ΑΚΑΔΗΜΙΑ ΕΜΠΟΡΙΚΟΥ ΝΑΥΤΙΚΟΥ ΜΑΚΕΔΟΝΙΑΣ

ΣΧΟΛΗ ΠΛΟΙΑΡΧΩΝ


**ΘΕΜΑ:COMMUNICATIONS AT SEA**

ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ ΤΟΥ:

ΓΕΩΡΓΙΟΥ ΑΝΔΡΙΑΝΟΥ

ΕΠΙΒΛΕΨΗ: ΠΑΝΑΓΟΠΟΥΛΟΥ Μ.

ΜΗΧΑΝΙΩΝΑ 2018

ΑΚΑΔΗΜΙΑ ΕΜΠΟΡΙΚΟΥ ΝΑΥΤΙΚΟΥ

# *Α.Ε.Ν   ΜΑΚΕΔΟΝΙΑΣ*

# ΠΤΥΧΙΑΚΗ   ΕΡΓΑΣΙΑ

**ΕΠΙΒΛΕΠΩΝ ΚΑΘΗΓΗΤΗΣ: ΠΑΝΑΓΟΠΟΥΛΟΥ Μ.**

***ΘΕΜΑ : COMMUNICATIONS AT SEA***

**ΤΟΥ ΣΠΟΥΔΑΣΤΗ:**

**ΓΕΩΡΓΙΟΥ ΑΝΔΡΙΑΝΟΥ  Α.Γ.Μ. 3228**

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| ***Α/Α*** | ***Ονοματεπώνυμο*** | ***Ειδικότης*** | ***Αξιολόγηση*** | ***Υπογραφή*** |
|---|---|---|---|---|
| ***1*** | ΤΣΟΥΛΗΣ Ν. | Δ/ΝΤΗΣ ΣΧΟΛΗΣ<br>ΠΛΟΙΑΡΧΟΣ Α | | |
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| ***ΤΕΛΙΚΗ ΑΞΙΟΛΟΓΗΣΗ*** | | | | |

***Ο ΔΙΕΥΘΥΝΤΗΣ  ΣΧΟΛΗΣ :***

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# ***SUMMARY***

With the advancement of technology, communications have been upgraded at sea, with the result that sailors and vessels are safer. Morse signals and flags that helped sailors, up to the naval instruments have changed a lot until the perfection of them, so we can communicate with other ships and land. There are devices of communication by telephone via fax and via the Internet and email. Also in cases of distress, communication becomes easier and faster so that the response is immediate. Satellites, earth stations and the search and rescue services are contribute to the immediate rescue of seafarers.

# ***PROLOGUE***

Telecommunications at sea have undergone radical changes over the last century. After the signage and flag seasons (in some cases still valid today), electronic communication has brought about a dramatic change in maritime communication.

Since the early years of the last century, ships have begun installing a radio for communications involving danger signs between ships but also between ship and land. Radiotelegraphy using Morse code was used for maritime communication at the beginning of the twentieth century.

In the 1970s, taking into account studies by the International Telecommunication Union, the IMO introduced a system where ship-to-ship communication was somewhat automated, where no one needed 24 hours a day to sit above.

Communication between ships on land is carried out with the help of systems on board ships, which transmit signals through the land and satellite channels. While ship-to-ship, communication can be performed by VHF with Digital Selective Calling (DSC), which transmits or receives emergency signals, emergency signals, security signals, routine messages or priority. Ship communication by ship may also - for long distances - also occur with MF (medium waves) HF (short waves). DSC controllers can now be integrated with the SOLAS VHF radio.

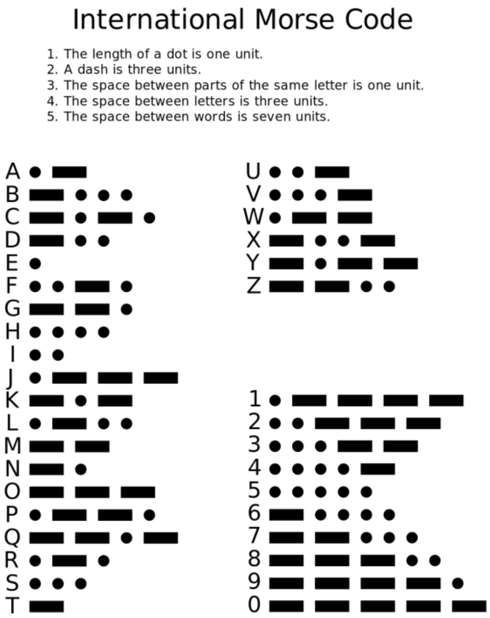
For satellite services - communications, unlike terrestrial communication systems, we need the help of geostationary satellites to transmit and receive signals. Our satellite communications are useful for areas where the signals we want to transmit can not reach land stations, mainly due to distance. Satellite maritime communication services are provided by INMARSAT and COSPAS - SARSAT.

While INMARSAT gives the scope of two-way communication, Corpas Sarsat has a system that is limited to receiving signals from the Emergency position and used on Radio Interference Markers (EPIRBs).

For international business requirements, the Global Maritime Safety System (GMDSS) has divided the land into four sub-regions. These are four geographical areas named as A1, A2, A3 and A4.

# MORSE CODE

**Morse code** is a method of transmitting text information as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special equipment. It is named for Samuel F. B. Morse, an inventor of the telegraph. The International Morse Code encodes the ISO basic Latin alphabet, some extra Latin letters, the Arabic numerals and a small set of punctuation and procedural signals (prosigns) as standardized sequences of short and long signals cadlled "dots" an "dashes", or "dits" and "dahs", as in amateur radio practice. Because many non-English natural languages use more than the 26 Roman letters, extensions to the Morse alphabet exist for those languages.




Each Morse code symbol represents either a text character (letter or numeral) or a prosign and is represented by a unique sequence of dots and dashes. The duration of a dash is three times the duration of a dot. Each dot or dash is followed by a short silence, equal to the dot duration. The letters of a word are separated by a space equal to three dots (one dash), and the words are separated by a space equal to seven dots. The dot duration is the basic unit of time measurement in code transmission. To increase the speed of the communication, the code was designed so that the length of each character in Morse varies approximately inversely to its frequency of occurrence in English. Thus the most common letter in English, the letter "E", has the shortest code, a single dot.

Morse code is used by some amateur radio operators, although knowledge of and proficiency with it is no longer required for licensing in most countries. Pilots and air traffic controllers usually need only a cursory understanding. Aeronautical navigational aids, such as VORs and NDBs, constantly identify in Morse code. Compared to voice, Morse code is less sensitive to poor signal conditions, yet still comprehensible to humans without a decoding device. Morse is, therefore, a useful alternative to synthesized speech for sending automated data to skilled listeners on voice channels. Many amateur radio repeaters, for example, identify with Morse, even though they are used for voice communications.

In an emergency, Morse code can be sent by improvised methods that can be easily "keyed" on and off, making it one of the simplest and most versatile methods of telecommunication. The most common distress signal is SOS or three dots, three dashes, and three dots, internationally recognized by treaty.

## **Development and history**

Beginning in 1836, the American artist Samuel F. B. Morse, the American physicist Joseph Henry, and Alfred Vail developed an electrical telegraph system. This system sent pulses of electric current along wires which controlled an electromagnet that was located at the receiving end of the telegraph system. A code was needed to transmit natural language using only these pulses, and the silence between them. Around 1837, Morse, therefore, developed an early forerunner to the modern International Morse code. Around the same time, Carl Friedrich Gauss and Wilhelm Eduard Weber (1833) as well as Carl August von Steinheil (1837) had already used codes with varying word lengths for their telegraphs.

In 1837, William Cooke and Charles Wheatstone in England began using an electrical telegraph that also used electromagnets in its receivers. However, in contrast with any system of making sounds of clicks, their system used pointing needles that rotated above alphabetical charts to indicate the letters that were being sent. In 1841, Cooke and Wheatstone built a telegraph that printed the letters from a wheel of typefaces struck by a hammer. This machine was based on their 1840 telegraph and worked well; however, they failed to find customers for this system and only two examples were ever built.

On the other hand, the three Americans' system for telegraphy, which was first used in about 1844, was designed to make indentations on a paper tape when electric currents were received. Morse's original telegraph receiver used a mechanical clockwork to move a paper tape. When an electrical current was received, an electromagnet engaged an armature that pushed a stylus onto the moving paper tape, making an indentation on the tape. When the current was interrupted, a spring retracted the stylus, and that portion of the moving tape remained unmarked.

The Morse code was developed so that operators could translate the indentations marked on the paper tape into text messages. In his earliest code, Morse had planned to transmit only numerals, and to use a codebook to look up each word according to the number which had been sent. However, the code was soon expanded by Alfred Vail in 1840 to include letters and special characters, so it could be used more generally. Vail estimated the frequency of use of letters in the English language by counting the movable type he found in the type-cases of a local newspaper in Morristown. The shorter marks were called "dots", and the longer ones "dashes", and the letters most commonly used were assigned the shorter sequences of dots and dashes. This code was used since 1844 and became known as *Morse landline code* or *American Morse code*.

In the original Morse telegraphs, the receiver's armature made a clicking noise as it moved in and out of position to mark the paper tape. The telegraph operators soon learned that they could translate the clicks directly into dots and dashes, and write these down by hand, thus making the paper tape unnecessary. When Morse code was adapted to radio communication, the dots and dashes were sent as short and long tone pulses. It was later found that people become more proficient at receiving Morse code when it is taught as a language that is heard, instead of one read from a page.

To reflect the sounds of Morse code receivers, the operators began to vocalize a dot as "dit", and a dash as "dah". Dots which are not the final element of a character became vocalized as "di". For example, the letter "c" was then vocalized as "dah-di-dah-dit". Morse code was sometimes facetiously known as "iddy-umpty", and a dash as "umpty", leading to the word "umpteen".

The Morse code, as it is used internationally today, was derived from a much refined proposal which became known as "Hamburg alphabet" by Friedrich Clemens Gerke in 1848. It was adopted by the Deutsch-Österreichischer Telegraphenverein (German-Austrian Telegraph Society) in 1851. This finally led to the International Morse code in 1865.

In the 1890s, Morse code began to be used extensively for early radio communication, before it was possible to transmit voice. In the late 19th and early 20th centuries, most high-speed international communication used Morse code on telegraph lines, undersea cables and radio circuits. In aviation, Morse code in radio systems started to be used on a regular basis in the 1920s. Although previous transmitters were bulky and the spark gap system of transmission was difficult to use, there had been some earlier attempts. In 1910, the US Navy experimented with sending Morse from an airplane. That same year, a radio on the airship *America* had been instrumental in coordinating the rescue of its crew. Zeppelin airships equipped with radio were used for bombing and naval scouting during World War I, and ground-based radio direction finders were used for airship navigation. Allied airships and military aircraft also made some use of radiotelegraphy. However, there was little aeronautical radio in general use during World War I, and in the 1920s, there was no radio system used by such important flights as that of Charles Lindbergh from New York to Paris in 1927. Once he and the *Spirit of St. Louis* were off the ground, Lindbergh was truly alone and incommunicado. On the other hand, when the first airplane flight was made from California to Australia in 1928 on the *Southern Cross*, one of its four crewmen was its radio operator who communicated with ground stations via radio telegraph.

Beginning in the 1930s, both civilian and military pilots were required to be able to use Morse code, both for use with early communications systems and for identification of navigational beacons which transmitted continuous two- or three-letter identifiers in Morse code. Aeronautical charts show the identifier of each navigational aid next to its location on the map.

Radiotelegraphy using Morse code was vital during World War II, especially in carrying messages between the warships and the naval bases of the belligerents. Long-range ship-to-ship communication was by radio telegraphy, using encrypted messages because the voice radio systems on ships then were quite limited in both their range and their security. Radiotelegraphy was also extensively used by warplanes, especially by long-range patrol planes that were sent out by those navies to scout for enemy warships, cargo ships, and troop ships.

In addition, rapidly moving armies in the field could not have fought effectively without radiotelegraphy because they moved more rapidly than telegraph and telephone lines could be erected. This was seen especially in the blitzkrieg offensives of the Nazi German in Poland, Belgium, France (in

1940), the Soviet Union, and in North Africa; by the British Army in North Africa, Italy, and the Netherlands; and by the U.S. Army in France and Belgium (in 1944), and in southern Germany in 1945.

Morse code was used as an international standard for maritime distress until 1999 when it was replaced by the Global Maritime Distress Safety System. When the French Navy ceased using Morse code on January 31, 1997, the final message transmitted was "Calling all. This is our last cry before our eternal silence." In the United States the final commercial Morse code transmission was on July 12, 1999, signing off with Samuel Morse's original 1844 message, "What hath God wrought", and the prosign "SK".

As of 2015, the United States Air Force still trains ten people a year in Morse. The United States Coast Guard has ceased all use of Morse code on the radio, and no longer monitors any radio frequencies for Morse code transmissions, including the international medium frequency (MF) distress frequency of 500 kHz. However, the Federal Communications Commission still grants commercial radiotelegraph operator licenses to applicants who pass its code and written tests. Licensees have reactivated the old California coastal Morse station KPH and regularly transmit from the site under either this Call sign or as KSM. Similarly, a few US Museum ship stations are operated by Morse enthusiasts.

## International Morse Code

Morse code has been in use for more than 160 years—longer than any other electrical coding system. What is called Morse code today is actually somewhat different from what was originally developed by Vail and Morse. The Modern International Morse code, or *continental code*, was created by Friedrich Clemens Gerke in 1848 and initially used for telegraphy between Hamburg and Cuxhaven in Germany. Gerke changed nearly half of the alphabet and all of the numerals, providing the foundation for the modern form of the code. After some minor changes, International Morse Code was standardized at the International Telegraphy Congress in 1865 in Paris and was later made the standard by the International Telecommunication Union (ITU). Morse's original code specification, largely limited to use in the United States and Canada, became known as American Morse code or *railroad code*. American Morse code is now seldom used except in historical re-enactments.

### Maritime Use

Through May 2013, the First, Second, and Third Class (commercial) Radiotelegraph Licenses using code tests based upon the CODEX standard word were still being issued in the United States by the Federal Communications Commission. The First Class license required 20 WPM code group and 25 WPM text code proficiency, the others 16 WPM code group test (five letter blocks sent as simulation of receiving encrypted text) and 20 WPM code text (plain language) test. It was also necessary to pass written tests on operating practice and electronics theory. A unique additional demand for the First Class was a requirement of a year of experience for operators of shipboard and coast stations using Morse. This allowed the holder to be chief operator on board a passenger ship. However, since 1999 the use of satellite and very high-frequency maritime communications systems (GMDSS) has made them obsolete. (By that point meeting experience requirement for the First was very difficult.) Currently, only one class of license, the Radiotelegraph Operator License, is issued. This is granted either when the tests are passed or as the Second and First are renewed and become this lifetime license. For new applicants, it requires passing a written examination on electronic theory and radiotelegraphy practices, as well as 16 WPM codegroup and 20 WPM text tests. However, the code exams are currently waived for holders of Amateur Extra Class licenses who obtained their operating privileges under the old 20 WPM test requirement.

Radio navigation aids such as VORs and NDBs for aeronautical use broadcast identifying information in the form of Morse Code, though many VOR stations now also provide voice identification. Warships, including those of the U.S. Navy, have long used signal lamps to exchange messages in Morse code. Modern use continues, in part, as a way to communicate while maintaining radio silence.

ATIS (Automatic Transmitter Identification System) uses Morse code to identify uplink sources of analog satellite transmissions.

## Morse code as an assistive technology

Morse code has been employed as an assistive technology, helping people with a variety of disabilities to communicate. Morse can be sent by persons with severe motion disabilities, as long as they have some minimal motor control. An original solution to the problem that caretakers have to learn to decode has been an electronic typewriter with the codes written on the keys. Codes were sung by users; see the voice typewriter employing morse or votem, Newell and Nabarro, 1968.

Morse code can also be translated by computer and used in a speaking communication aid. In some cases, this means alternately blowing into and sucking on a plastic tube ("sip-and-puff" interface). An important advantage of Morse code over row column scanning is that once learned, it does not require looking at a display. Also, it appears faster than scanning.

People with severe motion disabilities in addition to sensory disabilities (e.g. people who are also deaf or blind) can receive Morse through a skin buzzer.

In one case reported in the radio amateur magazine *QST* an old shipboard radio operator who had a stroke and lost the ability to speak or write could communicate with his physician (a radio amateur) by blinking his eyes in Morse. Two examples of communication in intensive care units were also published in *QST*, Another example occurred in 1966 when prisoner of war Jeremiah Denton, brought on television by his North Vietnamese captors, Morse-blinked the word *TORTURE*. In these two cases, interpreters were available to understand those series of eye-blinks.

# International maritime signal flags

**International maritime signal flags** refers to various flags used to communicate with ships. The principal system of flags and associated codes is the International Code of Signals. Various navies have flag systems with additional flags and codes, and other flags are used in special uses, or have historical significance.

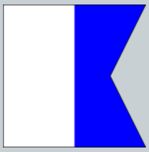
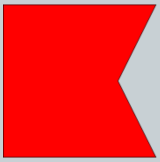
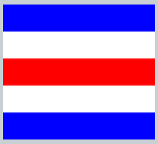
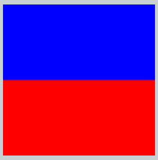
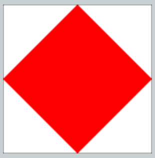
There are various methods by which the flags can be used as signals:

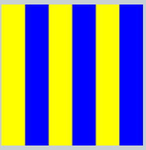
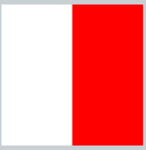
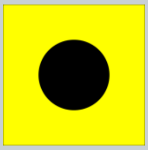
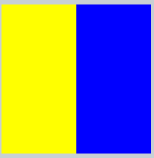
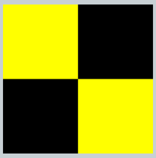
- Each flag spells an alphabetic message, letter by letter.
- Individual flags have specific and standard meanings; for example, diving support vessels raise the "A" flag indicating their inability to move from their current location because they have a diver underwater and to warn other vessels to keep clear to avoid endangering the diver(s) with their propellers.
- One or more flags form a code word whose meaning can be looked up in a code book held by both parties. An example is the Popham numeric code used at the Battle of Trafalgar.
- In yacht racing and dinghy racing, flags have other meanings; for example, the P flag is used as the "preparatory" flag to indicate an imminent start, and the S flag means "shortened course"

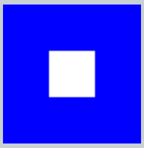
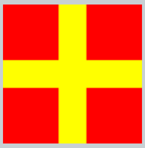
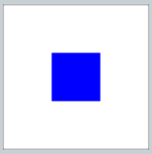
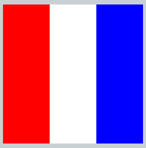
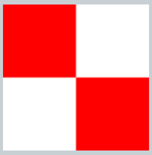
NATO uses the same flags, with a few unique to warships, alone or in short sets to communicate various unclassified messages. The NATO usage generally differs from the international meanings, and therefore warships will fly the Code/answer flag above the signal to indicate it should be read using the international meaning.

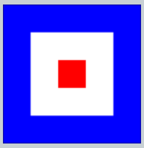
During the Allied occupations of Axis countries after World War II , use and display of those nations' national flags was banned. In order to comply with the international legal requirement that a ship identify its registry by displaying the appropriate national ensign, swallow-tailed versions of the C, D, and E signal flags were designated as, respectively, provisional German, Okinawan, and Japanese civil ensigns. Being swallowtails, they are commonly referred to as the "C-pennant" (German: C-Doppelstander), "D-pennant", and "E-pennant".

## Letter flags (with ICS meaning)

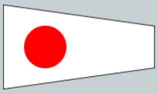
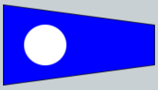
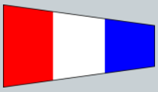
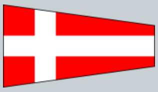
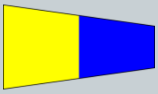
| Letter/ Phonetic name | Flag | ICS Meaning as single flag |
|---|---|---|
| **A**<br>**Alfa** |  | "I have a diver down; keep well clear at slow speed." |
| **B**<br>**Bravo** |  | "I am taking in or discharging or carrying dangerous goods." (Originally used by the Royal Navy specifically for military explosives.) |
| **C**<br>**Charlie** |  | "Affirmative." |
| **D**<br>**Delta** |  | "Keep clear of me; I am maneuvering with difficulty." |
| **E**<br>**Echo** |  | "I am altering my course to starboard." |
| **F**<br>**Foxtrot** |  | "I am disabled; communicate with me." |

| | | |
|---|---|---|
| **G**<br>**Golf** |  | "I require a pilot."<br><br>*By fishing vessels near fishing grounds:* "I am hauling nets." |
| **H**<br>**Hotel** |  | "I have a pilot on board." |
| **I**<br>**India** |  | "I am altering my course to port." |
| **J**<br>**Juliet** |  | "I am on fire and have dangerous cargo on board: keep well clear of me."<br><br>or<br><br>"I am leaking dangerous cargo." |
| **K**<br>**Kilo** |  | "I wish to communicate with you." |
| **L**<br>**Lima** |  | *In harbour:* "The ship is quarantined."<br><br>*At sea:* "You should stop your vessel instantly." |
| **M**<br>**Mike** |  | "My vessel is stopped and making no way through the water." |
| **N**<br>**November** |  | "Negative." |

| | | |
|---|---|---|
| **O**<br>**Oscar** |  | "Man overboard." (often attached to the *man overboard pole* on boats).<br><br>With a sinister hoist, the semaphore flag. |
| **P**<br>**Papa** |  | The *blue Peter*.<br><br>*In harbour:* All persons should report on board as the vessel is about to proceed to sea.<br><br>*At sea:* It may be used by fishing vessels to mean: "My nets have come fast upon an obstruction." |
| **Q**<br>**Quebec** |  | "My vessel is 'healthy' and I request free pratique." |
| **R**<br>**Romeo** |  | (No ICS meaning as single flag) |
| **S**<br>**Sierra** |  | "I am operating astern propulsion." |
| **T**<br>**Tango** |  | "Keep clear of me."<br><br>*Fishing boats:* "Keep clear of me; I am engaged in pair trawling." |
| **U**<br>**Uniform** |  | "You are running into danger." |

| | | |
|---|---|---|
| **V**<br>**Victor** |  | "I require assistance." |
| **W**<br>**Whiskey** |  | "I require medical assistance." |
| **X**<br>**Xray** |  | "Stop carrying out your intentions and watch for my signals." |
| **Y**<br>**Yankee** |  | "I am dragging my anchor." |
| **Z**<br>**Zulu** |  | "I require a tug."<br><br>*By fishing vessels near fishing grounds:* "I am shooting nets." |

## Number flags

| Number | ICS flag |
|---|---|
| 0 Zero |  |
| 1 One |  |
| 2 Two |  |
| 3 Three |  |
| 4 Four |  |
| 5 Five |  |
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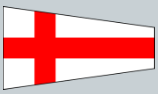
| 8 Eight |  |
| 9 Nine |  |

# Global Maritime Distress and Safety System

The **Global Maritime Distress and Safety System** (**GMDSS**) is an internationally agreed-upon set of safety procedures, types of equipment, and communication protocols used to increase safety and make it easier to rescue distressed ships, boats and aircraft.

GMDSS consists of several systems, some of which are new, but many of which have been in operation for many years. The system is intended to perform the following functions: alerting (including position determination of the unit in distress), search and rescue coordination, locating (homing), maritime safety information broadcasts, general communications, and bridge-to-bridge communications. Specific radio carriage requirements depend upon the ship's area of operation, rather than its tonnage. The system also provides redundant means of distress alerting, and emergency sources of power.

Recreational vessels do not need to comply with GMDSS radio carriage requirements, but will increasingly use the Digital Selective Calling (DSC) VHF radios. Offshore vessels may elect to equip themselves further. Vessels under 300 Gross tonnages (GT) are not subject to GMDSS requirements.

## History

Since the invention of radio at the end of the 19th century, ships at sea have relied on Morse code, invented by Samuel Morse and first used in 1844, for distress and safety telecommunications. The need for ship and coast radio stations to have and use radiotelegraph equipment, and to listen to a common radio frequency for Morse encoded distress calls, was recognized after the sinking of the liner RMS *Titanic* in the North Atlantic in 1912. The U.S. Congress enacted legislation soon after, requiring U.S. ships to use Morse code radiotelegraph equipment for distress calls. The International Telecommunications Union (ITU), now a United Nations agency, followed suit for ships of all nations. Morse encoded distress calling has saved thousands of lives since its inception almost a century ago, but its use requires skilled radio operators spending many hours listening to the radio distress frequency. Its range on the medium frequency (MF) distress band (500 kHz) is limited, and the amount of traffic Morse signals can carry is also limited.

Not all ship-to-shore radio communications were short range. Some radio stations provided long-range radiotelephony services, such as radio telegrams and radio telex calls, on the HF bands (3–30 MHz) enabling worldwide communications with ships. For example, Portishead Radio, which was the world's busiest radiotelephony station, provided HF long-range services. In 1974, it had 154 radio operators who handled over 20 million words per year. Such large radiotelephony stations employed large numbers of people and were expensive to operate. By the end of the 1980s, satellite services had started to take an increasingly large share of the market for ship-to-shore communications.

For these reasons, the International Maritime Organization (IMO), a United Nations agency specializing in safety of shipping and preventing ships from polluting the seas, began looking at ways of improving maritime distress and safety communications. In 1979, a group of experts drafted the International Convention on Maritime Search and Rescue, which called for development of a global search and rescue plan. This group also passed a resolution calling for development by IMO of a Global Maritime Distress and Safety System (GMDSS) to provide the communication support needed to implement the search and rescue plan. This new system, which the world's maritime nations are implementing, is based upon a combination of satellite and terrestrial radio services, and has changed international distress communications from being primarily ship-to-ship based to ship-to-shore (Rescue Coordination Center) based. It spelled the end of Morse code communications for all but a few users, such as amateur radio operators. The GMDSS provides for automatic distress alerting and locating in cases where a radio operator doesn't have time to send an SOS or MAYDAY call, and, for the first time, requires ships to receive broadcasts of maritime safety information which could prevent a distress from happening in the first place. In 1988, IMO amended the Safety of Life at Sea (SOLAS) Convention, requiring ships subject to it fit GMDSS equipment. Such ships were required to carry NAVTEX and satellite EPIRBs by August 1, 1993, and had to fit all other GMDSS equipment by February 1, 1999. US ships were allowed to fit GMDSS in lieu of Morse telegraphy equipment by the Telecommunications Act of 1996.

## Components of GMDSS

The main types of equipment used in GMDSS are:

### Emergency position-indicating radio beacon (EPIRB)

Cospas-Sarsat is an international satellite-based search and rescue system, established by Canada, France, the United States, and Russia. These four countries jointly helped develop the 406 MHz Emergency Position-Indicating Radio Beacon (EPIRB), an element of the GMDSS designed to operate with Cospas-Sarsat system. These automatic-activating EPIRBs, now required on SOLAS ships, commercial fishing vessels, and all passenger ships, are designed to transmit to alert rescue coordination centers via the satellite system from anywhere in the world. The original COSPAS/SARSAT system used polar orbiting satellites but in recent years the system has been expanded to also include 4 geostationary satellites. Newest designs incorporate GPS receivers to transmit highly accurate positions (within about 20 meters) of the distress position. The original COSPAS/SARSAT satellites could calculate EPIRB position to within about 3 nautical miles (5.6 km) by using Doppler techniques. By the end of 2010 EPIRB manufacturers may be offering AIS (automatic identification system) enabled beacons. The serviceability of these items is checked monthly and annually and they have limited battery shelf life, between two and five years using mostly lithium-type batteries. 406 MHz EPIRB's transmit a registration number which is linked to a database of information about the vessel.

## NAVTEX

Navtex is an international, automated system for instantly distributing maritime safety information (MSI) which includes navigational warnings, weather forecasts and weather warnings, search and rescue notices and similar information to ships. A small, low-cost and self-contained "smart" printing radio receiver is installed on the bridge, or the place from where the ship is navigated, and checks each incoming message to see if it has been received during an earlier transmission, or if it is of a category of no interest to the ship's master. The frequency of transmission of these messages is 518 kHz in English, while 490 kHz is sometime used to broadcast in a local language. The messages are coded with a header code identified by the using single letters of the alphabet to represent broadcasting stations, type of messages, and followed by two figures indicating the serial number of the message. For example: **FA56** where **F** is the ID of the transmitting station, **A** indicates the message category *navigational warning*, and **56** is the consecutive message number.

## Inmarsat

Satellite systems operated by the Inmarsat company, overseen by the International Mobile Satellite Organization (IMSO) are also important elements of the GMDSS. The types of Inmarsat ship earth station terminals recognized by the GMDSS are: Inmarsat B, C and F77. Inmarsat B and F77, an updated version of the now redundant Inmarsat A, provide ship/shore, ship/ship and shore/ship telephone, telex and high-speed data services, including a distress priority telephone and telex service to and from rescue coordination centers. Fleet 77 fully supports the Global Maritime Distress and Safety System (GMDSS) and includes advanced features such as emergency call prioritization. The Inmarsat C provides ship/shore, shore/ship and ship/ship store-and-forward data and email messaging, the capability for sending preformatted distress messages to a rescue coordination center, and the Inmarsat C Safety NET service. The Inmarsat C Safety NET service is a satellite-based worldwide maritime safety information broadcast service of high seas weather warnings, NAVAREA navigational warnings, radionavigation warnings, ice reports and warnings generated by the USCG-conducted International Ice Patrol, and other similar information not provided by NAVTEX. Safety NET works similarly to NAVTEX in areas outside NAVTEX coverage.

Inmarsat C equipment is relatively small and lightweight, and costs much less than an Inmarsat B or F77 station. Inmarsat B and F77 ship earth stations require relatively large gyro-stabilized unidirectional antennas; the antenna size of the Inmarsat C is much smaller and is omnidirectional.

Under a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA), combined meteorological observations and AMVER reports can now be sent to both the USCG AMVER Center, and NOAA, using an Inmarsat C ship earth station, at no charge.

SOLAS now requires that Inmarsat C equipment have an integral satellite navigation receiver, or be externally connected to a satellite navigation receiver. That connection will ensure accurate location information to be sent to a rescue coordination center if a distress alert is ever transmitted.

Also the new LRIT long range tracking systems are upgraded via GMDSS Inmarsat C which are also compliant along with inbuilt SSAS, or ship security alert system. SSAS provides a means to covertly transmit a security alert distress message to local authorities in the event of a mutiny, pirate attack, or other hostile action towards the vessel or its crew.

## High frequency

A GMDSS system may include high-frequency (HF) radiotelephone and radiotelex (narrow-band direct printing) equipment, with calls initiated by digital selective calling (DSC). Worldwide broadcasts of maritime safety information can also be made on HF narrow-band direct printing channels.

## Search and rescue locating device

The GMDSS installation on ships include one (two on vessels over 500 GT) Search and Rescue Locating device(s) called Search and Rescue Radar Transponders (SART) which are used to locate survival craft or distressed vessels by creating a series of twelve dots on a rescuing ship's 3 cm radar display. The detection range between these devices and ships, dependent upon the height of the ship's radar mast and the height of the Search and Rescue Locating device, is normally about 15 km (8 nautical miles). Once detected by radar, the Search and Rescue Locating device will produce a visual and aural indication to the persons in distress.

## Digital selective calling

The IMO also introduced digital selective calling (DSC) on MF, HF and VHF maritime radios as part of the GMDSS system. DSC is primarily intended to initiate ship-to-ship, ship-to-shore and shore-to-ship radiotelephone and MF/HF radiotelex calls. DSC calls can also be made to individual stations, groups of stations, or "all stations" in one's radio range. Each DSC-equipped ship, shore station and group is assigned a unique 9-digit Maritime Mobile Service Identity.

DSC distress alerts, which consist of a preformatted distress message, are used to initiate emergency communications with ships and rescue coordination centers. DSC was intended to eliminate the need for persons on a ship's bridge or on shore to continuously guard radio receivers on voice radio channels, including VHF channel 16 (156.8 MHz) and 2182 kHz now used for distress, safety and calling. A listening watch aboard GMDSS-equipped ships on 2182 kHz ended on February 1, 1999. In May 2002, IMO decided to postpone cessation of a VHF listening watch aboard ships. That watchkeeping requirement had been scheduled to end on February 1, 2005.

IMO and ITU both require that the DSC-equipped MF/HF and VHF radios be externally connected to a satellite navigation receiver (GPS). That connection will ensure accurate location information is sent to a rescue coordination center if a distress alert is transmitted. The FCC requires that all new VHF and MF/HF maritime radiotelephones type accepted after June 1999 have at least a basic DSC capability.

VHF digital selective calling also has other capabilities beyond those required for the GMDSS. The US Coast Guard uses this system to track vessels in Prince William Sound, Alaska, Vessel Traffic Service. IMO and the USCG also plan to require ships carry a Universal Shipborne automatic identification system, which will be DSC-compatible. Countries having a GMDSS A1 Area should be able to identify and track AIS-equipped vessels in its waters without any additional radio equipment. A DSC-equipped radio cannot be interrogated and tracked unless that option was included by the manufacturer, and unless the user configures it to allow tracking.

GMDSS telecommunications equipment should not be reserved for emergency use only. The International Maritime Organization encourages mariners to use GMDSS equipment for routine as well as safety telecommunications.

### Power supply requirements

GMDSS equipment is required to be powered from three sources of supply:

- ship's normal alternators/generators;
- ship's emergency alternator/generator (if fitted); and
- a dedicated radio battery supply.

The batteries are required to have a capacity to power the equipment for 1 hour on ships with an emergency generator or built prior to February 1995, and 6 hours on ships not fitted with an emergency generator or built after February 1995 in order to comply with SOLAS. The batteries must be charged by an automatic charger, which is also required to be powered from the main and emergency generators. Changeover from AC to battery supply must be automatic, and effected in such a way that any data held by the equipment is not corrupted ("no break").

During Coast Guard inspections, the batteries must be able to go from 100% discharge to fully charged in no longer than 10 hours in order to pass certification. The charger too must be obtainable at all times during vessel operation and should be inspected to make sure it functions properly. When the reserve source of energy consists of batteries, the battery capacity must be checked at intervals not exceeding 12 months. If not completed within past 12 months, this must be done during inspection.

Storage batteries provided as a reserve source of energy must be installed in accordance with applicable electrical codes and good engineering practice. They must be protected from adverse weather and physical damage. They must be readily accessible for maintenance and replacement.

## GMDSS SEA AREAS

GMDSS sea areas serve two purposes: to describe areas where GMDSS services are available, and to define what radio equipment GMDSS ships must carry (carriage requirements). Prior to the GMDSS, the number and type of radio safety equipment ships had to carry depended upon its tonnage. With GMDSS, the number and type of radio safety equipment ships have to carry depends upon the GMDSS areas in which they travel. GMDSS sea areas are classified into four areas: area1, area2, area3 and area 4.

In addition to equipment listed below, all GMDSS-regulated ships must carry a satellite EPIRB, a NAVTEX receiver (if they travel in any areas served by NAVTEX), an Inmarsat-C SafetyNET receiver (if they travel in any areas not served by NAVTEX), a DSC-equipped VHF radiotelephone, two (if between 300 and less than 500 GRT) or three VHF handhelds (if 500 GRT or more), and two 9 GHz search and rescue radar transponders (SART).

**Sea Area A1**

An area within the radiotelephone coverage of at least one VHF coast station in which continuous digital selective calling (Ch.70/156.525 MHz) alerting and radiotelephony services are available. Such an area could extend typically 30 to 40 nautical miles (56 to 74 km) from the Coast Station.

**Sea Area A2**

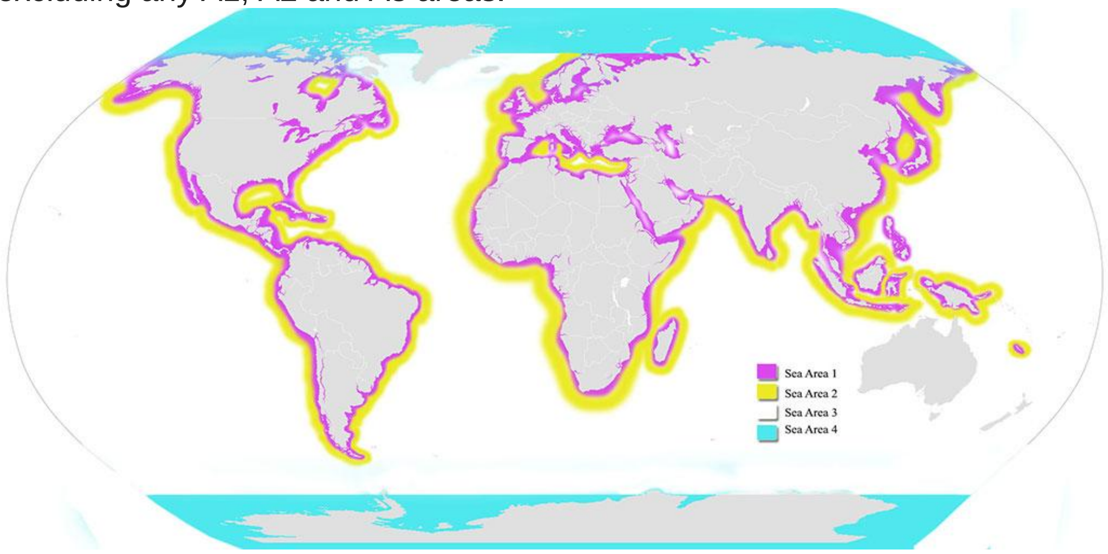
An area, excluding Sea Area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC (2187.5 kHz) alerting and radiotelephony services are available. For planning purposes, this area typically extends to up to 180 nautical miles (330 km) offshore during daylight hours, but would exclude any A1 designated areas. In practice, satisfactory coverage may often be achieved out to around 150 nautical miles (280 km) offshore during night time.

**Sea Area A3**

An area, excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite. This area lies between about latitude 76 Degrees North and South, but excludes A1 and/or A2 designated areas. Inmarsat guarantees their system will work between 70 South and 70 North though it will often work to 76 degrees South or North.

**Sea Area A4**

An area outside Sea Areas A1, A2 and A3 is called Sea Area A4. This is essentially the polar regions, north and south of about 76 degrees of latitude, excluding any A1, A2 and A3 areas.



### GMDSS radio equipment required for U.S. coastal voyages

Presently, until an A1 or A2 Sea Area is established, GMDSS-mandated ships operating off the U.S. coast must fit to Sea Areas A3 (or A4) regardless of where they operate. U.S. ships whose voyage allows them to always remain within VHF channel 16 coverage of U.S. Coast Guard stations may apply to the Federal Communications Commission for an individual waiver to fit to Sea Area A1 requirements. Similarly, those who remain within 2182 kHz coverage of U.S. Coast Guard stations may apply for a waiver to fit to Sea Area A2 requirements.

As of August 2013, the U.S. Coast Guard provides a Sea Area A1 service through its Rescue 21 system.

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## Licensing of operators

National maritime authorities may issue various classes of licenses. The General Operator’s Certificate is required on SOLAS vessels operating also outside GMDSS Sea Area A1, while a Restricted Operator’s Certificate is needed on SOLAS vessels operated solely within GMDSS Sea Area A1,

Long Range Certificate may be issued, and is required on non-SOLAS vessels operating outside GMDSS Sea Area A1, while a Short Range Certificate is issued for non-SOLAS vessels operating only inside GMDSS Sea Area A1.

Finally there is a restricted radiotelephone operator's certificate, which is similar to the Short Range Certificate but limited VHF DSC radio operation. Some countries do not consider this adequate for GMDSS qualification.

In the United States four different GMDSS certificates are issued:

- A GMDSS Radio Maintainer's License allows a person to maintain, install, and repair GMDSS equipment at sea.
- A GMDSS Radio Operator's License is necessary for a person to use required GMDSS equipment.
- The holder of both certificates can be issued one GMDSS Radio Operator/Maintainer License.
- Finally, the **GMDSS Restricted License** is available for VHF operations only within 20 nautical miles (37 km) of the coast.

To obtain any of these licenses a person must be a U.S. citizen or otherwise eligible for work in the country, be able to communicate in English, and take written examinations approved by the Federal Communications Commission. Like the amateur radio examinations, these are given by private, FCC-approved groups. These are generally not the same agencies who administer the ham tests. Written test elements 1 and 7 are required for the Operator license, and elements 1 and 7R for the Restricted Operator. (Passing element

1 also automatically qualifies the applicant for the Marine Radiotelephone Operator Permit, the MROP.)

For the Maintainer license, written exam element 9 must be passed. However, to obtain this certificate an applicant must also hold a General radiotelephone operator license(GROL), which requires passing commercial written exam elements 1 and 3 (and thus supersedes the MROP). Upon the further passing of optional written exam element 8 the ship radar endorsement will be added to both the GROL and Maintainer licenses. This allows the holder to adjust, maintain, and repair shipboard radar equipment.

Until March 25, 2008 GMDSS operator and maintainer licenses expired after five years but could be renewed upon payment of a fee. On that date all new certificates were issued valid for the lifetimes of their holders. For those still valid but previously issued with expiration dates, the FCC states:

Any GMDSS Radio Operator's License, Restricted GMDSS Radio Operator's License, GMDSS Radio Maintainer's License, GMDSS Radio Operator/Maintainer License, or Marine Radio Operator Permit that was active, i.e., had not expired, as of March 25, 2008, does not have to be renewed.

Since an older certificate does show an expiration date, for crewmembers sailing internationally it may be worth paying the fee (as of 2010 it was $60) to avoid any confusion with local authorities.

Finally, to actually serve as a GMDSS operator on most commercial vessels the United States Coast Guard requires additional classroom training and practical experience beyond just holding a license.

# Marine VHF radio

**Marine VHF radio** refers to the radio frequency range between 156.0 and 174 MHz, inclusive. The "VHF" signifies the very high frequency of the range. In the official language of the International Telecommunication Union the band is called the *VHF maritime mobile band*. In some countries additional channels are used, such as the L and F channels for leisure and fishing vessels in the Nordic countries (at 155.5–155.825 MHz).

Marine VHF radio equipment is installed on all large ships and most seagoing small craft. It is also used, with slightly different regulation, on rivers and lakes. It is used for a wide variety of purposes, including summoning rescue services and communicating with harbors, locks, bridges and marinas.

A marine VHF set is a combined transmitter and receiver and only operates on standard, international frequencies known as channels. **Channel 16** (156.8 MHz) is the international calling and distress channel. Transmission power ranges between 1 and 25 watts, giving a maximum range of up to about 60 nautical miles (111 km) between aerials mounted on tall ships and hills, and 5 nautical miles (9 km; 6 mi) between aerials mounted on small boats at sea level. Frequency modulation (FM) is used, with vertical polarization, meaning that antennas have to be vertical in order to have good reception.

Modern-day marine VHF radios offer not only basic transmit and receive capabilities. Permanently mounted marine VHF radios on seagoing vessels are required to have certification of some level of "Digital Selective Calling" (DSC) capability, to allow a distress signal to be sent with a single button press.

Marine VHF mostly uses "simplex" transmission, where communication can only take place in one direction at a time. A transmit button on the set or microphone determines whether it is operating as a transmitter or a receiver. Some channels, however, are "duplex" transmission channels where communication can take place in both directions simultaneously when the equipment on both ends allow it (full duplex), otherwise "semi-duplex" is used. Each duplex channel has two frequency assignments. Duplex channels can be used to place calls on the public telephone system for a fee via a marine operator. When full duplex is used, the call is similar to one using a mobile phone or landline. When semi-duplex is used, voice is only carried one way at a time and the party on the boat must press the transmit button only when speaking. This facility is still available in some areas, though its use has largely died out with the advent of mobile and satellite phones. Marine VHF radios can also receive weather radio broadcasts, where they are available.

## Types of equipment

Sets can be fixed or portable. A fixed set generally has the advantages of a more reliable power source, higher transmit power, a larger and more effective aerial and a bigger display and buttons. A portable set (often essentially a waterproof, VHF walkie-talkie in design) can be carried on a kayak, or to a lifeboat in an emergency, has its own power source and is waterproof if GMDSS-approved. A few portable VHFs are even approved to be used as emergency radios in environments requiring intrinsically safe equipment (e.g. gas tankers, oil rigs, etc.).

Marine radios can be "voice-only" or can include "Digital Selective Calling" (DSC).

**Voice-only** equipment is the traditional type, which relies totally on the human voice for calling and communicating.

Digital Selective Calling equipment, a part of the Global Maritime Distress Safety System (GMDSS), provides all the functionality of voice-only equipment and, additionally, allows several other features:

- a transmitter can automatically call a receiver equipped with Digital Selective Calling, using a telephone-type number known as a Maritime Mobile Service Identity (MMSI). The DSC information is sent on the reserved Channel 70. When the receiver picks up the call, their active

channel is automatically switched to the transmitter's channel and normal voice communication can proceed.
- a distress button, which automatically sends a digital distress signal identifying the calling vessel and the nature of the emergency
- a connection to a GPS receiver allowing the digital distress message to contain the distressed vessel's position

The MMSI is used for seagoing vessels and consists of a nine-digit number identifying a VHF set or group of sets. The left hand digits of MMSI indicate the country and type of station. For example, here are MMSI prefixes of four station types:

- Ship : 237, 239, 240, 241 are from Greece – e.g. a Greek ship : 240123456
- Coastal station : 00 – e.g. Olympia Radio : 002371000
- Group of stations : 0 – e.g. 024107823

For use on the inland waterways within continental Europe, a compulsory Automatic Transmitter Identification System (ATIS) transmission conveys the vessel's identity after each voice transmission. This is a ten-digit code that is either an encoded version of the ship's alphanumeric call sign, or for vessels from outside the region, the ship MMSI prefixed with "9". The requirement to use ATIS in Europe, and which VHF channels may be used, are strongly regulated, most recently by the Basel agreements.

## Channels and frequencies

Simplex channels here are listed with the A and B frequencies the same. The frequencies, channels, and some of their purposes are governed by the ITU. The original allocation of channels consisted of only channels 1 to 28 with 50 kHz spacing between channels, and the second frequency for duplex operation 4.6 MHz higher.

Improvements in radio technology later meant that the channel spacing could be reduced to 25 kHz with channels 60 to 88 interspersed between the original channels.

Channels 75 and 76 are omitted as they are either side of the calling and distress channel 16, acting as guard channels. The frequencies which would have been the second frequencies for simplex channels are not used for marine purposes and can be used for other purposes that vary by country. For example, 161.000 to 161.450 MHz are part of the allocation to the Association of American Railroads channels used by railways in the USA and Canada.

## Operating procedure

The accepted conventions for use of marine radio are collectively termed "proper operating procedure". These international conventions include:

- Stations should listen for 30 seconds before transmitting and not interrupt other stations.
- Maintaining a watch listening on Channel 16 when not otherwise using the radio. All calls are established on channel 16, except for distress working

switch to a working ship-to-ship or ship-to-shore channel. (procedure varies in US only when calls can be established on Ch 9)

- During distress operations silence maintained on ch 16 for other traffic until the channel is released by the controlling station using the pro-word "Silence Fini". If a station does use Ch 16 during distress operations controlling station issues the command "silence mayday".
- Using a set of international "calling" procedures such as the "Mayday" distress call, the "Pan-pan" urgency call and "Securite" navigational hazard call.
- Using "pro-words" based on the English language such as *Acknowledge, All after, All before, All stations, Confirm, Correct, Correction, In figures, In letters, Over, Out, Radio check, Read back, Received, Repeat, Say again, Spell, Standby, Station calling, This is, Wait, Word after, Word before, Wrong* (local language is used for some of these, when talking to local stations)
- Using the NATO Phonetic Alphabet : *Alfa, Bravo, Charlie, Delta, Echo, Foxtrot, Golf, Hotel, India, Juliet, Kilo, Lima, Mike, November, Oscar, Papa, Quebec, Romeo, Sierra, Tango, Uniform, Victor, Whiskey, X-ray, Yankee, Zulu*
- Using a phonetic numbering system based on the English language or a combination of English and Roman languages: *Wun, Too, Tree, Fow-er, Fife, Six, Sev-en, Ait, Nin-er, Zero, Decimal*, alternatively in marine communication: *unaone, bissotwo, terrathree, kartefour, pantafive, soxisix, setteseven, oktoeight, novenine, nadazero*

## MF/HF

**Medium frequency** (**MF**) is the ITU designation for radio frequencies (RF) in the range of 300 kilohertz (kHz) to 3 megahertz (MHz). Part of this band is the medium wave (MW) AM broadcast band. The MF band is also known as the **hectometer band** or **hectometer wave** as the wavelengths range from ten to one hectometer (1,000 to 100 m). Frequencies immediately below MF are denoted low frequency (LF), while the first band of higher frequencies is known as high frequency (HF). MF is mostly used for AM radio broadcasting, navigational radio beacons, maritime ship-to-shore communication, and transoceanic air traffic control.

A major use of these frequencies is AM broadcasting; AM radio stations are allocated frequencies in the medium wave broadcast band from 526.5 kHz to 1606.5 kHz in Europe; in North America this extends from 525 kHz to 1705 kHz. Some countries also allow broadcasting in the 120-meter band from 2300 to 2495 kHz; these frequencies are mostly used in tropical areas. Although these are medium frequencies, 120 meters is generally treated as one of the shortwave bands.

There are a number of coast guard and other ship-to-shore frequencies in use between 1600 and 2850 kHz. These include, as examples, the French MRCC on 1696 kHz and 2677 kHz, Stornoway Coastguard on 1743 kHz, the US Coastguard on 2670 kHz and Madeira on 2843 kHz. RN Northwood in England broadcasts Weather Fax data on 2618.5 kHz. Non-directional navigational radio beacons (NDBs) for maritime and aircraft navigation occupy a band from 190 to 435 kHz, which overlaps from the LF into the bottom part of the MF band.

2182 kHz is the international calling and distress frequency for SSB maritime voice communication (radiotelephony). It is analogous to Channel 16 on the marine VHF band. 500 kHz was for many years the maritime distress and emergency frequency, and there are more NDBs between 510 and 530 kHz.

Transmissions on 2182 kHz commonly use single-sideband modulation (SSB) (upper sideband only). However, amplitude modulation (AM) and some variants such as vestigial sideband are still in use, mainly by vessels with older equipment and by some coastal stations in an attempt to ensure compatibility with older and less sophisticated receivers.

## Range

2182 kHz is analogous to channel 16 on the marine VHF band, but unlike VHF which is limited to ranges of about 20 to 50 nautical miles (40 to 90 km) depending on antenna height, communications on 2182 kHz and nearby frequencies have a reliable range of around 50 to 100 nautical miles (90 to 190 km) during the day and 150 to 300 nautical miles (280 to 560 km) or sometimes more at night. The reception range of even a well-equipped station can be severely limited in summer because of static caused by lightning.

## Silence period

All stations using 2182 kHz were required to maintain a strictly enforced three-minute silence and listening period twice each hour, starting at h+00, h+30. This allowed any station with distress, urgent or safety traffic the best chance of being heard at that time, even if they were at some distance from other stations, operating on reduced battery power or perhaps reduced antenna efficiency, as for example from a dismasted vessel. As a visual aide-memoire, a typical clock in a ship's radio room would have these silence periods marked by shading the sectors from h+00 to h+03 and from h+30 to h+33 in green. Similar sectors were marked in red for what used to be the corresponding silence and listening period on 500 kHz between h+15 and h+18 and from h+45 to h+48. These silence periods are no longer required as the introduction of GMDSS has produced alternative automatic watchkeeping systems and the 500 kHz band is no longer in use for maritime traffic.

## Licensing

In order to operate a marine radio transmitter on 2182 kHz, the operator must hold a GMDSS General Operating Certificate for mandatory installations, a Long Range Certificate for voluntary ones, or other equivalent and recognised radio operator's qualifications. Both these certificates have a wider syllabus than those of the GMDSS Restricted Operators Course or the RYA Short Range Certificate that is necessary for marine VHF use. In practice, an unqualified operator would not be prosecuted for the use of either transmitter in what turns out to be a genuine distress situation.

## Related distress frequencies

2182 kHz forms an essential part of the Global Maritime Distress Safety System (GMDSS). It has an associated DSC frequency at 2187.5 kHz. Other international distress frequencies, in use as of 2008, include:

- 121.5 MHz and 243.0 MHz - civil aircraft emergency frequency
- 243 MHz - military aircraft emergency frequency
- 156.8 MHz - Marine VHF radio channel 16, short range maritime use
- 406 MHz / 406.1 MHz - Cospas-Sarsat international satellite-based search and rescue (SAR) distress alert detection and information distribution system

## Discontinued frequencies

- 500 kHz Morse code is no longer monitored.
- 121.5 or 243 MHz locators. (No longer automatically monitored by satellite, though still used for aircraft communication and short-range direction finding.)
- Effective 1 August 2013, the U. S. Coast Guard terminated its radio guard of the international voice distress, safety and calling frequency 2182 kHz and the international digital selective calling (DSC) distress and safety frequency 2187.5 kHz. Additionally, marine information and weather broadcasts transmitted on 2670 kHz terminated concurrently.

## Propagation

Radio waves at MF wavelengths propagate via ground waves and reflection from the ionosphere (called skywaves).Ground waves follow the contour of the Earth. At these wavelengths they can bend (diffract) over hills, and travel beyond the visual horizon, although they may be blocked by mountain ranges. Typical MF radio stations can cover a radius of several hundred miles from the transmitter, with longer distances over water and damp earth. MF broadcasting stations use ground waves to cover their listening areas.

MF waves can also travel longer distances via skywave propagation, in which radio waves radiated at an angle into the sky are reflected (actually refracted) back to Earth by layers of charged particles (ions) in the ionosphere, the E and F layers. However at certain times the D layer (at a lower altitude than the refractive E and F layers) can be electronically noisy and absorb MF radio waves, interfering with skywave propagation. This happens when the ionosphere is heavily ionised, such as during the day, in summer and especially at times of high solar activity,

At night, especially in winter months and at times of low solar activity, the ionospheric D layer can virtually disappear. When this happens, MF radio waves can easily be received hundreds or even thousands of miles away as the signal will be refracted by the remaining F layer. This can be very useful for long-distance communication, but can also interfere with local stations. Due to the limited number of available channels in the MW broadcast band, the same frequencies are re-allocated to different broadcasting stations several hundred miles apart. On nights of good skywave propagation, the signals of distant stations may reflect off the ionosphere and interfere with the signals of local stations on the same frequency. In North America, the North American Regional Broadcasting Agreement(NARBA) sets aside certain channels for nighttime use over extended service areas via skywave by a few specially licensed AM broadcasting stations. These channels are called clear channels, and the stations, called clear-channel stations, are required to broadcast at higher powers of 10 to 50 kW.

## Antennas

Transmitting antennas commonly used on this band include monopole mast radiators, top-loaded wire monopole antennas such as the inverted-L and T antennas, and wire dipole antennas. Ground wave propagation, the most widely used type at these frequencies, requires vertically polarized antennas like monopoles.

The most common transmitting antenna, the quarter wave monopole, is physically large at these frequencies (25 to 250 metres (82 to 820 ft) requiring a tall radio mast. Usually the metal mast itself is used as the antenna, and is mounted on a large porcelain insulator to isolate it from the ground; this is called a *mast radiator*. The monopole antenna, particularly if electrically short requires a good, low resistance Earth ground connection for efficiency, since the ground resistance is in series with the antenna and consumes transmitter power. Commercial radio stations use a ground system consisting of many heavy copper cables, buried a few feet in the earth, radiating from the base of the antenna to a distance of about a quarter wavelength. In areas of rocky or sandy soil where the ground conductivity is poor, above ground counterpoises are used.

Lower power transmitters often use electrically short quarter wave monopoles such as inverted-L or T antennas, which are brought into resonance with a loading coil at their base.

Receiving antennas do not have to be as efficient as transmitting antennas since in this band the signal to noise ratio is determined by atmospheric noise. The noise floor in the receiver is far below the noise in the signal, so antennas small in comparison to the wavelength, which are inefficient and produce low signal strength, can be used. The most common receiving antenna is the ferrite loopstick antenna (also known as a *ferrite rod aerial*), made from a ferrite rod with a coil of fine wire wound around it. This antenna is small enough that it is usually enclosed inside the radio case. In addition to their use in AM radios, ferrite antennas are also used in portable radio direction finder (RDF) receivers. The ferrite rod antenna has a dipole reception pattern with sharp nulls along the axis of the rod, so that reception is at its best when the rod is at right angles to the transmitter, but fades to nothing when the rod points exactly at the transmitter. Other types of loop antennas and random wire antennas are also used.

**High frequency (HF)** is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) between 3 and 30 megahertz (MHz). It is also known as the **decameter band** or **decameter wave** as its wavelengths range from one to ten decameters (ten to one hundred metres). Frequencies immediately below HF are denoted medium frequency (MF), while the next band of higher frequencies is known as the very high frequency(VHF) band. The HF band is a major part of the shortwave band of frequencies, so communication at these frequencies is often called shortwave radio. Because radio waves in this band can be reflected back to Earth by the ionosphere layer in the atmosphere – a method known as "skip" or "skywave" propagation – these frequencies are suitable for long-distance communication across intercontinental distances. The band is used by international shortwave broadcasting stations (2.31–25.82 MHz), aviation communication, government time stations, weather stations, amateur radio and citizens band services, among other uses.

## Propagation characteristics

The dominant means of long distance communication in this band is skywave ("skip") propagation, in which radio waves directed at an angle into the sky reflect (actually refract) back to Earth from layers of ionized atoms in the ionosphere. By this method HF radio waves can travel beyond the horizon, around the curve of the Earth, and can be received at intercontinental distances. However, suitability of this portion of the spectrum for such communication varies greatly with a complex combination of factors:

- Sunlight/darkness at site of transmission and reception
- Transmitter/receiver proximity to solar terminator
- Season
- Sunspot cycle
- Solar activity
- Polar aurora

At any point in time, for a given "skip" communication path between two points, the frequencies at which communication is possible are specified by these parameters

- Maximum usable frequency (MUF)
- Lowest usable high frequency (LUF) and a
- Frequency of optimum transmission (FOT)

The maximum usable frequency regularly drops below 10 MHz in darkness during the winter months, while in summer during daylight it can easily surpass 30 MHz. It depends on the angle of incidence of the waves; it is lowest when the waves are directed straight upwards, and is higher with less acute angles. This means that at longer distances, where the waves graze the ionosphere at a very blunt angle, the MUF may be much higher. The lowest usable frequency depends on the absorption in the lower layer of the ionosphere (the D-layer). This absorption is stronger at low frequencies and is also stronger with increased solar activity (for example in daylight); total absorption often occurs at frequencies below 5 MHz during daytime. The result of these two factors is that the usable spectrum shifts towards the lower frequencies and into the Medium Frequency(MF) range during winter nights, while on a day in full summer the higher frequencies tend to be more usable, often into the lower VHF range.

When all factors are at their optimum, worldwide communication is possible on HF. At many other times it is possible to make contact across and between continents or oceans. At worst, when a band is "dead", no communication beyond the limited groundwave paths is possible no matter what powers, antennas or other technologies are brought to bear. When a transcontinental or worldwide path is open on a particular frequency, digital, SSB and Morse code communication is possible using surprisingly low transmission powers, often of the order of milliwatts, provided suitable antennas are in use at both ends and that there is little or no man-made or natural interference. On such an open band, interference originating over a wide area affects many potential users. These issues are significant to military, safety and amateur radio users of the HF bands.

## Antennas

Since horizontally polarized radio waves work better for skywave propagation (due to the greater ground absorption of vertically polarized waves), antennas based on horizontal dipoles are typically used. The most common antennas in this band are wire antennas such as wire dipoles and the rhombic antenna; in the upper frequencies, multielement dipole antennas such as the Yagi, quad, and reflective array antennas. Powerful shortwave broadcasting stations often use large wire curtain arrays. For receiving, random wire antennas are often used.

# Digital selective calling

**Digital selective calling** or **DSC** is a standard for sending pre-defined digital messages via the medium-frequency (MF), high-frequency (HF) and very-high-frequency (VHF) maritime radio systems. It is a core part of the Global Maritime Distress Safety System (GMDSS).

## Workings

DSC was developed to replace a call in older procedures. Because a DSC signal uses a stable signal with a narrow bandwidth and the receiver has no squelch, it has a slightly longer range than analog signals, with up 25 percent longer range and significantly faster. DSC senders are programmed with the ship's Maritime Mobile Service Identity (MMSI) and may be connected to the ship's Global Positioning System (GPS), which allows the apparatus to know who it is, what time it is and where it is. This allows a distress signal to be sent very quickly.

Often, ships use separate VHF DSC and MF/HF DSC controllers. For VHF, DSC has its own dedicated receiver for monitoring Channel 70, but uses the main VHF transceiver for transmission. However, for the user, the controller is often a single unit. MF/HF DSC devices monitor multiple distress, urgency and securite bands in the 2, 4, 6, 8, 12 and 16 MHz bands. At minimum, controllers will monitor 2187.5 kHz and 8414.5 kHz and one more band. However for automated monitoring a second, receive-only antenna is often needed (especially on non-commercial leisure boats) since a separate tuner is used apart from the main one; this is separate from programming radios to monitor user-defined DSC frequencies (which would use the main antenna).

## Distress

When sending a distress signal, the DSC device will at minimum include the ship's MMSI number. It will also include the coordinates if available and, if necessary, the channel for the following radiotelephony or radiotelex messages. The distress can be sent either as a single-frequency or multi-frequency attempt. In the former, a distress signal is sent on one band and the system will wait up to four minutes for a DSC acknowledgment from a coast station. If none is received, it will repeat the distress alert up to five times. In a multi-frequency attempt, the distress signal is sent on the MF and all the HF distress frequencies in turn. As this requires retuning the antenna for each sending, without waiting for an acknowledgment, a multi-frequency attempt should only be done if there are only a few minutes until the ship's batteries are under water. As the distress message can only be sent on one of the bands, many ships and coast stations may be listening to a band without the message, and will after five minutes relay the distress signal to a coast station.

Distress calls can be both non designated and designated. The latter allows one of ten pre-defined designations to be sent along with the distress signal. These are "abandoning ship", "fire or explosion", "flooding", "collision", "grounding", "listing", "sinking", "disabled and adrift", "piracy or attack" and "man overboard". To avoid false distress alerts, distress buttons normally have protective covers, often with a spring-loaded cover so two hands need to be used simultaneously. Alternatively, some devices have two-button systems. Operators are required to cancel falsely sent distress alerts with a transmission on the channel designated by the distress signal.

A coast station which receives a DSC distress alert will immediately send an acknowledgment. The sending device will then both stop repeating the alert, and tune to the designated channel for the distress message to be sent. Ships receiving a distress alert who are outside coast station range or do not receive an acknowledgment, are required to relay the distress alert by any means to land.

## Other priorities

Class A devices, used on commercial ships, have the ability to send distress, distress relay, all ships urgency, all ships safety, individual, group, geographic area and telephone alerts. Class D devices, used for most leisure vessels, can send distress, all ships urgency, all ships safety and individual on VHF channels 06, 08, 72 and 77. The latter is only required to have one antenna and is thus not required to watch Channel 70 when in use. For routine alerts, which are used to establish communication with another station on a working channel, the receiver acknowledges to confirm that communication can be done on the appropriate channel.

While there are reserved frequencies for distress HF DSC calls, there is no prohibition against broadcasting non-distress, "routine" calls on other DSC-designated frequencies, which are defined in ITU M.541 as:

- 2177, 2189.5 kHz
- 4208, 4208.5, 4209 kHz
- 6312.5, 6313, 6313.5 kHz
- 8415, 8415.5, 8416 kHz
- 12577.5, 12578, 12578.5 kHz
- 16805, 16805.5, 16806 kHz
- 18898.5, 18899, 18899.5 kHz
- 22374.5, 22375, 22375.5 kHz
- 25208.5, 25209, 25209.5 kHz

There is a general consensus for routine calls to use 2177.0, 4208.0, 6312.5, 8415.0, 12577.5, and 16805.0 kHz (the first frequency listed above in each band).

# Inmarsat-C

**Inmarsat-C** is a two-way, packet data service operated by the telecommunications company Inmarsat which operates between mobile earth stations (MES) and land earth stations (LES). It became fully operational after a period of pre-operational trials in January 1991. The advantages of Inmarsat-C compared to Inmarsat-A are low cost, smaller and uses a smaller omni-directional antenna. The disavantages is that voice communication is not possible with Inmarsat-C. The service is approved for use under the Global Maritime Distress and Safety System (GMDSS), meets the requirements for Ship Security Alert Systems (SSAS) defined by the International Maritime Organization (IMO) and is the most widely used service in fishing Vessel Monitoring Systems (VMS).

The service works with a store-and-forward method which enables interface with data network transfer including; e-mail; SMS; telex; remote monitoring;

tracking (position reporting); chart and weather updates; maritime safety information (MSI); maritime security; GMDSS; and SafetyNET and FleetNET services; two-way messaging; data reporting and polling; Safety/Emergency alerting.

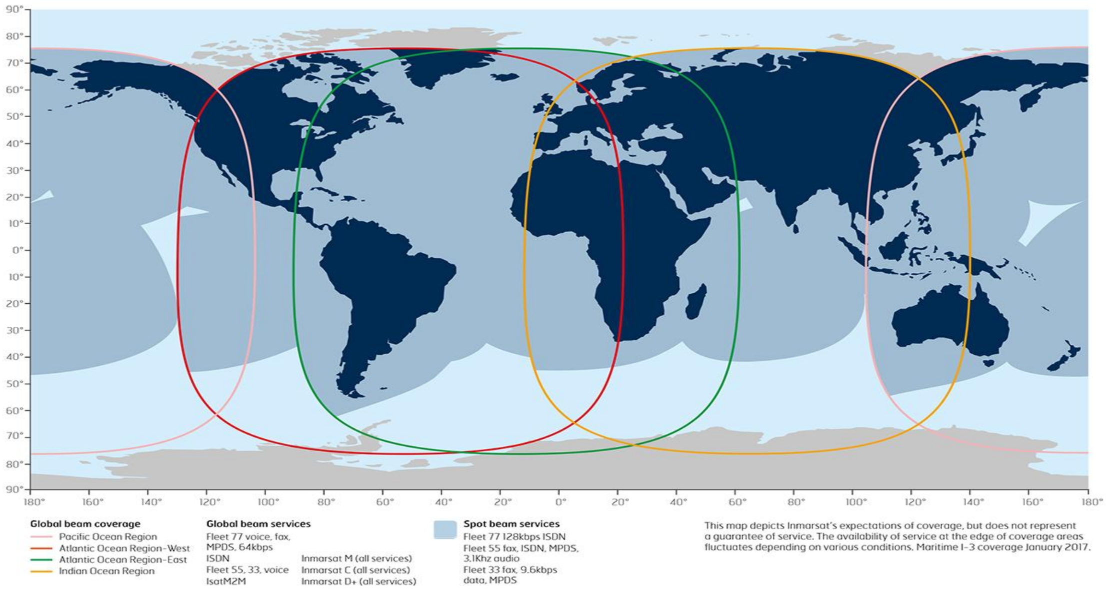
The service is operated via an Inmarsat-C Transceiver or a lower-power mini-C Transceiver. Data transfers between MES and LES at a rate of 600 bits/second. The frequencies for transmitting (TX) are 1626.5MHz - 1645.5MHz and for receiving (RX) are 1530.0MHz - 1545.0MHz.

The service is available for maritime, land mobile and aeronautical use.

## Maritime Rescue Coordination Centers

The headquarters for Inmarsat C is located in London. The four Ocean Regions that are covered by Inmarsat C are:

- the Atlantic Ocean Region East (AOR-E)
- Atlantic Ocean Region West (AOR-W)
- Pacific Ocean Region (POR)
- Indian Ocean Region (IOR).




Within each ocean region, there are approximately four or five Maritime Rescue Coordination Centers (MRCC). In total, there are over twenty MRCC's in the world, and each MRCC station contributes to a certain MRCC area. The MRCC stations are located in:

- Wellington (New Zealand)-POR
- Aussaguel (France)-IOR/AOR-E/AOR-W
- Beijing (China)-IOR/POR
- Burum (The Netherlands)-AOR-E/AOR-W/IOR
- Elk (Norway)-AOR-E/AOR-W/IOR
- Emeq Haela (Israel)-AOR-E/IOR
- Fucino (Italy) AOR-E/IOR
- Ex Goonhilly @ Burum (Netherlands)
- Hai Phong (Vietnam)-IOR/POR

- Kumsan (S. Korea) IOR/POR
- Lakhadaria (Algeria) AOR-E
- Nakhodka (Russia)-POR
- Nudol (Russian Fed.)-AOR-E/IOR
- Perth (Australia)-IOR/POR
- Psary (Poland)-AOR-E/IOR
- Pune (India)-IOR
- Santa Paula (USA)-POR
- Sentosa (Singapore)-IOR/POR
- Southbury (USA)-AOR-E/AOR-W
- Tangua (Brazil)-AOR-E
- Thermopylae (Greece)-AOR-E
- Yamaguchi (Japan)-IOR/POR.

## How to send a distress alert

When in a distress situation, your Mobile Earth Station is used to send out a distress alert. This distress alert is sent through a Land Earth Station, redirected to a land based Rescue Co-ordination Center (RCC). This will provide you with a communications link with yourself the RCC and Search and Rescue.

**Method 1**

Using the distress menu on your GMDSS, follow these steps:

1. Enter your vessel's position, course, speed, and any other vital information onto the form displayed on the screen.
2. Choose "Nature of Distress" from the toolbar list on top of the screen.
3. Choose the closest LES to your ship's coordinates near your Ocean Region. You may select any LES within your particular Ocean Region.
4. Using the distress button, send the alert by keeping it pressed for the required time (5 seconds).You should receive an acknowledgment from the LES within 5 minutes.
5. If no acknowledgment from the LES, send another distress alert.
6. After acknowledgment, further detailed information regarding the distress may be sent using the same method as above. This should be sent through the same LES as the original distress alert, this information will be sent to the same Rescue Co-ordination Center.

**Method 2**

There is usually little time to send a distress alert using the method above, therefore there is a quicker and simpler method:

1. Press and hold the distress button for the required time (5 seconds).

## Inmarsat Fleet 77

Inmarsat Fleet 77 is a fully integrated satellite communication service incorporating voice and data applications.Safety communications using Fleet 77.Inmarsat Fleet 77 offers voice and the choice of mobile ISDN up to 64kbps or an always-on Mobile Packet Data Services (MPDS) for cost-effective, global communications, outside of the Polar Regions.

Fleet 77 also meets the distress and safety specifications of the Global Maritime Distress and Safety System (GMDSS) for voice communication. Through four-stage voice pre-emption and prioritisation, the service supports the accreditation of ships' systems and ensures high priority distress and safety needs are met.Distress voice calls made on Fleet 77 are routed through a Land Earth Station (LES) to a Maritime Rescue Co-ordination Centre (MRCC).

Four levels of priority calls

The Inmarsat Fleet 77 network provides four levels of prioritisation for both ship-to-shore and shore-to-ship direction, with distress being the highest priority:

- Distress
- Urgency
- Safety
- Other (routine)

Fleet 77 data services (ISDN and MPDS) are categorised as routine priority communications and are stopped if a voice call using a higher priority is made either to or from the vessel. Distress calls will always pre-empt any other priority voice calls. Ship-originated voice calls will always pre-empt shore-originated calls of the same priority.

## Navtex

**Navtex** (**Nav**igational **Te**le**x**) is an international automated medium frequency direct-printing service for delivery of navigational and meteorological warnings and forecasts, as well as urgent maritime safety informations to ships.

Navtex was developed to provide a low-cost, simple, and automated means of receiving this information aboard ships at sea within approximately 370 km (200 nautical miles) off shore.

There are no user fees associated with receiving navtex broadcasts, as the transmissions are typically transmitted from the National Weather Authority (Italy) or Navy or Coast Guard (as in the US) or national navigation authority (Canada).

Where the messages contain weather forecasts, an abbreviated format very similar to the shipping forecast is used.

Navtex is a component of the International Maritime Organization/ International Hydrographic Organization Worldwide Navigation Warning Service (WWNWS). Navtex is also a major element of the Global Maritime Distress Safety System (GMDSS).International Convention foe the Safety of Life at Sea (SOLAS) mandated certain classes of vessels must carry navtex, beginning August 1, 1993.

## Technical information

Navtex transmissions are also called narrow-band direct printing (NBDP). The transmissions are layered on top of SITOR collective B-mode. SITOR-B is a forward error correcting (FEC) broadcast that uses the CCIR 476 character set.

SITOR-B is also used in amateur radio, where it is known as AMTOR-B or AMTOR-FEC.

- Navtex / SITOR / AMTOR broadcasts use 100 baud FSK modulation with a frequency shift of 170 Hz.

Navtex broadcasts are primarily made on the medium frequencies of 518 kHz and 490 kHz. The international navtex frequency is 518 kHz, and these broadcasts should always be in English. National transmission of navtex uses 490 kHz specifically for broadcasts in local languages. It is not used in the U.S.

Navtex Marine Safety Information (MSI) national transmissions also take place on HF at 4209.5 kHz using FEC mode.

Other transmission modes (like MT63, or Olivia) with better error correction properties have emerged since navtex was made the standard for maritime information transmissions. Overall, with slightly higher transmitter power most Navtex error correction issues tend to be absent.

## Navtex message format

Navtex messages are transmitted using binary frequency-shift keying (BFSK) at 100 bit/s and a 170 Hz frequency shift. The characters are encoded using the 7-bit CCIR 476 character set and basic error detection is enabled by employing forward error correction (FEC). This is the same format as the SITOR-B (AMTOR) format.

A navtex message is built on SITOR collective B-mode and consists of:

- a phasing signal of at least ten seconds
- the four characters "ZCZC" that identify the end of phasing
- a single space
- four characters $B_1$, $B_2$, $B_3$ *and* $B_4$ (see below)
- a carriage return and a line feed
- the information

- the four characters "NNNN" to identify the end of information
- a carriage return and two line feeds
- either

    - 5 or more seconds of phasing signal and another message starting with "ZCZC" *or*
    - an end of emission idle signal α for at least 2 seconds.

$B_1$ is an alpha character identifying the station, and $B_2$ is an alpha character used to identify the subject of the message. Receivers use these characters to reject messages from certain stations or if the message contains subjects of no interest to the user.

$B_3$ and $B_4$ are two-digit numerics identifying individual messages, used by receivers to keep already received messages from being repeated.

For example, a message containing $B_1B_2B_3B_4$ characters of 'FE01' from a U.S. navtex station indicates a weather forecast message from Boston, MA.

Navtex message example:

```
(phasing signals >= 10 seconds)
ZCZC FE01
(message text ...)
NNNN

(end of message phasing signals for >= 2 seconds before next message)
```

**Start of message**

ZCZC begins the message.

**Transmitter identity ($B_1$)**

This character defines the transmitter identity and its associated coverage area.

**Subject indicator character ($B_2$)**

The subject indicator character is used by the receiver to identify different classes of messages below. The indicator is also used to reject messages concerning certain optional subjects which are not required by the ship (e.g. LORAN C messages might be rejected in a ship which is not fitted with a LORAN C receiver).

**Navtex broadcasts use following subject indicator characters**:

| | |
|---|---|
| A | Navigational warnings [1] |
| B | Meteorological warnings [1] |
| C | Ice reports |
| D | Search & rescue information, and pirate warnings |
| E | Meteorological forecasts |
| F | Pilot service messages |
| G | AIS messages (formerly Decca messages) |
| H | LORAN messages |
| I | Not used (formerly OMEGA messages]) |
| J | SATNAV messages (i.e. GPS or GLONASS) |
| K | Other electronic navaid messages |
| L | Navigational warnings — additional to letter A (Should not be rejected by the receiver) |
| T | Test transmissions (UK only — not official) |
| V | Notice to fishermen (U.S. only — currently not used) |

| | |
|---|---|
| W | Environmental (U.S. only — currently not used) |
| X | Special services — allocation by IMO Navtex Panel |
| Y | Special services — allocation by IMO Navtex Panel |
| Z | No message on hand |

**Note:** Receivers use the $B_2$ character to identify messages which, because of their importance, can **not** be rejected (designated by a [1]). The subject indicator characters B, F and G are normally not used in the United States since the National Weather Service normally includes meteorological warnings in forecast messages. Meteorological warnings are broadcast using the subject indicator character E. U.S. Coast Guard District Broadcast Notices to Mariners affecting ships outside the line of demarcation, and inside the line of demarcation in areas where deep draft vessels operate, use the subject indicator character A.

**Serial number of message ($B_3$, $B_4$)**

These two characters define the serial number of each $B_2$ message type (class). Generally serial numbers start with the numbers '01', however in special circumstances, the numbers begin with '00'. This forces the receiver to print the message.

**Time of origin**

Time of origin is in the format of "DDHHmm UTC MMM" where DD is the date, HH hour, mm minute and MMM three-character abbreviation of month. The time of the transmission of the message is in UTC.

**Message text**

The full text of the message follows.

**End of message**

The end of the message is asserted when the characters "NNNN" are received.

## Navtex transmission schedule

Each station identifier has a fixed 10-minute time slot, starting with A at 0000UTC. The time slots are repeated at 4 hour intervals. Within each time slot, a mix of navigation warnings, weather forecasts, ice information and other content may be sent, and this is normally according to a structured plan for that specific station. For example, in the first and third time slot they may decide to transmit navigation warnings, and weather forecasts in the others. Normally each NAVAREA or sub-NAVAREA has only one station at each slot.

## Navtex receivers

Navtex receivers which are approved for GMDSS contain an internal printer and/or a scrollable display, and cost between $800–$1500. A new generation of navtex receivers intended for non-GMDSS applications such as the recreational community is entering the marketplace. These receivers include features such as LCD screens and RS-232 output and have a purchase price in the $300–$500 range. In the UK they can be purchased for £115. There are also a number of navtex engines available that do not have any user interface, and just output decoded data in RS-232 format, either as a simple ASCII data stream, or using the NMEA navtex sentences, or their own proprietary protocol.

There are also a number of software packages available, such as SeaTTY, Mscan, JNX, Fldigi or JVComm32, allowing messages to be decoded by a PC with a suitable receiver connected to the computer's soundcard. Any general communications receiver capable of audio reception at 518 kHz or 490 kHz single sideband can be used.

## Navtex via Internet

Some organisations have gateways through which web users can access the navtex bulletins using a browser:

- United Kingdom Hydrographic Office
- Greece (Hellenic National Meteorological Service HNMS) (click on Maritime Bulletin)
- JCOMM official web site provides the marine weather information broadcast via Inmarsat-C SafetyNET
- Worldwide NAVTEX messages Messages from live receivers across the world including Japanese language messages
- Messages from a live receiver in Suffolk, England.
- Messages from a live receiver in Suffolk, England. sent via Twitter!
- Messages from a live receiver in Kurzeme region, Latvia

# Telephone at Sea

Network innovations provides a variety of solutions for telephone voice communications at sea. Solutions are available to accommodate single users, small or large crews with PIN-based crew calling options to help manage and control usage. Some of the devices that are used to vessels are:

**Oceana 400** : Designed for use in maritime applications, the Oceana 400 features an intelligent RJ11/POTS interface, to enable connection of up to 5 standard phones or integration to a PABX system. The Oceana 400 is designed to operate with the Inmarsat Fleetphone service and is supplied with a dedicated active marine grade antenna system to provide a completely integrated solution that is ready for use anytime at sea.

**Oceana 800** : An all-in-one maritime communications terminal featuring an intelligent RJ11/POTS interface to enable connection of up to 5 standard phones or integration to a PABX system. An integrated GPS engine provides intelligent tracking and instant message reporting via SMS or email. The Oceana 800 is designed to operate with the Inmarsat Fleetphone service and is supplied with a dedicated active marine grade antenna system.

**RST100** : Combines robust design with intelligent technology to support RJ11 / POTS, voice and data services over the Iridium satellite network. The RST100 terminal is equipped with a range of interfaces to support the use of standard phones or integrated PBX communications. RST100 also gives the option to access voice services using a compact intelligent user handset. It also supports access to the complete range of data services provided by Iridium including Short Burst, Circuit Switched Data and Direct Internet as well as SMS.

**Sailor SC4000 Iridium telephone system** : An ideal satellite communication solution and well suited for all types of vessels cruising the high sea – from yachts to fishing vessels, from coasters to large merchant ships, from coast guards to naval vessels. With true global coverage and advantageous airtime rates, the SAILOR SC4000 Iridium is a great choice for anyone sailing along foreign coasts and onwards to as far as the arctic seas.

**Inmarsat IsatDock Marine** : An IP54 rated intelligent docking station for the IsatPhone Pro. The Marine Dock supports voice services via Bluetooth, RJ11/POTS, hands-free speaker-phone or the active privacy handset. The handset is completely enclosed in the docking unit while still giving full access and functionality to the user.

# Satellite Internet At Sea

As the satellite industry matures, more and more options are becoming available for internet connectivity on your boat and some of them can be very affordable. The options we've detailed here are intended for single users or small crew situations.

Satellite internet is still more expensive than any land-based internet you will find. How affordable (or not) it can be depends almost exclusively on how you use it.

Satellite Terminals for Marine Satellite Internet:

## FleetBroadband

**FleetBroadband** is a maritime global satellite internet, telephony, SMS texting and ISDN network for ocean-going vessels using portable domed terminal antennas. These terminal antennas range in size from 291 × 275 mm (The FB150) to the largest 605mm x 630mm (FB500) system, which is capable of 432 kbit/s speeds. These antennas, and corresponding indoor controllers, are used to connect phones and laptop computers from sailing vessels, on any ocean, with the rest of the world. All FleetBroadband antennas require line-of-sight to one of three geosynchronous orbit satellites, so the terminal can be used anywhere, even on land. Life at sea is easier with FleetBroadband. Increasing commercial demands on ship operations means enhanced connectivity is essential regardless of your vessel's position. Aside from navigation, the Master needs to perform a host of other duties, from updating weather information, route-planning and ordering supplies, to maintaining crew morale by enabling them to call and email home or read the latest football results online. FleetBroadband gives you the power to meet these challenges head on and takes your vessel into the IP era. Delivered via the Inmarsat satellite network, FleetBroadband provides constant, simultaneous access to voice and high-speed data services, on a near global basis. You can send and receive email with large file attachments, comfortably run complex data applications and make voice calls at the same time – more affordably than ever before. The terminal is quick and easy to install and you can be sure that it has been tested and approved to Inmarsat's exacting standards. Regardless of the type or size of the vessel, FleetBroadband offers a compact solution that can easily be accommodated, providing you with optimal connectivity – no matter what your position or the conditions at sea.

## Details

The FleetBroadband network was developed by Inmarsat and is composed of three geosynchronous orbiting satellites called I-4 that allow contiguous global coverage, except for the poles. FleetBroadband systems installed on vessels may travel from ocean to ocean without human interaction. If there is line-of sight to one of the three *I-4* satellites, then connectivity can be achieved, even in rough rolling seas. Since the FleetBroadband network uses the L band, rain fade is much less of an issue than the larger VSAT $K_u$ band or C Band systems.

The FleetBroadband service was modeled after terrestrial Internet services where IP-based traffic Internet Protocol dominated over ISDN and other earlier communication protocols. Many corporations and IT departments are standardizing around IP traffic for data, and voice and text communication, so it is assumed Inmarsat is filling that long-term communications requirement.

You can depend on Inmarsat, whatever the weather, with average network availability exceeding 99.99 percent. FleetBroadband terminals are designed specifically for use within the marine environment and have been rigorously tested to exacting standards.

## FleetBroadband Services

- Standard IP – For email, internet and intranet access, at speeds up to 432kbps over a shared channel.
- Streaming IP – Guaranteed data rates on demand up to 256kbps. Choose the data rate on a case by case basis, depending on your application.
- Voice – Make voice calls at the same time as accessing your data applications. Voicemail is also available. Group 3 fax is supported via the voice channel.
- ISDN – Supports ISDN at 64kbps for your legacy applications.
- SMS – Send and receive text messages – up to 160 characters.

**Superior Performance** – FleetBroadband gives faster, more cost-effective access to data services. Besides constant, real-time weather and ECDIS updates, you can use more complex applications with confidence. Its simultaneous voice and data capability means that operational systems can be running online and you can still access email, your intranet and make voice calls – all via a single terminal. So the Captain can get on with managing the ship, while the crew are calling or emailing home.

## Terminals

There are three terminal antenna types available. The small FB150 antenna (291 × 275 mm) capable of 150 kbit/s, to the mid-sized FB250 antenna (329 × 276 mm) capable of 284 kbit/s, to the largest and fastest FB500 antenna (605 × 630 mm) capable of up to 432 kbit/s. Current manufactures of FleetBroadband systems includes Thrane & Thrane (Sailor Systems), Wideye (Skipper), KVH, and JRC.

**SAILOR FleetBroadband Terminals** :Three models of terminals are available to accommodate everything from leisure vessels to fishing and transportation ships.

- SAILOR 150 – Entry Level with speeds up to 150 Kbps
- SAILOR 250 – Speeds up to 284 Kbps
- SAILOR 500 – Top of the line with speeds up to 432 Kbps

**Coverage and availability**

FleetBroadband provides global coverage, other than the Polar regions, on Inmarsat's I4 satellites.

# Iridium Pilot

The Iridium Pilot is a fixed installation antenna that provides broadband capability. It is one of the least-expensive hardware options for marine satellite internet. Although it runs slow by land speeds (up to 128kbps – about twice the speed of dial-up) it is significantly faster than a handheld satellite phone (which runs at 2.4 kbps – 25 times slower than dial-up).

Because of this and other operational features of the unit, doing basic activities like email, weather, and voice calling becomes incredibly inexpensive. Downloading a GRIB file over a handheld satellite phone will cost somewhere around $2.15 in airtime. Downloading the same GRIB file over the Pilot would cost about 2 cents in airtime. While the upfront costs of the unit are more than a handheld, the ongoing costs are significantly less. Adding in the ability to web-browse (which, while expensive and slow, is possible and a very nice feature to have in an emergency!) means that you get a much higher quality of service than with a handheld satellite phone.

Hardware cost: $4,793 for the Iridium Pilot Savings Bundle
Airtime cost: From as low as $39 a month, with seasonal contracts available.
Estimated low-usage cost: Around $50 – $100 a month will cover you for email, downloading weather GRIB files, and doing emergency web-browsing.
Estimated high-usage cost: Committing to bundle with 1,000 MB per month will cost you just over $1,000 a month, with per-MB overage from $0.56 each.
Coverage: Worldwide, pole-to-pole

# Maritime Vsat

**Maritime VSAT** is the use of satellite communication through a Very-Small-Aperture Terminal (VSAT) on a moving ship at sea. Since a ship at sea moves with the water, the antenna needs to be stabilized with reference to the horizon and True north, so that the antenna is constantly pointing at the satellite it uses to transmit and receive signals.

The Maritime VSAT (Business) Industry was first created for the US Navy in September 1986, by the joint venture team of Richard A. Hadsall, President and CEO of Crescomm Transmission Services and Robert J. Matthews, President of SeaTel Inc. The result of this business venture was the creation of the company Maritime Telecommunications Network, Inc. (MTN) MTN went on to commercialize the Maritime VSAT business by delivering services to Various Cruise Lines around the world as well as many Commercial Oil and Gas installations and vessels. MTN also pushed for global Maritime VSAT recognition with the petition for rule making from the FCC and the lobbying of the ITU's World Radio Commission (WRC) for recognition to use the fixed satellite service (FSS) in C and Ku band by creating new rulings to recognize Earth Stations on Vessels ESV. This was accomplished by revision of the Radio Regulations, complementing the Constitution and the Convention of the International Telecommunication Union ITU, which incorporated the decisions of the World Radio Communication Conferences of 2003 (WRC-03)

There are many different options to build a maritime broadband network onboard of a vessels. Each option has its advantage (and disadvantage) in cost, in the coverage, the signal strength and requirements for the antenna size (and thus the requirements of installation).

There are major differences in capabilities, features, cost and performance between VSAT (Geostationary orbit satellites in Ku-band, C-band and Ka-band) and Low Earth orbit or Medium Earth Orbit satellites with L-band technologies in use.

SAILOR

SAILOR Ku-Band and Ka-Band Marine VSAT systems feature high-performance, 3-axis stabilized antennas for reliable high-bandwidth connectivity. The SAILOR 800 and 900 VSAT Ku-Band antenna systems feature intelligent controllers and software electronics, providing high reliability and stunning performance. SAILOR 60 and 100 GX systems feature advanced tracking receiver technology to operate on the Inmarsat GX and FX network. SAILOR VSAT systems provide workboats, fishing vessels and yachts of any size with world-class, high-quality and reliable communications.

INTELLIAN

Intellian v-Series (80G, 130G) and GX (60, 100) antennas provide the highest quality for satellite systems in the marine market. The Intellian open platform design and always-on high speed broadband connection works in conjunction with any CDMA or TDMA VSAT network around the globe. Intellian marine

VSAT systems provide ease of use and high reliability. The built-in GPS and auto-skew angle control is used to acquire the satellite signal faster and optimize the strength of the signal. No matter where you are, no matter whom you want to communicate with, you can rely on your Intellian VSAT as your communications system.

Both L-band (LEO & MEO) and VSAT (GEO) systems are marketed with what appear to be a shared set of features and benefits.

# Emergency Position Indicator Radio Beacon

An **Emergency Position-Indicating Radiobeacon Station** or **Emergency Position Indicator Radio Beacon** (short: **EPIRS** or **EPIRB**) is a station in the mobile service used in search and rescue operations. In marine use the terminology Emergency Position Indicating Radio Beacon (EPIRB) is used.

## General description

*EPIRBs* are tracking transmitters which aid in the detection and location of boats, aircraft and people in distress. A **PLB** (personal locator beacon) is a particular type of EPIRB that is typically smaller, has a shorter battery life and unlike a proper EPIRB is registered to a person rather than a vessel. The terms **ELB** (emergency locator beacon) and **ELT** (emergency locator transmitter) are used interchangeably with EPIRB only when used on aircraft. Strictly, they are radiobeacons many of which interface with worldwide offered service of Cospas-Sarsat , the international satellite system for Search and Rescue (SAR). Transmitters broadcasting on 406 MHz are recognized. When manually activated, or automatically activated upon immersion or impact, such beacons send out a distress signal. The signals are monitored worldwide and the location of the distress is detected by non-geostationary satellites using the Doppler effect for trilateration, and in more recent EPIRBs also by GPS.

The basic purpose of a distress radiobeacon is to help rescuers find survivors within the so-called "golden day" (the first 24 hours following a traumatic event) during which the majority of survivors can usually be saved.

Since the inception of Cospas-Sarsat in 1982, distress radiobeacons have assisted in the rescue of over 28,000 people in more than 7,000 distress situations. In 2010 alone, the system provided information which was used to rescue 2,388 persons in 641 distress situations.

Most beacons are brightly colored and waterproof. EPIRBs and ELTs are larger, and would fit in a cube about 30 cm (12 in) on a side, and weigh 2 to 5 kg (4.4 to 11.0 lb). PLBs vary in size from cigarette-packet to paperback book and weigh 200 g to 1 kg (½ to 2½ lb). They can be purchased from marine suppliers, aircraft refitters, and (in Australia and the United States) hiking supply stores. The units have a useful life of 10 years, operate across a range of conditions −40 to 40 °C (−40 to 104 °F), and transmit for 24 to 48 hours. The cost of radiobeacons varies according to performance and specifications.

## Operation

A transmission usually gets processed as follows:

1. The transmitter is activated, either automatically in a crash or after sinking, or manually by survivors of an emergency situation.
2. At least one satellite picks up the beacon's transmission.
3. The satellites transfer the beacon's signal to their respective ground control stations.
4. The ground stations process the signals and forward the data, including approximate location, to a national authority.
5. The national authority forwards the data to a rescue authority
6. The rescue authority uses its own receiving equipment afterwards to locate the beacon and commence its own rescue or recovery operations.

Once the satellite data is received, it takes less than a minute to forward it to any signatory nation.

There are several systems in use, with beacons of varying expense, different types of satellites and varying performance. Carrying even the oldest systems provides an immense improvement in safety over carrying none.

## Activation

There are two ways to activate a beacon:

- manually
- automatically

Automatic EPIRBs are water activated, while automatic ELTs have impact monitors activated by g-force. Some EPIRBs also "deploy"; this means that they physically depart from their mounting bracket on the exterior of the vessel (usually by going into the water.)

For a marine EPIRB to begin transmitting a signal (or "activate") it first needs to come out of its bracket (or "deploy"). Deployment can happen either manually   where someone must physically remove it from its bracket   or automatically   where water pressure will cause a hydrostatic release unit to separate the EPIRB from its bracket. If it does not come out of the bracket it will not activate. There is a magnet in the bracket which operates a reed safety switch in the EPIRB. This prevents accidental activation if the unit gets wet from rain or shipped seas.

Once deployed, EPIRBs can be activated, depending on the circumstances, either manually (crewman flicks a switch) or automatically (when water contacts the unit's "sea-switch".) All modern EPIRBs provide both methods of activation and deployment, and thus are labeled "Manual and Automatic Deployment and Activation."

### *Automatic hydrostatic release unit*

A **hydrostatic release unit** or **HRU** is a pressure activated mechanism designed to automatically deploy when certain conditions are met. In the marine environment this occurs when submerged to a maximum depth of four meters. The pressure of the water against a diaphragm within the sealed casing causes a plastic pin to be cut thereby releasing the containment bracket casing, allowing the EPIRB to float free.

## Beacon Operation

### *GPS-based, registered*

The most modern 406 MHz beacons with GPS (US$300+ in 2010) track with a precision of 100 meters in the 70% of the world closest to the equator, and send a serial number so the responsible authority can look up phone numbers to notify the registrator (e.g., next-of-kin) in four minutes.

The GPS system permits stationary, wide-view geosynchronous communications satellites to enhance the doppler position received by low Earth orbit satellites. EPIRB beacons with built-in GPS are usually called GPIRBs, for GPS position-indicating radio beacon or global position-indicating radio beacon.

However, rescue cannot begin until a doppler track is available. The COSPAS-SARSAT specifications say  that a beacon location is not considered "resolved" unless at least two doppler tracks match or a doppler track confirms an encoded (GPS) track. One or more GPS tracks are not sufficient.

### *High-precision registered*

An intermediate technology 406 MHz beacon (now mostly obsolete in favor of GPS enabled units) has worldwide coverage, locates within 2 km (12.5 km² search area), notifies kin and rescuers in 2 hours maximum (46 min average), and has a serial number to look up phone numbers, etc. This can take up to two hours because it has to use moving weather satellites to locate the beacon. To help locate the beacon, the beacon's frequency is controlled to 2 parts per billion, and its power is five watts.

Both of the above types of beacons usually include an auxiliary 25 milliwatt beacon at 121.5 MHz to guide rescue aircraft.

### *Traditional ELT, unregistered*

The oldest, cheapest (US$139) beacons are aircraft emergency locator transmitters (ELTs) that send an anonymous warble on the aviation band distress frequency at 121.5 MHz The frequency is often routinely monitored by commercial aircraft, but has not been monitored by satellite since Feb. 1, 2009.

These distress signals could be detected by satellite over only 60% of the earth, required up to 6 hours for notification, located within 20 km (12 mi) (search area of 1200 km²), were anonymous, and couldn't be located well because their frequency is only accurate to 50 parts per million and the signals were broadcast using only 75–100 milliwatts of power. Coverage was partial because the satellite had to be in view of both the beacon and a ground station at the same time – the satellites did not store and forward the beacon's position. Coverage in polar and south-hemisphere areas was poor.

False alarms were common, as the beacon transmitted on the aviation emergency frequency, and there is interference from other electronic and electrical systems. To reduce false alarms, a beacon was confirmed by a second satellite pass, which could easily slow confirmation of a 'case' of distress to up to about 4 hours (although in rare circumstances the satellites could be position such that immediate detection becomes possible.)

### *Location by Doppler (without GPS)*

The Cospas-Sarsat system was made possible by Doppler processing. Local unit terminals (LUTs) detecting non-geostationary satellites interpret the Doppler frequency shift heard by LEOSAR and MEOSAR satellites as they pass over a beacon transmitting at a fixed frequency. The interpretation determines both bearing and range. The range and bearing are measured from the rate of change of the heard frequency, which varies both according to the path of the satellite in space and the rotation of the earth.
This triangulates the position of the beacon. A faster change in the doppler indicates that the beacon is closer to the satellite's orbit. If the beacon is moving toward or away from the satellite track due to the Earth's rotation, it is on one side or other of the satellite's path. Doppler shift is zero at the closest point of approach between the beacon and the orbit.

If the beacon's frequency is more precise, it can be located more precisely, saving search time, so modern 406 MHz beacons are accurate to 2 parts per billion, giving a search area of only 2 square km, compared to the older beacons accurate to 50 parts per million that had 200 square kilometers of search area.

In order to increase the useful power, and handle multiple simultaneous beacons, modern 406 MHz beacons transmit in bursts, and remain silent for about 50 seconds.

Russia developed the original system, and its success drove the desire to develop the improved 406 MHz system. The original system was a brilliant adaptation to the low quality beacons, originally designed to aid air searches. It used just a simple, lightweight transponder on the satellite, with no digital recorders or other complexities. Ground stations listened to each satellite as long as it was above the horizon. Doppler shift was used to locate the beacon(s). Multiple beacons were separated when a computer program analyzed the signals with a fast fourier transform. Also, two satellite passes per beacon were used. This eliminated false alarms by using two measurements to verify the beacon's location from two different bearings. This prevented false alarms from VHF channels that affected a single satellite. Regrettably, the second satellite pass almost doubled the average time before notification of the rescuing authority. However, the notification time was much less than a day.

# Satellites

Receivers are auxiliary systems mounted on several types of satellites. This substantially reduces the program's cost.

The weather satellites that carry the SARSAT receivers are in "ball of yarn" orbits, inclined at 99 degrees. The longest period that all satellites can be out of line-of-sight of a beacon is about two hours.

The first satellite constellation was launched in the early 1970s by the Soviet Union, Canada, France and the United States.

Some geosynchronous satellites have beacon receivers. Since the end of 2003, there are four such geostationary satellites (GEOSAR) that cover more than 80% of the surface of the earth. As with all geosynchronous satellites, they are located above the equator. The GEOSAR satellites do not cover the polar caps.

Since they see the Earth as a whole, they see the beacon immediately, but have no motion, and thus no doppler frequency shift to locate it. However, if the beacon transmits GPS data, the geosynchronous satellites give nearly instantaneous response.

## Search and Rescue response

Emergency beacons operating on 406 MHz transmit a unique 15, 22, or 30 character serial number called a Hex Code. When the beacon is purchased, the Hex Code should be registered with the relevant national (or international) authority. Registration provides Search and Rescue agencies with crucial information such as:

- phone numbers to call,
- a description of the vessel, aircraft, vehicle, or person (in the case of a PLB)
- the home port of a vessel or aircraft
- any additional information that may be useful to SAR agencies

Registration information allows SAR agencies to start a rescue more quickly. For example, if a shipboard telephone number listed in the registration is unreachable, it could be assumed that a real distress event is occurring. Conversely, the information provides a quick and easy way for the SAR agencies to check and eliminate false alarms (potentially sparing the beacon's owner from significant false alert fines.)

An unregistered 406 beacon still carries some information, such as the manufacturer and serial number of the beacon, and in some cases, an MMSI or aircraft tail number/ICAO 24-bit address. Despite the clear benefits of registration, an unregistered 406 beacon is very substantially better than a 121.5/243.0 beacon; this is because the Hex Code received from a 406 beacon confirms the authenticity of the signal as a real SAR alert.

Beacons operating on 121.5 and 243.0 MHz only simply transmit an anonymous siren tone, and thus carry no information to SAR agencies. Such beacons now rely solely on the terrestrial or aeronautical monitoring of the frequency. In the UK, the Distress and Diversion Cell of the Royal Air Force provides continuous monitoring of 121.5 and 243.0 MHz, with auto triangulation from a network of terrestrial receivers on both frequencies. In Canada, only air traffic service stations (control towers or flight service facilities) monitor 121.5 MHz during operating hours. Overflying commercial or private aircraft monitor 121.5 MHz only if equipped with a suitable receiver, and if time/courtesy permits; monitoring 121.5 MHz is not mandatory. SAR authorities have no way of knowing whether a 121.5/243.0 MHz signal is actually a SAR signal until they physically deploy to the location and home in on the source (and sound) of the transmission. Since SAR resources are scarce (and expensive), most countries do not deploy the most useful SAR homing assets (aircraft) until ambiguity has been resolved .

**Operational testing**

According to the U.S. Federal Aviation Administration, ground testing of A-, B-, and S-type ELTs is to be done within the first 5 minutes of each hour. Testing is restricted to three audio sweeps. Type I and II devices (those transmitting at 406 MHz) have a self test function and must not be activated except in an actual emergency.

The United States Coast Guard web page for EPIRBs states: "You may be fined for false activation of an unregistered EPIRB. The U.S. Coast Guard routinely refers cases involving the non-distress activation of an EPIRB (e.g., as a hoax, through gross negligence, carelessness or improper storage and handling) to the Federal Communications Commission. The FCC will prosecute cases based upon evidence provided by the Coast Guard, and will issue warning letters or notices of apparent liability for fines up to $10,000."

**Beacon modes**

The most important aspect of a beacon in classification is the mode of transmission. There are two valid transmission modes: digital and analog. Where digital usually has a longer range, analog is more reliable. Analog beacons are useful to search parties and SAR aircraft, though they are no longer monitored by satellite.

### Digital mode: 406 MHz beacons

406 MHz beacons transmit bursts of digital information to orbiting satellites, and may also contain a small integrated analog (121.5 MHz) homing beacon. They can be uniquely identified (via GEOSAR). Advanced beacons encode a GPS or GLONASS position into the signal. All beacons are located by doppler triangulation to confirm the location. The digital data identifies the registered user. A phone call by authorities to the registered phone number often eliminates false alarms (false alarms are the typical case). If there is a problem, the beacon location data guides search and rescue efforts. No beacon is ignored. Anonymous beacons are confirmed by two doppler tracks before beginning beacon location efforts.

The distress message transmitted by a 406 beacon contains the information such as:

- Which country the beacon originates from.
- A unique 15-digit hexadecimal beacon identification code (a "15-hex ID").
- The encoded identification of the vessel or aircraft in distress, either as an MMSI value, or as, in the case of an ELT, either the aircraft's registration or its ICAO 24-bit address(from its Mode-S transponder).
- When equipped, a GPS position.
- Whether or not the beacon contains a 121.5 MHz homing transmitter.

The digital distress message generated by the beacon varies according to the above factors and is encoded in 30 hexadecimal characters. The unique 15-character digital identity (the 15-hex ID) is hard-coded in the firmware of the beacon. The 406.025 MHz carrier signal is modulated plus or minus 1.1 radians with the data encoded using Manchester encoding, which ensures a net zero phase shift aiding Doppler location

***406 MHz beacon facts and transmission schedule***

- 406 MHz beacons transmit for a quarter of a second immediately when turned on, and then transmit a digital burst once every 50 seconds thereafter. Both GEOSAR and LEOSAR satellites monitor these signals.
- The repetition period shall not be so stable that any two transmitters appear to be synchronized closer than a few seconds over a 5-minute period. The intent is that no two beacons will have all of their bursts coincident. The period shall be randomized around a mean value of 50 seconds, so that time intervals between transmission are randomly distributed on the interval 47.5 to 52.5 seconds. (specification for First-Generation beacons)
- Preliminary Specification for Second-Generation Beacons. From beacon activation a total of [6] initial transmissions shall be made separated by fixed [5s ± 0.1s] intervals. The first transmission shall commence within [3] seconds of beacon activation. Transmissions shall then occur at nominally [30] second intervals until [30 ± 1] minutes after beacon activation. The repetition period between the start of two successive transmissions shall be randomized around the stated nominal value, so that intervals between successive transmissions are randomly distributed over ± [5] seconds. Subsequent transmissions [TBD].
- 406 MHz beacons will be the only beacons compatible with the MEOSAR (DASS) system.
- 406 MHz beacons must be registered .

***Hex codes***

Example hex codes look like the following:
90127B92922BC022FF103504422535

- A bit telling whether the message is short (15 hex digits) or long (30 hex digits) format.
- A country code, which lets the worldwide COSPAS/SARSAT central authority identify the national authority responsible for the beacon.
- Embedded 15-Hex ID or 15-hex transmitted distress message, for example, 2024F72524FFBFF The hex ID is printed or stamped on the

outside of the beacon and is hard-coded into its firmware. The 15-hex ID can only be reprogrammed by certified distress radiobeacon technicians. The national authority uses this number to look up phone numbers and other contact information for the beacon. This is crucial to handle the large number of false alarms generated by beacons.

- A location protocol number, and type of location protocol: EPIRB or MMSI, as well as all the data fields of that location protocol. If the beacon is equipped with GPS or GLONASS, a rough (rounded) latitude and longitude giving the beacon's current position. In some aircraft beacons, this data is taken from the aircraft's navigation system.
- When a beacon is sold to another country, the purchaser is responsible for having the beacon reprogrammed with a new country code and to register it with his/her nation's beacon registry, and the seller is responsible to de-register the deprecated beacon ID with his/her national beacon registry.
- One can use the beacon decoder web page at Cospas-Sarsat to extract the 15-hex ID from the 30-hex distress message.

**Analog mode: all other beacons**

- A simple analog siren tone is transmitted continuously until the battery dies.
- In the case of 121.5 MHz beacons, the frequency is known in aviation as the "VHF Guard" emergency frequency, and all U.S. civilian pilots (private and commercial) are required, by FAA policy, to monitor this frequency when it is possible to do so. The frequency can be used by Automatic Direction Finder (ADF) radionavigation equipment, which is being phased out in favor of VOR and GPS but is still found on many aircraft.
- The Cospas-Sarsat system detected this type of beacon – prior to 1 February 2009 – when a LEOSAR satellite was in view of both the beacon and a LEOLUT (ground segment). Satellite detection of 121.5 MHz beacons ceased on 1 February 2009 .

## Frequency

Distress beacons transmit distress signals on the following key frequencies; the frequency used distinguishes the capabilities of the beacon.
A *recognized* beacon can operate on one of the three (currently) Cospas-Sarsat satellite-compatible frequencies. In the past, other frequencies were also used as a part of the search and rescue system.

**Cospas-Sarsat (satellite) compatible beacon frequencies**

- see above for transmission schedule
- 406 MHz UHF- carrier signal at 406.025-406.076 MHz ± 0.005 MHz

Channel frequency (status)

- Ch-1 A: 406.022 MHz (reference)
- Ch-2 B: 406.025 MHz (in use today)

- Ch-3 C: 406.028 MHz (in use today)
- Ch-4 D: 406.031 MHz
- Ch-5 E: 406.034 MHz
- Ch-6 F: 406.037 MHz (in use today)
- Ch-7 G: 406.040 MHz (in use today)
- Ch-8 H: 406.043 MHz
- Ch-9 I: 406.046 MHz
- Ch-10 J: 406.049 MHz (operational at a future date)
- Ch-11 K: 406.052 MHz (operational at a future date)
- Ch-12 L: 406.055 MHz
- Ch-13 M: 406.058 MHz
- Ch-14 N: 406.061 MHz (operational at a future date)
- Ch-15 O: 406.064 MHz (operational at a future date)
- Ch-16 P: 406.067 MHz
- Ch-17 Q: 406.070 MHz
- Ch-18 R: 406.073 MHz (operational at a future date)
- Ch-19 S: 406.076 MHz (operational at a future date)

**Cospas-Sarsat incompatible beacon frequencies**

- Marine VHF radio channels 15/16 – these channels are used only on the obsolete Class C EPIRBs
- The obsolete Inmarsat-E beacons transmitted to Inmarsat satellites on 1646 MHz UHF.
- 121.5 MHz VHF ± 6 kHz (frequency band protected to ±50 kHz) (Satellite detection ceased on 1 February 2009, but this frequency is still used for short-range location during a search and rescue operation)
- 243.0 MHz UHF ± 12 kHz (frequency band protected to ± 100 kHz) (prior to 1 February 2009 – COSPAS-SARSAT Compatible)

## Types

The *type* of a beacon is determined by the environment for which it was designed to be used:

- **EPIRBs (emergency position indicating radio beacons)** signal maritime distress,
- **ELTs (emergency locator transmitters)** signal aircraft distress
- **PLBs (personal locator beacons)** are for personal use and are intended to indicate a person in distress who is away from normal emergency services; e.g., 9-1-1. They are also used for crewsaving applications in shipping and lifeboats at terrestrial systems. In New South Wales, some police stations and the National Parks and Wildlife Service provide personal locator beacons to hikers for no charge.

Each type is sub-classified:

### EPIRB sub-classification

Emergency position-indicating radio beacons (EPIRBs) are sub-classified as follows:

**Recognized categories:**

- Category I – 406/121.5 MHz. Float-free, automatically activated EPIRB. Detectable by satellite anywhere in the world. Recognized by GMDSS.
- Category II – 406/121.5 MHz. Similar to Category I, except is manually activated. Some models are also water activated.

**Unrecognized classes:**

- Class A – 121.5/243 MHz. Float-free, automatically activating. These devices have been phased out by the U.S. Federal Communications Commission (FCC) and *are no longer recognized*.
- Class B – 121.5/243 MHz. Manually activated version of Class A. These devices have been phased out by the FCC and *are no longer recognized*.
- Class S – 121.5/243 MHz. Similar to Class B, except it floats, or is an integral part of a survival craft (lifeboat). These devices have been phased out by the FCC and *are no longer recognized*.
- Class C – Marine VHF ch15/16. Manually activated, these beacons operate on maritime channels only, and therefore are not detectable by satellite or normal aircraft. These devices have been phased out by the FCC and *are no longer recognized*.
- Inmarsat-E – This service ended 1 December 2006; all former users have switched to Category I or II 406 MHz EPIRBs. These beacons were float-free, automatically activated EPIRBs operated on 1646 MHz. They were detectable by Inmarsat geostationary satellites, and were recognized by GMDSS.

### ELT sub-classification

Emergency locator transmitters (ELTs) for aircraft may be classed as follows:

- A ELT, automatically ejected
- AD ELT, automatic deployable
- F ELT, Fixed
- AF ELT, automatic fixed
- AP ELT, automatic portable
- W ELT, water activated
- S ELT, survival

Within these classes, an ELT may be either a digital 406 MHz beacon, or an analog beacon.

### PLB sub-classification

There are two kinds of personal locator beacon (PLB):

- PLB with GPS data (internally or externally provided)
- PLB with no GPS data

All PLBs transmit in digital mode on 406 MHz. There are AIS PLBs that transmit on VHF 70

## Obsolete types

### *Obsolete EPIRBs*

There are also several older types of EPIRB devices which are no longer recommended for use.

- *Class A* – A 121.5 MHz automatic activation unit. Due to limited signal coverage and possible lengthy delays in signal recognition, the U.S. Coast Guard no longer recommends use of this type.
- *Class C* – Operates on VHF channel 15/16. Designed for small crafts operating close to shore, this type was only recognized in the United States. Use of these units was phased out in 1999.
- *Class S* – A 121.5 MHz unit similar to Class B but is often included as an integral part of a lifeboat or survival suit. Their use is no longer recommended by the U.S. Coast Guard.
- *Inmarsat E* – entered service in 1997. The unit is an automatic activation unit operating on 1646 MHz and detectable by the Inmarsat geostationary satellite system. This class of EPIRB was approved by the Global Maritime Distress and Safety System (GMDSS), but not by the United States. In September 2004, Inmarsat announced that it was terminating its *Inmarsat E* EPIRB service as of December 2006 due to a lack of interest in the maritime community.

Furthermore, the U.S. Coast Guard recommend that no EPIRB of any type manufactured before 1989 be used.

### *Obsolete ELTs*

- Any ELT that is not a 406 MHz ELT with a Hex Code became obsolete February 1, 2009.

### *Obsolete PLBs*

- Military forces at one time used 121.5/243.0 MHz beacons such as the "PRC-106," which had a built-in VHF radio. These are being replaced by modern 406 MHz PLBs.

### Phase-out of 121.5 & 243 beacons

Since 1 February 2009, only 406 MHz beacons are detected by the international Cospas-Sarsat SAR satellite system. This affects all maritime beacons (EPIRBs), all aviation beacons (ELTs) and all personal beacons (PLBs). In other words, Cospas-Sarsat has ceased satellite detection and processing of 121.5/243 MHz beacons. These older beacons are now only detectable by ground-based receivers and aircraft.

121.5 and 243.0 MHz EPIRBs are banned on boats in the United States and in many other jurisdictions. More information about the switch to 406 is available on Cospas-Sarsat's 121.5/243 Phase-Out page.

Despite the switch to 406 MHz, pilots and ground stations are encouraged to continue to monitor for transmissions on the emergency frequencies, as many 406 beacons are also equipped with 121.5 "homers." Furthermore, the 121.5 MHz frequency continues to be used as a voice distress frequency especially in aviation.

## Statutory requirements

In North America and Australasia (and most jurisdictions in Europe) no special license is required to operate an EPIRB. In some countries (for example the Netherlands) a marine radio operators license is required. The following paragraphs define other requirements relating to EPIRBs, ELTs, and PLBs.

### Registration

All distress alerting beacons operating on 406 MHz should be registered; all vessels and aircraft operating under International Convention for the Safety of Life at Sea (SOLAS) and International Civil Aviation Organization (ICAO) regulations must register their beacons. Some national administrations (including the United States, Canada, Australia, and the UK) also require registration of 406 MHz beacons.

- There is no charge to register 406 MHz beacons.
- The U.S. Coast Guard warns that a user's "life may be saved as a result of registered emergency information" because it can respond more quickly to signals from registered beacons.
- Unless the national registry authority advises otherwise, personal information contained in a beacon is used exclusively for SAR distress alert resolution purposes.

The Cospas-Sarsat Handbook of Beacon Regulations provides the status of 406 MHz beacon regulations in specific countries and extracts of some international regulations pertaining to 406 MHz beacons.

The following list shows the agencies accepting 406 beacon registrations by country:

- United States – National Oceanic and Atmospheric Administration
- Canada – Canadian Beacon Registry, CFB Trenton for civil beacons, CMCC for military beacons
- Australia – Australian Maritime Safety Authority (AMSA)
- United Kingdom – United Kingdom Maritime and Coastguard Agency (MCA)
- Greece – Ministry of Merchant Marine and Hellenic Civil Aviation Authority
- France – CNES
- Italy – Stazione Satellitare Italiana - Cospas Sarsat
- Netherlands – Agentschap Telecom (NL)
- Denmark – Danish Maritime Authotity
- New Zealand - New Zealand Rescue Coordination Centre
- International – Cospas-Sarsat International 406 MHz Beacon Registration Database (IBRD)

**Responsible agencies**

In the U.S. the Coast Guard investigates offshore beacons and rescues victims. On-shore beacons are investigated by local search-and-rescue services in Alaska. The Air Force Rescue Coordination Center responds to land-based emergency signals, usually dispatching volunteer members from the United States Air Force Auxiliary Civil Air Patrol. In the U.S., there are no published notification systems for other locations.

**Environment-specific requirements**

**Marine (EPIRBs)**

EPIRBs are a component of the Global Maritime Distress and Safety System (GMDSS). Most commercial off-shore working vessels with passengers are required to carry a self-deploying EPIRB, while most in-shore and fresh-water craft are not.

As part of the United States efforts to prepare beacon users for the end of 121.5 MHz frequency processing by satellites, the FCC has prohibited the use of 121.5 MHz EPIRBs as of January 1, 2007 (47 CFR 80.1051).

**History**

Automatic SOS radios were developed as early as the 1930s.

# International Cospas-Sarsat Programme

Cospas-Sarsat is an international organization that has been a model of international cooperation, even during the Cold War. SARSAT means Search And Rescue Satellite Aided Tracking. **COSPAS** (КОСПАС) is an acronym for the Russian words "**Co**smicheskaya **S**istema **P**oiska **A**variynyh **S**udov" (Космическая Система Поиска Аварийных Судов), which translates to "Space System for the Search of Vessels in Distress". A consortium of Russia, the U.S., Canada and France formed the organization in 1982. Since then, 29 others have joined.

Cospas-Sarsat defines standards for beacons, auxiliary equipment to be mounted on conforming weather and communication satellites, ground stations, and communications methods. The satellites communicate the beacon data to their ground stations, which forward it to main control centers of each nation that can initiate a rescue effort.

The U.S. Coast Guard once promoted an emergency beacon on maritime VHF emergency channels. It now promotes the superior Cospas-Sarsat system, and no longer services emergency beacons on maritime VHF frequencies.

The **International Cospas-Sarsat Programme** is a treaty-based, nonprofit, intergovernmental, humanitarian cooperative of 43 nations and agencies (see box on right) dedicated to detecting and locating radio beacons activated by persons, aircraft or vessels in distress, and forwarding this alert information to authorities that can take action for rescue. The system utilizes a network of satellites that provide coverage anywhere on Earth. Distress alerts are detected, located and forwarded to over 200 countries and territories at no cost to beacon owners or the receiving government agencies. Cospas-Sarsat was conceived and initiated by Canada, France, the United States, and the former Soviet Union in 1979. The first rescue using the technology of Cospas-Sarsat occurred in September 1982. The definitive agreement of the organization was signed on 1 July 1988.

Cospas-Sarsat is best known as the system that detects and locates emergency beacons activated by aircraft, ships and people engaged in recreational activities in remote areas, and then send these distress alerts to search-and-rescue (SAR) authorities. Distress beacons capable of being detected by the Cospas-Sarsat System (406-MHz beacons) are available from several manufacturers and vendor chains. Cospas-Sarsat does not make or sell beacons.

Between September 1982 and December 2015 the Cospas-Sarsat System provided assistance in rescuing at least 41,750 people in 11,788 SAR events.

Cospas-Sarsat does not undertake search-and-rescue operations. This is the responsibility of national administrations that have accepted responsibility for SAR in various geographic regions of the world (typically the same geographic area as their flight information region). Cospas-Sarsat provides alert data to those authorities.

Cospas-Sarsat cooperates with United Nations-affiliated agencies, such as the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), and the International Telecommunication Union (ITU), among other international organizations, to ensure the compatibility of the Cospas-Sarsat distress alerting services with the needs, the standards and the applicable recommendations of the global community. Cospas-Sarsat is an element of the IMO's Global Maritime Distress Safety System (GMDSS), and is expected to become a component of ICAO's Global Aeronautical Distress and Safety System (GADSS). The IMO requires automatic-activating Cospas-Sarsat beacons (EPIRBs, see below) on all vessels subject to requirements of the International Convention for the Safety of Life at Sea (so-called SOLAS-class vessels), commercial fishing vessels, and all passenger ships in international waters. Similarly, ICAO requires Cospas-Sarsat beacons aboard aircraft on international flights. National administrations often impose requirements in addition to the international requirements of those agencies.

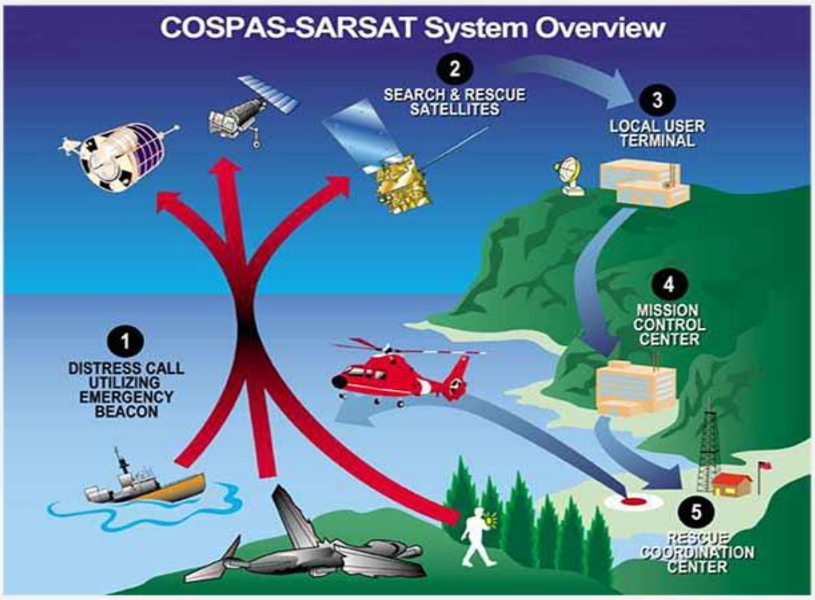
Cospas-Sarsat only monitors for alerts from digital distress beacons that transmit on 406 MHz (so-called 406 beacons). Older beacons that transmit only a legacy analogue signal on 121.5 MHz or 243 MHz rely on being received only by nearby aircraft or rescue personnel. For satellite reception of alerts by Cospas-Sarsat the beacon must be a model that transmits at 406 MHz.

Cospas-Sarsat has received many honors for its humanitarian work. One recent honor was induction into the Space Foundation's Space Technology Hall of Fame for space technologies improving the quality of life for all humanity.

**System operation**

The system consists of a ground segment and a space segment that include:

- Distress radio-beacons to be activated in a life-threatening emergency
- SAR signal repeaters (SARR) and SAR signal processors (SARP) aboard satellites
- Satellite downlink receiving and signal processing ground stations called LUTs (local user terminals)
- Mission control centers (MCCs) that distribute to rescue coordination centers distress alert data (particularly beacon location data) generated by the LUTs
- Rescue coordination centers (RCCs) that facilitate coordination of the SAR agency and personnel response to a distress situation.




**Beacons**

A Cospas-Sarsat distress beacon is a digital 406-MHz radio transmitter that can be activated in a life-threatening emergency to summon assistance from government authorities. Beacons are manufactured and sold by dozens of vendors. They are classified in three main types. A 406-MHz beacon designed for use in an aircraft is known as an emergency locator transmitter (ELT). One designed for use aboard a marine vessel is called an emergency position-indicating radio beacon (EPIRB). And one that is designed to be carried by an individual is known as a personal locator beacon (PLB). Sometimes PLBs are carried aboard aircraft or vessels, but whether this satisfies safety requirements depends on local regulations. A Cospas-Sarsat 406-MHz beacon does not transmit until it is activated in an emergency (or when certain testing features are activated by the user). Some beacons are designed to be manually activated by a person pressing a button, and some others are designed for automatic activation in certain circumstances (e.g., ELTs may be automatically activated by a physical shock, such as in a crash, and EPIRBs may be automatically activated by contact with water). There are ***no*** subscription or other costs imposed by Cospas-Sarsat for beacon ownership or use. (Some countries may impose licensing and/or registration charges for beacon ownership, and some jurisdictions may assess costs for rescue operations.)

## Space segment

The Cospas-Sarsat system space segment consists of SARR and/or SARP instruments aboard:

- Five satellites in polar low-altitude Earth orbit called LEOSARs
- Nine satellites in geostationary Earth orbit called GEOSARs
- Over 30 satellites in medium-altitude Earth orbit called MEOSARs

A SARR or SARP instrument is a secondary payload and associated antennas attached to those satellites as an adjunct to the primary satellite mission. A SARR instrument retransmits a beacon distress signal to a satellite ground station in real time. A SARP instrument records the data from the distress signal so that the information can later be gathered by a ground station when the satellite passes overhead.

## Ground segment

The satellites are monitored by receiving ground stations equipped to track (point at and follow) the satellites using satellite dishes or phased antenna arrays called local user terminals (LUT). LUTs are installed by individual national administrations or agencies. The distress messages received by a LUT are transferred to an associated mission control centre which uses a detailed set of computer algorithms to route the messages to rescue coordination centers worldwide.

## System architecture

When a distress beacon is activated, the Cospas-Sarsat system:

- decodes the binary coded message of the beacon, which contains information such as the identity of the vessel/aircraft and, for beacons equipped with the feature, the location of the beacon derived from a local navigation source (such as a GPS receiver incorporated into the beacon's design).
- performs a mathematical analysis of the signal to calculate the location of the beacon, even if the beacon's location is not reported in the distress message.

The Cospas-Sarsat system is the only satellite distress alerting system that is capable of this dual, redundant means of locating an activated distress beacon.

The SARR and/or SARP instrument typically is attached to a satellite that is being launched primarily for another purpose. The primary mission of all of the LEOSAR and GEOSAR satellites is meteorological (gathering of weather data). The primary mission of all of the MEOSAR satellites is navigation.

## LEOSAR

LEOSAR was the original Cospas-Sarsat space segment architecture. The complementary LEOSAR-satellite orbits provide periodic coverage of the entire Earth. Because of their relatively low altitude (and therefore, relatively small “footprint” of visibility of any particular part of the Earth at any given time), there are intervals of time when a LEOSAR satellite may not be over a particular geographic location. So there can be a delay in receiving an alert signal, and a delay in relaying that signal to the ground. For this reason, LEOSAR satellites are equipped with the “store-and-forward” SARP modules in addition to “real-time” SARR modules. The satellite can pass over a remote area of the Earth and receive a distress message, and then forward that data later when it passes into view of a ground station (that typically are located in less remote areas). The five satellites in the LEOSAR constellation have approximately 100 minute orbits. Because of their polar orbits the latency between satellite passes overhead is smallest at the poles and higher latitudes.

The Cospas-Sarsat LEOSAR system was made possible by Doppler processing. LUTs detecting distress signals relayed by LEOSAR satellites perform mathematical calculations based on the Doppler-induced frequency shift received by the satellites as they pass over a beacon transmitting at a fixed frequency. From the mathematical calculations, it is possible to determine both bearing and range with respect to the satellite. The range and bearing are measured from the rate of change of the received frequency, which varies both according to the path of the satellite in space and the rotation of the Earth. This allows a computer algorithm to trilaterate the position of the beacon. A faster change in the received frequency indicates that the beacon is closer to the satellite's ground track. When the beacon is moving toward or away from the satellite track due to the Earth's rotation, the Doppler shift induced by that motion also can be used in the calculation.

## GEOSAR

Because their geostationary orbit does not provide a relative motion between a distress beacon and a GEOSAR satellite, there is no opportunity to use the Doppler effect to calculate the location of a beacon. Therefore, the GEOSAR satellites only can relay a beacon’s distress message. If the beacon is a model with a feature to report its location (e.g., from an on-board GPS receiver) then that location is relayed to SAR authorities. While the inability to independently locate a beacon is a drawback of GEOSAR satellites, those satellites have an advantage in that the present constellation well covers the entire Earth in real time, except for the Polar Regions.

## MEOSAR

The most recent space segment augmentation for Cospas-Sarsat is MEOSAR. MEOSAR blends the advantages of the LEOSAR and GEOSAR systems, while avoiding the drawbacks. Over time there will be more than 70 MEOSAR satellites, and the MEOSAR system will become the dominant space-segment capability of Cospas-Sarsat. In addition to the large number of satellites, the MEOSAR system benefits from relatively large satellite footprints and sufficient satellite motion relative to a point on the ground to allow the use of Doppler measurements as part of the method of calculating a distress beacon's location. MEOSAR consists of SARR transponders aboard the following navigation-satellite constellations: the European Union's: Galileo, the Russian Federation's: Glonass and the United States': Global Positioning System (GPS). The current payloads aboard GPS satellites also are known as the Distress Alerting Satellite System (DASS) by NASA.

Operational distribution of MEOSAR alert data began at 1300 UTC on 13 December 2016. This operational phase of MEOSAR is known as the early operational capability (EOC), and is being carried out in parallel with continued testing and adjustment through the contemporaneous demonstration and evaluation (D&E) phase. Ultimately, the MEOSAR system will be able to provide near-instantaneous detection, identification, and location-determination of 406-MHz beacons. Prior to the operational introduction of MEOSAR, MEOSAR data was successfully used to assist in determining the crash location of EgyptAir flight 804 in the Mediterranean Sea. The location of a distress beacon is calculated by the receiving LUT by analyzing the frequency-difference-of-arrival (related to Doppler-induced variations), and/or the time-difference-of-arrival of a beacon's radio signal due to the differences in distance between the beacon and each MEOSAR satellite that may be in view.

Additionally, the Galileo component of the MEOSAR system will be able to download information back to the distress radio-beacon by encoding "Return Link Service" messages into the Galileo navigation data stream. Currently it is planned that this capability will be used to activate an indicator on the beacon to confirm receipt of the distress message.

## Ground segment

As at December 2016 the LEOSAR satellites are tracked and monitored by 53 LEOLUTs (low-altitude Earth-orbit local user terminals), the GEOSAR satellites by 21 GEOLUTs and the MEOSAR satellites by 17 experimental and operational MEOLUTs having a total of 76 antennas. The data from these earth stations is transferred to and distributed by 30 mission control centers. (See box for the countries and agencies that are ground-segment providers.)

## History

The first system satellite, "COSPAS-1" (Kosmos 1383), was launched from Plesetsk Cosmodrome on June 29, 1982. Cospas-Sarsat began tracking the two original types of distress beacons, EPIRBs and ELTs, in September, 1982. The first persons were rescued with the assistance of Cospas-Sarsat when the distress signal from a small plane was relayed by the COSPAS-1 satellite to a then-experimental ground station in Ottawa, Ontario, Canada. The story has been related by the plane's pilot, Jonathan Ziegelheim, who rescue authorities judged would probably have died of his injuries if it were not for Cospas-Sarsat.

In the early 2000s (in 2003 in the USA) a new type of distress beacon, the personal locator beacon (PLB), became available for use by individuals who cannot contact emergency services through normal telephone-originated services, such as 1-1-2 or 9-1-1. Typically PLBs are used by people engaged in recreational activities in remote areas, and by small-aircraft pilots and mariners as an adjunct to (or, when permitted, a substitute for) an ELT or EPIRB.

The four founding Party States led development of the 406-MHz marine EPIRB for detection by the system. The EPIRB was seen as a key advancement in SAR technology in the perilous maritime environment. Prior to the founding of Cospas-Sarsat, the civilian aviation community had already been using the 121.5 MHz frequency for distress, while the military aviation community utilized 243.0 MHz as the primary distress frequency with the 121.5 MHz frequency as the alternate. ELTs for general aviation aircraft were constructed to transmit on 121.5 MHz, a frequency monitored by airliners and other aircraft. Military aircraft beacons were manufactured to transmit at 243.0 MHz, in the band commonly used by military aviation. Early in its history, the Cospas-Sarsat system was engineered to detect beacon-alerts transmitted at 406 MHz, 121.5 MHz and 243.0 MHz. Because of a large number of false alerts, and the inability to uniquely identify such beacons because of their old, analogue technology, the Cospas-Sarsat system beginning in 2009 stopped receiving alerts from beacons operating at 121.5 MHz and 243.0 MHz, and now only receives and processes alerts from modern, digital 406-MHz beacons. Many ELTs include both a 406-MHz transmitter for satellite detection and a 121.5 MHz transmitter that can be received by local search crews using direction-finding equipment.

The design of distress beacons as a whole has evolved significantly since 1982. The newest 406-MHz beacons incorporate GPS receivers. Such beacons transmit in their distress message highly accurate position reports. The distress alert and location are forwarded almost instantly to SAR agencies via Cospas-Sarsat satellites. This provides a second method for Cospas-Sarsat to know the location of the distress, in addition to the calculations independently done by Cospas-Sarsat LUTs to determine the location. This two-tiered reliability and global coverage of the system has inspired the current motto of SAR agencies: "Taking the 'Search' out of Search and Rescue.". Technical specifications for the next generation of beacon technology are now being finalized, which will further increase reliability, precision and vital data sent to SAR agencies.

# ***EPILOGUE***

The various radio communication systems required to be equipped with the ships depend on the extent of the ship's operation. All oceans are covered by HF communication services for which the IMO needs to have two stations per area on the ocean coast. Today, almost all vessels are equipped with satellite equipment. And this is necessary in the event of distress or urgency or attempted occupation of the ship, the master may notify other ships, any land earth station and the company of the incident.

As we understand communication systems are very necessary for our shipping. They have saved many lives and give us more security.

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