrial marine radio systems.
EPIRB	Emergency Position Indicating Radio Beacon
FCC	US Federal Communications Commission
GMDSS	Global Maritime Distress and Safety System
GRT	Gross Registered Tons – statutory measurement of a vessel's size.
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
ITU	International Telecommunications Union
kHz	Kilo Hertz – measurement unit of radio frequency (1 thousand Hertz)
MHz	Mega Hertz – measurement unit of radio frequency (1 million Hertz)
MAYDAY	Radio pro-word indicating a voice distress priority message
MID	Maritime Identification Digits
MMSI	Maritime Mobile Service Identity (DSC identity number)
MOB	Man Overboard
MRCC	Maritime Rescue Coordination Centre
MSLD	Maritime Survivor Locating Device
MSLS	Maritime Survivor Locating System
PLB	Personal Locator Beacon (a small personal radio locating beacon, normally operating through the COSPAS-SARSAT system on 406 MHz and prior to 1 February 2009, on 121.5 MHz)
RCC	Rescue Coordination Centre
RTCM	Radio Technical Commission for Maritime Services
SAR	Search and Rescue
SOLAS	International Convention for the Safety of Life At Sea. Applies to vessels of 300 GRT and over, engaged on an international voyage.
USCG	US Coast Guard
VHF	Very High Frequency radio band – 30 to 300 MHz.

Introduction

This white paper describes the *Crewsafe V100 VHF DSC Locator Beacon* – a Maritime Survivor Locating Device (MSLD).

The paper is intended as an informative document for press, government, marine training, marine safety and legislative bodies globally.

The paper opens with a background on the Global Maritime Distress and Safety System (GMDSS). It then explores the GMDSS technology used to automate radio distress alerting – Digital Selective Calling (DSC).

Various MSLD and EPIRB technologies are identified and their advantages/disadvantages examined.

The *Crewsafe V100 VHF DSC Locator Beacon* is described in detail, including its operational parameters and how it integrates into the GMDSS architecture and the international marine radio standards framework.

Executive Summary

The Global Maritime Distress and Safety System (GMDSS) was introduced in 1999. The GMDSS has automated marine radio calling by the use of a technology known as Digital Selective Calling (DSC).

DSC is a paging system that uses data signals to automate the transmission and reception of calls. The DSC message automatically indicates the identity of the calling station and the priority/purpose of the call. Every DSC radio has a unique number, which is used to call other radios, just like a mobile phone. However, unlike mobile phones, ***DSC allows an operator to call every other radio in range at the same time.***

Personal Emergency Position Indicating Radio Beacons (EPIRBs) have saved many thousands of lives over the years; however they rely on shore infrastructure to process and then re-broadcast an alert message to ships in the vicinity of the person in distress. Depending on the location of the EPIRB, this could involve delays in the order of hours.

In most 'man overboard' situations, the parent vessel is in the best position to render immediate assistance. ***This is particularly the case in high latitudes, where hypothermia can render a person in the water unconscious within minutes.***

A Maritime Survivor Locating Device (MSLD) is intended to be a short range beacon, specifically designed to alert the parent vessel that they have lost one of their crew overboard.

DSC is a very suitable technology for a MSLD, as it allows alerting of both the parent vessel, and all other DSC-equipped vessels in the immediate vicinity.

The *Crewsafe V100 VHF DSC Locator Beacon* is equipped with an internal GPS receiver, and uses VHF DSC and synthesised radiotelephone (voice) transmissions to broadcast this GPS position to all boats and shore stations in range – a world first.

Each beacon is programmed with a unique identity number and is also fitted with a strobe light to enable visual homing on the person in the water.

The *Crewsafe V100 VHF DSC Locator Beacon* activates automatically on contact with water, or it can be manually switched on. It will provide alerting ranges in the order of 2 nautical miles from a typical small boat. Larger vessels and shore stations with higher antennas will receive the distress signal over longer ranges.

The beacon complies with all relevant international and national marine radio standards.

The Global Maritime Distress and Safety System (GMDSS)

Background

Since the time of the *RMS Titanic*, radio has helped to save tens of thousands of lives, and become the key element in marine Search and Rescue (SAR).

Before the introduction of the GMDSS in 1999, marine radio equipment fitted to ocean going vessels was required to provide operation over a minimum specified range of 150 nautical miles.

This was based on the (not unreasonable) assumptions that ships usually travelled well-used routes and that there were sufficient ships at sea and shore stations dispersed about the world to receive distress calls. However, if a ship was outside of the normal shipping lanes or was rapidly overwhelmed by the forces of nature, her distress alert may go unheard.

Many ships have gone to the bottom without any distress signal being sent - they have, to use the common parlance, "sunk without trace".

The International Maritime Organization (IMO) pondered the shortcomings of the existing marine distress systems in the mid to late 1970's.

The 1979 IMO Assembly decided that a new global distress and safety system should be established in conjunction with a coordinated SAR infrastructure to improve safety of life at sea. The system would take advantage of the latest technological developments.

And so was born the Global Maritime Distress and Safety System (GMDSS).

The GMDSS is specifically designed to automate a ship's radio distress alerting function, and, as a consequence, removes the requirement for manual (i.e. human) watch-keeping on distress channels.

The basic concept of the system is that Search and Rescue (SAR) authorities ashore, as well as shipping in the immediate vicinity of the ship or persons in distress will be rapidly alerted so that they can assist in a coordinated SAR operation with the minimum of delay.

The system also provides for urgency and safety messages and also for the broadcast of Maritime Safety Information (MSI) weather reports, navigation warnings and SAR Messages.

One of the principal advantages of the GMDSS is that the system is actually an amalgam of various individual radio systems, both terrestrial and satellite. Distress alerts may be sent and received over short and/or long distances.

In other words, every ship is able to perform those communication functions which are essential for the safety of the ship itself and of other ships operating in the same area - irrespective of the area through which it sails.

Application

The GMDSS applies to vessels subject to the International Convention for the Safety of Life at Sea (SOLAS Convention) - that is:

> *Commercial passenger ships engaged on international voyages and cargo ships of 300 Gross Registered Tons (GRT) and above, engaged on international voyages.*

The GMDSS became mandatory for such vessels as at February 1, 1999.

Radio equipment requirements for ships and pleasure craft engaged on domestic voyages are determined by the vessel's ***Flag State*** (i.e. the country of registry of the vessel).

Basic Concepts of the GMDSS

Equipment vs. Operational requirements

The major difference between the GMDSS and its predecessor systems is that the *radio communications equipment to be fitted to a GMDSS ship is determined by the ship's area of operation, rather than by its size.*

GMDSS Sea Areas

Because the various radio systems used in the GMDSS have different limitations with regards to range and services provided, the new system divides the world's oceans into 4 areas:

> **Area A1** lies within range of shore-based Very High Frequency (VHF) Coast Radio Stations (20 to 30 nautical miles);
>
> **Area A2** lies within range of shore based Medium Frequency (MF) Coast Radio Stations (excluding A1 areas) (approximately 100 - 150 nautical miles);
>
> **Area A3** lies within the coverage area of Inmarsat communications satellites (excluding A1 and A2 areas - latitude 70 degrees north to latitude 70 degrees south); and
>
> **Area A4** comprises the remaining sea areas outside areas A1, A2 and A3 (the polar regions).

Any sea area between 70 degrees north and south latitude that is not designated as Sea Area A1 or Sea Area A2 automatically defaults to Sea Area A3.

GMDSS Communication Systems

The GMDSS utilises both satellite and terrestrial (i.e. conventional) radio systems.

> **Sea Area A1** requires short-range radio services – VHF radio is used to provide voice and automated distress alerting via Digital Selective Calling (DSC).
>
> **Sea Area A2** requires medium-range services – MF radio is used for voice and DSC.
>
> **Sea Areas A3 and A4** require long-range alerting - High Frequencies (HF - 3 to 30 MHz) are used for alerting.

Equipment requirements vary according to the area the ship is trading to or through.

Accordingly, it is quite possible that a small 300 ton cargo vessel may carry the same amount of communications equipment as a 300,000 ton oil tanker, if they are both operating in the same area - a marked change from the pre-GMDSS systems.

GMDSS Sea Areas are illustrated in the diagram below:

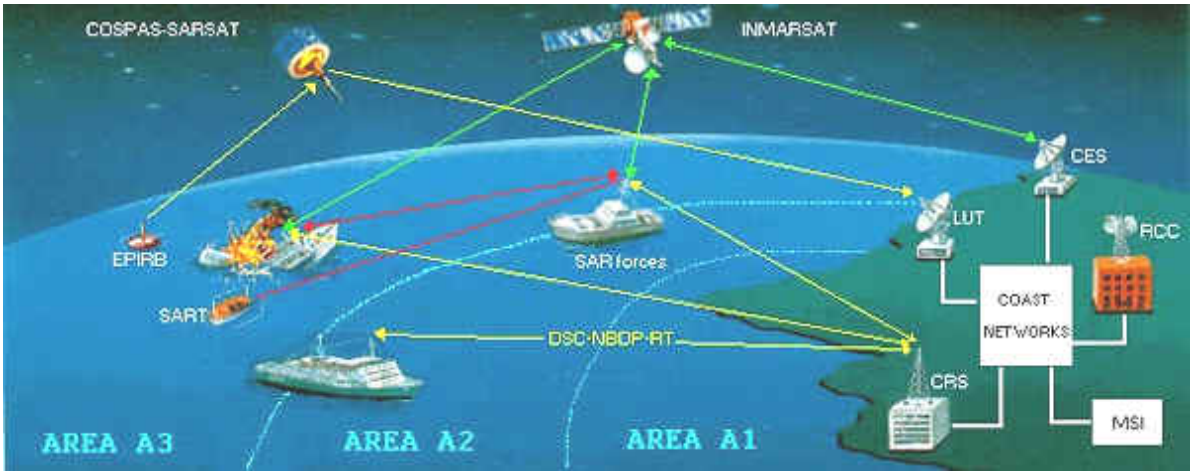


Diagram 1 – GMDSS communication systems vs. Sea Areas

Equipment requirements

The SOLAS GMDSS regulations are structured such that all GMDSS ships are required to carry a minimum set of equipment, with (basically) more equipment being required the further the ship travels from land.

As discussed previously, equipment fit requirements vary according to the Sea Area(s) a vessel operates in or through.

It should be noted that the requirements are cumulative in nature - i.e. an A3 vessel is also equipped, by definition, with equipment for A1 and A2 Sea Areas.

In areas where Sea Area A1 services are provided, coastal vessels are only required to fit VHF equipment, provided of course that they remain within the declared Sea Area - normally within 20 to 30 nautical miles of the coast.

Vessels that trade further from land are required to carry MF equipment, in addition to VHF.

Ocean going vessels fit VHF, MF, HF and Inmarsat satellite equipment.

The concept is depicted overleaf.

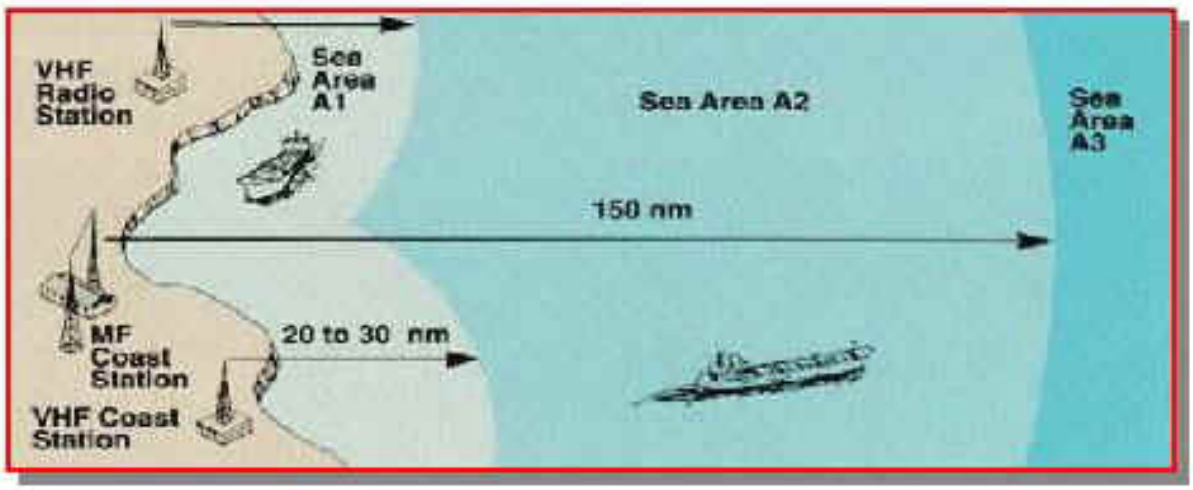


Diagram 2 – Sea Areas

However, it should be noted that the diagram above assumes a linear transition from A1 to A3 sea areas - *in many parts of the world, A3 areas extend right up to the coastline. GMDSS vessels operating in or through those areas are thus required to fit equipment for Sea Area A3.*

Most European, some US and some SE Asian coastal waters are designated as Sea Area A1. Australia, New Zealand and the Pacific are designated as Area A3.

In Sea Area A3, VHF DSC is used for *ship-ship* alerting. Therefore, the Australian Government is not required to provide VHF DSC *shore* infrastructure.

However, many Australian volunteer marine rescue organisations are starting to equip their base stations with GMDSS VHF DSC equipment.

Digital Selective Calling (DSC)

Automation

The GMDSS has automated many marine radio functions and processes, particularly those related to distress and safety.

The GMDSS is an amalgam of a number of individual radio systems. Satellite-based technology does play a part in the GMDSS, however 'normal' terrestrial radio continues as the primary system for ship-ship communications.

The GMDSS has automated marine radio calling by the use of a technology known as Digital Selective Calling (DSC).

Rather than just indicate that the sending station is in distress, the DSC system allows a great deal more information to be transmitted, including:

- The priority of the call;
- The address, i.e. all ships or a single ship/station;
- The identification of the ship in distress;
- The position of the ship in distress; and
- The nature of the distress.

Function

DSC is a paging system that uses data signals to automate the transmission and reception of calls.

A DSC message is a brief burst of data transmitted from one station to alert another station or stations. The DSC message automatically indicates the identity of the calling station and the priority/purpose of the call.

Every DSC radio has a unique number, which is used to call other radios, just like a mobile phone. However, unlike mobile phones, ***DSC allows an operator to call every other radio in range at the same time.***

Following an alert by DSC message, communications are established by radiotelephone on a different channel to that used for the DSC call.

DSC is used by ship and coast stations for sending and relaying distress alerts and for other urgency and safety traffic. It can also be used for routine calls.

DSC also offers the ability to send and receive GPS positions - all DSC radios can be connected to a GPS receiver.

VHF DSC Channel

VHF marine Channel 70 is dedicated to DSC. Voice calls are not permitted on Channel 70.

Call Categories

The DSC system supports a number of call categories. These categories mirror the standard maritime prioritisation of message traffic, i.e.:

DISTRESS

URGENCY

SAFETY

ROUTINE

Distress alerts are automatically addressed to all stations.

Urgency, safety and routine calls can be addressed to all stations, an individual station, or a group of stations.

Maritime Mobile Service Identity (MMSI)

All stations fitted with DSC are allocated a unique 9 digit identification number, known as a Maritime Mobile Service Identity (MMSI).

This MMSI is permanently programmed into the DSC equipment and is sent automatically with each transmission.

MMSI are allocated internationally, with the first 3 digits, known as the Maritime Identification Digits (MID), representing the station's country of origin.

For example, the Australian MID is 503 and the New Zealand MID is 512.

Government Search and Rescue (SAR) authorities maintain a database of MMSIs, which include details such as a physical description of the vessel in which the equipment is fitted and contact details for next of kin.

Should a DSC alert be received, this vessel and contact information is of considerable value for SAR planning.

DSC Call Types

The DSC system provides the following types of call;

Distress alert - these calls are always addressed to ALL stations by default. The call contains the distressed vessel's MMSI, her position, the nature of her distress and the time of the call.

DSC controllers offer the user a menu of possible "nature of distress" situations from which to choose:

Fire, explosion

Flooding

Collision

Grounding

Listing

Sinking

Disabled and adrift

Undesignated distress

Abandoning ship

Piracy/armed robbery attack

Man Overboard

If the "nature of distress" information is not selected, the DSC radio will send the default setting of "Undesignated".

The call will conclude with the advice that subsequent communications are to be carried out on radiotelephone.

The channel for ongoing communications on radiotelephone is not specified in DSC distress messages, as it is always the radiotelephone distress channel – 16.

Distress alert acknowledgment - normally sent by Coast Radio Stations in response to a distress alert from a ship.

Distress alert relay - normally only sent by Coast Radio Stations, these calls are addressed to ALL stations.

All stations - these broadcast messages can be sent as either URGENT or SAFETY priority calls. The DSC equipment will prompt the user to select the appropriate priority and the frequency or channel for subsequent communications.

Single ship (or station) - these calls can also be either URGENT or SAFETY priority. They are addressed to a particular ship or station.

Routine – the normal priority used to call another ship or shore station.

Distress Button

DSC equipment is fitted with a dedicated red DISTRESS or emergency button. The button requires 'two separate and independent' actions to activate a distress call.

This usually involves lifting a hinged flap over the button and holding the button down for a short period.

GPS Position and Time

As discussed previously, DSC distress alerts automatically include GPS-derived position and time. If, for some reason, a GPS is not connected or its position output is corrupted, the DSC radio will automatically substitute the digits 9 (sent 10 times) for the position and 8 (sent 4 times) for the time in a distress message.

Message Repetition

VHF DSC messages are sent at a relatively fast speed (1200 baud). Each distress alert is actually sent five consecutive times, which takes approximately 5 seconds.

If an operator initiates a DSC distress alert, and does not manually cancel it, the alert will repeat until the radio receives a DSC distress acknowledgement message from another ship or shore station.

Distress alerts are automatically repeated with a random delay of between three and a half and four and a half minutes. This allows acknowledgements arriving randomly to be received without being blocked by retransmission.

Incoming Message Alarms

DSC equipment is fitted with specific aural and visual alarms to indicate reception of a DISTRESS or URGENCY priority messages.

Alarms indicating DISTRESS or URGENCY messages are required to be reset manually, *they are not self cancelling.*

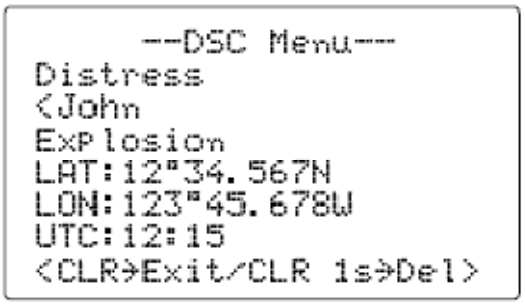
DSC distress message alarms are quite loud, and can be easily heard throughout the bridge of a merchant ship, or throughout the cabin of a yacht or power boat.

Information Displayed in a Received DSC Distress Alert

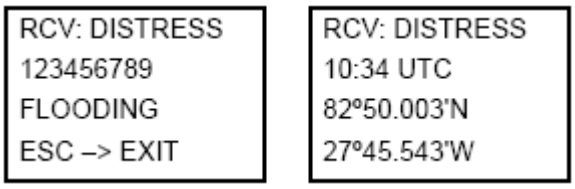
Different DSC radios will display varying amounts of information in a received DSC distress alert, depending on the size of the radio's LCD display. All will display basic information such as MMSI, position and nature of distress.

Some typical VHF DSC radio display screen shots are reproduced overleaf.

Icom:



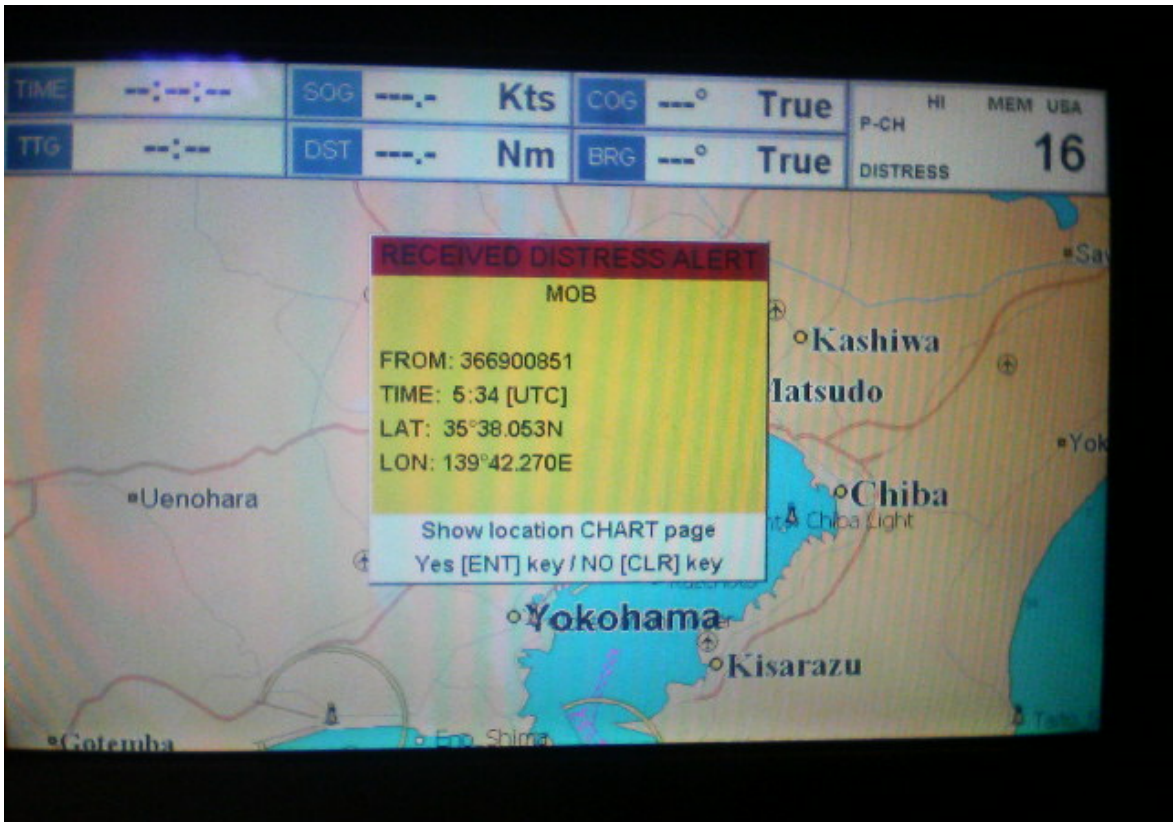
Navico 7200:



Vertex standard:

Position Output to a Connected Chart Plotter

Some DSC radios will output a position received in a distress alert to a connected GPS or electronic chart/plotter.



Maritime Survivor Locating Devices

EPIRB, VHF DSC Locator Beacon, PLB, MSLD?

The terms EPIRB, VHF DSC Locator Beacon, PLB, Man Overboard (MOB) System and/or MSLD can be somewhat confusing - they are defined as follows.

Emergency Position Indicating Radio Beacon (EPIRB)

EPIRBs were originally designed to operate on the aeronautical frequencies of 121.5 and 243 MHz only. They were intended to be used by downed pilots to summon help from SAR aircraft. Tracking (homing) was carried out by suitably equipped aircraft.

With the advent of the COSPAS-SARSAT satellite EPIRB detection system in the 1980's, EPIRB use spread to the maritime and land mobile sectors.

Modern EPIRBs now operate simultaneously on the 121.5/243 MHz aviation channels and also the 406 MHz COSPAS-SARSAT channel – hence the term *406 EPIRB.*

The COSPAS-SARSAT system uses a series of satellites to provide world-wide detection accuracy of around 3 nautical miles for older beacons, and around 100 m for new, GPS enabled EPIRBs. Final location of the beacon is undertaken by homing on the 121.5 or the 243 MHz channels.

In addition to the 406 MHz channel, the COSPAS-SARSAT system currently operates on the 121.5 and 243 MHz channels. From 1 February 2009, the system will cease to monitor 121.5 MHz, because of the high number of false alerts and interference. This will relegate 121.5 MHz to short range homing only.

It should be understood that the EPIRB system is designed to alert *shore authorities* to your plight, often over considerable distances. This involves an inherent time delay.

EPIRBs are not intended to provide direct ship-ship alerting*.*

The EPIRB system has saved many thousands of lives over the years, however its principal shortcoming is that it relies on shore infrastructure to process and then re-broadcast the alert message to ships in the vicinity of the person in distress.

Depending on the location of the EPIRB, this could involve delays in the order of hours.

Personal Locator Beacon (PLB)

A PLB is a miniaturised 406 EPIRB, designed to be attached to the wearer's clothing or lifejacket. PLBs are used by hikers, pilots and seafarers.

VHF DSC Locator Beacon

A VHF DSC Locator Beacon is essentially an emergency position indicating radio beacon operating in the marine VHF radio band rather than the COSPAS-SARSAT 406 MHz channel, utilising DSC technology to broadcast a distress signal to all VHF DSC radio-equipped vessels in the vicinity, including the parent vessel.

A VHF DSC Locator Beacon comprises a small DSC beacon, which is attached to the user's clothes or lifejacket. If the user falls overboard, the beacon activates and sends a distress format DSC message. Reception of the distress message from the beacon will sound an alarm on all VHF DSC radios within range.

If fitted with a GPS receiver, a VHF DSC Locator Beacon can also automatically transmit its position as part of the distress alert message, which will also be received on all VHF DSC radios in range. This is very useful if recovery could be delayed by sea conditions and/or weather.

A VHF DSC Locator Beacon requires that the parent vessel be fitted with a VHF DSC radio. VHF DSC equipment was originally designed for the commercial, merchant ship market. Equipment was expensive, and complex to operate.

However, manufacturers are now also producing VHF DSC equipment aimed specifically at the recreational sector. Equipment is simple to use and priced under $500.

All merchant ships are fitted with VHF DSC systems, and the low price of recreational craft systems is driving penetration into that market.

Unlike closed loop MSLD, a VHF DSC Locator* Beacon *'base station' (i.e. the boat's DSC radio) can be used for other tasks, such as automated calls to/from other vessels/shore stations and even distress alerts from the parent vessel, if needs be.

If the parent vessel is operating in an area covered by VHF DSC Coast Radio Stations, the beacon distress message may also be received by shore authorities.

However, there are still many recreational craft not fitted with DSC. For this reason, a VHF DSC Locator Beacon also provides alerts to those vessels fitted with only a basic radiotelephone marine VHF radio by means of a synthesised voice MAYDAY message transmitted on VHF channel 16.

The VHF DSC and VHF voice messages are repeated at 5 minute intervals for the first 30 minutes, updating the GPS position of the person in the water with each transmission, then the repetition period will change to ten minutes. This will continue until the device is switched off, or the batteries expire.

At present there is only one VHF DSC Locator Beacon model available, the Crewsafe V100 VHF DSC Locator Beacon.

Man Overboard Systems / Maritime Survivor Locating Devices (MSLD)

In most ‘man overboard’ situations, the parent vessel is in the best position to render immediate assistance to the person in the water. ***This is particularly the case in high latitudes, where hypothermia can render a person in the water unconscious within minutes.***

A man overboard system or MSLD is intended to be a short range beacon, specifically designed to alert the parent vessel that they have lost one of their crew overboard. Alerting of other ships and/or shore authorities is considered a bonus.

MSLD Technologies

This section analyses current MSLD technologies.

Proximity/polling type system

Proximity/polling type MSLD (such as the *Mobilarm* man overboard system) require each person on board the vessel to wear a small transceiver that continuously transmits a signal via a closed wireless network to a central console on the boat.

If a person falls into the water, the signal is broken, causing the system to raise an alarm. The GPS coordinates of the man overboard event are also recorded to a chart plotter to provide track back information, enabling the boat to recover the casualty.

Proximity/polling MSLD are very successful and popular; however they are a closed loop arrangement, which alert *only the parent vessel*.

121.5 MHz homing systems

Another MSLD variant uses small beacons operating on the aviation EPIRB frequency of 121.5 MHz, in conjunction with a receiver/direction finding (DF) system on the vessel.

If a person falls over the side, the beacon is manually activated or may automatically activate to transmit on 121.5 MHz, which causes the boat's receiver to alarm. The DF system is then used to home on the person in the water.

Because these systems operate on the 121.5 MHz EPIRB channel, there was some initial confusion as to whether they were, in fact, an EPIRB.

121.5 MHz homing type systems must be used in conjunction with a dedicated onboard receiver/DF, as ships do not normally carry 121.5 MHz receivers.

Because of the low power output of the beacons, 121.5 MHz MSLD are not intended to be used with the COSPAS-SARSAT system. Moreover, as discussed earlier, COSPAS-SARSAT will cease to monitor 121.5 MHz at the end of 2008.

This effectively makes 121.5 homing-type MOB systems closed loop arrangements.

The Crewsafe V100 VHF DSC Locator Beacon

The *Crewsafe V100 VHF DSC Locator Beacon* is a VHF DSC and radiotelephone based MSLD. This section describes the system characteristics and modes of operation.

Physical Characteristics

Construction

The *Crewsafe V100 VHF DSC Locator Beacon* is a portable, palm-sized unit, which is designed to be worn by the user. It is constructed of high visibility, impact resistant material which is waterproof and unaffected by prolonged exposure to sunlight and oil.

The unit will float and is water resistant to 10m (33ft). Weight is approximately 153g (5.4oz) excluding the antenna and clip.

The device will operate over a temperature range of -20 to +55^{o} C (-4^{o} to 131^{o}F), and can be stored in locations with a temperature range of -30 to +70^{o} C (-22^{o} to 158^{o}F).

An intrinsically safe version of the *Crewsafe V100 VHF DSC Locator Beacon* is also being designed (expected to be released in 2011), so it can be used in hazardous environments (gas/fuel vapours, etc).

A diagram of the unit is shown right.

GPS

The *Crewsafe V100 VHF DSC Locator Beacon* is fitted with an integrated, 20 channel parallel GPS receiver, which offers a time-to-first-fix of 45 to 60 seconds after power up.

Strobe

The *Crewsafe V100 VHF DSC Locator Beacon* is equipped with a strobe light to assist in location. The strobe, which flashes once per second, provides 180 degree coverage at 5 candela. It automatically starts flashing as soon as the device is activated and remains on until it is switched off or the batteries expire.

Manual and automatic activation

The *Crewsafe V100 VHF DSC Locator Beacon* is armed by sliding a switch on the front of the unit to the READY position, which allows the beacon to automatically activate when immersed in water for 5 seconds. A piezo sounds to alert the user to manually release the antenna and fully activate the beacon, since this increases the effective range of the distress call and GPS coordinates.

The antenna is extended by manually releasing it from the clip on the side of the unit. The beacon is fully activated by pressing and sliding the switch on the front of the unit to the ON position. This process also activates the beacon from the OFF position, i.e. even if it has not been armed beforehand as described above.

There is a period of 20 seconds before any distress call transmission is made (with visual and audible notification during this time that the beacon has been activated) to allow the device to be switched off, thereby catering for inadvertent operation of the switch (i.e. false alerts).

Audible and visual indication of transmission

The *Crewsafe V100 VHF DSC Locator Beacon* is fitted with a piezo sounder to indicate when the transmitter is actually sending distress messages – this feature can also assist in location of inadvertently activated beacons.

A multi-coloured, high intensity Light Emitting Diode (LED) indicates various system states, such as activated, GPS position received, transmitting, etc.

Duration

The *Crewsafe V100 VHF DSC Locator Beacon's* inbuilt battery will support emergency transmission for a minimum of 12 hours and has an operational life of 5 years.

Radio Parameters

DSC message composition

The DSC message from the beacon is formatted as a distress alert. As discussed earlier, DSC distress messages contain a 'nature of distress' field. This is set as 'man overboard' in the *Crewsafe V100 VHF DSC Locator Beacon*.

The beacon's inbuilt GPS receiver will take a finite amount of time to lock up and provide an accurate position. Given that time is of the essence in most man-overboard situations, it is vital that the beacon transmit an alert as soon as it is activated.

Accordingly, the initial DSC alert from the *Crewsafe V100 VHF DSC Locator Beacon* will have the position and time fields set to the default 'no position/time available'.

Subsequent DSC messages will include the GPS derived position/time immediately it is available (generally within 30 seconds).

Unique identification number

Each *Crewsafe V100 VHF DSC Locator Beacon* will be programmed with a unique identification number of a distinctive format, to identify transmissions from the beacon as a MSLD.

User/owner details for each unit will be registered either with the manufacturer or with SAR authorities (depending on regulatory requirements for the region where the unit is to be operated), so that point of contact information is available if a distress call is detected by another ship or shore station.

Voice alerting

Although some recreational craft have fitted DSC equipment, there are many who have only a basic radiotelephone VHF radio. For this reason, the *Crewsafe V100 VHF DSC Locator Beacon* will also broadcast a synthesised voice MAYDAY message once activated.

The MAYDAY message will be transmitted on VHF channel 16.

The MAYDAY will only be transmitted once a valid GPS position and time are available, as the international radio regulations require that voice distress messages contain position and time information.

The message will be transmitted in the following format.

MAYDAY MAYDAY MAYDAY

THIS IS (UNIQUE IDENTIFICATION NUMBER)

MAN OVERBOARD

POSITION xx.xxS/N xxx.xxE/W

TIME XXXX UTC

REPEAT*

POSITION xx.xxS/N xxx.xxE/W

TIME XXXX UTC

** repeating the position/time allows receiving vessels time to write it down*

Message repetition

Once the initial DSC distress alert has been sent, a second DSC distress alert with position will be transmitted immediately the internal GPS is able to provide an accurate position – generally within 30 seconds.

Once the DSC message with position has been sent, the beacon will broadcast the voice distress message (described previously) on channel 16. The DSC and voice messages will be repeated every five minutes.

This sequence will continue for thirty minutes (i.e. 6 transmissions of position), unless the device is manually switched off.

After the thirty minute interval, the repetition period will change to ten minutes. This will continue until the device is switched off, or the batteries expire.

Alerting range

The *Crewsafe V100 VHF DSC Locator Beacon* will provide alerting ranges in the order of 2 nautical miles from a typical small boat.

Larger vessels and shore stations with higher antennas will receive the distress call over longer ranges.

System Concept of Operations

Frequencies, timing and repetition

The following table summarises the *Crewsafe V100 VHF DSC Locator Beacon* frequencies of operation, timing and repetition rates.

Time	Action
0	***Crewsafe V100 VHF DSC Locator Beacon activated.*** ***Strobe light turns on, LED flashes and piezo sounds.***
20 seconds	***GPS receiver starts.*** ***Initial DSC distress alert with 'man overboard' and 'no position/time available' sent on VHF marine channel 70.***
Within 30 seconds	***GPS lock acquired and provides a position/time.*** ***DSC distress alert with 'man overboard' and position/time sent on VHF marine channel 70.*** ***then*** ***Synthesized voice MAYDAY message sent on VHF marine channel 16 with position and time.***
Every 5 minutes thereafter, for 30 minutes	***DSC distress alert and voice MAYDAY message sent as per above.***
Every 10 minutes thereafter until batteries expire or device turned off	***DSC distress alert and voice MAYDAY message sent as per above.***

Operations

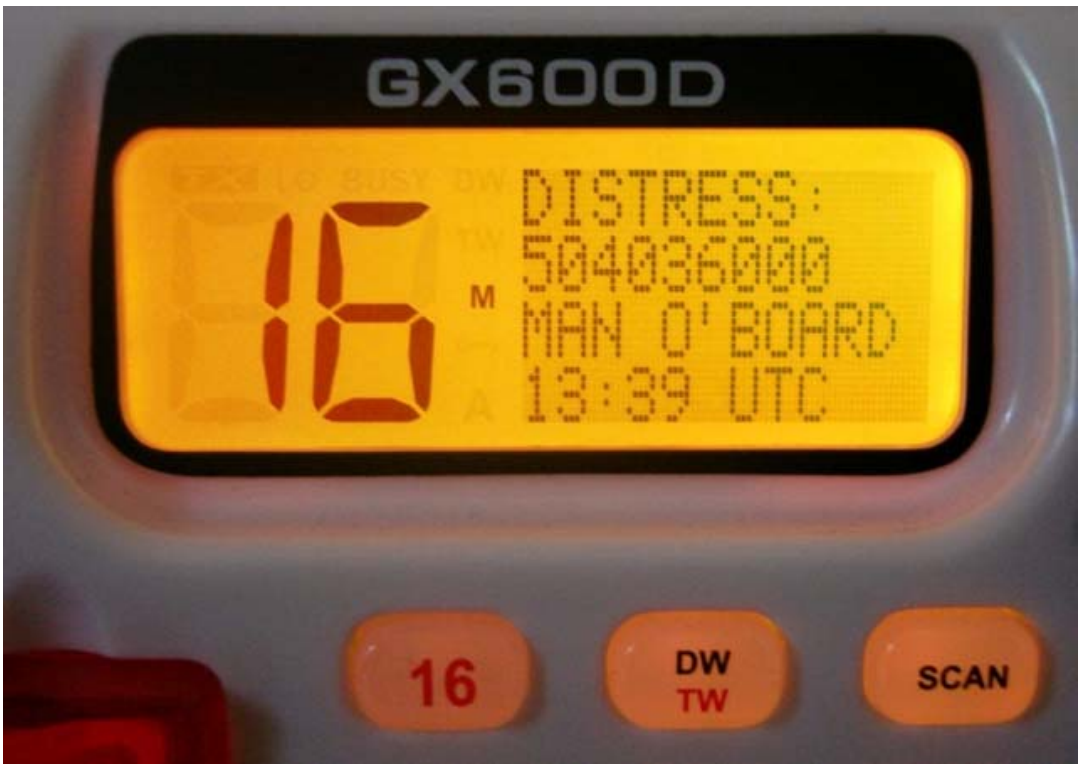
This section provides a narrative description of the *Crewsafe V100 VHF DSC Locator Beacon* operation.

A person wearing a *Crewsafe V100 VHF DSC Locator Beacon* in the READY position falls overboard.

Upon 5 seconds contact with water, the beacon goes into a warning state. The strobe light and LED starts flashing, and the piezo sounds to warn the wearer that water detection has occurred. After a 20 second delay, the GPS receiver powers up, and the beacon transmits an initial DSC distress alert.

Five seconds later, the DSC alert is received on board the parent vessel – the VHF DSC radio immediately emits a loud distress alarm, which will continue until manually cancelled.

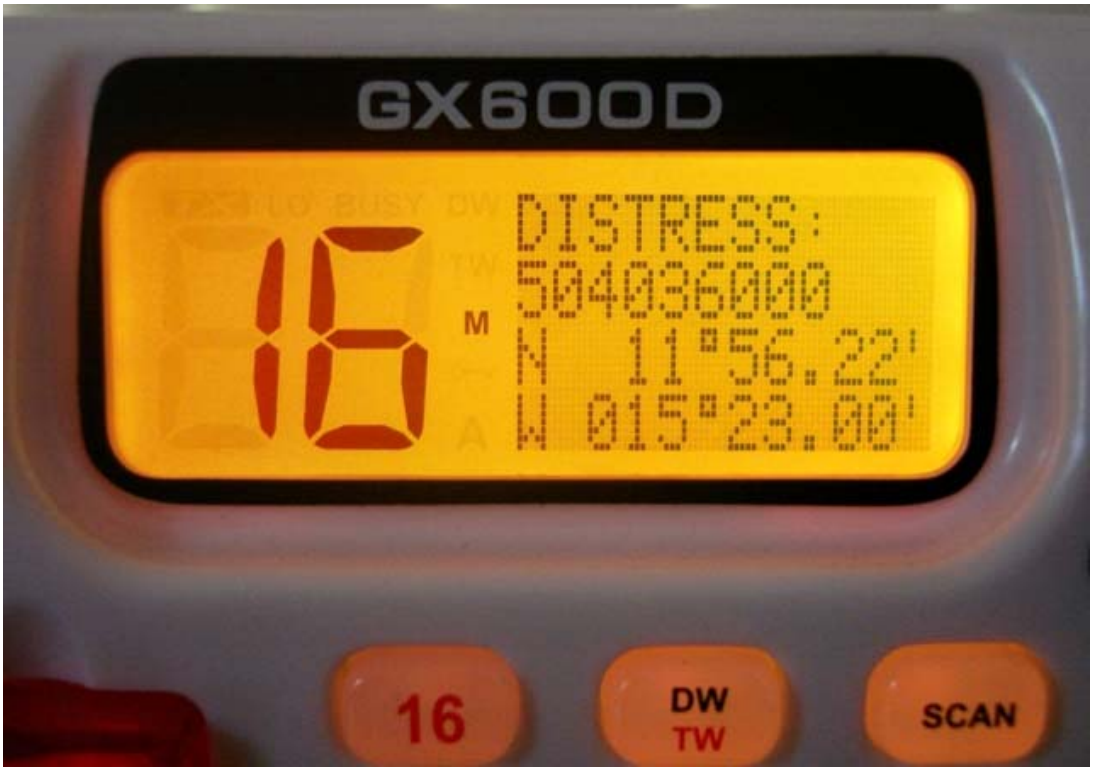
The beacon's identification number is displayed on the boat's DSC radio display – this unique number alerts the crew to the loss of one of their shipmates.



VHF DSC radio display screen showing alert from V100

They bring the boat about, and start the search. Meanwhile, the person in the water has manually released the antenna on the device to increase the effective range of the distress call.

By this time, the beacon's inbuilt GPS has acquired a lock, and the device transmits a new DSC call with this position included.



VHF DSC radio display screen, showing position from V100

The device then switches to radiotelephone mode, and transmits a voice MAYDAY call.

Other vessels in the area have now also received the MOB victim's position via the DSC distress alert and the voice MAYDAY message – they alter course, and converge on the GPS position.

Some of these vessels have their DSC and electronic charting systems interfaced together – they are able to see the position of the person in the water graphically with respect to their own position, i.e. as a distance and bearing from their own boat/ship.

Typical position output on chart plotter screen

Chart plotter display screen, showing distance and bearing information

If visibility is good, and conditions favourable, the parent vessel has by now located the person in the water.

If visibility is poor, and/or the seas are rough, the automatic broadcast of GPS position reduces the search area to a radius of approximately 10m around the MOB victim.

The strobe light on the device is used for final visual homing on the person in the water.

The illustration below depicts the *Crewsafe V100 VHF DSC Locator Beacon* operation.

The VHF DSC beacon directly alerts your boat and every other vessel or station in the immediate vicinity on channel 70 DSC and channel 16 radiotelephone

Advantages of the Crewsafe V100 VHF DSC Locator Beacon

- Directly alerts the parent vessel, who is in the best position to find and recover a person who has fallen overboard
- Also alerts all VHF DSC and radiotelephone stations in range – other ships and (possibly) shore authorities
- Broadcasts distress signal to standard VHF DSC or VHF radio, which as a multi-purpose base unit can be used for other tasks such as calling other ships/shore stations or sending a distress alert
- No requirement for costly dedicated receiving base station, direction finding equipment or satellite rental time
- Provides in-water tracking by GPS position – the MOB's position can be displayed graphically on an electronic chart program
- Two methods of location – electronic by GPS and visual by strobe light
- Automatic or manual activation, with 20 second transmission delay to reduce false alarms
- Audible and visual indication of operation states – GPS lock, transmitting, low battery, etc.
- Localised nature of distress call and manual activation delay reduces potential for false alerting

Technical Specifications

This section discusses the *Crewsafe V100 VHF DSC Locator Beacon's* technical specifications and how the device complies with the international marine radio standards framework.

Marine Radio Standards

International maritime radio standards

The principal driver for the creation of new marine radio standards is the International Maritime Organization (IMO) – in effect, the maritime arm of the United Nations.

The IMO set broad, high level operational parameters for marine radio equipment performance. They then task the International Telecommunications Union (ITU – the telecoms arm of the UN) with creation of technical specifications.

The ITU undertake this task through their 'Study Groups' – volunteer committees of marine radio specialists, normally drawn from Government agencies.

The ITU study groups produce what are known as the ITU-R M series of recommendations. These documents define specific operational and technical requirements for marine radio equipment and systems.

The DSC technical and operational specifications, for example, are ITU-R M series recommendations (ITU- R M.493-11 and ITU-R M.451-9).

However, the M series of recommendations can not actually be used as standards, as they do not include test methods, some of the more detailed technical requirements and climatic and durability specifications.

The task for creation of actual international marine standards to be used as the basis for approval of equipment falls to the International Electro-technical Commission (IEC). The IEC is a European body whose remit is to prepare and publish international standards for all electrical, electronic and related technologies.

These serve as a basis for national standardisation and as references when drafting international tenders and contracts.

The IEC and ITU standards have no force of law, per se. To be used, they must be called up in national legislation.

Many national standards (particularly in Australia and the US) either reference the corresponding IEC standard in its entirety, or reference a version modified for local requirements.

Australian marine radio standards

In Australia, regulation of the radio spectrum is undertaken by the Australian Communications and Media Authority (ACMA).

Radio equipment sold in Australia is covered by either a class licence (applicable to a general type/group of equipment – generally low power devices such as EPIRBs) or an apparatus licence (for individual types of equipment).

The Australian standards creation process

ACMA have delegated the creation of radio standards to Standards Australia. Standards Australia develops standards through a committee process – with the committee members being drawn from industry and Government.

Committee RC/4 is responsible for creation of marine radio standards, including those for EPIRBs and MSLD.

As with international standards, the Australian Standards produced by RC/4 do not have the force of law until they are called up in legislation.

ACMA class licences are used as the legislative vehicle for call up of the relevant Australian Standards.

Crewsafe V100 VHF DSC Locator Beacon compliance with standards

The *Crewsafe V100 VHF DSC Locator Beacon* has been designed to comply with all applicable national and international marine radio and MSLD standards. The major standards are detailed in the following sections – a complete list may be found in Annex A.

The *Crewsafe V100 VHF DSC Locator Beacon* technical specifications may be found in Annexes B and C.

International DSC technical protocol

The DSC message protocol is defined in International Telecommunications Union (ITU) Recommendation ITU-R M.493-11.

International climatic and durability standards

The environmental and physical requirements (i.e. heat, shock, vibration, etc) for marine radio equipment are defined in International Electrotechnical Commission (IEC) Standard 60945.

US standards

The US marine radio standards development body - Radio Technical Commission for Maritime Services - has developed a MSLD standard with a DSC-specific section – *RTCM standard 11901.0 – Maritime Survivor Locating Devices.*

Australian standards

At the moment, there is no Australian Standard that specifically covers DSC MSLD. The closest standard is that for a 121.5 MHz MSLS - *AS/NZS 4869.1:2006 Maritime Survivor Locating Systems (MSLS) - Operating on 121.5 MHz*.

Standards Australia Committee RC/4 is currently developing a MSLS standard specifically covering DSC. This will be largely based on international and US standards.

General requirements for VHF marine radio transmitters are defined in Australian Communications and Media Authority class licence – (Radiocommunications VHF Radiotelephone Equipment - Maritime Mobile Service) Standard 2004 and the Australian VHF marine radio standard - AS/NZS 4415.2:2003.

Operator qualifications

There are no operator qualification requirements for EPIRBs. As the *Crewsafe V100 VHF DSC Locator Beacon* operates in an identical fashion to an EPIRB – i.e. it can be either turned on or off – operator qualifications are not required.

Annex A - Bibliography

Marine Radio and MSLD Standards

IEC 60529 - Degrees of protection provided by enclosures (IP Code)

IEC 60945 - Maritime navigation and radio communication equipment and systems general requirements (climatic and durability) - methods of testing and required test results (2002-08)

IEC 61097-3 – Global maritime distress and safety system (GMDSS) - Part 3: Digital selective calling (DSC) equipment - Operational and performance requirements, methods of testing and required testing results

IEC 61097-7 – Global maritime distress and safety system (GMDSS) - Part 7: Shipborne VHF radiotelephone transmitter and receiver - Operational and performance requirements, methods of testing and required test results

IEC 62238 – Maritime navigation and radiocommunication equipment and systems – VHF radiotelephone equipment incorporating Class 'D' Digital Selective Calling (DSC) - Methods of testing and required test results

IEC 61108-1 - Maritime navigation and radio communication equipment and systems – Global navigation satellite systems (GNSS) – Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results (2003-07)

ITU-R M.493-11 - Digital selective-calling system for use in the maritime mobile service

ITU-R M.821-1 - Optional expansion of the digital selective-calling system for use in the maritime mobile service

ITU-R M.541-9 - Operational procedures for the use of digital selective-calling equipment in the maritime mobile service

ITU-R M.693 – Technical characteristics of VHF emergency position-indicating radio beacons using digital selective calling (DSC VHF EPIRB)

ITU-R SM.332-4 - Selectivity of receivers

ITU-R M.690-1 - Technical characteristics of emergency position-indicating radio beacons (EPIRBs) operating on the carrier frequencies of 121.5 MHz and 243 MHz

AS/NZS 4869.1:2006 Maritime Survivor Locating Systems (MSLS) - Operating on 121.5 MHz

AS/NZS xxxxx Maritime Survivor Locating Systems (MSLS) - Operating on frequencies other than 121.5 MHz (draft – under development)

AS/NZS 4415.2:2003 - Radiotelephone transmitters and receivers for the maritime mobile service operating in the VHF bands—Technical characteristics and methods of measurement

RTCM standard 11901.0 – Maritime Survivor Locating Devices.

General GMDSS References

Internet:

www.gmdss.info

www.vhf-dsc.info

Manuals:

Admiralty List of Radio Signals Volume 5 - GMDSS

Annex B –Technical Specifications

(amalgamated from all applicable standards)

DSC Transmitter

In accordance with ITU Recommendation ITU-R M.493-11:

Frequency: 156.525 MHz

Class of emission: G2B.

Frequency tolerance: not to exceed 10 parts per million.

Necessary bandwidth: less than 16 kHz.

Spurious emissions: shall not exceed 75 dBμV/m, when measured in the vertical plane at a distance of 10 m from the antenna.

Output power: at least 1W.

The emission should be vertically polarized at the source.

Frequency modulation with a pre-emphasis of 6 dB/octave (phase modulation) with

frequency-shift of the modulating sub-carrier between 1 300 and 2 100 Hz; the sub-carrier being at 1 700 Hz;

Frequency tolerance of the 1300 and 2100 Hz tones: +-10 Hz;

Modulation rate: 1200 bauds.

Modulation index: 2.0 + l0%.

DSC Message Format

In accordance with ITU Recommendation ITU-R M.493-11, table 4.1, line 1:

Nature of distress indication: "Man overboard" (symbol 110)

Radiotelephone Transmitter

Frequency: 156.375 MHz (or other frequency if required by local considerations)

Class of emission: G3E (frequency modulation with a pre-emphasis of 6 dB/octave)

Frequency tolerance: not to exceed 10 parts per million.

Maximum deviation: +- 5 kHz

Spurious emissions: shall not exceed 75 dBμV/m, when measured in the vertical plane at a distance of 10 m from the antenna.

Output power: at least 1W.

The emission should be vertically polarized at the source.

Radiotelephone Distress Message Format

The beacon shall only transmit a synthesised voice message after a valid fix has been obtained from the in built GPS receiver.

Message format:

MAYDAY MAYDAY MAYDAY

THIS IS (UNIQUE IDENTIFICATION NUMBER)

MAN OVERBOARD

POSITION xx.xxS/N xxx.xxE/W

REPEAT

POSITION xx.xxS/N xxx.xxE/W

TIME XXXX UTC

Equipment Controls

The equipment shall be fitted with the following controls:

READY	In the **READY** mode, the transmitter is normally inactive, but automatically activates when the unit is immersed in water.
ON	In the **ON** mode, the transmitter is activated, whether in or out of the water. This function must be provided by a separate mechanism in addition to the automatic actuator.
OFF	In the **OFF** mode, the transmitter is deactivated.
TEST	See Test Mode paragraph below

When the beacon has been automatically or manually activated, no transmission should occur for the first 20 second of operation (to allow users to deactivate the device if it is an inadvertent activation).

The water-activation function shall be protected against inadvertent activation from salt-water spray or rain. The water contacts should be physically protected from spray and a short electronic delay in activation should be used to avoid inadvertent activation of the water switch.

Test Mode

The device shall include a self-test facility designed to test the beacon's radio frequency circuitry. The test facility shall be capable of operation only by mechanical actions that are distinctly separate from those normally required for activation of the transmitter.

These actions shall be designed so as to preclude accidental operation of the test facility and shall be non-locking. During the self test function, the beacon shall transmit in such a way that it will not cause a distress alert to be radiated.

Strobe Light

An inbuilt strobe light shall commence operation immediately the beacon is activated and is radiating RF energy, and shall remain on until the beacon is switched off or the batteries expire.

Audible Indication of Transmission

The beacon shall be fitted with an audible warning to indicate when the beacon is radiating radio frequency energy. This need only operate during actual transmissions.

Battery Requirements

The beacon shall be self-contained and operate independently of any external power source when activated.

The battery shall be contained within the equipment. Replacement of the battery, if user-replaceable, shall be possible with relative ease, and any interface connections shall be such as to prevent incorrect installation.

If it is possible to install the battery in a reverse polarity manner, the circuitry shall be designed to work equally well on either polarity. Provision shall be made to ensure beacon watertight integrity upon replacement of the battery.

In addition, the battery shall; -

- Have the capacity to operate the beacon continuously for at least 12 hours under all temperature conditions (-10C to +55C).;
- Be leak-proof under all conditions of stowage and operation;
- Have a minimum battery shelf life of two years; and
- Not be rechargeable.

It is recommended the battery be replaced at half the declared shelf life and the expiry date shall be clearly and durably marked on the battery sub-assembly where practicable and on the outside of the device in all cases.

A declaration of battery shelf life achievable at a steady temperature of +20^{o}C shall be provided.

Inbuilt GPS Receiver

The unit shall be fitted with an inbuilt GPS receiver, which shall comply with IEC standard *61108-1 - Maritime navigation and radio communication equipment and systems – Global navigation satellite systems (GNSS) – Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results (2003-07)*

The Time To First Fix (TTFF) of the GPS receiver shall be less than 10 minutes regardless of the start configuration of the beacon.

The device shall be fitted with a LED to indicate that the GPS is providing a fix.

If a valid GPS fix has not been obtained, then the Position field in the DSC messages shall be replaced with the digit 9 and the Time field shall be replaced with the digit 8.

If valid GPS updates cannot be maintained after an initial fix, then the last valid encoded position (and time) shall continue to be transmitted for a period of 3 hours.

If within this time a valid fix is obtained then the new updated position shall be transmitted. If however after 3 hours a valid fix has not been obtained, then the DSC message shall revert to the no position and time indicators as described above.

Annex C - Physical and Climatic/Durability Requirements

(extract from IEC 60945)

Basic Construction

The device shall meet the following construction requirements:

- Manufacture shall be from suitable materials and the device shall be designed and constructed to ensure reliable operation in the marine environment when exposed to shock, vibration, magnetic influences, rain, sea spray, hose wash down spray thermal extremes and other environmental conditions likely to be encountered in an exposed above-deck condition when at sea.
- Impact-resistant materials shall be used for its casing. The material shall be resistant to deterioration from prolonged exposure to sunlight, and shall not be unduly affected by seawater or oil.
- Its electronic components shall be protected to prevent malfunction under prolonged conditions of high humidity, including condensation.
- The transmitter shall be effectively protected from damage due to short or open circuit of the antenna when transmitting at maximum power.
- The beacon shall be capable of being easily deployed.
- The device shall be manufactured as one watertight unit and have a smooth exterior design with no sharp projection (including the antenna) which may cause damage to an inflatable life raft, safety harness, PFD or lifejacket.
- The unit shall have sufficient positive buoyancy to float.
- Finish shall be a highly-visible colour such as Dayglo orange or yellow

Tethering Arrangement

The beacon shall be fitted with either:

- A highly visible and coloured (such as Dayglo orange or yellow) rot-proof and chafe-resistant buoyant line of at least 2 metres in length with a breaking strain including the tether point of not less than 120 N; or
- A personal tethering device such as a neck or wrist strap.

Markings

All labeling on the exterior of the unit shall be resistant to deterioration by prolonged exposure to sunlight, should not be unduly affected by seawater or oil, and should be abrasion resistant.

The outside of the unit shall be marked indelibly and legibly with the following; -

- Concise operating instructions
- The name and address of the manufacturer.
- The type number or model identification
- Storage and operating temperature range
- Self-test instructions.
- Compass safe distance.
- The statement that DELIBERATE MISUSE MAY INCUR A SEVERE PENALTY

Stowage Temperature

-30^{o} to $+70^{o}$ C (-22^{o} to 158^{o} F).

Climatic and Durability Requirements

The device shall meet the climactic and durability tests as specified in IEC Standard 60945 for portable equipment.

Tests shall be carried out in the order specified in IEC 60945:

- Dry heat
- Damp heat
- Low temperature
- Thermal shock
- Drop
- Vibration
- Immersion
- Solar radiation
- Oil resistance
- Corrosion
- Immunity to electrostatic discharge

In the drop test, the three drop orientations may be carried out concurrently with three samples of the same device.

Compass Safe Distance

The beacon, whilst not activated, shall be subjected to the compass safe distance test in IEC 60945.

-Ends-