SPECIFICATION FOR COSPAS-SARSAT 406 MHz DISTRESS BEACONS

C/S T.001
Issue 3 - Revision 3
October 1999

COSPAS SARSAT

October 2000

CORRIGENDUM 1 TO DOCUMENT

" SPECIFICATION FOR COSPAS-SARSAT 406 MHz DISTRESS BEACONS "

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Please make the following amendments to Issue 3 - Revision 3 of C/S T.001. These amendments, shown as ~~strike-out~~ or *Italics*, will be included in the next revision of the document.

- **Page 4 - 4, section 4.5.5.2:**
  Paragraph 4 should read:

"If, after providing valid data, the navigation input fails or is not available, the beacon message shall retain the last valid position for 4 hours *(± 5 min)* after the last valid position data input. After 4 hours the encoded position shall be set to the default values specified in Annex A."

- **Page A - 21, Figure A6:**
  Bit designation 37 - 39 for USER-LOCATION PROTOCOLS should exclude protocol code 100 to read:

3 010 110 001 011 111 ~~100~~	USER-LOCATION PROTOCOLS (P=1) Identification Data (same as User Protocols) See Figure A7

SPECIFICATION FOR COSPAS-SARSAT 406 MHz DISTRESS BEACONS

History

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to define the minimum requirements to be used for the development and manufacture of 406 MHz Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs), and Personal Locator Beacons (PLBs). In this document, the term ELT indicates an aviation distress beacon, an EPIRB a maritime distress beacon, and a PLB a distress beacon for personal use.

Specifications which are critical to the Cospas-Sarsat System are defined in detail; specifications which could be developed by the national authorities are identified in more general terms.

1.2 Scope

This document contains the minimum requirements that apply to Cospas-Sarsat 406 MHz distress beacons. It is divided into the following sections:

a) Section 1 is the introduction.

b) Section 2 gives the system requirements applicable to all types of beacons. When met, these requirements will enable the beacons to provide the intended service in terms of location probability and accuracy and will not disturb the system operation.

c) Section 3 deals with the beacon message content. Basic message structure is defined. Assignment and meaning of the available data bits are defined in Annex A to this specification.

d) Section 4 defines a set of environmental and operational requirements. These requirements are not meant to be exhaustive and may be complemented by more detailed national or international standards (e.g. RTCA standards for ELTs). However, they represent the minimum environmental and operational performance requirements for a 406 MHz beacon to be compatible with the Cospas-Sarsat System.

e) Annex A defines the beacon coding.

f) Annex B provides samples of error-correcting code calculations.

g) Annex C provides a list of acronyms used in this document.

- END OF SECTION 1 -

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2. SYSTEM REQUIREMENTS

2.1 Beacon Functional Elements

This section defines the requirements for the two following functional elements of a 406 MHz distress beacon:

a) digital message generator; and

b) modulator and 406 MHz transmitter.

2.2 Digital Message Generator

The digital message generator will key the modulator and transmitter so that the message defined in section 3 is transmitted.

2.2.1 Repetition Period

The period between transmissions shall be 50 sec ±5 percent. 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 to randomize the period between transmission bursts such that no two beacons will have all of their bursts coincident.

An acceptable alternative for a production run of any type or model of beacon would be an equal distribution of fixed repetition periods of 8 or more values approximately equally spaced over the range of 47.5 to 52.5 seconds.

2.2.2 Total Transmission Time

The total transmission time, measured at the 90 percent power points, shall be 440 ms ±1 percent for the short message and 520 ms ±1 percent for the long message.

2.2.3 Unmodulated Carrier

The initial 160 ms ±1 percent of the transmitted signal shall consist of an unmodulated carrier at the transmitter frequency measured between the 90 percent power point and the beginning of the modulation.

2.2.4 Digital Message

a. Short Message

The final 280 ms ±1 percent of the transmitted signal shall contain a 112-bit message at a bit rate of 400 bps ±1 percent;

b. Long Message

The final 360 ms ±1 percent of the transmitted signal shall contain a 144-bit message at a bit rate of 400 bps ±1 percent.

2.2.4.1 Bit Synchronization

A bit-synchronization pattern consisting of "1"s shall occupy the first 15-bit positions.

2.2.4.2 Frame Synchronization

A frame synchronization pattern consisting of 9 bits shall occupy bit positions 16 through 24. The frame synchronization pattern in normal operation shall be 000101111. However, if the beacon radiates a modulated signal in the self-test mode, the frame synchronization pattern shall be 011010000 (i.e. the last 8 bits are complemented).

2.2.4.3 Format Flag

Bit 25 is a format (F) flag bit used to indicate the length of the message to follow. Value "0" indicates a short message; value "1" indicates a long message.

2.2.4.4 Message Content

The content of the remaining 87 bits (short message - see Figure 2.1) or 119 bits (long message - see Figure 2.2) is defined in section 3.

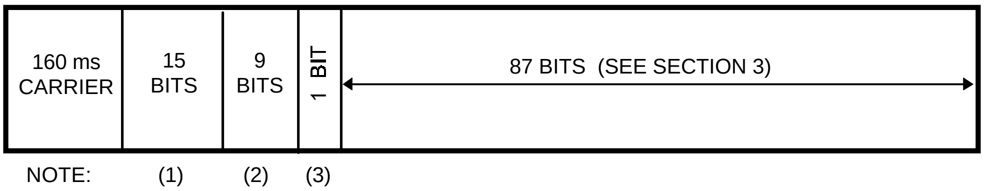

Figure 2.1: Short Message Format

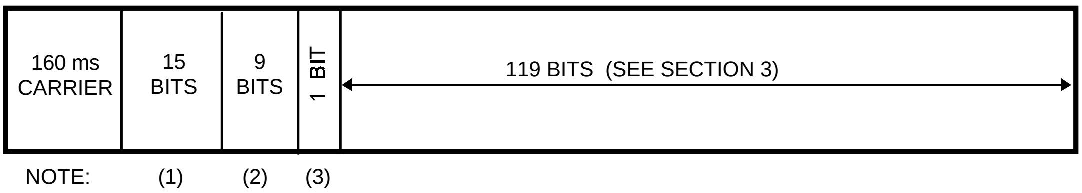

Figure 2.2: Long Message Format

Notes:
(1) Bit Synchronization : 15 "1" bits
(2) Frame Synchronization : 000101111 (except as in section 4.5.4)
(3) "0" bit indicates short-message format
"1" bit indicates long-message format

2.3 Modulator and 406 MHz Transmitter

2.3.1 Transmitted Frequency*

The transmitted frequency shall initially be set at 406.025 MHz $\pm$ 2 kHz. The transmitted frequency shall not vary more than $\pm$ 5 kHz in 5 years including the initial offset. It shall not vary more than 2 parts in 10^9 in 100 ms.

From 1 January 2000 new 406 MHz beacon models submitted for type approval can be set to transmit at 406.028 MHz ± 1 kHz. The transmitted frequency shall not vary more than +2 kHz /-5 kHz from 406.028 MHz in 5 years. It shall not vary more than 2 parts in 10^9 in 100 ms. After 1 January 2002, all new beacon models submitted for type approval must be set at the frequency 406.028 MHz ± 1 kHz and satisfy the above stability requirements.

The transmitted frequency medium-term stability shall be defined by the mean slope of the frequency versus time over a 15-minute period and by the residual frequency variation about the mean slope. The mean slope shall not exceed 1 part in 10^9 per minute. The residual frequency variation shall not exceed 3 parts in 10^9.

This performance shall be met for all defined environmental conditions, including the temperature gradient defined in section 4.2.2, after a maximum warm-up period of 15 minutes.

It is recommended that distress transmissions commence as soon as possible after activation, but in accordance with section 4.5.6.

The mean slope and the residual frequency variation shall be measured as follows: Data shall be obtained by making 18 sequential frequency measurements, one every repetition period (50 sec $\pm$5 percent, see section 2.2.1) over an approximate 15 minute interval; each measurement shall be a 100-ms frequency average performed during the modulated part of the message.

The mean slope is defined as that of the least-squares straight-line fit to the 18 data points. Residual frequency variation is defined as the root mean square (RMS) error of the points relative to the least-squares estimate.

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* This section of the beacon specification only applies to distress beacons, and does not apply to Cospas-Sarsat System beacons (i.e. orbitography or calibration beacons). The transmitted frequency requirements for orbitography beacons are detailed in document C/S T.006.

2.3.2 Transmitter Power Output

The transmitter power output shall be within the limits of 5 W ± 2 dB (35 to 39 dBm) measured into a 50-Ohm load with a voltage standing-wave ratio (VSWR) not greater than 1.25:1. This power output shall be maintained during 24-hour operation at any temperature throughout the specified operating temperature range. Power output rise time shall be less than 5 ms measured between the 10% and 90% power points. The power output is assumed to rise linearly from zero and therefore must be zero prior to about 0.6 ms before the beginning of the rise time measurement; if it is not zero, the maximum acceptable level is -10 dBm.

2.3.3 Antenna Characteristics

The following antenna characteristics are defined for elevation angles greater than 5° and less than 60°:

- Pattern : hemispherical
- Polarization : circular (RHCP) or linear
- Gain : between -3 dBi and 4 dBi over 90% of the above region
- Gain variation (azimuth) : less than 3 dB
- Antenna VSWR : not greater than 1.5:1

The antenna characteristics should be measured in a configuration as close as possible to its operational condition.

2.3.4 Spurious Emissions

The in-band spurious emissions shall not exceed the levels specified by the signal mask in Figure 2.3, when measured in a 100 Hz resolution bandwidth.

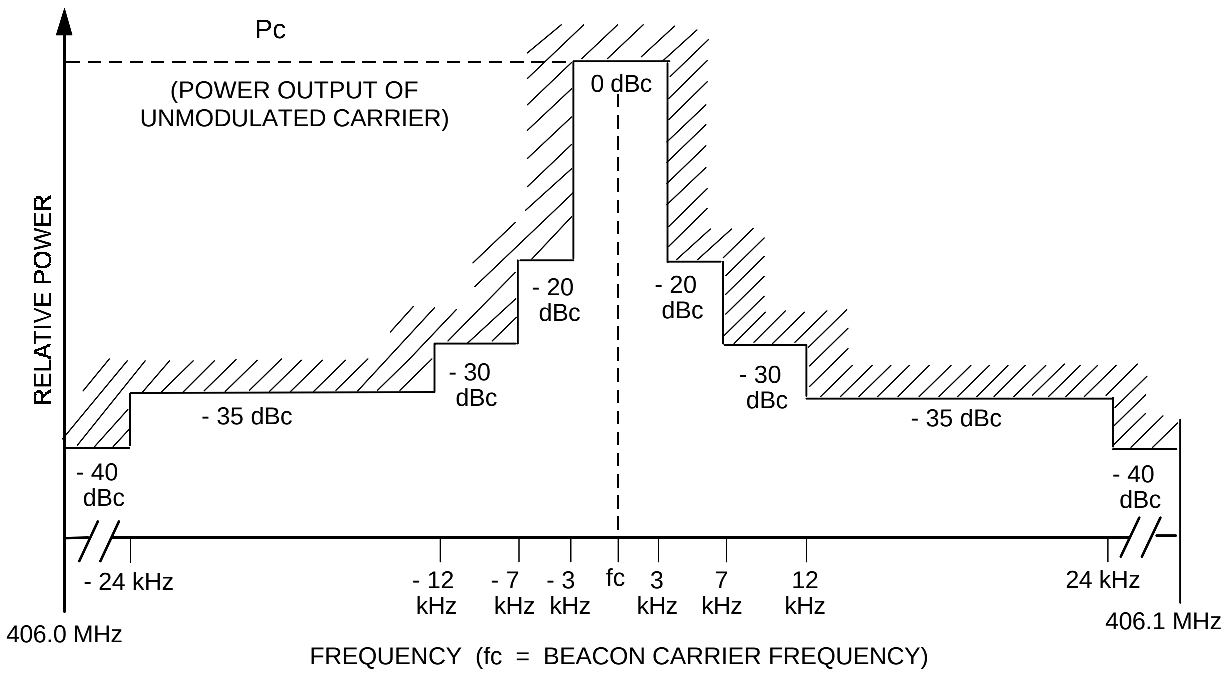


Figure 2.3: Spurious Emission Mask for 406.0 to 406.1 MHz Band

2.3.5 Data Encoding

The data shall be encoded biphase L, as shown in Figure 2.4.

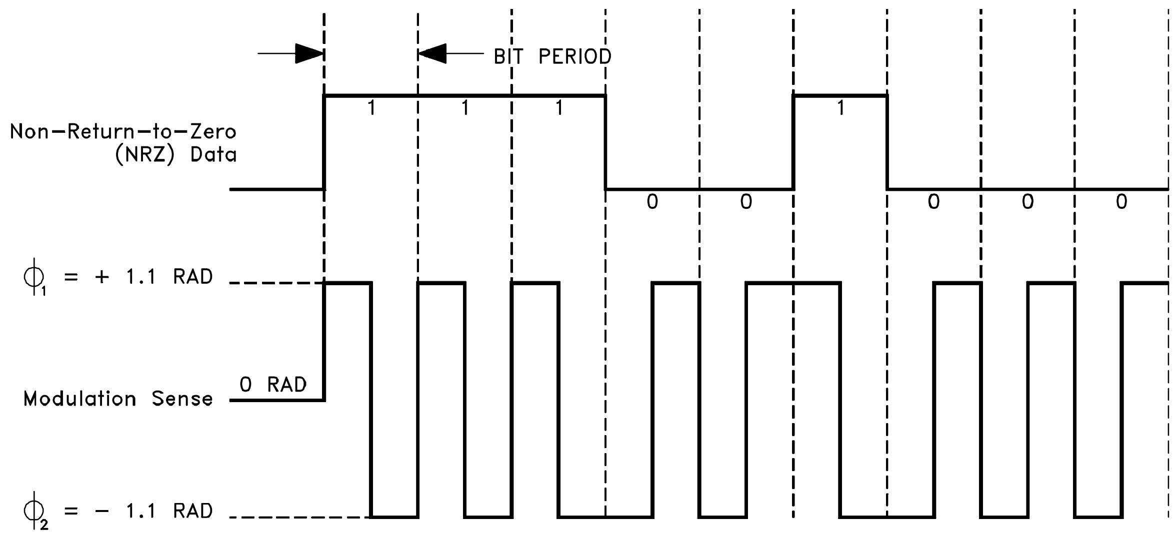


Figure 2.4: Data Encoding and Modulation Sense

2.3.6 Modulation

The carrier shall be phase modulated positive <u>and</u> negative 1.1 ± 0.1 radians peak, referenced to an unmodulated carrier. Positive phase shift refers to a phase advance relative to nominal phase. Modulation sense shall be as shown in Figure 2.4.

The rise (τ_R) and fall (τ_F) times of the modulated waveform, as shown in Figure 2.5, shall be 150 ± 100 µs.

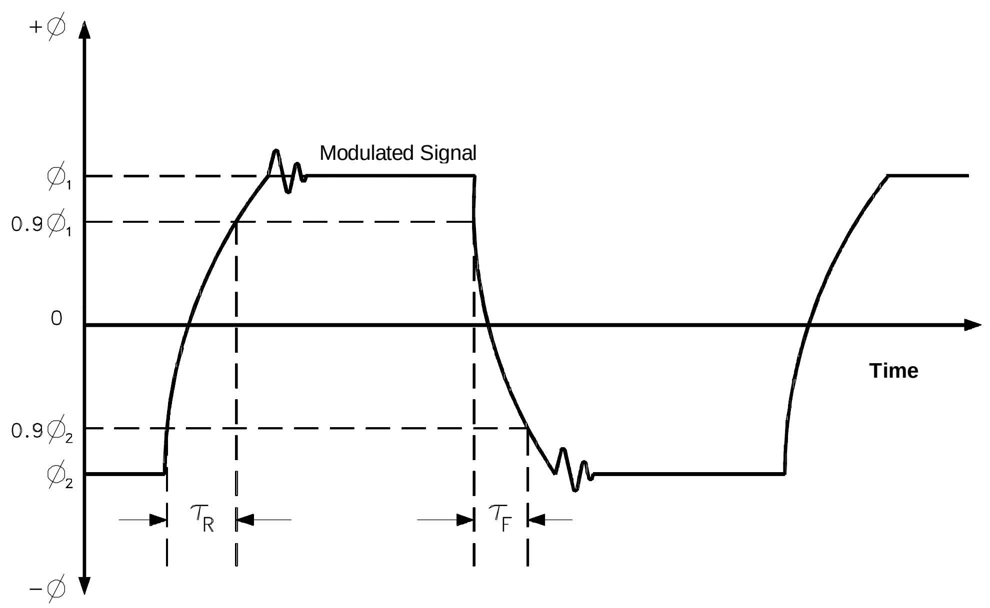


Figure 2.5*: Definition of Modulation Rise and Fall Times

* Figure not to scale.

Modulation symmetry (see Figure 2.6) shall be such that:

$$\frac{|\tau_1 - \tau_2|}{\tau_1 + \tau_2} \leq 0.05$$

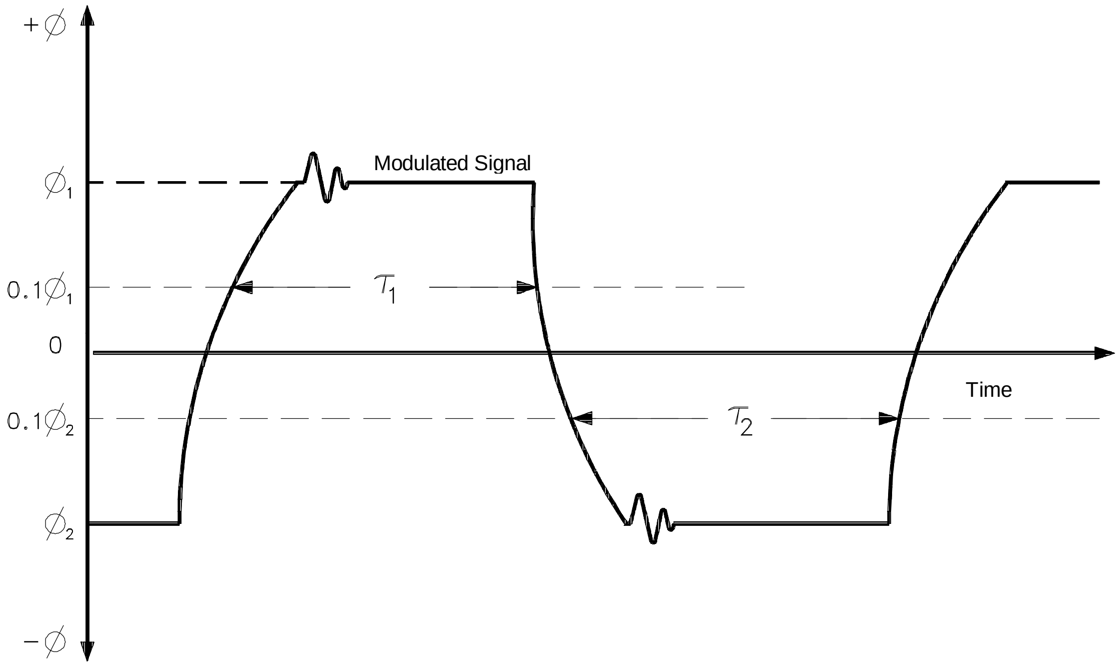


Figure 2.6*: Definition of Modulation Symmetry

* Figure not to scale.

2.3.7 Voltage Standing-Wave Ratio

The modulator and 406 MHz transmitter shall be able to meet all requirements, except for those in paragraph 2.3.2 (transmitter power output), at any VSWR between 1:1 and 3:1, and shall not be damaged by any load from open circuit to short circuit.

2.3.8 Maximum Continuous Transmission

The distress beacon shall be designed to limit any inadvertent continuous 406 MHz transmission to a maximum of 45 seconds.

- END OF SECTION 2 -

3. DIGITAL MESSAGE STRUCTURE

3.1 Basic Structure

The digital message which is transmitted by the 406 MHz beacon consists of:

a) 112 bits for the short message; and

b) 144 bits for the long message.

These bits are divided into five groups:

(1) The first 24 bits transmitted, positions 1 through 24, are system bits; they are defined in section 2 and are used for bit and frame synchronization.

(2) The following 61 bits, positions 25 through 85, are data bits. This bit group is referred to as the first protected data field (PDF-1). The first data bit (position 25) indicates if the message is short or long: "0" = short message, "1" = long message.

(3) The following 21 bits, positions 86 through 106, are a Bose-Chaudhuri-Hocquenhem or BCH (82,61) error-correcting code. This bit group is referred to as the first BCH error correcting field (BCH-1). This code is a shortened form of a BCH (127,106) triple error-correcting code, as described in Annex B. This code can detect and correct up to three bit errors in the 82 bits of (PDF-1 + BCH-1). The combination of PDF-1 and BCH-1 is referred to as the first protected field.

(4) The following group consists of data bits, the number and definition of these bits depends on the message format, as follows:

a) Short message: the last 6 bits of the message in positions 107 through 112, these data bits are not protected. This bit group is referred to as the non-protected data field;

b) Long message: the following 26 bits of the message in positions 107 through 132. This bit group is referred to as the second protected data field (PDF-2).

(5) The last 12 bits of the long message, positions 133 through 144, are a Bose-Chaudhuri-Hocquenhem or BCH (38,26) error-correcting code. This bit group is referred to as the second BCH error correcting field (BCH-2). This code is a shortened form of a BCH (63,51) double error-correcting code, as described in Annex B. This code can detect and correct up to 2 bit errors in the 38 bits of (PDF-2 + BCH-2). The combination of PDF-2 and BCH-2 is referred to as the second protected field.

3.2 Beacon Coding

Beacon coding methods are defined in Annex A to this specification. Specific operational requirements for beacon coding, such as the self-test mode and the encoding of position data, are defined in section 4 of this specification.

The 15 hexadecimal characters that uniquely identify each 406 MHz beacon is called the beacon identification or beacon 15 Hex ID. This beacon identification comprises bits 26 to 85 of PDF-1. For location protocols, the position data bits in PDF-1 are set to the default values specified in Annex A. It is recommended that the beacon 15 Hex ID be permanently marked on the exterior of the beacon.

- END OF SECTION 3 -

4. ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS

4.1 General

As explained in section 1.2, the environmental and operational requirements defined in this section are not intended to be exhaustive. They are minimum requirements which may be complemented by national or international standards.

4.2 Thermal Environment

4.2.1 Operating Temperature Range

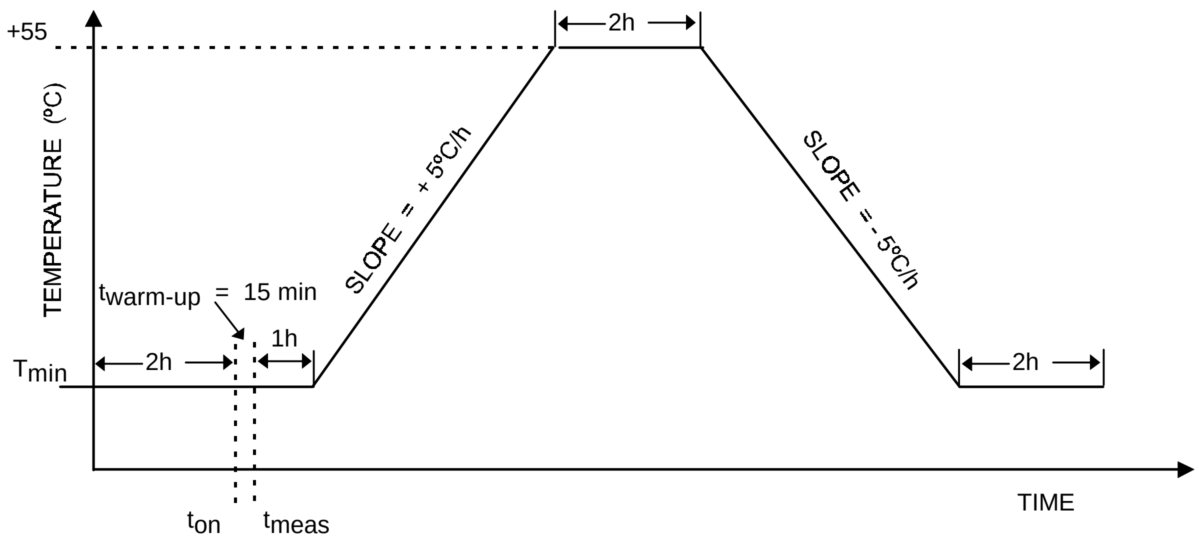
Two standard classes of operating temperature range are defined, inside which the system requirements of section 2 shall be met:

Class 1: -40°C to +55°C
Class 2: -20°C to +55°C

The operating temperature range shall be permanently marked on the beacon.

4.2.2 Temperature Gradient

All system requirements of section 2, including the frequency requirements defined in section 2.3.1, shall be met when the fully packaged beacon is subjected to the temperature gradient shown in Figure 4.1.



NOTES: T_{min} = - 40°C (Class 1 beacon)
T_{min} = - 20°C (Class 2 beacon)
t_{on} = beacon turn-on time after 2 hour “cold soak”
t_{meas} = start time of frequency stability measurement (t_{on} + 15 min)

Figure 4.1: Temperature Gradient

4.2.3 Thermal Shock

All system requirements of section 2 shall be met for measurements beginning 15 minutes after simultaneously activating the beacon and applying a thermal shock of 30°C within the specified operating temperature range of the beacon. Subsequently, system requirements shall continue to be met for a minimum period of two (2) hours.

4.3 Mechanical Environment

Beacons shall be submitted to vibration and shock tests consistent with their intended use.

Internationally-recognized standards such as RTCA/DO-183 for ELTs could be used by the national authorities.

4.4 Other Environmental Requirements

Other environmental requirements such as humidity tests, altitude tests, over/under pressure tests, waterproofness tests, sand and dust tests, fluids susceptibility tests, etc., may be defined by national authorities, preferably using internationally-recognized standards.

4.5 Operational Requirements

4.5.1 Duration of Continuous Operation

The minimum duration of continuous operation shall be at least 24 hours* at any temperature throughout the specified operating temperature range. This characteristic shall be permanently marked on the beacon.

4.5.2 Other Operational Requirements

Other operational requirements such as installation and maintenance methods, remote monitoring, activation methods on planes or boats, etc. may be defined by national authorities.

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* For installations meeting IMO GMDSS requirements, a minimum operating lifetime of 48 hours at any temperature throughout the specified operating temperature range is necessary.

4.5.3 Auxiliary Radio-Locating Device

The distress beacon may incorporate an auxiliary radio-locating device at another frequency (121.5 MHz, 9 GHz SART, etc.) which is compatible with existing radio-locating equipment.

Any such auxiliary radio-locating device must satisfy all the national performance standards applicable to radio-locating devices at the selected auxiliary frequency.

4.5.4 Beacon Self-Test Mode

Beacons in the self-test mode may transmit a digital message encoded in accordance with Annex A to this specification. For location protocol beacons the content of the encoded position data field of the self-test message shall be the default values specified in Annex A. The content of the self-test message shall always provide the beacon 15 Hex ID.

If the beacon transmits in the self-test mode the signal must have a frame synchronization pattern of 011010000. This bit pattern complements the last 8 bits of the normal frame synchronization pattern so that this test burst will not be processed by the satellite equipment.

The complete self-test transmission must be limited to one burst only. The maximum duration of the self-test mode transmission should be 440 ms (+1%) for a short message and 520 ms (+1%) for a long message. If a 440 ms transmission is used for beacons encoded with the long format messages, it is recommended that the message be truncated without changing the format flag bit.

4.5.5 Encoded Position Data*

4.5.5.1 General

Beacon position data, obtained from a navigation device internal or external to the beacon, may be encoded in the beacon message. Position data can be encoded in either the short message, the long message extension, or some in both parts of the message.

Note: * ELTs carried to satisfy the requirements of ICAO Annex 6, Parts I, II and III shall operate in accordance with ICAO Annex 10.

Three levels of position resolution can be encoded in the beacon message:

- position data with resolution of 4 seconds in PDF-2, given as an offset of the position data provided in PDF-1 with a resolution of either 15 minutes or 2 minutes;
- position data with resolution of 4 minutes in PDF-2, together with any of the user protocol identification methods used in PDF-1; and
- position data in the short message with a resolution of either 15 minutes or 2 minutes, together with a subset of the beacon identification methods (i.e. with shortened identification data).

Operation or failure of an internal or external navigation device providing position data to the beacon shall not degrade beacon performance.

4.5.5.2 Message Content and Timing

Position data shall be encoded into the beacon message according to one of the methods specified in Annex A. The identification data and encoded position data are protected by a BCH error-correcting code. A 21-bit BCH code protects the data of the first protected field (PDF-1 and BCH-1) and a 12-bit BCH code protects the data of the second protected field (PDF-2 and BCH-2). The BCH codes shall always match the message content. The beacon shall recompute these codes each time the message content is changed.

The beacon shall commence transmissions upon activation even if no valid position data are available. Until valid data is available, the content of the encoded position data field of the message shall be the default values specified in Annex A. The first input of position data into the beacon message shall occur as soon as valid data is available. If the beacon has the capability to provide updated position data, subsequent transmissions of the updated position shall not occur more frequently than every 20 minutes.

If, after providing valid data, the navigation input fails or is not available, the beacon message shall retain the last valid position for 4 hours after the last valid position data input. After 4 hours the encoded position shall be set to the default values specified in Annex A.

If the beacon radiates a 406 MHz signal in the self-test mode, the content of the encoded position of the self-test message shall be set to the default values specified in Annex A.

4.5.5.3 Internal Navigation Device Performance

An internal navigation device shall be capable of global operation and shall conform to an applicable international standard. An internal navigation device shall incorporate self-check features to ensure that erroneous position data is not encoded into the beacon message. The self-check features shall prevent position data from being encoded into the beacon message unless minimum performance criteria are met. These criteria could include the proper internal functioning of the device, the presence of a sufficient number of navigation signals, sufficient quality of the signals, and sufficiently low geometric dilution of precision.

The distance between the position provided by the navigation device, at the time of the position update, and the true beacon position shall not exceed 5 km.

The internal navigation device shall provide valid data within 30 minutes after its activation.

4.5.5.4 External Navigation Device Input

It is recommended that beacons which are designed to accept data from an external navigation device be compatible with an applicable international standard, such as the IEC Standard on Digital Interfaces (IEC Publication 1162).

Features should be provided to ensure that erroneous position data is not encoded into the beacon message.

For a beacon designed to operate with an external navigation device, if appropriate navigation data input is present, the beacon shall produce a digital message with the properly encoded position data and BCH code(s) within 1 minute after its activation.

If a beacon is designed to accept position data from an external navigation device prior to beacon activation, navigation data input should be provided at intervals not longer than:

- 20 minutes for EPIRBs and PLBs; or
- 1 minute for ELTs.

4.5.6 Beacon Activation

The beacon should be designed to prevent inadvertent activation.

After activation, the beacon shall not transmit a 406 MHz distress message until at least one repetition period (as defined in section 2.2.1) has elapsed.

- END OF SECTION 4 -

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ANNEXES
TO THE SPECIFICATION FOR
COSPAS-SARSAT
406 MHz DISTRESS BEACONS

ANNEX A

BEACON CODING

A1 GENERAL

A1.1 Summary

This annex defines the 406 MHz beacon digital message coding. The digital message is divided into various bit fields as follows:

Short Message Format (see Figure A1)

Bit Field Name	Bit Field Location
1. Bit synchronization	bit 1 through bit 15
2. Frame synchronization	bit 16 through bit 24
3. First protected data field (PDF-1)	bit 25 through bit 85
4. First BCH error correcting field (BCH-1)	bit 86 through bit 106
5. Non-protected data field	bit 107 through bit 112

Long Message Format (see Figure A2)

Bit Field Name	Bit Field Location
1. Bit synchronization	bit 1 through bit 15
2. Frame synchronization	bit 16 through bit 24
3. First protected data field (PDF-1)	bit 25 through bit 85
4. First BCH error correcting field (BCH-1)	bit 86 through bit 106
5. Second protected data field (PDF-2)	bit 107 through bit 132
6. Second BCH error correcting field (BCH-2)	bit 133 through bit 144

The bit synchronization and frame synchronization fields are defined in sections 2.2.4.1 and 2.2.4.2, respectively.

The first protected data field (PDF-1) and the non-protected data field of the short message are defined in section 3.1 and section A2 of this Annex, and shown in Figures A1, A3 and A4.

The first protected data field (PDF-1) and the second protected data field (PDF-2) of the long message are defined in section 3.1 and section A3 of this Annex, and shown in Figures A2, A5, A6, A7, A8 and A9.

The BCH error correcting fields BCH-1 and BCH-2 fields are defined in section 3.1 and the corresponding 21 bit BCH error-correcting code and 12 bit BCH error-correcting code are described at Annex B.

A1.2 Message Format Flag, Protocol Flag, and Country Code

The bit allocations for the message format flag, protocol flag and country code are identical in all beacon protocols. They are assigned in PDF-1 of the short and the long messages as follows:

Bits	Usage
25	format flag (F)
26	protocol flag (P)
27-36	country code

A1.2.1 Format Flag

The format flag (bit 25) shows whether the message is short or long using the following code:

F=0	short format
F=1	long format

A1.2.2 Protocol Flag

The protocol flag (bit 26) indicates which type of protocol is used to define the structure of encoded data, according to the following code:

P=0	standard-short location protocols, standard location protocols, national-short location protocol or national location protocol
P=1	user protocols or user-location protocols.

The various protocols are identified by a specific protocol code, as described in section A1.3.

A1.2.3 Country Code

Bits 27-36 designate a three-digit decimal country code number expressed in binary notation. Country codes are based on the International Telecommunication Union (ITU) Maritime Identification Digit (MID) country code shown in Table 1 of Appendix 43 of the ITU Radio Regulations. National administrations allocated more than one MID code may opt to use only one of these codes. However, when the 6 trailing digits of a MMSI are used to form the unique beacon identification, the country code shall always correspond to the first 3 digits of the MMSI code.

For all types of protocols, except the test protocols, the country code designates the country of beacon registration, where additional information can be obtained from a data base.

A1.3 Protocol Codes

Each coding protocol is identified by a unique protocol code defined as follows:

- 3-bit code in bits 37 to 39, for the user protocols and the user-location protocols;

- 4-bit code in bits 37 to 40, for the standard-short location protocol, the standard location protocol, the national-short location protocol or the national location protocol.

Table A1 shows the combinations of the format flag and the protocol flag which identify each category of coding protocols. The protocol codes assignments are summarized in Table A2.

Table A1: Format Flag and Protocol Flag Combinations

Format Flag (bit 25) → **Protocol Flag (bit 26) ↓**	**0** **(short)**	**1** **(long)**
0 **(protocol code: bits 37-40)**	Standard-Short Location Protocols National-Short Location Protocol	Standard Location Protocols National Location Protocol
1 **(protocol code: bits 37-39)**	User Protocols	User Protocols User-Location Protocols

Figure A1: Data Fields of the Short Message Format

	Bit Synchronization	Frame Synchronization	First Protected Data Field (PDF-1)				BCH-1	Non-Protected Data Field
Unmodulated Carrier (160 ms)	Bit Synchronization Pattern	Frame Synchronization Pattern	Format Flag	Protocol Flag	Country Code	Identification or Identification plus Position Data	21-Bit BCH Code	Emergency Code/ National Use or Supplement. Data
Bit No.	1-15	16-24	25	26	27-36	37-85	86-106	107-112
	15 bits	9 bits	1 bit	1 bit	10 bits	49 bits	21 bits	6 bits

Figure A2: Data Fields of the Long Message Format

	Bit Synchronization	Frame Synchronization	First Protected Data Field (PDF-1)				BCH-1	Second Protected Data Field (PDF-2)	BCH-2
Unmodulated Carrier (160 ms)	Bit Synchronization Pattern	Frame Synchronization Pattern	Format Flag	Protocol Flag	Country Code	Identification or Identification plus Position Data	21-Bit BCH Code	Supplementary and Position or National Use Data	12-Bit BCH Code
Bit No.	1-15	16-24	25	26	27-36	37-85	86-106	107-132	133-144
	15 bits	9 bits	1 bit	1 bit	10 bits	49 bits	21 bits	26 bits	12 bits

Table A2: Protocol Codes Assignments

A2-A: User Protocol and User-Location Protocol **(F=0, P=1) short message**
(F=1, P=1) long message

		Protocol Codes (Bits 37 - 39)
1. EPIRB - Maritime User Protocol:	(MMSI, 6 digits)	010
	(radio call sign, 6 characters)	010
2. EPIRB - Radio Call Sign User Protocol		110
3. ELT - Aviation User Protocol	(aircraft registration markings)	001
4. Serial User Protocol:		011

bits 40, 41, 42 used to identify beacon type:
- 000 ELTs with serial identification number;
- 001 ELTs with aircraft operator designator & serial number;
- 010 float free EPIRBs with serial identification number;
- 100 non float free EPIRBs with serial identification number;
- 110 PLBs with serial identification number;
- 011 ELTs with aircraft 24-bit address;
- 101 & 111 spares.

bit 43 = 0: serial identification number is assigned nationally; or
bit 43 = 1: identification data include the C/S type approval certificate number.

	Protocol Codes (Bits 37 - 39)
5. Test User Protocol	111
6. Orbitography Protocol	000
7. National User Protocol *	100
8. Spare	101

A2-B: Standard-Short and National-Short Location Protocols **(F=0, P=0) short message**
Standard Location and National Location Protocols **(F=1, P=0) long message**

		Protocol Codes (Bits 37 - 40)
Standard-Short Location Protocols and Standard Location Protocols		
1. EPIRB - MMSI/Location Protocol		0010
2. ELT - 24-bit Address/Location Protocol		0011
3. Serial Location Protocols	a) ELT - serial	0100
	b) ELT - aircraft operator designator	0101
	c) EPIRB-serial	0110
	d) PLB-serial	0111
4. National-Short Location Protocol and National Location Protocol		
	a) ELT	1000
	b) Spare	1001
	c) EPIRB	1010
	d) PLB	1011
5. Test location Protocols		
	a) Standard Test Location Protocol	1110
	b) National Test Location Protocol	1111
6. Reserved (orbitography)		0000, 0001
7. Spare		1100, 1101

* The National User Protocol has certain bits which are nationally defined, as described in section A2.8.

A2 USER PROTOCOLS

This section defines the user protocol message formats which can be used to encode the beacon identification and other data in the message transmitted by a 406 MHz distress beacon.

A2.1 Structure of User Protocols

The user protocols have the following structure:

bits	usage
25	format flag (short message =0, long message =1)
26	protocol flag (=1)
27-36	country code
37-39	protocol code
40-83	identification data
84-85	auxiliary radio-locating device type(s)

Bits 37-39 in the protocol code field designate one of the user protocol codes as listed in Table A2-A, and indicate how the remaining bits of identification data are encoded/decoded.

Bits 40-83 are used to encode the identification data of the beacon and, together with the protocol flag, the country code, the protocol code, and bits 84-85, shall form a unique identification for each beacon, i.e. the beacon 15 Hex ID. They will be discussed separately for each user protocol.

Bits 84-85 are used to indicate for all user protocols excluding the orbitography protocol, the type of auxiliary radio-locating device(s) forming part of the particular beacon. The assignment of bits is as follows:

bits 84-85	auxiliary radio-locating device type
00	no auxiliary radio-locating device
01	121.5 MHz
10	maritime 9 GHz Search and Rescue Radar Transponder (SART)
11	other auxiliary radio-locating device(s)

If other auxiliary radio-locating device(s) is (are) used in addition to 121.5 MHz, the code for 121.5 MHz (i.e. 01) should be used.

The bit assignments for user protocols, in PDF-1 of the 406 MHz beacon digital message, are summarized in Figure A3.

Figure A3: Bit Assignment for the First Protected Data Field (PDF-1) of User Protocols

1. MARITIME USER PROTOCOL

Bits	25	26	27 36	37 39	40 81	82 83	84 85
.....	0	1	Country Code	0 1 0	MMSI or Radio Call Sign (42 bits)	0 0	R L

2. RADIO CALL SIGN USER PROTOCOL

Bits	25	26	27 36	37 39	40 81	82 83	84 85
.....	0	1	Country Code	1 1 0	Radio Call Sign (42 bits)	0 0	R L

3. SERIAL USER PROTOCOL

Bits	25	26	27 36	37 39	40 42	43	44 73	74 83	84 85
.....	0	1	Country Code	0 1 1	T T T	C	Serial Number and other Data	C/S Cert. No or National Use	R L

4. AVIATION USER PROTOCOL

Bits	25	26	27 36	37 39	40 81	82 83	84 85
.....	0	1	Country Code	0 0 1	Aircraft Registration Marking (42 bits)	0 0	R L

5. NATIONAL USER PROTOCOL

Bits	25	26	27 36	37 39	40 85
......	F	1	Country Code	1 0 0	National Use (46 bits)

6. TEST USER PROTOCOL

Bits	25	26	27 36	37 39	40 85
.....	F	1	Country Code	1 1 1	Test Beacon Data (46 bits)

7. ORBITOGRAPHY PROTOCOL

Bits	25	26	27 36	37 39	40 85
......	F	1	Country Code	0 0 0	Orbitography Data (46 bits)

<u>Notes</u>:

RL = Auxiliary radio-locating device (see section A2.1)

TTT =
- 000 - ELT with serial number
- 011 - ELT with 24-bit aircraft address
- 001 - ELT with aircraft operator designator and serial number
- 010 - float free EPIRB with serial number
- 100 - non float free EPIRB with serial number
- 110 - personal locator beacon (PLB) with serial number

C = C/S Type Approval Certificate Flag:
"1" = C/S Type Approval Certificate number encoded in bits 74 to 83
"0" = other national use

F = Format Flag ("0" = short message, "1" = long message)

Table A3: Modified-Baudot Code

Letter	Code MSB LSB	Letter	Code MSB LSB	Figure	Code MSB LSB
A	111000	N	100110	( )*	100100
B	110011	O	100011	(-)**	011000
C	101110	P	101101	/	010111
D	110010	Q	111101	0	001101
E	110000	R	101010	1	011101
F	110110	S	110100	2	011001
G	101011	T	100001	3	010000
H	100101	U	111100	4	001010
I	101100	V	101111	5	000001
J	111010	W	111001	6	010101
K	111110	X	110111	7	011100
L	101001	Y	110101	8	001100
M	100111	Z	110001	9	000011

MSB: most significant bit
LSB: least significant bit

* Space
** Hyphen

Note: The modified-Baudot code is used to encode alphanumeric characters in EPIRB messages containing MMSI or radio call sign identification, and in ELTs containing the aircraft registration marking or the 3-letter aircraft operator designator.

A2.2 Maritime User Protocol

The maritime user protocol has the following structure:

Bits	Usage
25	format flag (=0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=010)
40-75	radio call sign or trailing 6 digits of MMSI
76-81	specific beacon number
82-83	spare (=00)
84-85	auxiliary radio-locating device type(s)

Bits 40-75 designate the radio call sign or the last 6 digits of the 9 digit maritime mobile service identity (MMSI) using the modified-Baudot code shown in Table A3.

This code enables 6 characters to be encoded using 36 bits (6x6 = 36). This data will be right justified with a modified-Baudot space (100100) being used where no character exists. If all characters are digits, the entry is interpreted as the trailing 6 digits of the MMSI.

Bits 76 to 81 are used to identify specific beacons on the same vessel (the first or only float free beacon shall be coded with a modified-Baudot zero (001101); additional beacons shall be numbered consecutively using modified-Baudot characters 1 to 9 and A to Z).

The maritime user and the radio call sign user protocols may be used for beacons that require coding with a radio call sign. The maritime user protocol may be used for radio call signs of 6 or fewer characters. Radio call signs of 7 characters must be encoded using the radio call sign user protocol.

A2.3 Radio Call Sign User Protocol

The radio call sign user protocol is intended to accommodate a vessel's radio call sign of up to seven characters, where letters may be used only in the first four characters, thereby complying with the ITU practice on formation of radio call signs.

The radio call sign user protocol has the following structure:

Bits	Usage
25	format flag (=0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=110)
40-75	radio call sign
• 40-63	first 4 characters (modified-Baudot)
• 64-75	last 3 characters (binary-coded decimal)
76-81	specific beacon number
82-83	spare (=00)
84-85	auxiliary radio-locating device type(s)

Bits 40 to 75 contain the radio call sign of up to 7 characters. Radio call signs of fewer than 7 characters should be left justified in the radio call sign field (bits 40-75) and padded with "space" (1010) characters in the binary-coded decimal field (bits 64-75).

Bits 76 to 81 are used to identify specific beacons on the same vessel (the first or only float free beacon shall be coded with a modified-Baudot zero (001101); additional beacons shall be numbered consecutively using modified-Baudot characters 1 to 9 and A to Z).

A2.4 Aviation User Protocol

The aviation user protocol has the following structure:

Bits	Usage
25	format flag (=0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=001)
40-81	aircraft registration marking
82-83	spare (=00)
84-85	auxiliary radio-locating device type(s)

Bits 40-81 designate the aircraft registration marking which is encoded using the modified-Baudot code shown in Table A3. This code enables 7 characters to be encoded using 42 bits (6x7=42). This data will be right justified with a modified-Baudot space (100100) being used where no character exists.

A2.5 Serial User Protocol

The serial user protocol is intended to permit the manufacture of beacons whose 15 Hex ID will be identified in a data base giving specifics about the unit. The following types of serial identification data can be encoded in the beacon:

- serial number
- 24-bit aircraft address number
- aircraft operator designator and a serial number.

Bits 40-42 indicate the beacon type with serial identification data encoded, as follows:

000 indicates an aviation ELT serial number is encoded in bits 44-63
010 indicates a maritime float free EPIRB serial number is encoded in bits 44-63
100 indicates a maritime non float free EPIRB serial number is encoded in bits 44-63
110 indicates a personal locator beacon (PLB) serial number is encoded in bits 44-63
011 indicates the aircraft 24-bit address is encoded in bits 44-67 and each additional ELT on the same aircraft is numbered in bits 68-73
001 indicates an aircraft operator designator and a serial number are encoded in bits 44-61 and 62-73, respectively.

Bit 43 is a flag bit to indicate that the Cospas-Sarsat type approval certificate number is encoded.

If bit 43 is set to 1:

- bits 64-73 should either be set to all 0s or allocated for national use and control (and will be made public when assigned by the responsible administration) or used as defined for coding the aircraft 24-bit address or aircraft operator designator;

- bits 74-83 should be encoded with the Cospas-Sarsat type approval certificate number which is assigned by the Cospas-Sarsat Secretariat for each beacon model approved according to the type approval procedure of document C/S T.007. The certificate number is to be encoded in binary notation with the least significant bit on the right.

If bit 43 is set to 0:

- bits 64-83 are for national use and control (and will be made public when assigned by the responsible administration) or used as defined for coding the aircraft 24-bit address or aircraft operator designator.

Details of each type of serial identification data are given hereunder.

A2.5.1 Serial Number

The serial user protocol using a serial number encoded in the beacon message has the following structure:

```
Bits  25 26 27          36 37    40     44              63 64          73 74           83  85
   |  |  | Country      |      |     | |   (20 bits)     |  All "0" or | C/S cert. No.  |   |
   |0 |1 | Code         |0 1 1 |T T T|C|  Serial Number  |  Nat. Use   | or Nat. Use    |R L|
```

Bits	Usage
25	format flag (= 0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=000, 010, 100 or 110)
43	flag bit for Cospas-Sarsat type approval certificate number
44-63	serial number
64-73	all 0s or national use
74-83	C/S type approval certificate number or national use
84-85	auxiliary radio-locating device type(s)

Bits 44-63 designate a serial identification code number ranging from 0 to 1,048,575 (i.e. 2^{20}-1) expressed in binary notation, with the least significant bit on the right.

This serial number encoded in the beacon message is not necessarily the same as the production serial number of the beacon.

A2.5.2 Aircraft 24-bit Address

The serial user protocol using the aircraft 24-bit address has the following structure:

Bits 25	26	27 36	37	40		44 67	68 73	74 83	85
0	1	Country Code	0 1 1	0 1 1	C	Aircraft 24-bit Address	Additional ELT No.s	C/S Cert.No. or Nat. Use	R L

Bits	Usage
25	format flag (= 0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=011)
43	flag bit for Cospas-Sarsat type approval certificate number
44-67	aircraft 24-bit address
68-73	ELT number of additional ELTs carried on same aircraft
74-83	C/S type approval certificate number or national use
84-85	auxiliary radio-locating device type(s)

Bits 44-67 are a 24-bit binary number assigned to the aircraft. Bits 68-73 contain the ELT number, in binary notation with the least significant bit on the right, of additional ELTs carried in the same aircraft or default to 0s when only one ELT is carried.

A2.5.3 Aircraft Operator Designator and Serial Number

The serial user protocol using the aircraft operator designator and serial number has the following structure:

Bits 25	26	27 36	37	40		44 61	62 73	74 83	85
0	1	Country Code	0 1 1	0 0 1	C	Operator 3-letter Designator	Serial Number	C/S Cert. No. or Nat. Use	R L

Bits	Usage
25	format flag (=0)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=001)
43	flag bit for Cospas-Sarsat type approval certificate number
44-61	aircraft operator designator

62-73	serial number assigned by operator
74-83	C/S type approval certificate number or national use
84-85	auxiliary radio-locating device type(s)

Bits 44-61 are a 3-letter aircraft operator designator from the list* of "Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services" published by the International Civil Aviation Organization (ICAO). The 3 letters are encoded using the modified-Baudot code of Table A3.

Bits 62 to 73 are a serial number (in the range of 1 up to 4095) as designated by the aircraft operator, encoded in binary notation, with the least significant bit on the right.

A2.6 Test User Protocol

The test user protocol will be used for demonstrations, type approval, national tests, training exercises, etc.. Mission Control Centres (MCCs) will not forward messages coded with this protocol unless requested by the authority conducting the test.

The test user protocol has the following structure:

Bits	Usage
25	format flag (short message = 0, long message = 1)
26	protocol flag (=1)
27-36	country code
37-39	test user protocol code (=111)
40-85	national use

A2.7 Orbitography Protocol

The orbitography protocol is for use by special system calibration transmitters and is intended for use only by operators of the Local User Terminals. Therefore, it is not further described in this document.

* The list of designators, comprising about 3000 operating agencies, authorities or services world-wide, is published by ICAO in document 8585, and can be purchased from ICAO in printed and electronic form.

A2.8 National User Protocol

The national user protocol is a special coding format having certain data fields, indicated as "national use", which are defined and controlled by the national administration of the particular country which is coded into the country code field.

The national user protocol may be either a short or a long message, as indicated by the format flag (bit 25). The correct BCH code(s) must be encoded in bits 86-106, and in bits 133-144 if a long message is transmitted.

The national user protocol has the following structure:

```
Bits  25 26 27       36|37    |40                          85 86        106 107       132|133  144|
   ---|---|--|----------|------|----------------------------|--------------|-----------|--------|
      |   |  | Country  |      |       National Use         |    BCH Code  |National Use  BCH Code|
      |F  |1 | Code     |1 0 0 |        (46 bits)           |   (21 bits)  |  (26 bits)  |(12 bits)
    __|___|__|__________|______|____________________________|______________|___________|________|
```

Bits	Usage
25	format flag (short message =0, long message =1)
26	protocol flag (=1)
27-36	country code
37-39	national user protocol code (=100)
40-85	national use
86-106	21-bit BCH code
107-112	national use
113-132	national use (if long message)
133-144	12-bit BCH code (if long message)

Once the beacon has been activated, the content of the message in bits 1 to 106 must remain fixed, but bits 107 onwards are permitted to be changed periodically, provided the correct 12-bit BCH code is also recomputed and that such changes do not occur more frequently than once every 20 minutes.

It should be noted that distress alert messages encoded with the national user protocol can be passed within the Cospas-Sarsat System only as hexadecimal data, and the content of the message can only be interpreted by the appropriate national administration.

A2.9 Non-Protected Data Field

The non-protected data field consists of bits 107 to 112, which can be encoded with emergency code / national use data as described below. However, when neither the emergency code nor the national use data have been implemented, nor such data entered, the following default coding should be used for bits 107 to 112:

000000: for beacons that can be activated only manually,
i.e. bit 108 = 0 (see below)

010000: for beacons that can be activated both manually and automatically, i.e. bit 108 = 1 (see below).

Bit 107 is a flag bit that should be automatically set to (=1) if emergency code data has been entered in bits 109 to 112, as defined below.

Bit 108 indicates the method of activation that has been built into the beacon:

bit 108 set to (=0) indicates that the beacon is the type that can be activated only manually;

bit 108 set to (=1) indicates that the beacon is the type that can be activated both manually and automatically.

A2.9.1 Maritime Emergency code

The emergency code is an optional feature that may be incorporated in a beacon to permit the user to enter data in the emergency code field (bits 109-112) after beacon activation of any maritime protocol (i.e. maritime user protocol, maritime serial–user protocols, and radio call sign user protocol). If data is entered in bits 109 to 112 after activation, then bit 107 should be automatically set to (=1) and bits 109 to 112 should be set to an appropriate maritime emergency code shown in Table A4. If a beacon is pre-programmed, bits 109 to 112 should be coded as "unspecified distress" (i.e. 0000).

A2.9.2 Non-Maritime Emergency code

The emergency code is an optional feature that may be incorporated in a beacon to permit the user to enter data in the emergency code field (bits 109-112) of any non-maritime protocol (i.e. aviation user protocol, serial user aviation and personal protocols, or other spare protocols). If data is entered in bits 109 to 112, then bit 107 should be automatically set to (=1) and bits 109 to 112 should be set to an appropriate non-maritime emergency code shown in Table A5.

Table A4: Maritime Emergency Codes in Accordance with the Modified [(1)] IMO Nature of Distress Indication

IMO Indication[(2)]	Binary Code	Usage
1	0001	Fire/explosion
2	0010	Flooding
3	0011	Collision
4	0100	Grounding
5	0101	Listing, in danger of capsizing
6	0110	Sinking
7	0111	Disabled and adrift
8	0000	Unspecified distress [(3)]
9	1000	Abandoning ship
	1001 to 1111	Spare (could be used in future for assistance desired or other information to facilitate the rescue if necessary)

(1) Modification applies only to code "1111", which is used as a "spare" instead of as the "test" code.
(2) IMO indication is an emergency code number, it is different from the binary encoded number.
(3) If no emergency code data has been entered, bit 107 remains set to (=0).

Table A5: Non-Maritime Emergency Codes

Bits	Usage [(1)]
109	No fire (=0); fire (=1)
110	No medical help (=0); medical help required (=1)
111	Not disabled (=0); disabled (=1)
112	Spare (=0)

(1) If no emergency code data has been entered, bit 107 remains set to (=0).

A2.9.3 National Use

When bit 107 is set to (=0), codes (0001) through (1111) for bits 109 to 112 may be used for national use and should be set in accordance with the protocol of an appropriate national authority.

Figure A4: Summary of User Protocols Coding Options

b 25:	Message format flag:	0 = short message, 1 = long message
b 26:	Protocol flag:	1 = User protocols
b 27 - b 36:	Country code number:	3 digits, as listed in Appendix 43 of the ITU Radio Regulations
b 37 - b 39:	User protocol code:	000 = Orbitography 001 = Aviation 010 = Maritime 011 = Serial 110 = Radio call sign 111 = Test 100 = National 101 = Spare

b 37 - b 39: 010 = Maritime user	110 = Radio call sign user	011 = Serial user	001 = Aviation user	100 = National User
b 40 - b 75: Trailing 6 digits of MMSI or radio call sign (modified-Baudot)	b 40 - b 63: First four characters (modified-Baudot)	b 40 - 42: Beacon type 000 = Aviation 001 = Aircraft Operator 011 = Aircraft Address 010 = Maritime (float free) 100 = Maritime (non float free) 110 = Personal b 43: C/S Certificate flag	b 40 - b 81: Aircraft Registration Marking (modified - Baudot)	b 40 - 85: National use
	b 64 - b 75: Last three characters (binary coded decimal)	b 44 - b 73: Serial No. and other data		
b 76 - b 81: Specific beacon (modified-Baudot)	b 76 - b 81: Specific beacon (modified-Baudot)	b 74 - b 83: C/S Cert. No. or National use		
b 82 - b 83: 00 = Spare	b 82 - b 83: 00 = Spare		b 82 - b 83: 00 = Spare	

b 84 - 85:	Auxiliary radio-locating device type(s):	00 = No Auxiliary radio-locating device 01 = 121.5 MHz 10 = Maritime locating: 9 GHz SART 11 = Other auxiliary radio-locating device(s)	(b 40 - 85: National use)
b 86 - b 106:	BCH code:	21-bit error-correcting code for bits 25 to 85	
b 107:	Emergency code use of b 109 - b 112:	0 = National use, undefined (default = 0) 1 = Emergency code flag	b 107 - 112: National use
b 108:	Activation type:	0 = Manual activation only type of beacon 1 = Automatic and manual activation type of beacon	
b 109 - b 112:	Nature of distress:	Maritime emergency codes (see Table A.4) (default = 0000) Non-maritime emergency codes (see Table A5) (default = 0000)	

A3 LOCATION PROTOCOLS

This section defines the protocols which can be used with the 406 MHz beacon message formats for encoding beacon position data, as well as the beacon identification data, in the digital message transmitted by a 406 MHz distress beacon.

A3.1 Summary

Five types of location protocols are defined for use either with the long message format or with the short message format, as shown in Figure A5.

User-Location Protocols. These location protocols are for use with the long message format. The beacon identification data is provided in PDF-1 by one of the user protocols defined in section A2 (see Figure A3). Position data is provided as latitude and longitude, to 4-minute resolution, encoded into PDF-2.

Standard Location Protocols. These location protocols are for use with the long message format. The beacon identification data is provided in a standardized format in 24 bits of PDF-1. Position data to 15-minute resolution is also given in PDF-1, with position offsets to 4-second resolution in PDF-2.

Standard-Short Location Protocols. The short message format version of the standard location protocols provides for the same beacon identification methods as the long format version and allows encoding beacon position data to 15-minute resolution in PDF-1. The supplementary data in the non-protected data field (bits 107-112) is not protected by a BCH code.

National Location Protocol. These location protocols are for use with the long message format. The beacon identification data is provided in a nationally-defined format in 18 bits of PDF-1. Position data, to 2-minute resolution, is given in PDF-1, with position offsets to 4-second resolution in PDF-2.

National-Short Location Protocol. The short message format version of the national location protocols provides for the same beacon identification methods as the long format version and allows encoding beacon position data to 2-minute resolution in PDF-1. The supplementary data in the non-protected data field (bits 107-112) is not protected by a BCH code.

A3.2 Default Values in Position Data

The following default values shall be used in all encoded position data fields of the location protocols, when no valid data is available:

a) all bits in degrees fields set to "1", with N/S, E/W flags set to "0";

b) all bits in the minutes fields set to "0", with Δ signs set to "1"; and

c) all bits in the seconds fields set to "1" (the value "1111" = 60 sec is out of range).

This pattern shall also be transmitted if the beacon radiates a 406 MHz message in the self-test mode.

Figure A5: Outline of Location Protocols

User - Location Protocols							
bit 26	bits 27-39	bits 40-83	bits 84-85	bits 86-106	bit 107	bits 108-132	bits 133-144
1	....	Identification Data (44 bits)	Radio-locating Device	21-Bit BCH code	Posit. Data Source	Position Data to 4 min Resolution (25 bits)	12-Bit BCH code

Standard Location Protocols							
bit 26	bits 27-40	bits 41-64	bits 65-85	bits 86-106	bits 107-112	bits 113-132	bits 133-144
0	....	Identification Data (24 bits)	Position Data to 15 min Resolution (21 bits)	21-Bit BCH code	Supplementary Data	Position Data to 4 sec Resolution (20 bits)	12-Bit BCH code
Standard - Short Location Protocols							

National Location Protocol								
bit 26	bits 27-40	bits 41-58	bits 59-85	bits 86-106	bits 107-112	bits 113-126	bits 127-132	bits 133-144
0	....	Identification Data (18 bits)	Position Data to 2 min Resolution (27 bits)	21-Bit BCH code	Supplementary Data	Position Data to 4 sec Resolution (14 bits)	National Use	12-Bit BCH code
National - Short Location Protocol								

A3.3 Definition of Location Protocols

The general structure of location protocols is illustrated in Figure A6.

A3.3.1 Position Data

All position information is encoded as degrees, minutes and seconds of latitude or longitude, or as fractions of these units. Latitude and longitude data are rounded off (i.e. not truncated) to the available resolution. When a position is encoded in PDF-1, the higher resolution information given in PDF-2 is an offset (Δ latitude and Δ longitude) relative to position provided in PDF-1. In order to minimise the frequency of updates of the position data in PDF-1 the Δ latitude and Δ longitude offsets have a range of ± 2 times the resolution of PDF-1. It is recommended that an encoded co-ordinate should not be changed when position data supplied by a navigation device varies by less than 7″ relative to the encoded value.

The position is initially encoded as follows. The initial coarse position encoded in PDF-1 is selected to be as close as possible to the actual position. The initial offset encoded in PDF-2 (when applicable) is selected so that it may be summed with the coarse position to produce a finer position that is as close as possible to the actual position. Subsequent position updates (if applicable) are then encoded by retaining the coarse position and changing only the offset, provided that the required value is within the range of the offset. If the position update cannot be encoded by changing the offset alone, then both PDF-1 and PDF-2 are reset according to the above procedure for the initial position encoding.

The latitude and longitude values contained in PDF-1 are positive numbers regardless of their directions. The offset is applied by adding or subtracting the offset value in accordance with the offset sign in PDF-2. For example:

100° E. longitude + 30′ offset = 100° 30′ E. longitude
100° W. longitude + 30′ offset = 100° 30′ W. longitude (not 99° 30′ W. longitude)
100° W. longitude - 30′ offset = 99° 30′ W. longitude (not 100° 30′ W. longitude).

A3.3.2 Supplementary Data

The following supplementary data are provided in location protocols, in addition to the required identification data and available position data.

A3.3.2.1 Source of Position Data

This information is encoded in bit 107 for the user-location protocol or bit 111 for the standard and national location protocols (short and long versions) with the following interpretation:

"0" = the encoded position data is provided by an external navigation device
"1" = the encoded position data is provided by an internal navigation device.

A3.3.2.2 Auxiliary Radio Locating Device (homing transmitter) Code

The "121.5 MHz homing" data is encoded in bit 112 for the standard and national location protocols (short and long versions) where:

"1" = indicates a 121.5 MHz auxiliary radio locating device
"0" = indicates other or no auxiliary radio locating devices;

and in bits 84-85 for the user-location protocols as follows:

"00" = no auxiliary radio locating device
"01" = 121.5 MHz auxiliary radio locating device
"10" = maritime locating: 9 GHz Search and Rescue Radar Transponder (SART)
"11" = other auxiliary radio-locating device(s).

A3.3.3 Test Location Protocols

The test protocol for all coding methods (i.e. "user" and "location" protocols) is encoded by setting bits 37-39 (protocol code) to "111". In addition, bit 40 is used to distinguish between the test format of the standard location protocols (bit 40 = "0") and national location protocols (bit 40 = "1").

Figure A6: General Format of Long Message for Location Protocols

←1 24→	25 26	←27 36→	←37 39→	40	←41 83→	84 85	←86 106→	←107 112→	←113 132→	←133 144→
	←----------- 61 BITS PDF-1 ----------→						BCH-1	←------ 26 BITS PDF-2 ------→		BCH-2
BIT & FRAME SYNCHRONIZAT. PATTERNS	2	10	4		45		21	6	20	12
	FORMAT & PROTOCOL FLAGS	COUNTRY CODE	3 010 110 001 011 111 100		USER-LOCATION PROTOCOLS (P=1) Identification Data (same as User Protocols) See Figure A7	2	21-BIT BCH ERROR CORRECTING CODE		USER-LOCATION PROTOCOLS Latitude / Longitude Data (4 Minute Resolution) See Figure A7	12-BIT BCH ERROR CORRECTING CODE
			4 0010 0011 0100 0101 0110 0111 1110		STANDARD LOCATION PROTOCOLS (P=0) Identification & Position Data (1/4 Degree Resolution) See Figure A8				STANDARD LOCATION PROTOCOLS Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A8	
			4 1000 1001 1010 1011 1111		NATIONAL LOCATION PROTOCOLS (P=0) Identification & Position Data (2 Minute Resolution) See Figure A9				NATIONAL LOCATION PROTOCOLS Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A9	

↑ F= 1 P=0 /1

↑ PROTOCOL CODE See Table A2

SHORT MESSAGE FORMAT - 112 BITS→ |

LONG MESSAGE FORMAT - 144 BITS→

A3.3.4 User-Location Protocols (See Figure A7)

A3.3.4.1 These protocols (identified by F=1, P=1) provide for encoding latitude / longitude data with resolution to 4 minutes in PDF-2. Beacon identification data shall be encoded in PDF-1 using any of the user protocols defined in section 2, except the orbitography protocol and the national user protocol which are specific to a particular application or a particular country.

A3.3.4.2 The protocol codes (bits 37 to 39) are defined in Table A2-A for user and user-location protocols.

A3.3.4.3 The 26 bits available in PDF-2 are defined as follows:

a) bit 107: encoded position data source

"0" = the encoded position data is provided by an external navigation device
"1" = the encoded position data is provided by an internal navigation device;

b) bits 108 to 119: latitude data (12 bits) with 4 minute resolution, including:

- bit 108: N/S flag (N=0, S=1)
- bits 109 to 115: degrees (0 to 90) in 1 degree increments
- bits 116 to 119: minutes (0 to 56) in 4 minute increments

(default value of bits 108 to 119 = 0 1111111 0000); and

c) bits 120 to 132: longitude data (13 bits) with 4 minute resolution including:

- bit 120: E/W flag (E=0, W=1)
- bits 121 to 128: degrees (0 to 180) in 1 degree increments
- bits 129 to 132: minutes (0 to 56) in 4 minute increments

(default value of bits 120 to 132 = 0 11111111 0000).

Figure A7: User-Location Protocols

←1 … 24→	25 26	←27 … 36→	←37 … 39→	←40 … 83→	85→	←86 … 106→	←107 … 112→	←113 … 132→		←133 … 144→
	←------ 61 BITS PDF-1 ------→					BCH-1	←------ 26 BITS PDF-2 ------→			BCH-2
	2	10	3	44	2	21	1	12	13	12
BIT & FRAME SYNCHRONIZ. PATTERNS	FORMAT & PROTOCOL FLAGS	COUNTRY CODE	PROTOCOL CODE (PC)	IDENTIFICATION DATA		21-BIT BCH ERROR CORRECTING CODE	POSITION DATA (ALL USER-LOCATION PROTOCOLS)			12-BIT BCH ERROR CORRECTING CODE
				MARITIME USER PROTOCOL (MMSI OR RADIO CALL SIGN) (PC=010)			1	LATITUDE	LONGITUDE	
				RADIO CALL SIGN USER PROTOCOL (PC=110)						
				AIRCRAFT NATIONALITY AND REGISTRATION MARKINGS (PC=001)						
				SERIAL USER PROTOCOL (ELTs, PLBs, EPIRBs) (PC=011)						

LATITUDE			LONGITUDE		
1	7	4	1	8	4
N / S	DEG 0 - 90 (1 deg.)	MIN 0 - 56 (4min)	E / W	DEG 0 - 180 (1 deg.)	MIN 0 - 56 (4min)

↑ F=1 P=1

↑ See Table A2

↑ See Figure A3 for details of identification data

↑ 84,85 = Homing

↑ 107 = Encoded Position Data source: 1= Internal, 0 = external

A3.3.5 Standard Location Protocols (see Figure A8)

A3.3.5.1 The standard location protocols, identified by the flags F=1, P=0 and the protocol codes no. 1 to 3 of Table A2-B, have the following structure:

a) PDF-1:

bits 37 to 40: 4-bit protocol code as defined in Table A2-B
bits 41 to 64: 24 bits of identification data
bits 65 to 85: 21 bits of encoded position data to 15 minute resolution;

b) PDF-2:

bits 107 to 112: 4 fixed bits and 2 bits of supplementary data
bits 113 to 132 20-bit position offset (Δ latitude, Δ longitude), to 4 second resolution.

A3.3.5.2 The 24 bits of identification data (bits 41 to 64) can be used to encode:

a) (PC=0010) the last six digits of MMSI in binary form in bits 41 to 60 (20 bits), plus a 4-bit specific beacon number (0 to 15) in bits 61 to 64, to distinguish between several EPIRBs on the same ship;

b) (PC=0011) a 24-bit aircraft address (only one ELT per aircraft can be identified using this protocol); or

c) (PC=01xx, see Note 1) a 24-bit unique serial identification including:

(i) the 10-bit Cospas-Sarsat type approval certificate number of the beacon (1 to 1,023) in bits 41 to 50, and a 14 bit serial number (1 to 16,383) in bits 51 to 64; or

(ii) a 15-bit aircraft operator designator (see Notes 1 & 2) in bits 41 to 55, and a 9-bit serial number (1 to 511) assigned by the operator in bits 56 to 64.

A3.3.5.3 The 21 bits of position data in PDF-1 are encoded as follows:

a) bits 65 to 74: latitude data (10 bits) providing 15 minute resolution, including:
- bit 65: N/S flag (N=0, S=1)
- bits 66 to 74: degrees (0 to 90) in 1/4 degree increments

(default value of bits 65 to 74 = 0 111111111); and

Notes: 1. The last two bits of the protocol code (bits 39-40) are used as follows (see also Table A2):

00 ELT-serial	10 EPIRB-serial
01 ELT-aircraft operator designator	11 PLB-serial

2. The aircraft operator designator (3 letters) can be encoded in 15 bits using a shortened form of the modified-Baudot code (i.e.: all letters in the modified-Baudot code are coded in 6 bits, with the first bit = "1". This first bit can, therefore, be deleted to form a 5-bit code).

b) bits 75 to 85: longitude data (11 bits) providing 15 minute resolution, including:
- bit 75: E/W flag (E=0, W=1)
- bits 76 to 85: degrees (0 to 180) in 1/4 degree increments

(default value of bits 75 to 85 = 0 1111111111).

A3.3.5.4 The 26 bits available in PDF-2 are defined as follows:

a) bits 107 to 109: ="110" (fixed);

b) bit 110: ="1" (fixed);

c) bit 111: encoded position data source

"0" = the encoded position data is provided by an external navigation device
"1" = the encoded position data is provided by an internal navigation device;

d) bit 112: 121.5 MHz auxiliary radio locating device included in beacon (1 = yes, 0 = no);

e) bits 113 to 122: Δ latitude with 4 second resolution:
- bit 113: Δ sign (0 = minus, 1 = plus)
- bits 114 to 118: Minutes (0 to 30) in 1 minute increments
- bits 119 to 122: Seconds (0 to 56) in 4 second increments

(default value of bits 113 to 122 = 1 00000 1111); and

f) bits 123 to 132: Δ longitude with 4 second resolution:
- bit 123: Δ sign (0 = minus, 1 = plus)
- bits 124 to 128: Minutes (0 to 30) in 1 minute increments
- bits 129 to 132: Seconds (0 to 56) in 4 second increments

(default value of bits 123 to 132 = 1 00000 1111).

A3.3.5.5 The test protocol using the above format is encoded by setting bits 37-39 to "111" and bit 40 to "0".

A3.3.6 Standard-Short Location Protocols

The standard-short location protocols are for use with the short message format (F=0). The structure of PDF-1 for standard-short location protocols is identical to the structure of PDF-1 of the standard location protocols, as defined in sections A3.3.5.1 to A3.3.5.3.

The supplementary data in bits 107 to 112 (6 bits) of the non-protected data field have the same definition as the corresponding bits in the standard location protocols, as defined in section A3.3.5.4, items (a) to (d).

Figure A8: Standard Location Protocols

←1 … 24→	25 26	←27 … 36→	←37 … 40→	←41 … 85→	←86 … 106→	107 112	←113 … 132→	←133 … 144→
	←----------- 61 BITS PDF-1 ------------→				BCH-1	←------- 26 BITS PDF-2 --------→		BCH-2
	2	10	4	45	21	6	20	12
BIT & FRAME SYNCHRONIZ PATTERNS	FORMAT & PROTOCOL FLAG	COUNTRY CODE	PC	24 BITS IDENTIFICATION DATA / 21 BITS LATITUDE LONGITUDE	21-BIT BCH ERROR CORRECTING CODE	SUPPLEMENTARY DATA	Δ LATITUDE / Δ LONGITUDE	12-BIT BCH ERROR CORRECTING CODE

PC and 24 BITS IDENTIFICATION DATA:

PC		24 BITS IDENTIFICATION DATA	
00	10	20: MMSI (last 6 digits, binary)	4: B.No 0 -15
00	11	AIRCRAFT 24 BIT ADDRESS	
01	01	15: AIRCRAFT OPER. DESIGNATOR	9: SERIAL No 1 - 511
01	00 10 11	10: C/S TA No 1 - 1023	14: SERIAL No 1 - 16383

21 BITS LATITUDE LONGITUDE:

1	9	1	10
N S	LAT DEG 0 - 90 (1/4 d.)	E W	LON DEG 0 - 180 (1/4 d.)

Δ LATITUDE / Δ LONGITUDE:

Δ LATITUDE			Δ LONGITUDE		
1	5	4	1	5	4
- +	MINUTES 0 - 30 (1min)	SECONDS 0-56 (4s)	- +	MINUTES 0-30 (1min)	SECONDS 0-56 (4s)

↑ F=1, P=0

↑ 0100 ELT-Serial
0110 EPIRB-Serial
0111 PLB
1110 Test

↑ 107 = "1"
↑ 108 = "1"
↑ 109 = "0"
↑ 110 = "1"
↑ 111 = Encoded Position Data Source: 1= int., 0 = ext.
↑ 112 = 121.5 MHz Homing: 1=Yes, 0 = No

A3.3.7 National Location Protocol (see Figure A9)

A3.3.7.1 The national location protocol, identified by the flags F=1, P=0 and the protocol codes in series no. 4 of Table A2-B, has the following structure:

a) PDF-1:

bits 37 to 40: 4-bit protocol code as defined in Table A2-B,

bits 41 to 58: 18-bit identification data consisting of a serial number assigned by the appropriate national authority,

bits 59 to 85: 27 bits of position data to 2 minute resolution;

b) PDF-2:

bits 107 to 112: 3 fixed bits set to "110", 1-bit additional data flag, describing the use of bits 113 to 132, and 2 bits of supplementary data,

bits 113 to 126: 14-bit position offset (Δ latitude, Δ longitude) to 4 second resolution, or alternate national use, and

bits 127 to 132: 6 bits reserved for national use (additional beacon type identification or other).

A3.3.7.2 The 27 bits of position data in PDF-1 are encoded as follows:

a) bits 59 to 71: latitude data (13 bits) with 2 minute resolution:
- bit 59: N/S flag (N=0, S=1)
- bits 60 to 66: degrees (0 to 90) in 1 degree increments
- bits 67 to 71: minutes (0 to 58) in 2 minute increments

(default value of bits 59 to 71 = 0 1111111 00000); and

b) bits 72 to 85: longitude data (14 bits) with 2 minute resolution:
- bit 72: E/W flag (E=0, W=1)
- bits 73 to 80: degrees (0 to 180) in 1 degree increments
- bits 81 to 85: minutes (0 to 58) in 2 minute increments

(default value of bits 72 to 85 = 0 11111111 00000).

A3.3.7.3 The 38 bits available in PDF-2 are defined as follows:

a) bit 107 to 109: ="110" (fixed);

b) bit 110: additional data flag (1 = Δ position data as described below in bits 113 to132; 0 = other to be defined nationally);

c) bits 111: encoded position data source

"0" = the encoded position data is provided by an external navigation device
"1" = the encoded position data is provided by an internal navigation device;

d) bit 112: 121.5 MHz auxiliary radio locating device included in beacon (1 = yes, 0 = no);

e) bits 113 to 119: Δ latitude with 4 second resolution:
- bit 113: Δ sign (0 = minus, 1 = plus)
- bits 114 to 115: minutes (0 to 3) in 1 minute increments
- bits 116 to 119: seconds (0 to 56) in 4 second increments

(default value of bits 113 to 119 = 1 00 1111);

f) bits 120 to 126: Δ longitude with 4 second resolution:
- bit 120: Δ sign (0 = minus, 1 = plus)
- bits 121 to 122: minutes (0 to 3) in 1 minute increments
- bits 123 to 126: seconds (0 to 56) in 4 second increments

(default value of bits 120 to 126 = 1 00 1111); and

g) bits 127 to 132: Additional beacon identification (national use) (default value of bits 127 to 132 = 000000).

A3.3.7.4 The test protocol using the above format is encoded by setting bits 37-39 to "111" and bit 40 to "1".

A3.3.8 National-Short Location Protocol

The national-short location protocol is for use with the short message format (F=0). The structure of PDF-1 for the national-short location protocol is identical to the structure of PDF-1 of the national location protocol, as defined in sections A3.3.7.1(a) and A3.3.7.2.

The supplementary data in bits 107-109 and bits 111-112 of the non-protected data field have the same definition as the corresponding bits in the national location protocol, as defined in section A3.3.7.3, items (a), (c) and (d). Bit 110 should be set to "1".

Figure A9: National Location Protocol

←1 24→	25 26	←27 36→	←37 40→	←41						85→	←86 106→	107 112	←113					132→		←133 144→
	←------- 61 BITS PDF-1 ------→										BCH-1	←------ 26 BITS PDF-2 -----→								BCH-2
	2	10	4	45							21	6	7			7			6	12
				18 BITS IDENTI-FICATION	27 BITS LATITUDE			LONGITUDE					Δ LATITUDE			Δ LONGITUDE				
				18	1	7	5	1	8	5			1	2	4	1	2	4		
BIT & FRAME SYNCHRONIZ. PATTERNS	FORMAT & PROTOCOL FLAG	COUNTRY CODE	PROTOCOL CODE	NATIONAL ID NUMBER	N S	DEGREES 0 - 90 (1 deg)	MINUTES 0 - 58 (2 m)	E W	DEGREES 0 - 180 (1 deg)	MINUTES 0 - 58 (2m)	21-BIT BCH ERROR CORRECTING CODE	SUPPLEMENTARY DATA	- +	MINUTES 0 - 3 (1m)	SECONDS 0 - 56 (4 s.)	- +	MINUTES 0 - 3 (1m)	SECONDS 0 - 56 (4 s.)	NATIONAL USE	12-BIT BCH ERROR CORRECTING CODE

↑ F=1 P=0 (format & protocol flag)

↑ See Table A2 (protocol code)
1000 ELT
1010 EPIRB
1011 PLB
1111 Test

↑ 107 = "1"
↑ 108 = "1"
↑ 109 = "0"
↑ 110 = Additional Data Flag: 1 = Δ Position, 0 = Nat. Assignment
↑ 111 = Encoded Position Data Source: 1 = Internal, 0 = external
↑ 112 = 121.5 MHz Homing: 1= Yes, 0 = No

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- END OF ANNEX A -

ANNEX B

SAMPLE BOSE-CHAUDHURI-HOCQUENGHEM ERROR-CORRECTING CODE CALCULATION

B1 Sample 21-Bit BCH Code Calculation

The error-correcting code used in the first protected field of all 406 MHz messages is a shortened form of a (127,106) Bose-Chaudhuri-Hocquenghem (BCH) code. The shortened form (82,61) consists of 61 bits of data followed by a 21-bit triple error-correcting code. The code is used to detect and correct up to three errors in the entire 82-bit pattern (bits 25 through 106 of the 406 MHz message).

Note: For the purpose of error correction, all calculations shall be performed with the full length code. Therefore, 45 zeros are placed before the 61 data bits to form the 106 bit pattern of the (127,106) BCH code. These padding zeros do not affect the generation of the BCH code as described below.

For the (82,61) BCH code, a generator polynomial g(X) (the same as for (127,106) BCH code) is defined as follows:

$$g(X) = LCM\ (m_1 (X)\ ,\ m_3 (X)\ ,\ m_5 (X))$$

where LCM = Least Common Multiple.

In the above case:

$$m_1 (X) = X^7 + X^3 + 1$$
$$m_3 (X) = X^7 + X^3 + X^2 + X + 1$$
$$m_5 (X) = X^7 + X^4 + X^3 + X^2 + 1$$

from which,

$$g(X) = m_1 (X)\ m_3 (X)\ m_5 (X)$$

$$= X^{21} + X^{18} + X^{17} + X^{15} + X^{14} + X^{12} + X^{11} + X^8 + X^7 + X^6 + X^5 + X + 1$$

a determination of g(X) results in the following 22-bit binary number:

g(X) = 1001101101100111100011

To generate the BCH code, an information polynomial, m(x) is formed from the 61 data bits as follows:

$$m(X) = b_1\ X^{60} + b_2\ X^{59} + ... + b_{60}\ X + b_{61}$$

where b_1 is the first bit (i.e. format flag), and b_{61} is the last bit of PDF-1.

m (X) is then extended to 82 bits by filling the least significant bits with 21 "0". The resulting 82-bit binary string is then divided by g(X) and the remainder, r(X), becomes the BCH code (the quotient portion of the result of the module-2 binary division is discarded).

The above process may be clarified by the following example:

Message Format	Short Message
Protocol Flag	User Protocol
Country Code	366 (USA)
User Protocol Type	Serial
Beacon Type	Float free EPIRB
Manufacturer's ID	002
Sequence Number	1
Beacon Model Number	1
Production Run Number	1
National Use Bits	00000000
Homing	121.500 MHz
Emergency/National Use	Not Used
Beacon Activation	Automatic or Manual

for which:

Beacon 15 Hex ID:	ADCD0 08004 40401 (bits 26-85)
Short Message:	56E68 04002 20200 96552 50 (bits 25-112)
Bits 25-112:	0101 0110 1110 0110 1000 0000 0100 0000 0000 0010 0010 0000 0010 0000 0000 1001 0110 0101 0101 0010 0101 0000

The division[1] described above is shown in Figure B1 and results in a remainder of:

0001011001010101001001

The most significant bit position of the remainder will always be a "0" and is deleted to obtain the 21-bit BCH code:

BCH Error-Correcting Code: 001011001010101001001

REFERENCE

An Introduction to Error Correcting Codes, Shu Lin, Prentice-Hall 1970

[1] Modulo 2 division prohibits a "borrow" in the subtraction portion of the long division

```
     |                                                            |                    |
---->|<------------- Bits  25 - 85 ----------------------------->|<---Bits 86-106---->|
45’0’|               (Data bits)                                  |     (21 "0"s)      |
m(X)=0101011011100110100000000100000000000010001000000010000000001000000000000000000000
g(X)= 1001101101100111100011
      0011011010101010001100
        1001101101100111100011
        0100000111001101101111
         1001101101100111100011
         00011000111111001111100000
            1001101101100111100011
            0101110010000000000110
             1001101101100111100011
             001000100110011110010100
               1001101101100111100011
               0001001011111001110111000
                  1001101101100111100011
                  00001100101010010110110001
                      1001101101100111100011
                      01010001111100010100100
                       1001101101100111100011
                       001110001000010100011100
                         1001101101100111100011
                         01111001011100111111111
                          1001101101100111100011
                          01101001100000000111000
                           1001101101100111100011
                           01001000011001110110110
                            1001101101100111100011
                            00001011101010010101010000
                                1001101101100111100011
                                001000011111001011001101
                                  1001101101100111100011
                                  0001110010101100101110000
                                     1001101101100111100011
                                     01111110000000100100110
                                      1001101101100111100011
                                      01100111011000110001010
                                       1001101101100111100011
                                       01010101101000011010010
                                        1001101101100111100011
                                        001100000010010011000100
                                          1001101101100111100011
                                          01011011111101001001110
                                           1001101101100111100011
                                           001011001000111010110110
                                             1001101101100111100011
                                             001010010101110101010100
                                               1001101101100111100011
                                               001111100001001011011100
                                                 1001101101100111100011
                                                 01100011001011001111110
                                                  1001101101100111100011
                                                  01011101001111100111010
                                                   1001101101100111100011
                                                   001000010001101101100100
                                                     1001101101100111100011
                                                     0001111100001010000111000
                                                        1001101101100111100011
                                                        01100011001101110110110
                                                         1001101101100111100011
                                                         01011101000010010101010
                                                          1001101101100111100011
                                                          001000010111010100100100
                                                            1001101101100111100011
                                                            0001111010110011000111000
                                                               1001101101100111100011
                                                               01101110111111110110110
                                                                1001101101100111100011
                                                                01000110100110010101010
                                                                 1001101101100111100011
                                            22-bit remainder  =  0001011001010101001001
                                                                  |                    |
                                                                  |<------ BCH ------>|
                                                                  |  (last 21 bits)    |
```

Figure B1: Sample 21-Bit BCH Error-Correcting Code Calculation

B2 Sample 12-Bit BCH Code Calculation

The BCH error correcting code (bits 133-144) used in the second protected field of the long message is capable of detecting and correcting up to two bit errors in the bits 107-144. The generator polynomial used as a basis for this code is:

$$g(x) = (1 + x + x^6)(1 + x + x^2 + x^4 + x^6)$$
$$= (1 + x^3 + x^4 + x^5 + x^8 + x^{10} + x^{12})$$

An example of the 12-bit BCH code which protects the 38-bit second protected field (i.e. bits 107 through 144) is shown below for the user-location protocol. The position in this example is as follows:

actual latitude:	43°33.63' N
actual longitude:	001° 28.85' E
latitude rounded to nearest 4' increment:	43°32' N
longitude rounded to nearest 4' increment:	001°28' E

binary message:

- Encoded Position Data Source is Internal	bit 107:	1
- North latitude	bit 108:	0
- Latitude 43°	bits 109-115:	0101011
- Latitude 32'	bits 116-119:	1000
- East longitude	bit 120:	0
- Longitude 1°	bits 121-128:	00000001
- Longitude 28'	bits 129-132:	0111
- BCH code	bits 133-144:	(see Figure B2)

Placing the binary bits 107-132 in order gives:

10 0101 0111 0000 0000 0001 0111

and the BCH code is calculated as shown in Figure B2. The resultant 12-bit BCH code is:

0001 0101 0001

```
     |                        |           |
---->|<---Bits 107-132------->|<-133-144->|
25’0’|     (Data bits)        | (12 "0"s) |
m(X)=10010101110000000000010111000000000000
g(X)=1010100111001
       1111000000100
       1010100111001
        1011001111010
        1010100111001
           1101000011000
           1010100111001
            1111001000010
            1010100111001
             1011011110110
             1010100111001
                1111001111101
                1010100111001
                 1011010001001
                 1010100111001
                    1110110000100
                    1010100111001
                     1000101111010
                     1010100111001
                       1000100001100
                       1010100111001
                         1000011010100
                         1010100111001
                           1011110110100
                           1010100111001
                              1010001101000
                              1010100111001
          13-bit remainder =  0000101010001
                               |          |
                               |<---BCH-->|
                               | (12 bits)|
```

Figure B2: Sample 12-Bit BCH Error-Correcting Code Calculation

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ANNEX C

LIST OF ACRONYMS

BCD	binary-coded decimal
BCH	Bose-Chaudhuri-Hocquenghem (code)
BCH-1	first BCH error correcting field
BCH-2	second BCH error correcting field
C/S	Cospas-Sarsat
ELT	emergency locator transmitter
EPIRB	emergency position indicating radio beacon
F	format flag
GHz	gigahertz
GLONASS	Global Navigational Satellite System (Russia)
GPS	Global Positioning System (USA)
Hex	Hexadecimal
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
ITU	International Telecommunication Union
LSB	least significant bit
LUT	local user terminal
MHz	megahertz
MID	maritime identification digits
MMSI	maritime mobile service identity
ms	millisecond
MSB	most significant bit
P	protocol flag
PC	protocol code
PDF-1	first protected data field
PDF-2	second protected data field
PLB	personal locator beacon
RHCP	right hand circular polarization
RMS	root mean square
RTCA	Radio Technical Commission for Aeronautical Services (USA)
SART	search and rescue radar transponder
TAC	type approval certificate
VSWR	voltage standing-wave ratio

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