
**SPECIFICATION FOR
COSPAS-SARSAT
406 MHz DISTRESS BEACONS**

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SPECIFICATION FOR COSPAS-SARSAT
406 MHz DISTRESS BEACONS

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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 that 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.

Where there are specific requirements in this document for a distress tracking ELT (ELT(DT)) these refer to a specific type of ELT designed to be activated prior to a crash and to function in compliance with the ICAO GADSS* requirements for the location of an aeroplane in distress, aimed at establishing, to a reasonable extent, the location of an accident site within a 6 NM radius. An ELT(DT) may be activated automatically upon detection of a distress condition while in flight or it may also be activated manually.

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 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.
- b) 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.
- c) Section 4 defines a set of environmental and operational requirements. These requirements are not intended 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.

* See ICAO Convention on International Civil Aviation Annex 6, Part 1.

- d) Annex A defines the beacon coding.
- e) Annex B provides samples of error correcting code calculations, M_{offset} calculations and CRC code sample.

A full list of acronyms used in this document can be found in document C/S G.004, “Cospas-Sarsat Glossary”.

- END OF SECTION 1 -

This document has been
superseded by a later version

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 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 randomised around a mean value of 50 seconds, so that time intervals between transmissions are randomly distributed on the interval 47.5 to 52.5 seconds.

For ELT(DT)s the value of the repetition period shall be:

- a) 5 seconds ± 0.0 / - 0.2 seconds during the first 120 seconds after beacon activation;
- b) 10 seconds ± 0.0 / - 0.2 seconds between 120 seconds and 300 seconds after beacon activation; and
- c) after the first 300 seconds after beacon activation until the beacon is deactivated the period shall be randomised around a mean value of 28.5 seconds, so that time intervals between transmissions are randomly distributed on the interval 27.0 to 30.0 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.

For ELT(DT)s, and RLS location protocol beacons, the final 360 ms ± 1 percent of the transmitted signal shall contain a 144-bit message at a bit rate of 400 bps ± 0.1 percent.

c) Cancellation Message (ELT(DT) only)

ELT(DT)s shall also have means of deactivation by the same means of activation which shall be followed by a cancellation message sequence, as defined in section 3.3.

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

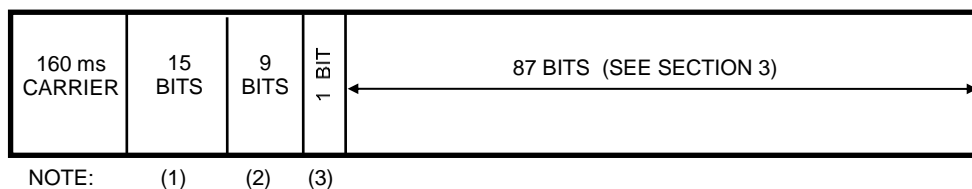
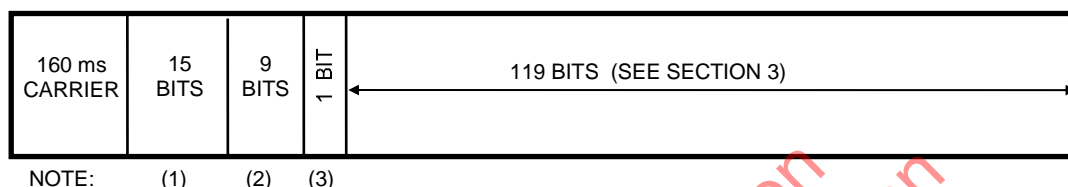
A frame synchronization pattern consisting of 9 bits shall occupy bit positions 16 through 24. The frame synchronization pattern in normal operation shall be 000101111. However, if the beacon radiates a modulated signal in the self-test mode, the frame synchronization pattern shall be 011010000 (i.e.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

To ensure adequate System capacity and an efficient use of the available frequency spectrum in the band 406.0 - 406.1 MHz allocated by the ITU for the operation of low-power satellite emergency position-indicating radiobeacons, a number of channels have been defined in the allocated band and will be assigned by Cospas-Sarsat from time to time, as necessary to satisfy capacity requirements.

The frequency channels in the band 406.0 - 406.1 MHz are defined by the centre frequency of the channels, as assigned by Cospas-Sarsat.

Except as provided below for beacons type approved by Cospas-Sarsat for operation at 406.025 MHz and 406.028 MHz, the beacon carrier frequency shall be set in accordance with the Cospas-Sarsat 406 MHz Channel Assignment Table, as provided in document C/S T.012 "Cospas-Sarsat 406 MHz Frequency Management Plan", at the designated centre frequency of the appropriate channel ± 1 kHz, and shall not vary more than ± 5 kHz from that channel centre frequency in 5 years.

* This section of the beacon specification 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.

The carrier frequency of beacons operating in the 406.025 MHz channel in accordance with the Cospas-Sarsat 406 MHz Channel Assignment Table shall be set at 406.025 MHz \pm 2 kHz. The carrier frequency shall not vary more than \pm 5 kHz from 406.025 MHz in 5 years.

The carrier frequency of beacons operating in the 406.028 MHz channel in accordance with the Cospas-Sarsat 406 MHz Channel Assignment Table shall be set at 406.028 \pm 1 kHz. The carrier frequency shall not vary more than +2 kHz /-5 kHz from 406.028 MHz in 5 years.

The transmitted frequency short-term variations shall not exceed 2 parts in 10^9 in 100 ms.

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, except as noted below. The residual frequency variation shall not exceed 3 parts in 10^9 .

After allowing 15-minutes for beacon warm-up, the medium-term frequency stability requirements shall be met for all defined environmental conditions, except for the temperature gradient and the thermal shock as defined in sections 4.2.2 and 4.2.3 respectively.

The mean slope of the medium-term frequency stability measurements shall not exceed 2 parts in 10^9 per minute, and the residual frequency variation shall not exceed 3 parts in 10^9 :

- during the variable temperature conditions of the temperature gradient (+/- 5° C/h slope) defined in section 4.2.2 and for the 15 minute periods immediately after the temperature had stabilised at the maximum or minimum values; and
- during the thermal shock defined in section 4.2.3.

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.

For ELT(DT)s, the requirement of medium term stability (mean slope and residual frequency variation) does not apply.

2.3.2 Transmitter Power Output

For all beacon types other than ELT(DT), the transmitter power output shall be within the limits of 35 to 39 dBm measured into a 50-Ohm load. This power output shall be maintained during the minimum operating lifetime of 24 hours (or for a longer period, as specified by National Administrations, or by International Organisations, or as declared by the beacon manufacturer, if it is

different from 24 hours), 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.

For ELT(DT)s, the transmitter power output shall be within the limits of 36 dBm to 39 dBm measured into a 50-Ohm load. This power output shall be maintained during the minimum operating lifetime of 370-minutes (or for a longer period, as specified by National Administrations or by International Organisations, or as declared by the beacon manufacturer, if it is different from 370 minutes), at any temperature throughout the specified operating temperature range. Power output rise time shall be less than 2 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 all azimuth angles and 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
 - 2 dBi and 6 dBi over 90% of the above region for ELT(DT)s
- 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.

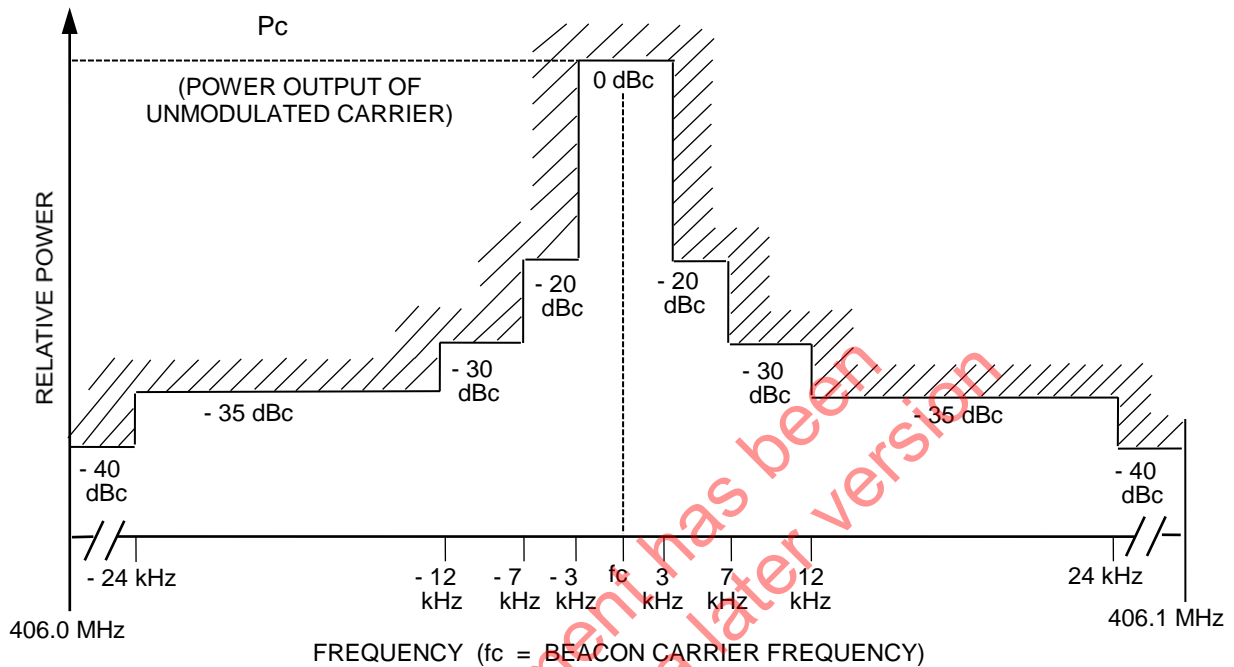


Figure 2.3: Spurious Emission Mask for 406.0 to 406.1 MHz Band

2.3.5 Data Encoding

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

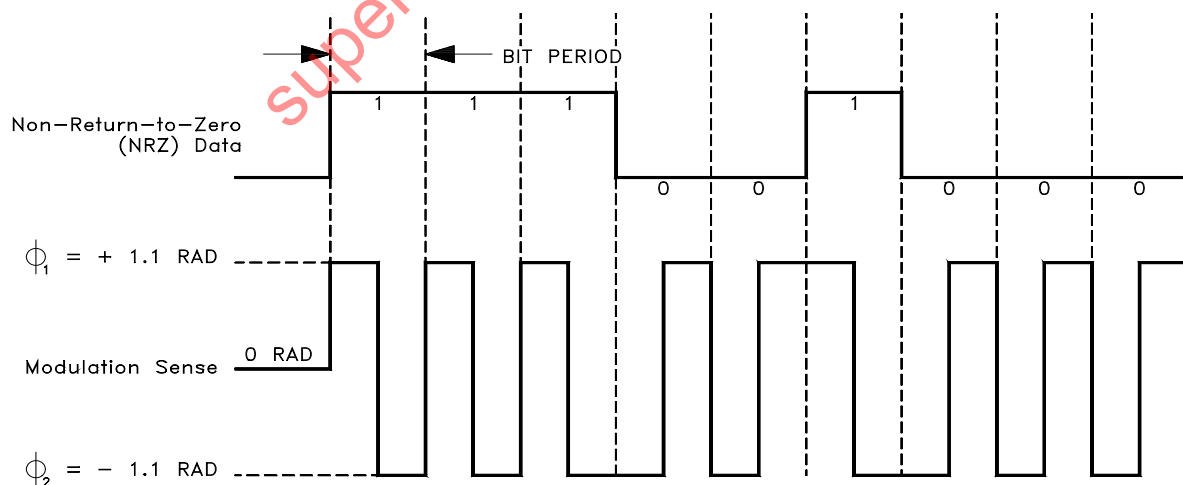


Figure 2.4: Data Encoding and Modulation Sense

2.3.6 Modulation

The carrier shall be phase modulated positive and 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 $150 \pm 100 \mu\text{s}$.

For ELT(DT)s, the rise (τ_R) and fall (τ_F) times of the modulated waveform, shall be between $50 \mu\text{s}$ and $150 \mu\text{s}$.

Modulation symmetry (see Figure 2.6) shall be such that: $\frac{|\tau_1 - \tau_2|}{\tau_1 + \tau_2} \leq 0.05$

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.

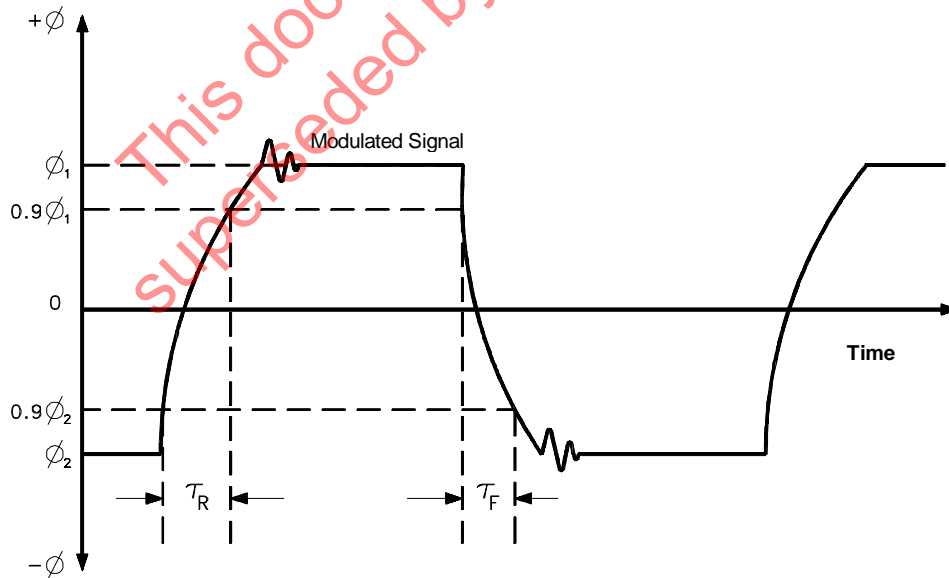


Figure 2.5*: Definition of Modulation Rise and Fall Times

* Figure not to scale.

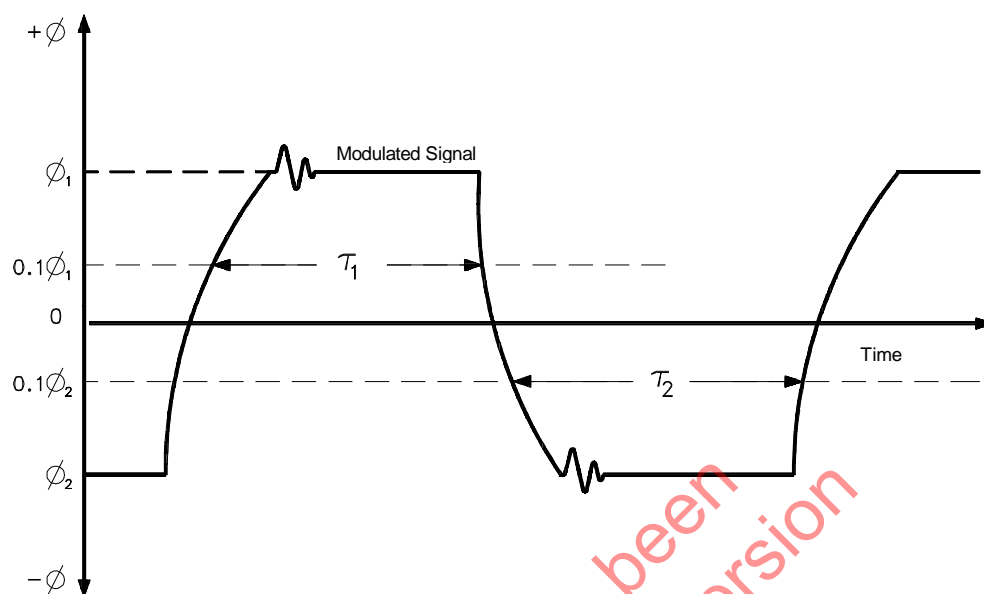


Figure 2.6*: Definition of Modulation Symmetry

- END OF SECTION 2 -

* Figure not to scale.

3. DIGITAL MESSAGE CONTENT

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-Hocquenghem 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-Hocquenghem 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.

Beacon message protocols that support encoded location information (e.g., User-Location, Standard Location and National Location) shall only be used in beacons that are designed to accept encoded location information from a navigation system.

The 15 hexadecimal characters that uniquely identify each 406 MHz beacon are 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.

3.3 Cancellation Message (ELT(DT) only)

When the ELT(DT) is deactivated the ELT(DT) shall transmit the first cancellation messages within 5 seconds, and transmit a total of 10 identical cancellation messages at intervals of 10 seconds ± 0.5 seconds, after which time the beacon shall cease transmitting. In the case the ELT(DT) is activated (e.g., triggered) during the cancellation sequence, the beacon shall terminate the cancellation transmission sequence and reinitiate the alert sequence per section 2.2.1.

The content of the Cancellation Message is documented in Annex A, section A3.3.8 and table A11.

- 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

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

Class 0: -55°C to +70°C

Class 1: -40°C to +55°C

Class 2: -20°C to +55°C

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.

4.2.3 Thermal Shock

All system requirements of section 2 shall be met, including the mean slope of the medium-term frequency stability measurements which shall not exceed 2.0 parts in 10^9 per minute, 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.

For ELT(DT)s all system requirements of section 2 shall be met, excluding the medium-term frequency stability requirements, for measurements beginning with the first transmission after simultaneously activating the beacon and applying a thermal shock of 50°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.

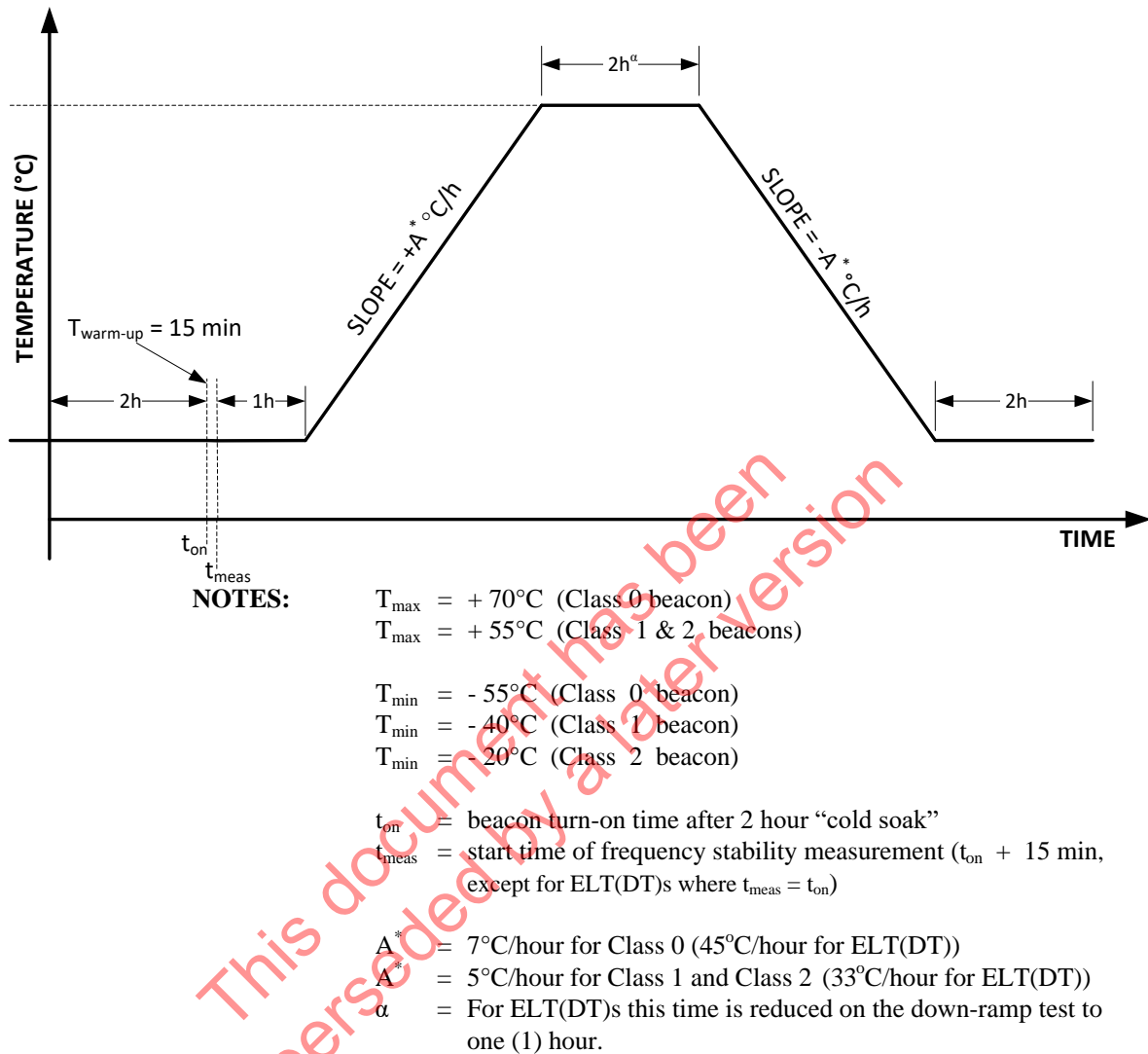


Figure 4.1: Temperature Gradient

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.

The minimum duration of continuous operation for an ELT(DT) to meet the ICAO GADSS requirement at any temperature throughout the specified operating temperature range shall be 370 minutes†.

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.

4.5.3 Auxiliary Radio-Locating Device

The transmission of the 406 MHz satellite signal shall take precedence over any Radio-Locating Signals. Homing signal types should be momentarily interrupted, delayed, rescheduled, or eliminated according to the relevant standard for each type, in order to ensure that homing signals are not transmitted at the same time as the 406-MHz signal to satellites.

The distress beacon may transmit radio-locating signals in compliance with appropriate national or international standards. The inclusion of any Radio-Locating Signals within a beacon and the prioritization of these Radio-Locating Signals is the responsibility of the appropriate national or international bodies.

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

4.5.4 Beacon Self-Test Mode

All beacons shall include a self-test mode of operation.

In the self-test mode beacons shall transmit a digital message encoded in accordance with Annex A to this specification. The content of the self-test message shall always provide the beacon 15 Hex ID, except for location protocol beacons when transmitting a GNSS self-test message encoded with location data.

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

† This duration is based on ICAO standards for Extended Diversion Time operations (EDTO) and the maximum diversion time capability of existing aircraft types, as of April 2018.

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 regardless of the duration of activation of the self-test control. 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.

The self-test mode shall be activated by a separate switch position.

The self-test function shall perform an internal check and provide distinct indication (which shall occur during the declared timeframe for the self-test mode) that:

- a) the self-test mode has been initiated;
- b) RF power is being emitted at 406 MHz and at 121.5 MHz, if applicable;
- c) the internal check has passed successfully, or has failed; and
- d) the beacon battery may not have sufficient energy to support beacon operation for the manufacturer-declared minimum operating lifetime.^{*†}

The beacon shall be designed to ensure an automatic termination of the self-test mode immediately after completion of the self-test cycle and indication of the self-test results.

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. Additionally, location protocol beacons may optionally provide for the transmission of a GNSS self-test message encoded with location data.

Location protocol beacons which provide for the transmission of an encoded position in a GNSS self-test message shall:

- a) activate the GNSS self-test mode via a distinct operation from the normal self-test mode, but the GNSS self-test mode may be activated via the same self-test switch(es) or operation provided that it shall require a separate, deliberate action by the user that would limit the likelihood of inadvertent activation, and shall not

^{*} By decision of the Cospas-Sarsat Council at its Fifty-seventh Session, this requirement will only be mandatory for new beacon models submitted for type approval testing after 1 January 2018, as a target, subject to further review and consideration.

[†] Self-test indication of insufficient battery energy shall commence prior to the point, at which the residual battery energy is less than the energy required to support the declared minimum operating lifetime, as declared by the beacon manufacturer.

result in more than a single self-test burst regardless of the duration of activation of the GNSS self-test control;

- b) provide for that in the case of internal GNSS receivers powered by the primary* beacon battery the number of GNSS self-tests shall be limited by the beacon design to prevent inadvertent battery depletion;
- c) provide a distinct indication to register successful completion or failure of the GNSS self-test;
- d) provide, for beacons with internal navigation devices:
 - a separate distinct indication that the limited number of GNSS self-test attempts has been attained, which shall be immediately indicated to the user once the GNSS Self-test has been initiated,
 - a means to prevent any RF-transmissions or further GNSS receiver power drain, if further GNSS self-test activations are attempted, once the GNSS Self-test limit has been reached;
- e) ensure that the duration of the GNSS self test is limited to a maximum time duration set by the manufacturer, noting that:
 - in the case where the beacon fails to encode the location into the 406 MHz message within this time limit the GNSS self-test shall cease, the beacon shall indicate a GNSS self-test failure and may transmit a single self-test burst with default location data,
 - in the case where the beacon encodes the location into the 406 MHz message within this time limit the GNSS self-test shall cease at that time (before the time limit is reached), indicate a GNSS self-test pass and may transmit a single self-test burst containing the valid location data;
- f) provide an automatic termination of GNSS self-test mode, irrespective of the switch position, immediately after completion of the GNSS self-test cycle and indication of the test results; and
- g) include instructions for the GNSS self-test in the Beacon Instruction Manual which shall include a clear warning on the use and limitations of this function, noting that instructions for the GNSS self-test shall not be included on the beacon itself.

* The primary battery is the battery which is powering the 406 MHz function.

4.5.5 Encoded Position Data*

4.5.5.1 General

Beacon position data, obtained from a navigation device internal, integral[†] or external to the beacon, may be encoded in the beacon message. Position data can be encoded in either the PDF-2 part of the message, or in both PDF-1 and PDF-2 parts of the message.

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.

ELT(DT)s shall comply with the requirements of section 4.5.5.6 instead of sections 4.5.5.2 to 4.5.5.5.

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. All beacons with internal navigation devices shall provide updated position data, in accordance with section 4.5.5.4.

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.

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

[†] An integral navigation device is a part of the beacon system but may be separate to the beacon transmitter and shall comply with the performance requirements of an internal navigation device.

When 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, except for location protocol beacons when transmitting an optional GNSS self-test when the beacon shall radiate a single self-test message with encoded position.

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 transmitted in the beacon message and the known* beacon position at the time of the position update shall not exceed:

- 500 m for beacons transmitting messages encoded with the Standard, or National, or RLS Location protocols,
- 5.25 km for beacons transmitting messages encoded with the User-Location protocol.

The encoded position data shall be provided in the WGS 84 or GTRF geodetic reference systems.

The internal navigation device shall provide valid data within 10 minutes after its activation.

Internal navigation device cold start shall be forced at every beacon activation. Cold start refers to the absence of time dependent or position dependent data in memory, which might affect the acquisition of the GNSS position.

4.5.5.4 Internal Navigation Device Timing[†]

The internal navigation device within the beacon shall be activated immediately after the beacon is turned on. Once the navigation device acquires a fix it shall continue to attempt to acquire locations for a further period of at least 10 seconds and encode the location with the lowest HDOP obtained during this period into the next available beacon message. Between each attempt to obtain a 'fix' the

* The known beacon position shall have a 2-D location accuracy of ± 10 meters or better, which may be achieved by placing the beacon on the earth surface in a surveyed position with known geographical coordinates, or by determining the beacon position with a high-resolution GNSS receiver.

[†] These requirements are mandatory for new beacon models first submitted for type approval testing after **1 December 2021**, however manufacturers may voluntarily choose to comply with these requirements before this date. For beacons first submitted for type approval prior to this date, the version of C/S T.001 in force at the time of submission shall apply. Type approved beacons subject to change notices do not have to comply with these latest internal navigation device timing requirements and may continue to comply with the version of C/S T.001 that was in force at the time of the original type approval, unless the manufacturer decides to update the beacon navigation system, in which case the applicability of these requirements will be as of **1 December 2022**.

navigation device may be put into a sleep mode that may retain ephemeris and / or almanac data, such that when it is subsequently woken up it warm starts. Subsequent valid updated location ‘fixes’ shall be encoded into the next available beacon message. The navigation device search/sleep timing should be determined by the beacon manufacturer to optimize location performance whilst conserving battery capacity, subject to the following minimum requirements:

The internal navigation device shall make an attempt to obtain an initial location for a period of at least 10 minutes after beacon activation unless a location is obtained sooner than this. After this initial attempt to obtain a location, the internal navigation device shall make subsequent attempts to obtain an initial location, or an updated location, as applicable, at least every 15 minutes and no more frequently than every 4 minutes and 25 seconds, from the end of the last update attempt, for the remainder of the manufacturer declared minimum operating lifetime of the beacon*. Whenever an updated location is obtained, it shall be encoded into the next available beacon message to be transmitted. If an updated location is not obtained prior to the transmission of the next beacon message then the previous location (or if there was no previous location, default location) shall be transmitted until either a location is available or 4 hours have elapsed.

Attempts at obtaining an initial location or location update shall require the navigation device to be powered up for a period of at least 90 seconds each time, unless a location is obtained sooner than this, in which case the navigation device may then be put into a sleep mode 10 seconds later (noting that if this occurs after 80 seconds, this 10-second period can be reduced accordingly to maintain the total 90 seconds navigation device ‘on’ time).

4.5.5.5 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 61162).

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.

* For EPIRBs with VDR functionality, after at least 48 hours of operation, the update rate can be extended to a maximum of once every 60 minutes for the remainder of the operating lifetime, if required.

4.5.5.6 ELT(DT) Navigation Device Requirements

ELT(DT)s shall incorporate an internal navigation device and may incorporate an interface to an external navigation device (e.g., the aircraft avionics), which produce navigation data for encoding into the beacon message. ELT(DT) shall be encoded with the ELT(DT) Location Protocol. The BCH codes shall always match the message content. The ELT(DT) shall recompute these codes each time the message content is changed.

The first ELT(DT) transmission shall occur within 5 seconds of the beacon activation. If, after the ELT(DT) activation, navigation data is not available, then the ELT(DT) shall transmit its first and subsequent 406-MHz messages with the default position values specified in Annex A until such time, as navigation data becomes available from an internal GNSS receiver or, if applicable, from an external navigation device. If navigation data is available, 406-MHz transmissions shall contain a valid encoded position that was calculated within the 2 seconds immediately prior to a 406-MHz transmission.

The initial position transmitted in the first burst may be obtained from either the internal navigation device or from the external navigation device input.* The transmission in the beacon message of this external source of position is only subsequently allowed if the internal GNSS receiver is not able to produce a valid encoded position less than 2 seconds before the burst. If position data is available from both sources, within 2 seconds before any subsequent burst, then the location produced by the internal GNSS receiver has priority over the external source of data.

Internal navigation device cold start shall be forced on each initial power up of the internal navigation device, but shall not occur if the ELT(DT) is subsequently activated or between ELT(DT) transmissions. Cold start refers to the absence of time dependent or position dependent data in the beacon's or in the GNSS receiver's memory, which might affect the acquisition of the GNSS position.

ELT(DT)s shall attempt to acquire fresh position information prior to every 406 MHz transmission and shall encode the latest position obtained within less than 2 seconds (defined as current position) prior to each burst into that transmission.

If an updated position is not available within 2 seconds immediately prior to every 406 MHz transmission, then the ELT(DT) shall transmit the latest position that it has, unless this position is more than 4 hours old, in accordance with section 4.5.5.2, in which case it shall revert to transmitting the default position until such time as an updated position is available.

The freshness of the encoded location transmitted by the ELT(DT) shall be indicated in the ELT(DT) message as defined in Annex A.3.3.8.

The internal navigation device shall be capable of global operation and shall conform to an applicable international standard. The internal navigation device shall incorporate self-check features to ensure

* The internal navigation device or even the entire ELT(DT) may be powered by an external source prior to its activation in order to comply with this requirement.

that erroneous position data is not encoded into the beacon message. The self-check features shall prevent position data from being encoded into the ELT(DT) 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 navigation device shall provide a 3-D position which shall be encoded into the ELT(DT) message in accordance with Annex A.3.3.8. If a 3-D position is not available, then a 2-D position shall be provided and the altitude bits in the message shall be set to their default values.

The distance between the position provided by the internal navigation device, at the time of the position update, and the 2D position contained in the next 406 MHz transmission from the ELT(DT) while static shall not exceed 200 m. The distance between the altitude provided by the internal navigation device, at the time of the position update, and the altitude contained in the next 406 MHz transmission from the ELT(DT) while static shall not exceed 700 m. The encoded position data shall be provided in the WGS 84 or GTRF geodetic reference systems.

The distance between the position provided by the internal navigation device, at the time of the position update, and the 2D position contained in the next 406 MHz transmission from the ELT(DT) while static shall not exceed 200 m. The distance between the altitude provided by the internal navigation device, at the time of the position update, and the altitude contained in the next 406 MHz transmission from the ELT(DT) while static shall not exceed 700 m. The encoded position data shall be provided in the WGS 84 or GTRF geodetic reference systems.

If the ELT(DT) incorporates an interface to an external navigation device, it is recommended that this be compatible with an applicable international standard, such as the IEC Standard on Digital Interfaces (IEC Publication 61162).

When the ELT(DT) 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, except when transmitting an optional GNSS self-test, when the ELT(DT) shall radiate a single self-test message with encoded position.

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. Thereafter the beacon shall not transmit more frequently than the minimum repetition period (as defined in section 2.2.1) regardless of the duration of activation of any controls or the activation of any combination of controls. Once activated and transmitting the activation of any control other than the 'Off' or 'Reset' controls shall not stop the beacon from transmitting or result in inverted frame sync (self-test) mode.

ELTs when automatically activated by G-switch / deformation shall transmit the first 406 MHz distress message as soon as possible, which shall be within no more than 15 seconds after beacon activation*.

For ELT(DT)s, the transmission shall start within 5 seconds after beacon activation, as defined in section 2.2.1.

4.5.6.1 ELT(DT) Modes of Operation

ELT(DT)s shall allow for automatic and manual means of activation. ELT(DT)s shall also have means of deactivation by the same means of activation which shall be followed by a cancellation message sequence.

Consequently:

- If the ELT(DT) has been automatically activated by the triggering system[†], it shall only be de-activated by the same means.
- If the ELT(DT) has been automatically activated by the beacon[‡], it shall only be deactivated by manually resetting the beacon.
- If the beacon has been manually activated (i.e., from the cockpit), it shall only be manually de-activated.
- If the beacon has been activated by any combination of activation means, it can only be de-activated once each activation means has been deactivated.
- Bits 107 and 108 of the ELT(DT) Location Protocol message shall indicate the most recent means of activation. If one means of activation is removed but others remain then Bits 107 and 108 shall revert to indicating the previous most recent means of activation.

Thus an ELT(DT) shall as a minimum have the following modes of operation:

OFF - The complete ELT(DT) (and any related components) is/are unpowered.

ARMED - The ELT(DT) or some parts of it may if required be powered up, such that when it is activated automatically[§] or manually, it can start transmitting within 5 seconds and meet the requirements in this specification for ELT(DT)s including the provision of encoded location in the first burst. However until the ELT(DT) is activated there are no outputs from the ELT(DT) at all (e.g. no 406 MHz or Homing Signal transmissions).

* This requirement is mandatory to new beacon models submitted for type-approval testing at accepted test facilities after 1 January 2018.

[†] For example, triggered in compliance with EUROCAE ED-237

[‡] For example, triggered by G-switch / deformation.

[§] For example, triggered in compliance with EUROCAE ED-237 or by G-switch / deformation.

ON - The ELT(DT) has been either activated automatically and/or has been manually activated and is transmitting 406 MHz signals in full compliance with the ELT(DT) requirements in this specification.

RESET – The ELT(DT) is deactivated and ceases transmitting distress alerts and instead transmits a sequence of cancellation messages as defined by section 3.3. Upon completion of the cancellation message sequence, the ELT(DT) reverts to the ARMED condition. The ELT(DT) can only be deactivated as defined above.

4.5.7 RLS Beacon Requirements

Beacons with a Return Link Service (RLS) function shall support message encoding with the RLS Location Protocol and a Location Test Protocol*, and shall meet the following additional requirements.

4.5.7.1 GNSS Receiver

The RLS beacon shall contain an internal GNSS Receiver capable of receiving and decoding Return Link Messages (RLMs) from a Cospas-Sarsat recognised Return Link Service Provider (RLSP) and of providing these messages to the beacon in an IEC 61162-1 compliant sentence, or in an equivalent proprietary sentence defined by the GNSS-receiver manufacturer.

The following Return Link Messages have been defined to date:

- Acknowledgement Type-1 RLM: An automated response that acknowledges receipt of the RLS request,
- Test Return Link Message: An RLM dedicated for testing, including automatic response that acknowledges receipt of the RLS request from an RLS beacon coded with an RLS Location Test Protocol.

The definition of the RLM message content included as part of the Galileo L1 navigation message is defined in the Galileo Open Service Public Signal in Space ICD Issue 1.3.

4.5.7.2 RLS GNSS Receiver Operation

4.5.7.2.1 Operation Cycle

In addition to the beacons normal GNSS receiver operating cycle as defined in section 4.5.5.4, or as defined by the beacon manufacturer if in excess of this requirement, the RLS beacon shall:

- a) when encoded with an RLS Location Protocol maintain the GNSS receiver in an active mode of operation for a minimum period of 30 minutes after beacon activation or until a valid RLM message is acquired or the beacon is deactivated,

* The location test protocol may be either Standard Location Test or National Location Test protocol and must be used in addition to the RLS Location Test protocol.

if this occurs first, such that it can continuously check for receipt of an RLM message and UTC, during this period;

- b) as soon as possible determine Coordinated Universal Time (UTC) from the GNSS receiver and maintain a clock for at least 6 hours from the time the beacon was first activated, to an accuracy of better than three seconds (once UTC has been acquired) or until the beacon is deactivated (if UTC is not acquired see (e) below);
- c) if an RLM message has not been received within the first 30 minutes period, then, at the end of this time, utilise UTC time to next activate the GNSS receiver at the next occurrence of UTC M_{offset} minutes (where $0 \leq M_{\text{offset}} \leq 59$), to check for receipt of an RLM, for a minimum period of 15 minutes, or until an RLM message is acquired (e.g. if the first 30 minute period ended at 02:29 and M_{offset} is 15 minutes, then next activate the GNSS receiver at 03:15, or if M_{offset} is 44 minutes, then next activate the GNSS receiver at 02:44);
- d) then during each subsequent hour reactivate the GNSS receiver to check for receipt of an RLM for a minimum period of 15 minutes at M_{offset} minutes, with $0 \leq M_{\text{offset}} \leq 59$, past the hour until either an RLM message is received or 6 hours has elapsed since the beacon was activated
- e) if UTC cannot be determined within 30 minutes after beacon activation the beacon shall attempt to obtain UTC using the timings detailed in section 4.5.5.4. If UTC is then determined the beacon shall continue as per c) and d) above from the next occurrence of UTC M_{offset} minutes; and
- f) once a RLM message is received, or after 6 hours has elapsed since beacon activation, whichever is sooner, the beacon shall revert to the GNSS timings in section 4.5.5.4.

For instance, if the beacon is activated at 03.17h UTC, then the GNSS receiver would remain active until at least 03.47h UTC, or until an RLM message is acquired if sooner, or the beacon is deactivated, if it is deactivated before that time. If an RLM message is acquired within this period, then the beacon reverts to the GNSS timings in section 4.5.5.4. If an RLM message is not acquired, then it would re-activate at the next occurrence of M_{offset} past the hour and remain active until at least $M_{\text{offset}}+15$, or until an RLM message is acquired, or the beacon is deactivated and it would then reactivate again during the next hour at M_{offset} until $M_{\text{offset}}+15$, etc. The scheme continues as above until an RLM message is acquired, or 6 hours has elapsed since beacon activation, that is in this example until 09.17h UTC, at which time if an RLM wasn't acquired earlier the GNSS Receiver reverts to the GNSS timings in section 4.5.5.4. If the beacon is deactivated then the entire operation cycle commences again from the beginning when the beacon is next activated.

NOTE – The Galileo system will cease sending RLM messages back to the beacon, either once it receives an RLM Acknowledgement confirming that the RLM has been received by the beacon, or 6 hours have elapsed since the first RLS Request message from the beacon was received by the RLSP, whichever is the sooner.

4.5.7.2.2 Derivation of M_{offset}

The value of M_{offset} per each beacon is computed from the beacon 15 Hex ID, where the 19 bits containing the coarse position of the beacon are considered to be filled with default bits. More specifically:

$$M_{\text{offset}} = \text{BIN2DEC}(\text{CRC16}(\text{Beacon 15 Hex ID in Binary})) \bmod 60$$

Where BIN2DEC and CRC16 are functions performing the conversion of binary number to a decimal number and the CRC-16 of a stream of bits with polynomial $x^{16}+x^{15}+x^2+1$ respectively. The CRC-16 is used to obtain a uniform distribution of M_{offset}.

An example calculation of M_{offset} is shown in Figure B.3 in Annex B.

4.5.7.3 RLS Indicator

The beacon shall be provided with an RLS indicator designed to advise the user when a Type 1 RLS or RLS Test has been received by the RLSP and the beacon has received a Type 1 Return Link Message (RLM) or Test Return Link Message (Test RLM) respectively. The RLS Indicator shall:

- a) be readily visible to the user when the beacon is operated in all its normal operational configurations as declared by the manufacturer;
- b) be clearly visible to the user in direct sunlight;
- c) provide a distinct unique indication;
- d) remain inactive at all times when the beacon message is encoded with any protocol other than the RLS Location Protocol or RLS Location Test Protocol;
- e) within 5 seconds of the beacon transmitting an initial RLS request through the RLS Location Protocol or RLS Location Test Protocol, commence indication of an RLS request until either a valid RLM Type 1 or Test RLM message respectively is received, or the beacon is deactivated, or the beacon battery is expired;
- f) within 5 seconds of the beacon receiving a valid RLM Type 1 or Test RLM message acknowledgement, commence a distinct indication until either the beacon is deactivated or the beacon battery is expired; and
- g) only provide the indication of receipt of an RLS request acknowledgment when the received RLM Type 1 or Test RLM message contains the unique 15 Hex ID programmed into that beacon and the beacon has validated that this matches its own 15 Hex ID.

4.5.7.4 Confirmation of a Return-Link Message Receipt

Upon receipt of an Acknowledgement Type-1 RLM or a Test RLM associated with the beacon 15 HEX ID, the beacon shall, within 1 minute, acknowledge the RLM receipt by changing the coding of its message as defined in the RLS Location Protocol, as described in section A.3.3.7.3. Once changed,

bits 111 and 112 shall no longer be changed until the beacon is switched off or the beacon battery is depleted.*

Once the beacon has received an Acknowledgement Type-1 RLM or a Test RLM and has acknowledged the RLM receipt, the GNSS Receiver shall continue to function as required by section 4.5.7.2.1 unless the beacon is coded as a "Type-1 only capable" RLS beacon as defined in section A.3.3.7.3. In this specific case only, the GNSS receiver may revert to operating as defined within Section 4.5.5.4, taking into account the time elapsed between the moment of activation and the moment when the Type-1 RLM message is received, until either the beacon is deactivated or the beacon performance ceases to meet specification due to battery depletion.

Example:

A beacon is activated at 9:00. It transmits emergency signals for 2 hours and 30 minutes. During the period from 11:00 to 11:15 it receives a Type-1 RLM Acknowledgement. The GNSS receiver could then revert to operating in accordance to the requirements for internal GNSS receiver without the RLS capability which specifies that, for the first 6 hours after beacon activation, the navigation device shall attempt location update at least once every 30 minutes.

4.5.7.5 RLS Beacon Documentation

The operation of the RLS function shall be clearly explained in the User Manual including any limitations of the overall RLS system.

4.5.8 Beacon Labelling and Marking

All beacons shall have the following information permanently marked on the exterior of the beacon:

- a) beacon model name,
- b) beacon manufacturers name,
- c) Cospas-Sarsat type approval certificate number (TAC),
- d) beacon 15-Hex ID,
- e) beacon operating temperature range,
- f) minimum operating lifetime,
- g) an indication if the beacon has the Return Link Service function,
- h) labelling of the RLS indicator (if applicable).

* Transmission of RLMs associated with the beacon 15 HEX ID may be stopped by the RLSP upon a successful receipt of the confirmation of the RLM reception by the beacon.

4.5.9 Operator Controlled Voice Transceivers

If an operator-controlled voice transceiver integrated with a beacon uses the same power source as the beacon, then there are additional considerations affecting the beacon operating lifetime:

- the maximum cumulative duration of voice-transceiver transmission that does not reduce available power-source energy below the amount needed to operate the beacon for its declared minimum operating lifetime; and
- transceiver operational features that mitigate the effects of unintentional transmissions by limiting the duration of each transmission to a certain maximum time (“time-out timer”).

An operator-controlled voice transceiver that shares a power source with the beacon is assumed to be a transceiver used only in distress situations (similar to a 121.5-MHz homing signal sharing a beacon’s power source). Therefore, the voice transceiver shall not be capable of drawing power from the shared power source until after the beacon has been activated. The manufacturer shall specify a maximum cumulative voice-transceiver transmit-mode ‘on’ time that ensures that sufficient energy is available from the common (beacon/transceiver) power supply to allow the beacon to meet the manufacturer’s declared Minimum Operating Lifetime.

The declared maximum cumulative transmit-mode ‘on’ time shall not be less than 10% of the declared Minimum Operating Lifetime for the beacon. The declared maximum cumulative transmit-mode ‘on’ time shall be clearly reflected in the beacon instruction manual, together with an explanation/warning to the user that voice-transceiver transmit operation exceeding the declared maximum cumulative transmit-mode ‘on’ time will reduce duration of operation of the activated 406-MHz beacon.

An operator controlled voice transceiver as described above should ideally include a means to prevent continuous transmission by the voice transceiver beyond a predetermined limit of time set by the beacon manufacturer’s design, once the Push-To-Talk (PTT) switch has been operated (“time-out” timer). If this feature is included in the design, continuous transmission by the voice transceiver shall not exceed 30 minutes. Releasing and reactivating the PTT switch should reset the “time-out timer” for this function.

Operator controlled voice transceivers in beacons without the above “time-out timer” function shall be deemed to transmit continuously for the purposes of the operating lifetime at minimum temperature test.

4.5.10 ELT(DT)s Specifically Designed to Withstand a Crash Impact

4.5.10.1 Introduction

Potentially there may be ELT(DT)s that have additional functionality, as defined by National Administrations and/or Aviation Authorities, which are designed to:

- 1) function both prior to a crash and after a crash, and withstand crash impact conditions;
- 2) be activated in-flight or by crash;
- 3) have homing and locating signals; and/or
- 4) have extended operating life.

If there is a conflict between the requirements of this section and any other section of this document, then this section takes precedence.

4.5.10.2 Beacon Hex ID

The Hex ID of the ELT(DT) shall not change from when activated in flight compared to when operating after a crash.

4.5.10.3 Burst Repetition Period (with Crash Detection)

If the ELT(DT) includes a crash detection function, within 5 seconds of a crash the ELT(DT) shall restart the transmission schedule for an ELT(DT) as if the ELT(DT) had just been activated and maintain this transmission schedule for the 30 minutes after the crash detection. Beyond 30 minutes, the ELT(DT) shall transmit bursts with a repetition period randomized around a mean value of 120 seconds, so that time intervals between transmissions are randomly distributed over the interval of 115 to 125 seconds.

4.5.10.4 GNSS Update Rate (after Crash Detection)

During a 30-minute period after a crash detection, the GNSS encoded location shall be updated before each transmitted burst, as per section 4.5.5.6.

Beyond 30 minutes, the GNSS encoded location shall be updated in accordance with section 4.5.5.4.

4.5.10.5 Duration of Continuous Operation

The minimum duration of continuous operation for this type of ELT(DT) shall be at least 24 hours at any temperature throughout the specified operating temperature range. This is to be understood to mean the total operating time which is a combination of the time prior to a crash and post-crash.

4.5.10.6 Homing and Locating Signals

The inclusion or otherwise of one or more homing signals in the ELT(DT) and the activation and duration of any homing signal transmissions are the responsibility of national administrations.

4.5.11 ELT(DT)s Combined with Automatic ELTs

4.5.11.1 Introduction

Potentially there may be ELT(DT)s that have combined functionality, that is they function as an ELT(DT) during a flight, but on detection of an incident perform as an Automatic ELT (either an

ELT(AD), ELT(AF) or ELT(AP)), such a combined ELT would be required to meet the regulatory requirements set by National Administrations and/or Aviation Authorities, for both an ELT(DT) and the type of Automatic ELT that it is combined with.

However, from a Cospas-Sarsat perspective there are certain key functions of such a combined ELT that need to be clearly defined related to its performance and operation and the transition from an ELT(DT) to either an ELT(AD), ELT(AF) or ELT(AP) as follows.

If there is a conflict between the requirements of this section and any other section of this document, then this section takes precedence.

4.5.11.2 Beacon Coding and Beacon Hex ID

The combined ELT(DT) and Automatic ELT shall be encoded with the ELT(DT) Location Protocol at all times. The Beacon Coding shall not change to another Protocol when operating as an Automatic ELT.

The 15-Hex ID shall remain the same regardless of whether the device is operating as an ELT(DT) or as an automatic ELT.

Bits 107 and 108 in the ELT(DT) Location Protocol shall be used to indicate both the ELT(DT) and Automatic ELT means of activation. The most recent means of activation, whether by the ELT(DT) or the Automatic ELT shall be encoded and transmitted in the beacon message.

4.5.11.3 Burst Repetition Period

When activated as an ELT(DT) the beacon shall meet the burst repetition requirements for an ELT(DT) as defined in section 2.2.1. When activated as an Automatic ELT or if transitioning from an ELT(DT) to an Automatic ELT then the combined device shall commence the burst repetition requirements for a non-ELT(DT) 406 MHz beacon as defined in section 2.2.1.

4.5.11.4 System Requirements

The combined ELT(DT) and Automatic ELT shall meet the more stringent requirements that apply to either part of the device (except where stated otherwise below), for the operating temperature range (as per section 4.2.1) of the beacon under test. Specifically, the combined device shall:

- a) comply with the Digital Message Requirements for an ELT(DT) (section 2.2.4 b));
- b) comply with the Medium-Term Frequency Stability Requirements for a non-ELT(DT) 406 MHz beacon (section 2.3.1);
- c) meet the Transmitter Power Output requirements for an ELT(DT) (section 2.3.2) while operating as an ELT(DT), when operating as an Automatic ELT or when transitioning from an ELT(DT) to an Automatic ELT then the Power Output requirement of the combined device may be relaxed to that of a non-ELT(DT) 406 MHz beacon (section 2.3.2);
- d) comply with the Modulation rise and fall times for an ELT(DT) (section 2.3.6);
- e) comply with both the Temperature Gradient requirements for an ELT(DT) and the Temperature Gradient requirements for a non-ELT(DT) 406 MHz beacon (section 4.2.2); and
- f) comply with both the Thermal Shock requirements for an ELT(DT) and the Thermal Shock requirements for a non-ELT(DT) 406 MHz beacon (section 4.2.3).

4.5.11.5 Cancellation Message

The cancellation message shall function as it would for an ELT(DT) (as defined in section 3.3) while functioning as an Automatic ELT as well as while functioning as an ELT(DT).

4.5.11.6 Encoded Position Data and Navigation Device Performance

While operating as an ELT(DT) the navigation device shall comply with the requirements of section 4.5.5.6. When operating as an Automatic ELT, that is automatically activated, the navigation device shall comply with the requirements of sections 4.5.5.3 and 4.5.5.4. When operating as an Automatic ELT, that is manually activated, the navigation device shall comply with the requirements of section 4.5.5.6, for a period of at least 6 hours and 10 minutes, after which time it shall comply with the requirements of sections 4.5.5.3 and 4.5.5.4.

4.5.11.7 Duration of Continuous Operation

The minimum duration of continuous operation for this type of combined ELT shall be a combination of the minimum duration of continuous operation for an ELT(DT) and the minimum duration of continuous operation for a non-ELT(DT) 406 MHz beacon (i.e. at least 30 hours and 10 minutes).

4.5.11.8 Class of Operation

The combined device may, if required, function at different classes of temperature as an ELT(DT) or Automatic ELT (e.g. the ELT(DT) part of the device may be specified to operate as a Class 1 device, while the Automatic ELT part of the device may be specified to operate as a Class 2 device).

4.5.11.9 Homing and Locating Signals

The inclusion or otherwise of one or more homing signals in the combined device and the activation and duration of any homing signal transmissions are the responsibility of national administrations.

4.5.12 External Power Source for ELT(DT)s

The ELT(DT) shall have its own integral or internal power source. However, when available, the ELT(DT) may use the external aircraft electrical power source. An ELT(DT) shall comply with all applicable requirements regardless of power source. In addition, the ELT(DT) performance shall not be impacted by switching between power sources.

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

This document has been
superseded by a later version

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)

<u>Bit Field Name</u>	<u>Bit Field Location</u>
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)

<u>Bit Field Name</u>	<u>Bit Field Location</u>
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, A9, A10 and A11.

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:

<u>Bits</u>	<u>Usage</u>
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 location protocols 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 available on the ITU website (<http://www.itu.int/en/ITU-R/terrestrial/fmd/Pages/mid.aspx>). National administrations which were 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. This coding method should be used only if the first 3 digits (MID) forming part of a unique 9-digit code of ship station identity correspond to the 3 digit country code encoded in bits 27 to 36.

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 database.

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 user and user-location protocols;
- 4-bit code in bits 37 to 40 for standard location and national location protocols, RLS Location Protocol and ELT(DT) 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)	Not Used	Standard Location Protocols National Location Protocol RLS Location Protocols ELT(DT) 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 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	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 and User-Location Protocols****(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. | |
| 5. Test User Protocol | 111 |
| 6. Orbitography Protocol | 000 |
| 7. National User Protocol* | 100 |
| 8. Not to be used (allocated to Second Generation Beacons) | 101 |

A2-B: Standard National, RLS and ELT(DT) Location Protocols**(F=1, P=0) long message****Protocol Codes****(Bits 37 - 40)**

- | | |
|---|------|
| <u>Standard Location Protocols</u> | |
| 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. Ship Security | 1100 |
| 5. <u>National Location Protocol</u> | |
| a) ELT | 1000 |
| b) EPIRB | 1010 |
| c) PLB | 1011 |

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

6. <u>Test location Protocols</u>	
a) Standard Test Location Protocol	1110
b) National Test Location Protocol	1111
7. RLS Location Protocol	1101
8. ELT(DT) Location Protocol	1001
9. Spare	0000, 0001

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:

<u>bits</u>	<u>usage</u>
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:

<u>bits 84-85</u>	<u>auxiliary radio-locating device type</u>
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)				E N ¹		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)								
8. SGB PROTOCOL (Reserved for SGB – but not transmitted)																
Bits	25	26	27	36	37	39	40	85								
.....	...	1	Country Code		1	0	1	As Defined in C/S T.018 (46 bits)								

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

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

EN = Specific ELT number on designated aircraft (see section A2.4) *

* Effective as of 1 November 2011.

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. This coding method should be used only if the first 3 digits (MID) forming part of a unique 9-digit code of ship station identity correspond to the 3 digit country code encoded in bits 27 to 36.

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:

<u>Bits</u>	<u>Usage</u>
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:

<u>Bits</u>	<u>Usage</u>
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	specific ELT number ¹
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.

Bits 82-83 are used to create a unique ELT identification when several ELTs coded with the Aviation User protocol are installed on the same aircraft. “00” indicates the first ELT on the aircraft coded with this protocol and “01”, “10” and “11” identify additional ELTs, all coded with the Aviation User protocol.*

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 specific ELT number in bits 68-73 if several ELTs, encoded with the same 24 bit address, are carried in the same aircraft
- 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;
-

* Effective as of 1 November 2011.

- 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
	0	1		0	1	1	T T T C	(20 bits)		All "0" or		C/S cert. No.	
			Country Code					Serial Number		Nat. Use		or Nat. Use	R L

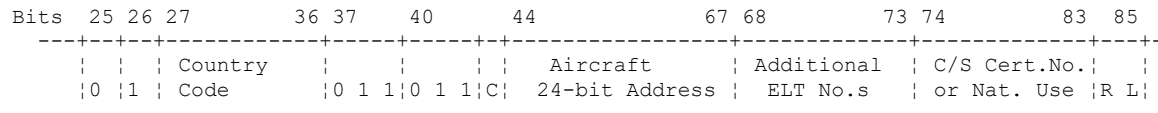
Bits	Usage
25	format flag (= 0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=000, 010, 100 or 110)
43	flag bit for Cospas-Sarsat type approval certificate number
44-63	serial number
64-73	all 0s or national use
74-83	C/S type approval certificate number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

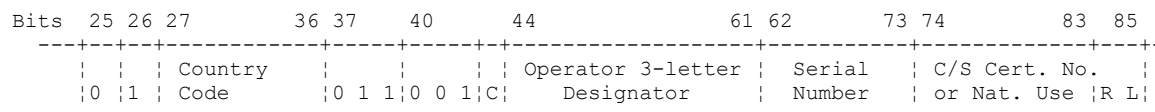


<u>Bits</u>	<u>Usage</u>
25	format flag (= 0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=011)
43	flag bit for Cospas-Sarsat type approval certificate number
44-67	aircraft 24-bit address
68-73	specific ELT number, if several ELTs encoded with the same 24-bit address are carried in the 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 6-bit specific ELT number, in binary notation with the least significant bit on the right, which is an order number of the ELT in the aircraft, where “000000” indicates the first ELT on the aircraft coded with this protocol and “000001”, “000010”, “000011”, etc., identify additional ELTs, all coded with the Aircraft 24-bit Address User protocol. The purpose of this specific number is to produce different 15 Hex numbers containing the same 24-bit address.

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:



<u>Bits</u>	<u>Usage</u>
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:

<u>Bits</u>	<u>Usage</u>
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.

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:

* 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.

bit 108 set to (=1) indicates that the beacon can be activated either manually or automatically.

A float-free beacon shall have bit 108 set to 1.

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.

This document has been
superseded by a later version

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	
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 64 - b 75: Last three characters (binary coded decimal)		b 43: C/S Certificate flag 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: Specific ELT number*	
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 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 1 = Automatic and manual activation			
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)			

* Effective as of 1 November 2011.

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 with the long message^{*}, 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.

National Location Protocol. This location protocol is 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.

Return Link Service (RLS) Location Protocol[†]. This location protocol is for use with the long message format. The beacon identification data is provided in 26 bits of PDF-1 where the first two bits define the beacon type and the remaining 24 bits define the RLS truncated TAC number and serial number. Position data, to 30-minute resolution, is given in PDF-1, with position offsets to 4-second resolution in PDF-2. PDF-2 also contains six supplementary data bits which contain RLS data.

ELT(DT) Location Protocol[‡]. This location protocol is for use with the long message format. The beacon identification data is provided in 26 bits of PDF-1 where the first two bits define the type of beacon identity and the remaining 24 bits provide that identity. Position data to 30-minute resolution is also given in PDF-1, with position offsets to 4-second resolution in PDF-2. PDF-2 also contains six supplementary data bits which contain altitude and other ELT(DT) data.

^{*} Cospas-Sarsat no longer permits the use of short format location protocols. Information on these protocols is available in C/S T.001, Issue 3- Revision 7.

[†] By decision of the Cospas-Sarsat Council at its Fifty-Seventh Session, this protocol will be effective as of 1 January 2018, as a target, subject to further review and consideration.

[‡] By decision of the Cospas-Sarsat Council at its Fifty-Seventh Session, this protocol will be effective as of 1 January 2018, as a target, subject to further review and consideration.

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. Additionally, if a location protocol beacon includes an optional GNSS self-test and this fails to provide a valid location to encode into the transmitted self-test message, then the beacon may radiate a single self-test message with the above default data. However if a location protocol beacon with optional GNSS self-test obtains a location, then the beacon may radiate a single self-test message with encoded position.

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

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

ELT (DT) and RLS Location Protocol							
bit 26	bits 27-40	bits 41-66	bits 67-85	bits 86-106	bits 107-114	bits 115-132	bits 133-144
0	Identification Data (26 bits)	Position Data to 30 min Resolution (19 bits)	21-Bit BCH code	Supplementary Data (8 bits)	Position Data to 4 sec Resolution (18 bits)	12-Bit BCH code

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. All rounding shall follow normal rounding conventions, for example with a resolution of 4, 0.000 to 1.999 shall be rounded down to 0 and 2.000 to 3.999 shall be rounded up to 4. In each location field the Most Significant Bit (MSB) is the lowest numbered bit in the message which is not a N/S, E/W or Δ sign flag bit.

For User Location Protocols, the position encoded in PDF-2 shall be as close as possible to the actual position.

For Standard Location, National Location, RLS Location, and ELT(DT) Location Protocols the position is encoded as follows. The coarse position encoded in PDF-1 is selected to be as close as possible to the actual position. The actual position is then rounded following the above rules to the nearest 4 seconds. The offset to be encoded in PDF-2 is then calculated by subtracting the coarse position encoded in PDF-1 from the rounded position, ensuring that the sign of the offset is included in PDF-2[†]. If there is no offset in either latitude or longitude (or both) in PDF-2 (i.e. the offset minutes and seconds are all zeroes) then the appropriate offset data flag shall be set to its default value (i.e., 1).

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.

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.

* Beacons submitted for type approval testing prior to 1 November 2010 may at manufacturers choice use the location protocol coding system defined in A3.3.1 or the previous system as defined in section A3.3.1 of document C/S T.001, Issue 3 - Revision 8. Manufacturers who choose to use the location encoding system defined in A3.3.1 may use the answer sheets in C/S T.007, Issue 3 - Revision 9. Manufacturers who submit for type approval testing after 1 November 2010 must use the answer sheets in C/S T.007, Issue 3 - Revision 10.

[†] Note that the encoded location in PDF-1 will be closest to the actual, but in some cases may not be the closest location to the rounded location.

A3.3.2.1 Source of Position Data

This information is encoded in bit 107 for the user-location protocol and RLS location protocol or bit 111 for the standard and national location protocols 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) and in bit 108 for the RLS location protocol 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).

A3.3.2.3 ELT(DT) Activation mechanism

This information is encoded in bits 107 and 108 for the ELT(DT) Location Protocol with the following interpretation:

- "00": manual activation by user
- "01": automatic activation by the beacon
- "10": automatic activation by external means
- "11": spare

If the beacon receives more than one triggering command, then the most recent triggering event is indicated in the bits 107-108.

A3.3.2.4 ELT(DT) Altitude above sea level

This information is encoded in bits 109 to 112 for the ELT(DT) Location Protocol with the following interpretation:

“0000”: altitude is less than 400 m (1312 ft)
 “0001”: altitude is between 400 m (1312 ft) and 800 m (2625 ft)
 “0010”: altitude is between 800 m (2625 ft) and 1200 m (3937 ft)
 “0011”: altitude is between 1200 m (3937 ft) and 1600 m (5249 ft)
 “0100”: altitude is between 1600 m (5249 ft) and 2200 m (7218 ft)
 “0101”: altitude is between 2200 m (7218 ft) and 2800 m (9186 ft)
 “0110”: altitude is between 2800 m (9186 ft) and 3400 m (11155 ft)
 “0111”: altitude is between 3400 m (11155 ft) and 4000 m (13123 ft)
 “1000”: altitude is between 4000 m (13123 ft) and 4800 m (15748 ft)
 “1001”: altitude is between 4800 m (15748 ft) and 5600 m (18373 ft)
 “1010”: altitude is between 5600 m (18373 ft) and 6600 m (21654 ft)
 “1011”: altitude is between 6600 m (21654 ft) and 7600 m (24934 ft)
 “1100”: altitude is between 7600 m (24934 ft) and 8800 m (28871 ft)
 “1101”: altitude is between 8800 m (28871 ft) and 10000 m (32808 ft)
 “1110”: altitude is greater than 10000 m (32808 ft)
 “1111”: default value if altitude information is not available.

A3.3.2.5 ELT(DT) Encoded Location Status

This information is encoded in bits 113 and 114 for the ELT(DT) Location Protocol with the following interpretation:

- “00”: encoded location in message is greater than 5 minutes old or, in case the default encoded position is transmitted,
- “01”: encoded location in message is between 60 seconds and 5 minutes old,
- “10”: encoded location in message is greater than 2 seconds and less than 60 seconds old,
- “11”: encoded location in message is current.

A3.3.2.6 RLS Data

Bits 109 and 110 Return Link Message (RLM) Request
 Bits 111 and 112 Beacon Feedback (on receipt of RLM)
 Bits 113 and 114 Return Link Service (RLS) Provider

A3.3.3 Test Location Protocols

The test protocol for all coding methods (i.e. "user" and "location" protocols, except for the ELT(DT) and RLS 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").

The ELT(DT) and RLS location protocols both have their own test protocols build into their protocol.

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	
	F O R M A T & P R O T O C O L	C O U N T R Y C O D E	3	<u>USER-LOCATION PROTOCOLS</u> (P=1)		21-BIT BCH ERROR CORRECTING CODE	<u>USER-LOCATION PROTOCOLS</u>				12-BIT BCH ERROR CORRECTING CODE
			010 110 001 011 111	Identification Data (same as User Protocols) See Figure A7			Latitude / Longitude Data (4 Minute Resolution) See Figure A7				
			4	<u>STANDARD LOCATION PROTOCOLS</u> (P=0)			<u>STANDARD LOCATION PROTOCOLS</u>				
			0010 0011 0100 0101 0110 0111 1100 1110	Identification & Position Data (1/4 Degree Resolution) See Figure A8			Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A8				
			4	<u>NATIONAL LOCATION PROTOCOLS</u> (P=0)			<u>NATIONAL LOCATION PROTOCOLS</u>				
			1000 1010 1011 1111	Identification & Position Data (2 Minute Resolution) See Figure A9			Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A9				
	4	<u>RLS LOCATION PROTOCOLS</u> (P=0)		<u>RLS LOCATION PROTOCOLS</u>							
	1101	Identification & Position Data (30 Minute Resolution) See Figure A10		Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A10							
	4	<u>ELT-DT LOCATION PROTOCOL</u> (P=0)		<u>ELT-DT LOCATION PROTOCOL</u>							
1001	Identification & Position Data (30 Minute Resolution) See Figure A11		Δ Latitude / Δ Longitude (4 Second Resolution) + Supplementary Data See Figure A11								
↑ F= 1 P= 0 or 1		↑ PROTOCOL CODE See Table A2		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

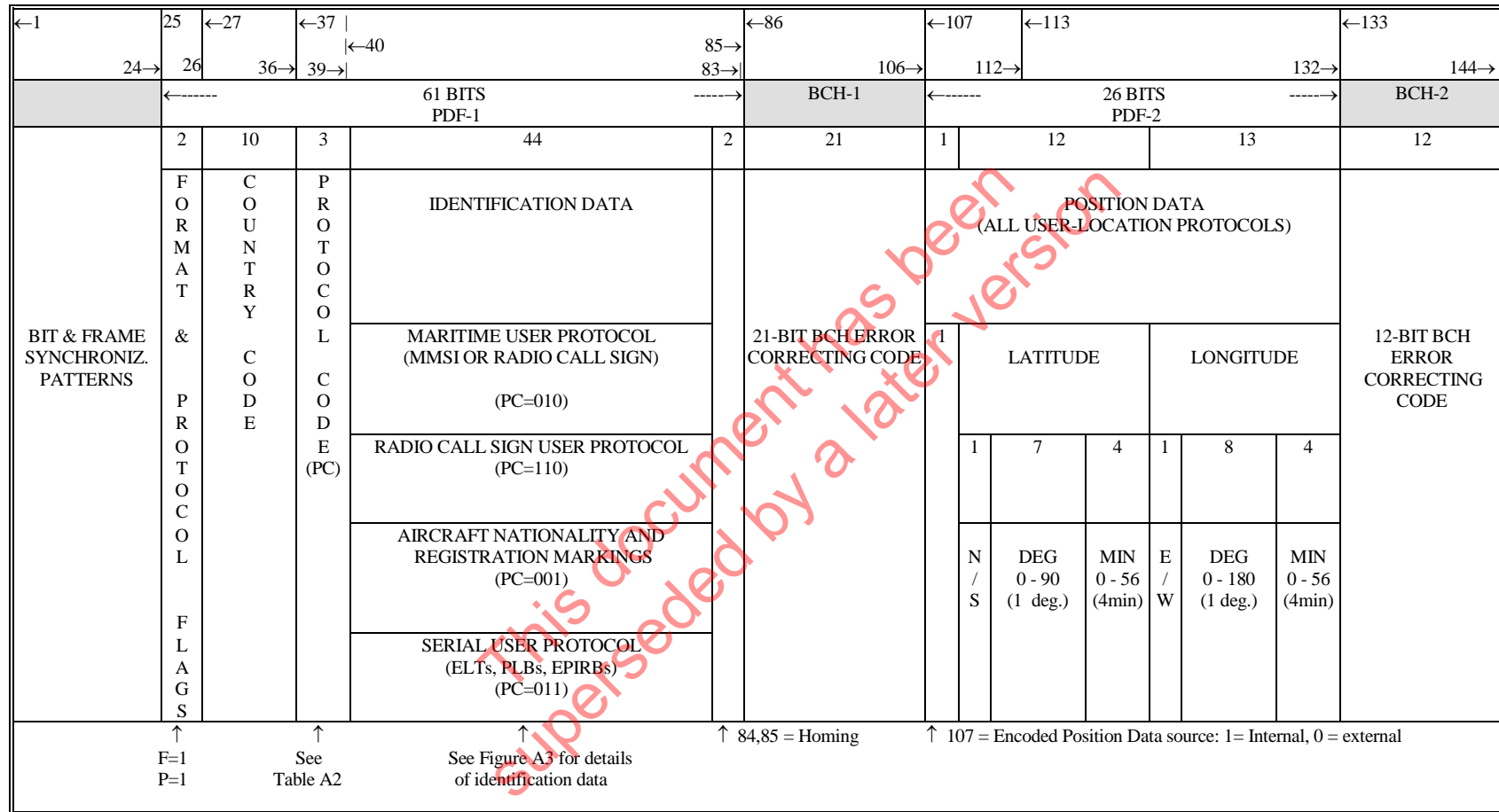
"1" = the encoded position data is provided by an internal navigation device;

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 Protocol

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 4 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.
- d) (PC=1100) the last six digits of MMSI in binary form in bits 41 to 60 (20 bits), plus four spare fixed bits, 61 to 64, set to "0000".

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)

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
- 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); 121.5 MHz auxiliary radio locating devices are not authorised for beacons coded with the ship security format (i.e. when bits 37 – 40 = 1100);
- 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".

* A3.3.5 defines the coding scheme for all Standard Location Protocols, some newer beacons where the coarse position in PDF-1 is always selected to be as close as possible to the actual position will have a maximum offset in PDF-2 of +/- 7 minutes 30 seconds, in which case bits 114, 115, 124 and 125 of the message will not be used and should be permanently set to "0".

Figure A8: Standard Location Protocols

←1	25	←27	←37		←86	107	←113		←133																						
24→	26	36→	40→←41		85→	106→	112	132→	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		F O R M A T & P R O T O C O L F L A G	C O U N T R Y C O D E	PC	24 BITS IDENTIFICATION DATA			21 BITS LATITUDE LONGITUDE			S U P P L E M E N T A R Y D A T A	Δ LATITUDE			Δ LONGITUDE			12-BIT BCH ERROR CORRECTING CODE													
						20		4	1	9		1	10		1	5	4		1	5	4										
				00	10	MMSI (last 6 digits, binary)		B.No 0 -15		N		LAT	E	LON	-	M I N U T E S	-		M I N U T E S	-	M I N U T E S	S E C O N D S									
				00	11	AIRCRAFT 24 BIT ADDRESS																	S	DEG	E	DEG	+	0 - 30 (1min)	0-56 (4s)	0-30 (1min)	0-56 (4s)
				01	01	15		9																							
				01	01	AIRCRAFT OPER. DESIGNATOR		SERIAL No 1 - 511		(1/4 d.)		0 - 90	W	0 -180	(1/4 d.)																
				00		10		14																							
				01	10 11	C/S TA No 1 – 1023		SERIAL No 1 - 16383																							
				11	00	20		4																							
						MMSI (last 6 digits, binary)		Fixed 0000																							
↑ F=1 P=0				0100 ELT-Serial 0110 EPIRB-Serial 0111 PLB				↑ 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																							
				1110 Test																											

A3.3.6 National Location Protocol (see Figure A9)

A3.3.6.1 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).

A3.3.6.2 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).

A3.3.6.3 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 to 132; 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: if bit 110 = 1, 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);
 bits 113 to 119: if bit 110 = 0, national use;
- f) bits 120 to 126: if bit 110 = 1, 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);
 bits 120 to 126: if bit 110 = 0, national use; and
- g) bits 127 to 132: Additional beacon identification (national use) (default value of bits 127 to 132 = 000000).

A3.3.6.4 The test protocol using the above format is encoded by setting bits 37-39 to "111" and bit 40 to "1".

* A3.3.6 defines the coding scheme for all National Location Protocols, some newer beacons where the coarse position in PDF-1 is always selected to be as close as possible to the actual position will have a maximum offset in PDF-2 of +/- 1 minute, in which case bits 114 and 121 of the message will not be used and should be permanently set to "0".

27 BITS						21-BIT BCH ERROR CORRECTING CODE	S U P P L E M E N T A R Y D A T A	Δ LATITUDE		
LATITUDE			LONGITUDE					1	2	4
1	7	5	1	8	5					
	D E G R E E S 0 - 90 (1 deg)	M I N U T E S 0 - 58 (2 m)	E W	D E G R E E S 0 - 180 (1 deg)	M I N U T E S 0 - 58 (2m)				- +	M I N U T E S 0 - 3 (1m)

←1	25	←27	←37				←86				107	←113				←133									
24→	26	36→	40→←41				85→				106→	112	132→				144→								
		61 BITS PDF-1								BCH-1		26 BITS PDF-2								BCH-2					
BIT & FRAME SYNCHRONIZ. PATTERNS	2	10	4	45								21	6	7			7			6	12				
	F O R M A T & P R O T O C O L F L A G	C O U N T R Y C O D E	P R O T O C O D E	18 BITS	27 BITS										21-BIT BCH ERROR CORRECTING CODE	S U P P L E M E N T A R Y D A T A	Δ LATITUDE			Δ LONGITUDE			N A T I O N A L U S E	12-BIT BCH ERROR CORRECTING CODE	
				IDENTI- FICATION	LATITUDE					LONGITUDE															
				18	1	7	5	1	8	5															
				NATIONAL ID NUMBER	N	D E G R E E S	M I N U T E S	E A S T	W E S T	D E G R E E S	M I N U T E S														
					S		0 - 90	0 - 58		0 - 180	0 - 58														
						(1 deg)	(2 m)			(1 deg)	(2m)														
↑		↑																↑ 107 = "1"							
F=1		See																↑ 108 = "1"							
P=0		Table A2																↑ 109 = "0"							
		1000 ELT																↑ 110 = Additional Data Flag: 1 = Δ Position, 0 = Nat. Assignment							
		1010 EPIRB																↑ 111 = Encoded Position Data Source: 1 = Internal, 0 = external							
		1011 PLB																↑ 112 = 121.5 MHz Homing: 1= Yes, 0 = No							
		1111 Test																							

A3.3.7 RLS Location Protocol (see Figure A10)

A3.3.7.1 The RLS location protocol, identified by the flags F=1, P=0 and the protocol code in series no. 7 of Table A2-B, has the following structure:

a) PDF-1:

- bits 37 to 40: 4-bit protocol code defined as 1101,
- bits 41 to 42: 2-bit beacon type data set to “00” for ELT, “01” for EPIRB, “10” for PLB, and “11” for Location Test Protocol except when bits 43 to 46 have the value “1111” in which case these bits indicate the following; “00” First EPIRB on Vessel, “01” Second EPIRB on Vessel, “10” PLB and “11” Location Test Protocol.
- bits 43 to 46: Set to “1111” indicate that this is an RLS Location Protocol coded with an MMSI, and bits 41 to 42 and bits 47 to 66 have a different use as defined above and below
- bits 43 to 46: Set to any combination of bits other than “1111” indicate that the RLS Location Protocol is coded with either a TAC or National RLS and Serial Number
- bits 43 to 52: 10 bit truncated^{*†} C/S RLS TAC number or National RLS Number except when bits 43 to 46 are set to “1111”,

* The 10-bit RLS truncated TAC or National RLS number is the last 3 decimal numbers in the TAC number data field, which allows a range of 1 to 949. The RLS beacon TAC number or National RLS number series are assigned as follows:

1000 series is reserved for EPIRBs (i.e. 1001 to 1949),
 2000 series is reserved for ELTs (i.e. 2001 to 2949), and
 3000 series is reserved for PLBs (i.e. 3001 to 3949).

These are represented in the RLS messages as bits 41 to 42 (except when bits 43 to 46 are set to “1111”) indicating the beacon type series (EPIRB, ELT, or PLB) and a 10 bit (1-1024) TAC number which is added to the series to encode the full TAC number. (e.g., TAC 1042 would be encoded as “01” for EPIRB in bits 41 to 42 representing 1nnn, where “nnn” is “042” determined by “0000101010” in bits 43 to 52, and form a binary representation “00 0010 1010” of the decimal number “42”.

† The numbers 920 to 949 (i.e., National RLS Numbers 920 to 949) are set aside for National Use by Competent Authorities. That is full National RLS Numbers 1920 to 1949 for EPIRBs, 2920 to 2949 for ELTs, and 3920 to 3949 for PLBs.

bits 53 to 66: 14-bit identification data consisting of a production serial number (1 to 16,383) assigned by the manufacturer associated with a C/S RLS TAC number (001 to 919), except when bits 43 to 46 are set to “1111”,

or

bits 53 to 66: 14-bit identification data consisting of a Competent Authority assigned serial number (1 to 16,383), associated with a National RLS Number that has been allocated to an Administration by the Cospas-Sarsat Programme (920 to 949^{*}), except when bits 43 to 46 are set to “1111”[†],

bits 47 to 66: When bits 43 to 46 are set to “1111” then and only then, do these bits provide the last six digits of the MMSI in binary form[‡]

bits 67 to 85: 19 bits of position data to 30 minute resolution;

b) PDF-2:

bits 107 & 108: 2 bits of supplementary data

bits 109 to 114: 6 bits reserved for RLS Data.

bits 115 to 132: 18-bit position offset (Δ latitude, Δ longitude) to 4 second resolution.

The 19 bits of position data in PDF-1 are encoded as follows:

a) bits 67 to 75: latitude data (9 bits) with 30 minute resolution, including:

- bit 67: N/S flag (N=0, S=1)
- bits 68 to 75: degrees (0 to 90) in 1/2 degree increments (default value of bits 67 to 75 = 0 11111111); and

b) bits 76 to 85: longitude data (10 bits) with 30 minute resolution, including:

- bit 76: E/W flag (E=0, W=1)
- bits 77 to 85: degrees (0 to 180) in 1/2 degree increments (default value of bits 76 to 85 = 0 11111111).

^{*} TAC numbers 950 to 959 are currently unallocated.

[†] The RLS MMSI protocol option is not approved for use in beacons prior to [CSC-64 in November 2020 pending Council approval].

[‡] The full 9-digit MMSI is comprised of the Country Code in bits 27 to 36 providing the Flag State (MID) of the vessel and bits 47 to 66 providing the unique 6-digit identity for the vessel.

A3.3.7.2 The 26 bits available in PDF-2 are defined as follows:

a) bits 107 and 108 Supplementary Data

(1) bits 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;

(2) bit 108: 121.5 MHz auxiliary radio locating device included in beacon
(1 = yes, 0 = no);

b) bits 109 to 114: RLS Data

(1) Bits 109-110: RLM Request

- bit 109: Capability to process RLM Type-1:
"1": Acknowledgement Type-1 (automatic acknowledgement) accepted by this beacon,
"0": Acknowledgement Type-1 not requested and not accepted by this beacon;
- bit 110: Capability to process manually generated RLM (e.g., Type-2)*:
"1": Manually generated RLM (such as Acknowledgement Type-2) accepted by this beacon,
"0": Manually generated RLM (such as Acknowledgement Type-2) not requested and not accepted by this beacon.

(2) Bits 111-112: Beacon feedback (acknowledging the reception of the RLM):

- bit 111: Feedback on RLM Type-1:
"1": Acknowledgement Type-1 (automatic acknowledgement) received by this beacon,
"0": Acknowledgement Type-1 not (yet) received by this beacon;
- bit 112: Feedback on RLM Type-2 (or any other manually generated RLM) :
"1": RLM Type-2 received by this beacon,
"0": RLM Type-2 not (yet) received by this beacon.

(3) Bits 113-114: RLS Provider Identification:

"01": GALILEO Return Link Service Provider

* The condition bit 109 = "0" and bit 110 = "0" is an invalid condition; at least one of these two bits must always be a "1".

"10": GLONASS Return Link Service Provider

"00" and "11": Spares (for other RLS providers)

- c) bits 115 to 123: Δ latitude with 4 second resolution:
- bit 115: Δ sign (0 = minus, 1 = plus)
 - bit 116 to 119: minutes (0 to 15) in 1 minute increments*
 - bits 120 to 123: seconds (0 to 56) in 4 second increments
(default value of bits 115 to 123 = 1 0000 1111);
- d) bits 124 to 132: Δ longitude with 4 second resolution:
- bit 124: Δ sign (0 = minus, 1 = plus)
 - bits 125 to 128: minutes (0 to 15) in 1 minute increments†
 - bits 129 to 132: seconds (0 to 56) in 4 second increments
(default value of bits 124 to 132 = 1 0000 1111)

A3.3.7.3 Users should utilize the Return Link Service Location Test protocol identified with bits 41-42 set to "11" described in section A3.3.7.1 when testing an RLS-capable beacon.

* Section A3.3.7 defines the coding scheme for the RLS Location Protocol. For these new beacons the coarse position in PDF-1 is always selected to be as close as possible to the actual position and will have a maximum offset in PDF-2 of +/- 15 minutes.

Figure A10: RLS Location Protocol

←1	25 26	←27 36→	←37 40→←41 				85→				←86 106→	107 114	←115 132→				←133 144→								
		←----- 61 BITS ----- PDF-1										BCH-1	←----- 26 BITS ----- PDF-2										BCH-2		
BIT & FRAME SYNCHRONIZ PATTERNS	2	10	4	45												21	8	9			9				12
	F O R M A T & P R O T O C O L F L A G	C O U N T R Y C O D E	P R O T O C O L C O D E	26 BITS			19 BITS									21-BIT BCH ERROR CORRECTING CODE	S U P P L E M E N T A R Y D A T A	Δ LATITUDE			Δ LONGITUDE			12-BIT BCH ERROR CORRECTING CODE	
				IDENTIFICATION			LATITUDE			LONGITUDE			1					4			4				
				2	10	14	1	8		1	9		1	4	4			1	4	4					
				B	RLS TAC	RLSR LS ID	N	D	E	G	E	R	E	S	M			S	I	E	C				
				A	or	S N	S	E	W	E	E	O	N	D											
				C	NRN	E U		S		S		T	S	S											
				O		R M		0 - 90		0 - 180															
				N		I B		(1/2 deg)		(1/2 deg)															
				T	or	A E																			
P		L R																							
E				Bits 43-46 '1111' Bits 47-66 Last 6 digits of MMSI																					
If bits 43 to 46 = 1111																									
F=1		1101		“00” =ELT				“00” Fisrt EPIRB				107 = Encoded Position Data Source: 1 = Internal, 0 = external													
P=0				“01”=EPIRB				“01” Second EPIRB				108 = 121.5 MHz Homing: 1= Yes, 0 = No													
				“10”=PLB								109 and 110 = Return Link Message (RLM) Request													
				“11”=RLS Location Test protocol								111 and 112 = Beacon Feedback (on receipt of RLM)													
												113 and 114 = Return Link Service (RLS) Provider													
NRN – National RLS Number (see section A.3.3.7.1)																									

A3.3.8 ELT(DT) Location Protocol (see Figure A11)

A3.3.8.1 The ELT(DT) location protocol, identified by the flags F=1, P=0 and the protocol code in series no. 8 of Table A2-B, has the following structure:

a) PDF-1:

bits 37 to 40: 4-bit protocol code defined as 1001;

bits 41 to 42: 2-bits for type of beacon identity set to “00” for Aircraft 24 bit address, “01” for Aircraft operators designator and serial number, “10” for TAC with serial number, and “11” reserved for future use;

bits 43 to 66: 24 bits of beacon identification data, or ELT(DT) Location Test protocol when bits 43 to 66 are encoded with either all “0”s, or all “1”s;

bits 67 to 85: 19 bits of position data to 30 minute resolution;

b) PDF-2:

bits 107 & 108: means of activation

bits 109 to 112: encoded altitude

bits 113 & 114: encoded location currency

bits 115 to 132: 18-bit position offset (Δ latitude, Δ longitude) to 4 second resolution.

A3.3.8.2 The 19 bits of position data in PDF-1 are encoded as follows:

- a) bits 67 to 75: latitude data (9 bits) with 30 minute resolution, including:
- bit 67: N/S flag (N=0, S=1)
 - bits 68 to 75: degrees (0 to 90) in 1/2 degree increments (default value of bits 67 to 75 = 0 11111111); and

- b) bits 76 to 85: longitude data (10 bits) with 30 minute resolution, including:
- bit 76: E/W flag (E=0, W=1)
 - bits 77 to 85: degrees (0 to 180) in 1/2 degree increments (default value of bits 76 to 85 = 0 11111111).

A3.3.8.3 The 26 bits available in PDF-2 are defined as follows:

- a) bits 107 and 108 means of activation
 - “00”: manual activation by the user
 - “01”: automatic activation by the beacon
 - “10”: automatic activation by external means
 - “11”: spare
- b) bits 109 to 112: encoded altitude
 - “0000”: altitude is less than 400 m (1312 ft)
 - “0001”: altitude is between 400 m (1312 ft) and 800 m (2625 ft)
 - “0010”: altitude is between 800 m (2625 ft) and 1200 m (3937 ft)
 - “0011”: altitude is between 1200 m (3937 ft) and 1600 m (5249 ft)
 - “0100”: altitude is between 1600 m (5249 ft) and 2200 m (7218 ft)
 - “0101”: altitude is between 2200 m (7218 ft) and 2800 m (9186 ft)
 - “0110”: altitude is between 2800 m (9186 ft) and 3400 m (11155 ft)
 - “0111”: altitude is between 3400 m (11155 ft) and 4000 m (13123 ft)
 - “1000”: altitude is between 4000 m (13123 ft) and 4800 m (15748 ft)
 - “1001”: altitude is between 4800 m (15748 ft) and 5600 m (18373 ft)
 - “1010”: altitude is between 5600 m (18373 ft) and 6600 m (21654 ft)
 - “1011”: altitude is between 6600 m (21654 ft) and 7600 m (24934 ft)
 - “1100”: altitude is between 7600 m (24934 ft) and 8800 m (28871 ft)
 - “1101”: altitude is between 8800 m (28871 ft) and 10000 m (32808 ft)
 - “1110”: altitude is greater than 10000 m (32808 ft)
 - “1111”: default value if altitude information is not available
- c) bits 113 & 114: encoded location freshness:
 - “00”: encoded location in message is greater than 5 minutes old or, in case the default encoded position is transmitted,
 - “01”: encoded location in message is between 60 seconds and 5 minutes old,
 - “10”: encoded location in message is greater than 2 seconds and less than 60 seconds old,
 - “11”: encoded location in message is current.
- d) bits 115 to 123: Δ latitude with 4 second resolution:
 - bit 115: Δ sign (0 = minus, 1 = plus)
 - bit 116 to 119: minutes (0 to 15) in 1 minute increments*
 - bits 120 to 123: seconds (0 to 56) in 4 second increments
(default value of bits 115 to 123 = 1 0000 1111);

* Section A3.3.8 defines the coding scheme for the ELT(DT) Location Protocol. For these new beacons the coarse position in PDF-1 is always selected to be as close as possible to the actual position and will have a maximum offset in PDF-2 of +/- 15 minutes.

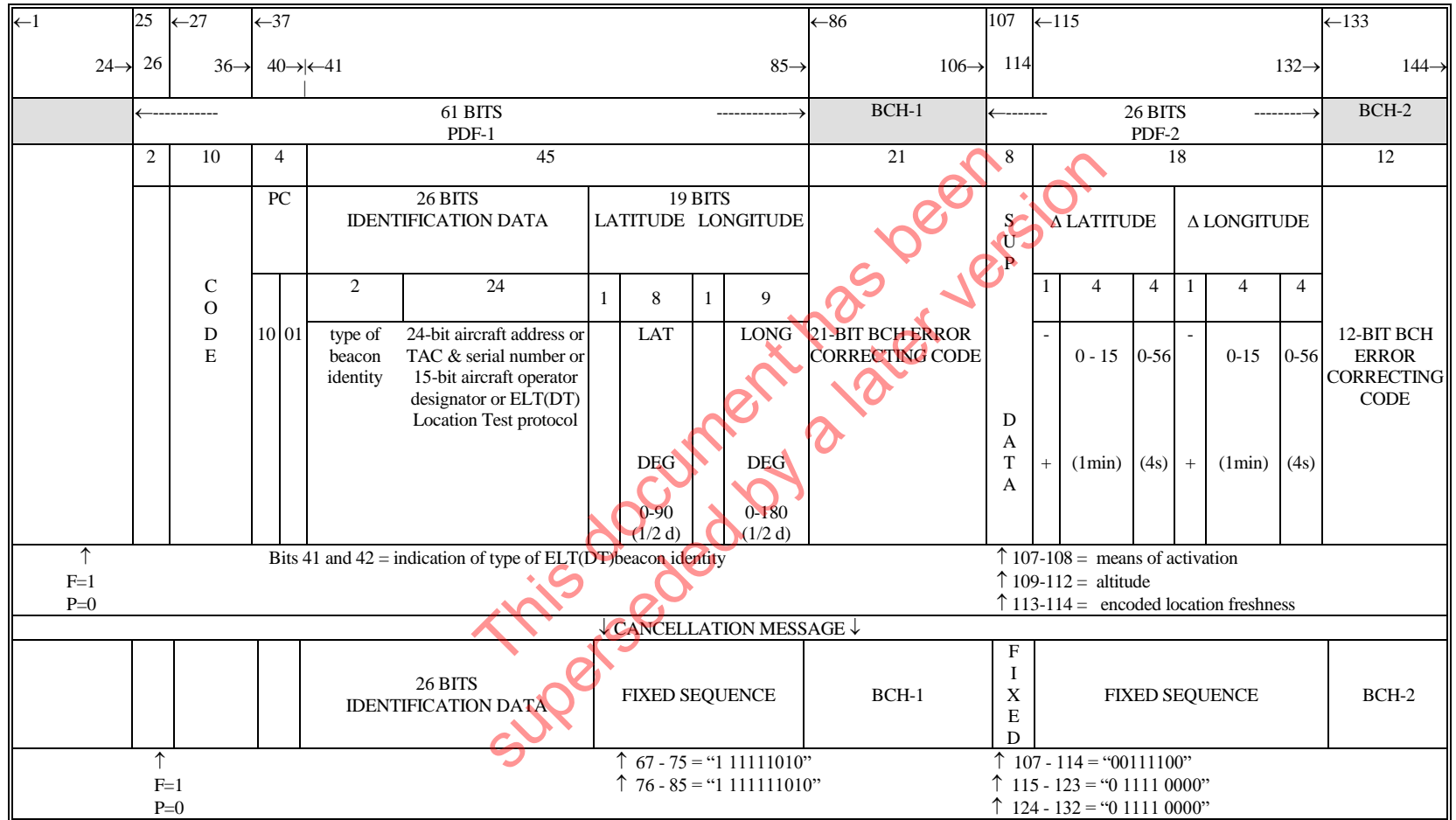
- e) bits 124 to 132: Δ longitude with 4 second resolution:
- bit 124: Δ sign (0 = minus, 1 = plus)
 - bits 125 to 128: minutes (0 to 15) in 1 minute increments*
 - bits 129 to 132: seconds (0 to 56) in 4 second increments
(default value of bits 124 to 132 = 1 0000 1111)

A3.3.8.4 Users should utilize the ELT(DT) Location Test protocol identified with bits 43-66 described in section A3.3.8.1 when testing an ELT(DT).

A3.3.8.5 Cancellation message

In case of alert cancellation, a specific message shall be sent with the following bit assignment:

bits 37 to 40:	4-bit protocol code as defined as 1001;
bits 41 to 42:	2-bits for type of beacon identity;
bits 43 to 66:	24 bits of beacon identification data, or ELT(DT) Location Test protocol;
bits 67 to 75:	fixed sequence “1 11111010”;
bits 76 to 85:	fixed sequence “1 111111010”;
bits 86 to 106:	BCH-1;
bits 107 to 114:	fixed sequence “00111100”;
bits 115 to 123:	fixed sequence “0 1111 0000”;
bits 124 to 132:	fixed sequence “0 1111 0000”;
bits 133 to 144:	BCH-2.

Figure A11: ELT(DT) Location Protocol

- END OF ANNEX A -

ANNEX B BCH AND CRC CALCULATIONS

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:

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

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:

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

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* 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

* 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)=01010110111001101000000001000000000001000100000001000000000100000000000000000000
g(X)= 1001101101100111100011
      001101101010101010001100
      1001101101100111100011
      0100000111001101101111
      1001101101100111100011
      0001100011111100111100000
      1001101101100111100011
      01011100100000000000110
      1001101101100111100011
      001000100110011110010100
      1001101101100111100011
      0001001011111001110111000
      1001101101100111100011
      00001100101010010110110001
      1001101101100111100011
      01010001111100010100100
      1001101101100111100011
      001110001000010100011100
      1001101101100111100011
      0111100101110011111111
      1001101101100111100011
      01101001100000000111000
      1001101101100111100011
      01001000011001110110110
      1001101101100111100011
      00001011101010010101010000
      1001101101100111100011
      001000011111001011001101
      1001101101100111100011
      0001110010101100101110000
      1001101101100111100011
      01111110000000100100110
      1001101101100111100011
      01100111011000110001010
      1001101101100111100011
      01010101101000011010010
      1001101101100111100011
      00110000010010011000100
      1001101101100111100011
      01011011111101001001110
      1001101101100111100011
      001011001000111010110110
      1001101101100111100011
      001010010101110101010100
      1001101101100111100011
      001111100001001011011100
      1001101101100111100011
      01100011001011011011100
      1001101101100111100011
      0110001100101100111110
      1001101101100111100011
      01011101001111100111010
      1001101101100111100011
      001000010001101101100100
      1001101101100111100011
      0001111100001010000111000
      1001101101100111100011
      01100011001101110110110
      1001101101100111100011
      01011101000010010101010
      1001101101100111100011
      001000010111010100100100
      1001101101100111100011
      0001111010110011000111000
      1001101101100111100011
      01101110111111110110110
      1001101101100111100011
      01000101000110010101010
      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:

$$\begin{aligned} g(x) &= (1 + x + x^6) (1 + x + x^2 + x^4 + x^6) \\ &= (1 + x^3 + x^4 + x^5 + x^8 + x^{10} + x^{12}) \end{aligned}$$

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)=100101011100000000000010111000000000000
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

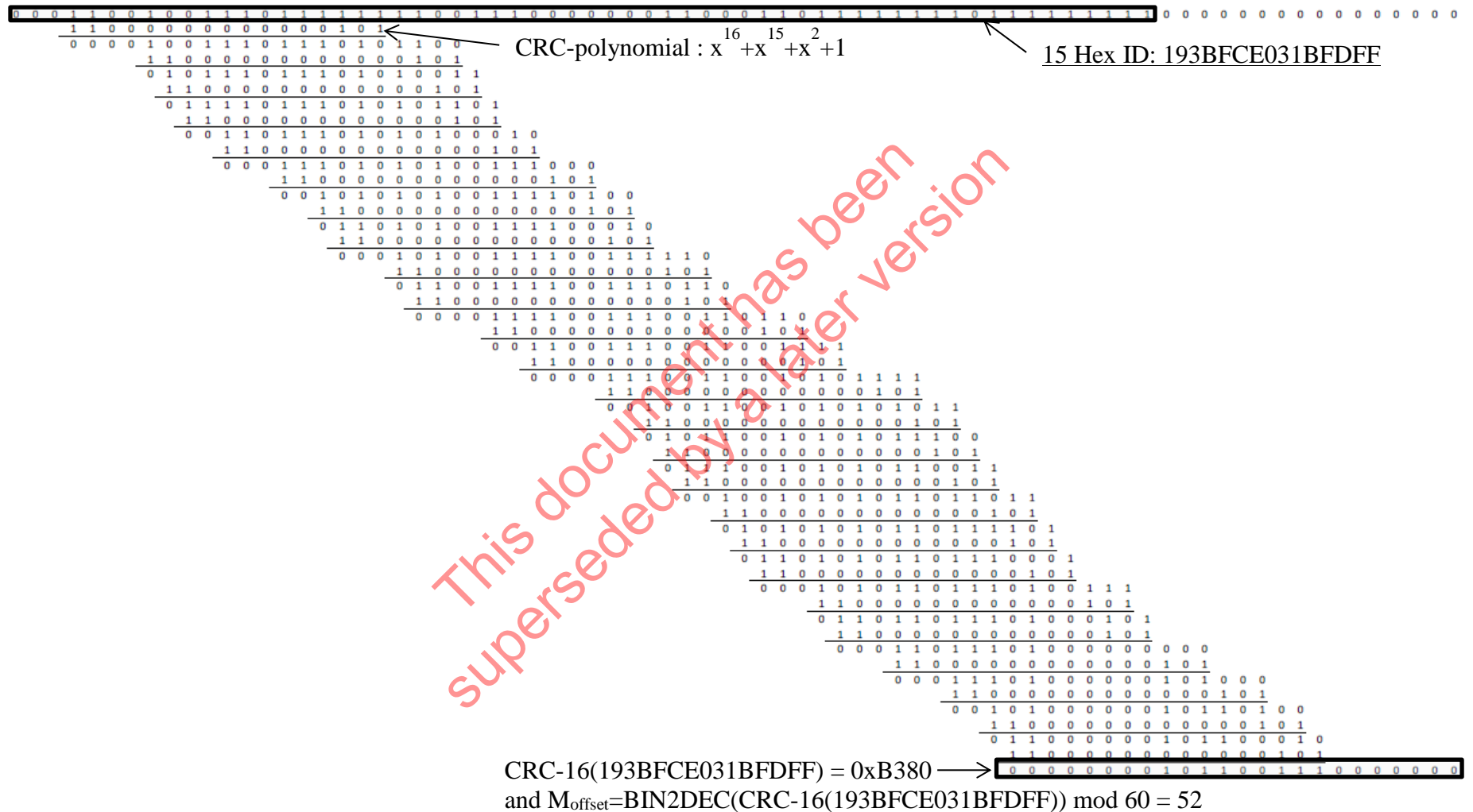
B3 SAMPLE M_{offset} CALCULATIONS AND CRC-CODE

FIGURE B3: SAMPLE M_{OFFSET} CALCULATION
- END OF ANNEX B -

ANNEX C EXAMPLES OF RLS GNSS RECEIVER TIMING

The operation of the RLS GNSS Receiver is defined in section 4.5.7.2 of this document in. A set of examples of RLS operation are provided in Table C1, which cover a range of conditions to clarify the interpretation of the M_{offset} timing, and are summarized below:

- 1) UTC + M_{offset} of 59 minutes - No RLM received;
- 2) No UTC + M_{offset} of 1 minute - UTC acquired at 2:34 - RLM received at 4:07;
- 3) UTC + M_{offset} of 17 minutes - No RLM received;
- 4) UTC + M_{offset} of 20 minutes - RLM received at 2:29; and
- 5) UTC + M_{offset} of 11 minutes - RLM received at 0:45.

These examples are provided to ensure a common understanding of the expected functioning of the M_{offset} capability and are intended to be used as the basis for the development test scenarios. The above five examples are believed to cover all of the timing scenarios that can exist, between the activation of the RLS GNSS Receiver and various values of M_{offset} , and specifically cover the following situations:

- UTC acquired soon after beacon activated;
- UTC not acquired until sometime after the beacon is activated;
- no RLM received within the 6-hour RLS operational timeframe;
- GNSS timing changes between the M_{offset} timing and the regular GNSS receiver timing;
- correct occurrence of the first M_{offset} GNSS Receiver timing versus beacon activation time; and
- ideal functioning of the RLS system.

Table C1: Example Scenarios for RLS GNSS Timing

Description of GNSS and Beacon Operation	Beacon RLM Attempt	Example 1	Example 2
		UTC + M_{offset} 59 minutes, No RLM received	No UTC + M_{offset} 1 minutes, UTC acquired at 2:34, RLM received at 4:07
Time at which Beacon is Activated		0:00	0:17
Time of first RLM Request transmission	1	0:01	0:18
GNSS Receiver first 30 minute on period		0:30	0:47*
GNSS Receiver next turns on at	2	0:59	1:02
GNSS Receiver next turns off at		1:14	1:05
GNSS Receiver next turns on at	3	1:59	1:17
GNSS Receiver next turns off at		2:14	1:20
GNSS Receiver next turns on at	4	2:59	1:32
GNSS Receiver next turns off at		3:14	1:35
GNSS Receiver next turns on at	5	3:59	1:47
GNSS Receiver next turns off at		4:14	2:02
GNSS Receiver next turns on at	6	4:59	2:32
GNSS Receiver next turns off at		5:14	2:34†
GNSS Receiver next turns on at	7	5:59	3:01
GNSS Receiver next turns off at		6:00‡	3:16
GNSS Receiver next turns on at	8		4:01
GNSS Receiver next turns off at			4:07§
GNSS Receiver reverts to non-RLS operation		6:00	4:07

Note that interleaved with the GNSS Receiver timings, the GNSS receiver also turns on in accordance with section 4.5.5.4, as well in Examples 1, 3 and 4, but these GNSS 'on' periods are omitted for clarity in the tables.

* Timing reverts to schedule per document C/S T.001, section 4.5.5.4.

† UTC acquired, back to RLS schedule

‡ Last 'on' period, 1-minute duration, as 6 hours have elapsed from beacon turn-on.

§ With no UTC reference, receiver reverts to document C/S T.001, section 4.5.5.4 timing, until UTC is obtained.

Table C1 (Continued): Example Scenarios for RLS GNSS Timing

Description of GNSS and Beacon Operation	Beacon RLM Attempt	Example 3	Example 4	Example 5
		UTC + M _{offset} 17 minutes, No RLM received	UTC + M _{offset} 20 minutes, RLM received at 2:29	UTC + M _{offset} 11 minutes, RLM received at 0:45
Time at which Beacon is Activated		0:58	0:14	0:40
Time of first RLM Request transmission	1	0:59	0:15	0:41
GNSS Receiver first 30 minute on period		1:28	0:44	0:45*
GNSS Receiver next turns on at	2	2:17	1:20	
GNSS Receiver next turns off at		2:32	1:35	
GNSS Receiver next turns on at	3	3:17	2:20	
GNSS Receiver next turns off at		3:32	2:29†	
GNSS Receiver next turns on at	4	4:17		
GNSS Receiver next turns off at		4:32		
GNSS Receiver next turns on at	5	5:17		
GNSS Receiver next turns off at		5:32		
GNSS Receiver next turns on at	6	6:17		
GNSS Receiver next turns off at		6:32		
GNSS Receiver next turns on at	7	‡		
GNSS Receiver next turns off at				
GNSS Receiver reverts to non-RLS operation		6:32	2:29	0:45

- END OF ANNEX C-

- END OF DOCUMENT-

* GNSS only 'on' for 4 min until RLM received, M_{offset} never needed.

† GNSS only 'on' for 9 min, until RLM received.

‡ 6 hours up at 6:58, so no seventh attempt is initiated for this case.

This document has been
superseded by a later version

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