SPECIFICATION FOR SECOND-GENERATION COSPAS-SARSAT 406-MHz DISTRESS BEACONS

C/S T.018
Preliminary Issue B
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NOTE:

This specification is a preliminary release and contains some text and values in square brackets [ ] which represent information that is to be confirmed. This release of the specification is provided for awareness and is subject to change.

SPECIFICATION FOR SECOND-GENERATION COSPAS-SARSAT 406-MHz DISTRESS BEACONS

History

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Preliminary Issue A		October 2014	Approved by CSC-53
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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 Second Generation 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.

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 technical 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 as well as the assignment and meaning of the available data bits are defined in this section.

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.

d) Appendix 1 for narrowband beacons is provided for information only at this time and possible future use.

e) Appendix 2 provides a list of acronyms used in this document.

1.3 Type of Beacon

There are four different types of Cospas-Sarsat 406 MHz beacons; Emergency Locator Transmitters (ELTs), Emergency Position Indicating Radio Beacons (EPIRBs), Personal Locator Beacons (PLBs) and Ship Security Alert System (SSAS) Beacons. This standard does not address requirements for Second Generation SSAS Beacons.

In addition to the four different types of beacon there are two Classes of operating temperature range for 406 MHz beacons as follows:

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

Any type of beacon can be supplied with either a Class 1 or Class 2 operating temperature range.

Unless otherwise stated herein this specification applies to all types and classes of 406 MHz beacons identified in this section apart from SSAS beacons.

Emergency Locator Transmitters (ELTs)

Are designed for aviation distress purposes and are available as the following types; Automatic Fixed (ELT (AF)), Automatic Portable (ELT (AP)), Survival (ELT (S)) and Automatic Deployable (ELT (AD)).

Automatic Fixed (ELT (AF))

This type of ELT is intended to be permanently attached to the aircraft before and after a crash and is designed to aid SAR teams in locating a crash site.

Automatic Portable (ELT (AP))

This type of ELT is intended to be rigidly attached to the aircraft before a crash, but readily removable from the aircraft after a crash. It functions as an ELT (AF) during the crash sequence. If the ELT does not employ an integral antenna, the aircraft-mounted antenna may be disconnected and an auxiliary antenna connected in its place. This type of ELT is intended to aid SAR teams in locating the crash site or survivor(s).

Survival (ELT (S))

This type of ELT is intended to survive the crash forces, and then to be generally manually activated by survivors. There are two sub classes of ELT(S) Class A which is buoyant and designed to operate when floating in water and Class B which is non buoyant and may be manually or automatically activated. This type of ELT is intended to aid SAR teams in locating survivor(s).

Automatic Deployable (ELT(AD))

This type of ELT is intended to be rigidly attached to the aircraft before a crash and automatically deployed after the crash sensor has determined that a crash has occurred. This type of ELT shall float in water and is intended to aid SAR teams in locating the crash site.

Emergency Position Indicating Radio Beacons (EPIRBs)

Are designed for maritime distress purposes and are available as Float free and Non Float Free types of EPIRB.

Float Free EPIRB

This type of EPIRB is intended to float free of the vessel on which it is fitted if the vessel sinks, in which case it will automatically activate, it can also be manually activated.

Non Float Free EPIRB

This type of EPIRB is intended to be manually released from its mounting bracket and then either manually activated or dropped in the water so that it will then activate automatically. Some national administrations permit the use of manually activated EPIRBs only without the automatic activation in water feature.

Personal Locator Beacons (PLBs)

Are designed for use by persons in distress who may be on land, in the air or at sea. PLBs are manually activated by the person in distress.

1.4 Optional Features

Beacons may contain optional features that are defined in this specification.

Encoded location capability is optional, however in the case of ELT devices intended for in-flight automatic activation the inclusion of a GNSS capability is mandatory.

All types of beacons may also be provided with the Return Link Service capability.

[All types of beacons (except SSAS beacons) may be provided with one or more additional radio-locating transmitters for Homing and On-scene Locating purposes.]

1.5 Additional Features

Beacons may contain additional functionality that may change the transmitted 406 MHz satellite signal or affect other beacon parameters such as operating lifetime. For example, a beacon may contain a flashing strobe light that while it probably has no effect on the transmitted signal, would reduce the battery life.

Any additional functionality that is not defined in this specification shall not adversely degrade the performance of the beacon to the extent that it no longer complies with this specification.

- END OF SECTION 1 -

2. TECHNICAL REQUIREMENTS

2.1 Beacon Functional Elements

This section defines requirements for the functional elements of spread-spectrum 406 MHz distress beacons.

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. This section describes the structure of the proposed signal.

2.2.1 Repetition Period

From beacon activation a total of [6] initial transmissions shall be made separated by fixed [5s ± 0.1s] intervals. The first transmission shall commence within [3] seconds of beacon activation.

Transmissions shall then occur at nominally [30] second intervals until [30 ± 1] minutes after beacon activation. The repetition period between the start of two successive transmissions shall be randomised around the stated nominal value, so that intervals between successive transmissions are randomly distributed over ± [5] seconds.

Subsequent transmissions [TBD].

The transmission schedule is summarised in the table below:

Table 2.1: Transmission Schedule

IAMSAR Stage	Time from Activation	Transmission Repetition Interval	Randomization
Initial	[0 to 30] Seconds	[5] Seconds	[0]
Action / Planning	[30 seconds to 5 minutes]	[30] Seconds	± [5] seconds
	[5 minutes to 30 minutes]	[30] Seconds	± [5] seconds
	[30 minutes +]	TBD	TBD

2.2.2 Total Transmission Time

The total transmission time of each burst, measured at the 90 percent power points, shall be 1000 ms ±1 ms.

2.2.3 Direct Sequence Spread Spectrum

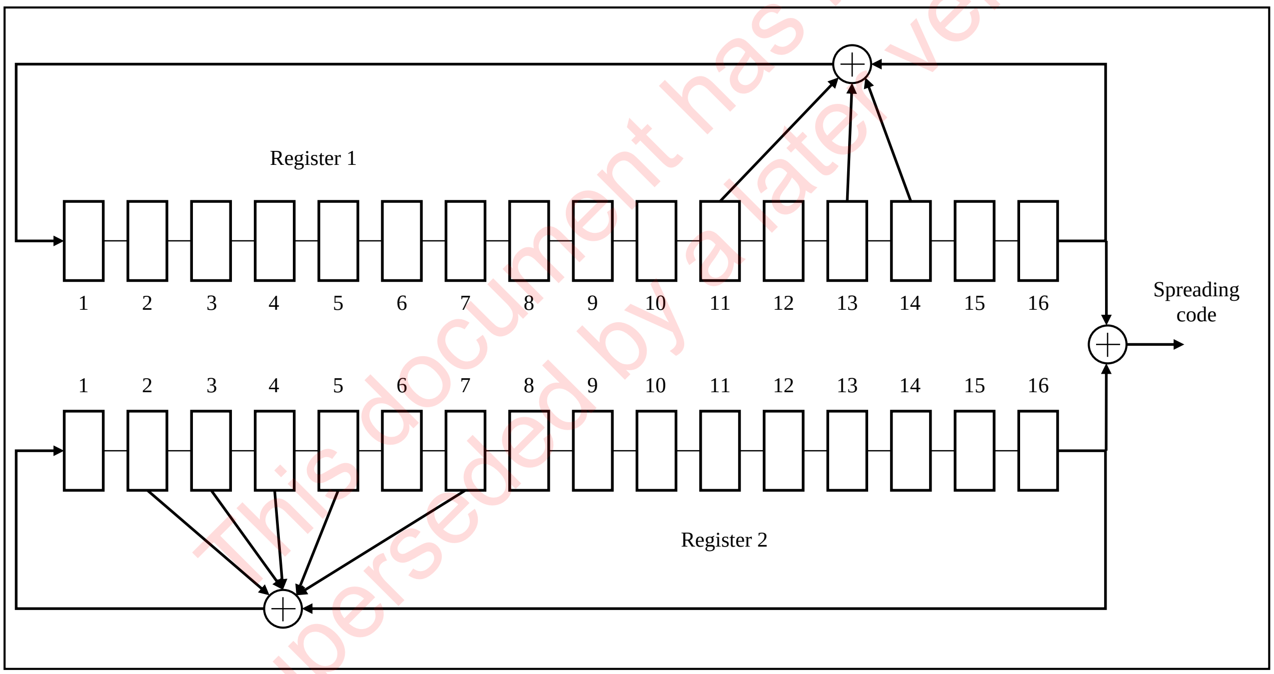
The digital message is spread with a PRN (Pseudo-Random Noise) sequence. This sequence is deterministic and must be known by the receiver. The spread sequence has the same duration as the burst length (1s). The spread sequence is composed of 38,400 symbols, named ‘chips’. So, the chip rate is 38,400 chips/sec (see 2.3.1.2 for further details).

Note: Multiple codes may be used to differentiate between beacon groups.

The following two proposed approaches to PRN sequences are under consideration:

Proposal A

Spreading sequences may be generated with the following shift registers generator described in the figure below:



The first register is described by the polynomial expression: $G_1 = X^{16} + X^{14} + X^{13} + X^{11} + 1$ and the second register is described by the polynomial expression: $G_2 = X^{16} + X^7 + X^5 + X^4 + X^3 + X^2 + 1$.

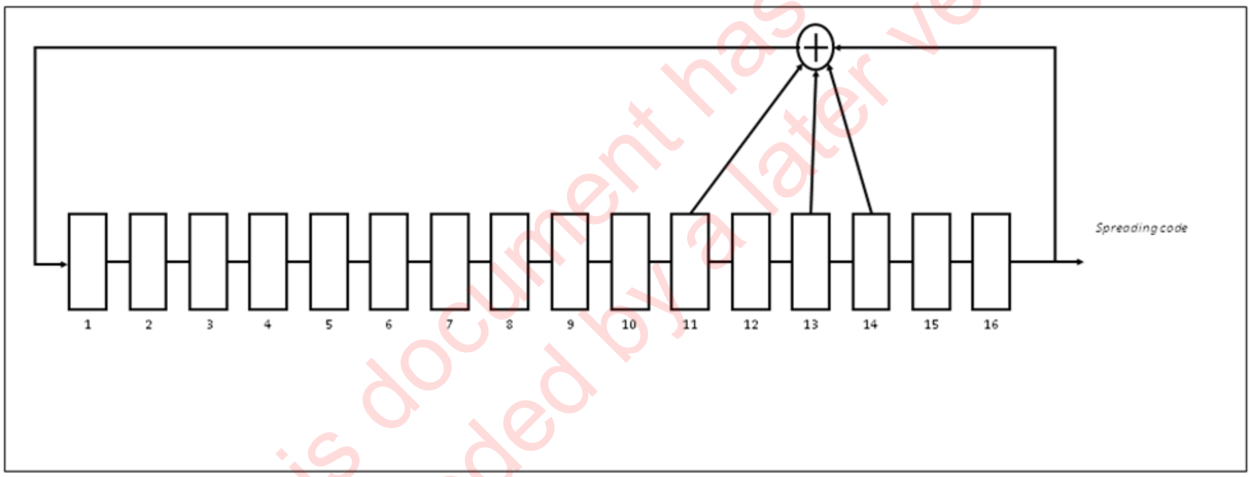
First register is initialized with a sequence of 16 ones. Second register initialization sequence defines the spreading codes. The table below shows the initialization sequence for the different spreading codes, together with the first and last 100 chips of each sequence:[

Beacon Mode	Spreading sequence	Second register initialization	First 100 chips (Hexadecimal)	Last 100 chips (Hexadecimal)
Live Beacon	Nominal (I)	0000000000000001	7FFFB410C95BDD183E1DE1F2B	662F7BBE64917A52B3CF4EFF5
	Nominal (Q)	0000000000000010	BFFF5A1EE685305A96E72CC29	3A097B941612A18846E9DDF4B
Self-Test	Self-test (I)	0000000000000011	3FFFEE152C11862659B45AE2A	523284584AEFCCE4E0D2C0060
	Self-test (Q)	0000000000000100	DFFF2D19F16A46FBC29A4A5A8	141A7B812F534C653C7A94714
TBD	Spare 1 (I)	0000000000000101	5FFF99123BFEF0870DC93C7AB	7C21844D73AE21099A418983F
	Spare 1 (Q)	0000000000000110	9FFF771C14201DC5A533F14A9	20078467012DFAD36F671A881
TBD	Spare 2 (I)	0000000000000111	1FFFC317DEB4ABB96A60876AA	483C7BAB5DD097BFC95C077AA
	Spare 2 (Q)	0000000000001000	EFFF169A7A9DFDAB68A4F9168	0313FB8BB3F3BA93813330B3B

Proposal B

The spread sequence is imposed on both the I&Q components of the message with offset as shown in section 2.3.3.

Spreading sequences are generated with the following shift register generator described in the figure below:



$$Generator\ polynomial =$$

$$G(X) = X^{16} + X^{14} + X^{13} + X^{11} + 1$$

The register is initialized left to right with the values [0 1 1 0 1 0 1 1 0 0 0 1 1 0 1 0]. These values minimize the one step autocorrelation lag taken over the length of the preamble. The choice taken is designed to maximize the probability of detection. The normalized minimum is -0.0291 where zero lag autocorrelation is one. The maximum nonzero lag normalized autocorrelation is 0.0347. The maximum value affects false alarms and is low enough to be of negligible importance.

Other beacon types can be accommodated using the same generator with different initialization values. Three suitable additional values represent consecutive preamble offset values (6400) from the first and are:

Beacon Mode	Register initialization
Normal	0 1 1 0 1 0 1 1 0 0 0 1 1 0 1 0
Self-Test	1 0 0 0 1 1 0 0 0 1 1 1 1 0 0 0
TBD	0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0
TBD	1 0 1 0 0 1 1 1 1 0 1 1 1 0 1 1

2.2.4 Preamble

The initial 166.7 ms ± 0.5 ms of the transmitted signal shall consist of 6400 chips of the PN code used to spread the entire message. There will be no data encoded on this portion of the message.

2.2.5 Digital Message

The remaining 833.3 ms ±0.5 ms of the transmitted signal shall contain a 250-bit message at a bit rate of 300 bps ±1 % .

2.2.6 Message Content

The content of the 250 bit message is defined in section 3.

The 250 bit message is composed of two parts:

a) the useful message: 202 bits containing the information transmitted by the beacon.

b) the error correction bits: 48 bits BCH(250,202) containing bits used for error correction at reception.

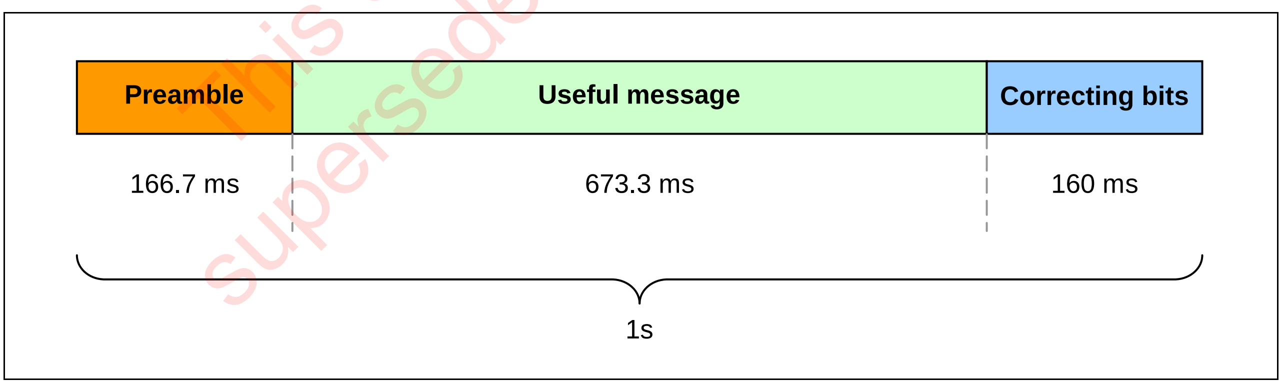


Figure 2.1: Burst general structure

2.2.7 In-Phase (I) and Quadrature-Phase (Q) Components

The odd bits of the 250 bit message are used to generate the in-phase (I) component of the message, while the even bits are used to generate the quadrature-phase (Q) component of the message. The timing of the odd and even bits are offset by half a chip period. The bit rate for each channel shall be 150 bits/sec±1%.

Each component starts with a 6400 chip preamble described in 2.2.4 and is spread with the PRN sequence described in section 2.2.3 as shown in Figure 2.2.

The preamble and any bits allocated as '1' are represented by the PN sequence, bits allocated as '0' are sent as the PN sequence inverted for the duration of the bit. This is the method of modulating data onto the PN sequence.

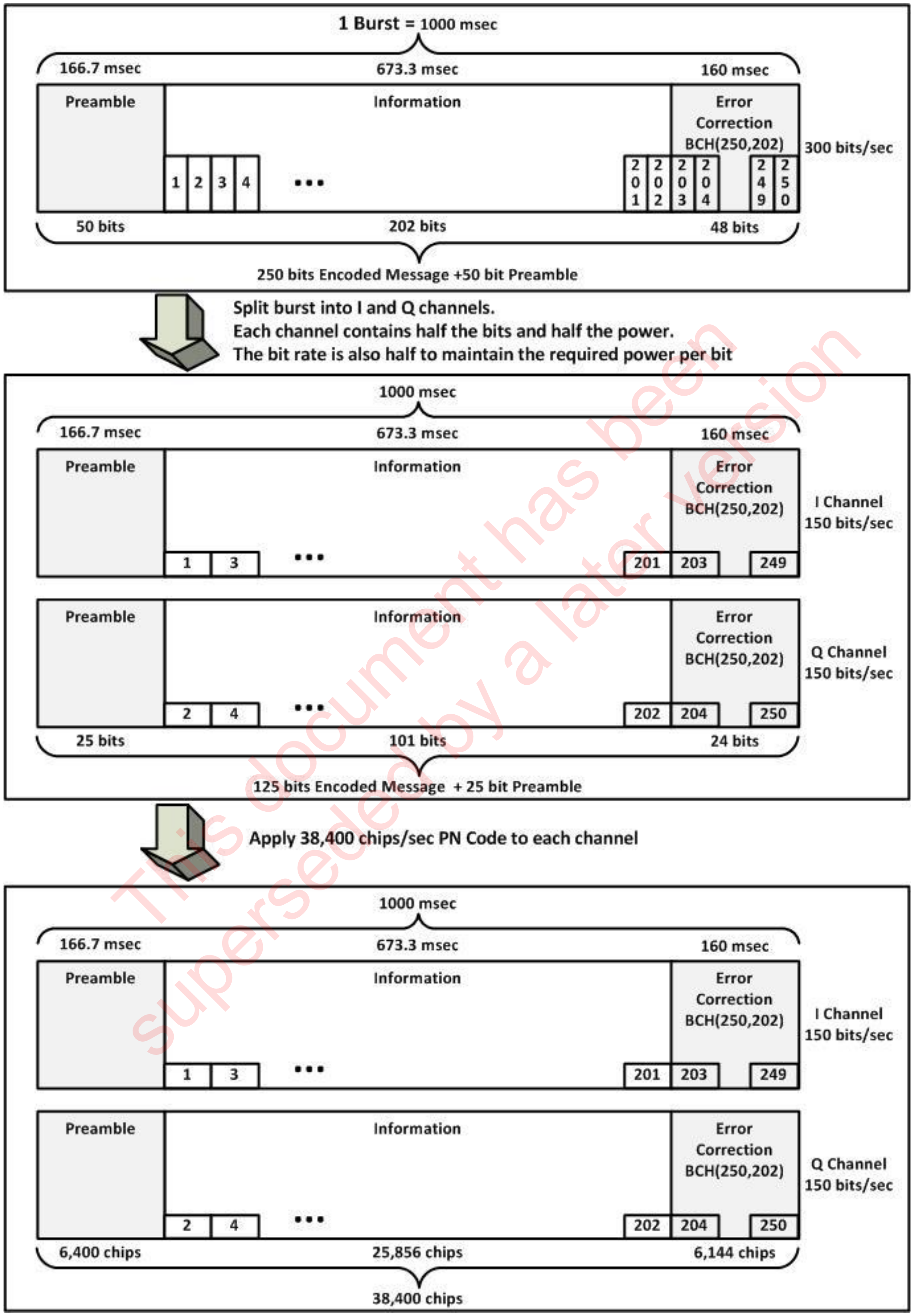


Figure 2.2: I and Q Component Message Structure

2.3 Modulator and 406 MHz Transmitter

2.3.1 Transmitted Frequency

The following sections define the frequency stability requirements for the Carrier Frequency and the Chip Rate.

2.3.1.1 Carrier Frequency Offset/Drift over aging, thermal, shock and vibration

a. Long Term Stability Requirement

The driver of the frequency offset due to aging, temperature, shock and vibration is driven by the bandwidth of the repeater relative to the bandwidth and center frequency of the DSSS signal. The signal shall be transmitted at 406.05MHz. The guard band required to guarantee that the signal is not clipped by the repeater due to uplink Doppler is 1200Hz on either side of the signal. If we constrain the signal's presence to the window of center frequency +/- 1200 Hz, the carrier frequency tolerance shall be ±3 ppm:

(which is derived from $\frac{\Delta f}{f} = \frac{1200}{406.05e6} \cong 3PPM$)

b. Short Term Stability Requirement

This requirement applies throughout the operating temperature range and during situations of temperature shock.

[Transmit frequency shall not change by more than [XX] Hz throughout the transmission burst.]

2.3.1.2 Chip Rate Short Term Frequency Variation and Timing Jitter

The driver of short term variation is the detection process of the receiver. The receiver will correlate a replica of the PN sequence with the beacon's received signal over the duration of the preamble. The stability of the chip clock generator is specified in both the frequency domain and time domain. The mismatch in the frequency of correlated sequences will cause a reduction in the coherent integration gain. If we wish to minimize the detector loss to << 1dB, we can set the loss to 0.1 of a chip or

$$Loss = 10 * log10\left(\frac{4095.9}{4096}\right) \ll 1dB$$

The variation in chip rate, shall be:

$$\Delta f = \frac{1}{2\pi}\frac{d\varphi}{dt} = \frac{1}{2\pi}\frac{0.1\,\pi}{\left(\frac{4096}{38.4e3}\right)} = 0.47Hz$$

[Rather than an aggregate across the duration of the preamble, jitter represents the fraction of a chip that is misaligned for each chip across the preamble. Demanding the same physical constraints (1dB loss across 6400 chips) that we used in the frequency domain, the permissible jitter (Δt) outer bound can be determined as

$$\Delta t < \frac{10^{(lossdB-gaindB)/10}}{fchip} = \frac{10^{(1-10log10(4096))/10}}{38.4e3} = 8ns$$

Thus the specification on the chip rate jitter is +/-8ns.]

2.3.2 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.

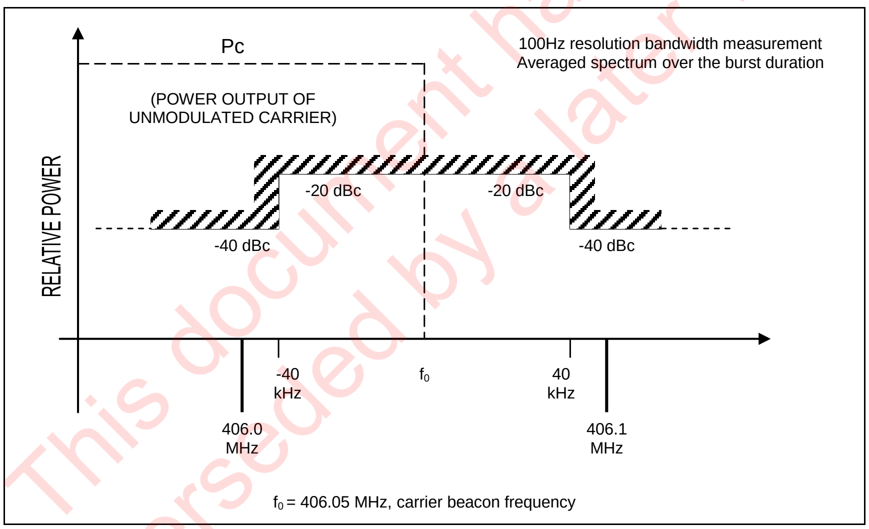


Figure 2.3: Spurious emission mask

Furthermore, out of band emissions must be limited to less than 1% of the total transmitted power[1].

2.3.3 Modulation

The RF modulation is OQPSK (Offset Quadrature Phase Shift Keying). The first chip and subsequent odd chips are used to modulate the in-phase (I) component of the carrier, while the even chips are used to modulate the quadrature-phase (Q) component of the carrier. The timing of the odd and even chips are offset by half a chip period ± [10]% of the chip duration. In the constellation diagram shown below, it can be seen that this will limit the phase-change to no more than 90° at a time. The Error Vector Magnitude (EVM) of the constellation points away from ideal shall be less than [15]%.

[1] The 1% out of band emission is extracted from the recommendation ITU-R SM.1541-4, article 1.153

The figure below illustrates the OQPSK modulation:

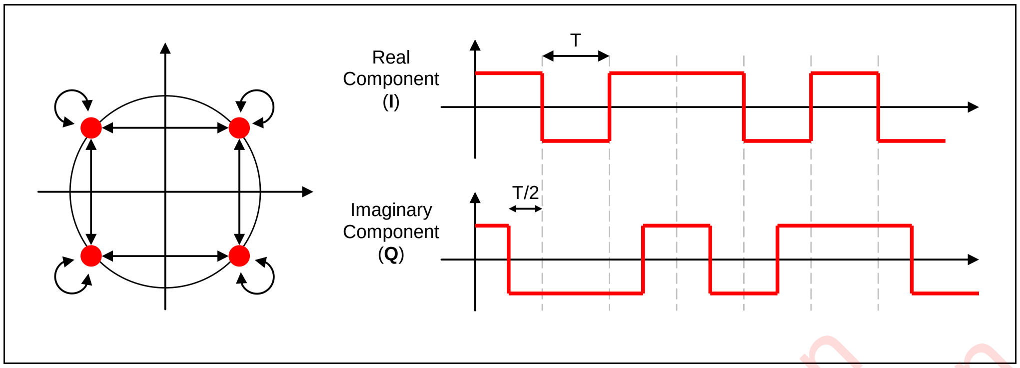


Figure 2.4: OQPSK modulation illustration

2.3.4 Voltage Standing-Wave Ratio

The modulator and 406 MHz transmitter shall be able to meet all requirements within this standard at any VSWR between 1:1 and 3:1, and shall not be damaged by any load from open circuit to short circuit.

2.3.5 Maximum Continuous Transmission

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

2.4 Transmitter Power Output

2.4.1 Transmitter Rise Time

The transmitter RF output power shall not exceed -10dBm prior to 25ms before the commencement of, or 25 ms after the end of, any 406 MHz burst. Power output rise time shall be less than 0.5 ms measured between the 10% and 90% power points. Pre-amble content shall be transmitted during the power rise time.

2.4.2 Effective Isotropic Radiated Power (EIRP)

Power output is defined in terms of EIRP, not power into a 50-ohm load. Required EIRP varies with elevation angle according to the table below. Greater than [TBD%] of measured EIRP values shall meet the limits shown.

Table 2.2: Required EIRP

Elevation (°)	5	10	20	30	40	50	60	70	80	90
Max dBm	[46]	[45]	[45]	[45]	[45]	[45]	[44]	[44]	[44]	[44]
Min dBm	[35]	[34]	[34]	[34]	[34]	[34]	[34]	[33]	[33]	[33]

The horizontal (azimuth) antenna pattern should be substantially omnidirectional and shall remain within the minimum and maximum values of EIRP provided in the above table.

Power output shall be maintained within the above limits throughout the minimum operating lifetime of the beacon at any temperature throughout the operating temperature range. Changes in beacon output power due to for example temperature and operation over the beacons minimum lifetime when operating into a 50-ohm test load shall be taken into account during determination of compliance with the minimum and maximum EIRP limits.

2.4.3 Antenna Characteristics

Antenna polarization shall be either circular (RHCP) or linear. Antenna pattern should be hemispherical and should include coverage at high elevation angles, subject to the EIRP limits given in section 2.4.1 (effective isotropic radiated power). An ideal antenna pattern is shown below for illustration purposes.

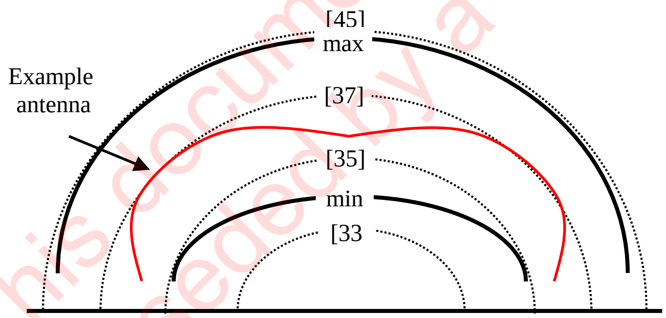


Figure 2.5: Ideal Antenna Pattern

Remote antennas or detachable antennas shall always be approved with a beacon and shall meet the EIRP requirements in 2.4.1 (effective isotropic radiated power) when operating with the minimum and maximum stated cable loss between the antenna and the beacon.

Remote antennas or detachable antennas when measured directly at the antenna feed point shall achieve a VSWR not greater than 1.5:1 referred to 50Ω and the characteristic impedance and minimum and maximum loss of the antenna feed cable shall be specified. Beacons designed to work with a specific manufacturer supplied / specified antenna cable shall be tested with that cable.

The following different types of antenna may be specified for use with a 406 MHz beacon:

External Antenna

An antenna that is external to the casing of the beacon and that is permanently attached to the beacon and that cannot be removed by the user.

Detachable Antenna

An antenna that is external to the casing of the beacon and that is attached directly to the beacon by such means as an RF connector without any intermediate cable which can be removed and replaced by the user.

Internal Antenna

An antenna that is contained within the case of the beacon where the user has no access to the antenna.

Remote Antenna

An antenna that is external to the casing of the beacon and which is remote from the beacon, being attached to it by means of an RF cable. The antenna and the RF cable may be permanently attached to the beacon or one or both parts (antenna or cable) may be detachable by the user.

All antennas and cabling arrangements to be approved with a beacon shall be specified by the manufacturer and shall meet all the requirements of Section 2.4.

2.5 406 MHz Homing Transmitter

The distress beacon may transmit a 406 MHz Homing signal as defined in this section.

Details TBD

- END OF SECTION 2 -

3. DIGITAL MESSAGE CONTENT

3.1 Basic Structure

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

a) 202 information bits; and

b) 48 bits for BCH(250,202) error correction

The 202 information bits are further divided into:
154 bits within the main data field (transmitted in every burst),
48 bits within a rotating data field (may be 1 of 16 different content types),

Message content structure is shown in Figure 3.1 below. Data transmission starts with bit 1, the left-hand (most significant) bit of the 154 bit main field.

<table>
<tr><td colspan="10">202 information bits</td><td colspan="5">48 error correction bits</td></tr>
<tr><td colspan="5">154 bit main field</td><td colspan="5">48 bit rotating field</td><td colspan="5">48 bit BCH field</td></tr>
<tr><td>1</td><td>2</td><td>……………………………</td><td>153</td><td>154</td><td>155</td><td>156</td><td>……….</td><td>201</td><td>202</td><td>203</td><td>204</td><td>…………….</td><td>249</td><td>250</td></tr>
</table>

Figure 3.1: Message content bits

3.2 Beacon Message Content – Main Field

The main field provides for the minimum requirements of document C/S G.008 using sub-fields as shown in Table 3.1 below.

Unless stated otherwise all sub-fields are separately binary encoded, with the Least Significant Bit to the right (i.e. the highest numbered bit in that particular message field).

Table 3.1: Minimum Requirement main field in the beacon message (transmitted in every burst)

C/S G.008 reqmt Para.	Description	Number of bits	Content
3.7.1a	TAC Number + Serial Number	30	- 20 bits TAC # (0 to 1,048,575), followed by a 10 bits serial # (0 to 1023)
3.7.1a	Country code	10	A three-digit decimal country code number (0 to 999). Country codes are based on the International Telecommunication Union (ITU) Maritime Identification Digit (MID) country code available on

C/S G.008 reqmt Para.	Description	Number of bits	Content
			the ITU website (www.itu.int/cgi-bin/htsh/glad/cga_mids.sh).
3.7.1d	Status of homing device	1	A ‘1’ indicates that a homing device is functional and transmitting. A ‘0’ indicates that no homing device is functional or it has been deliberately disabled
3.7.1e	Self-Test function	1	A ‘1’ indicates Normal Beacon operation (transmitting a distress). A ‘0’ indicates a Self-Test Transmission
3.7.1f	User cancellation	1	All ‘1s’ indicates a User cancellation message. All ‘0s’ indicates Normal Beacon operation (transmitting a distress or self-test message) [To be reviewed in light of recent changes to C/S G.008 Section 3.11.1, see also Section 4.5.7 of this specification]
3.7.1g	Encoded GNSS location	 1 7 15 1 8 15	Location is provided to 3.4m resolution max in the following order: N/S flag (N=0, S=1) Degrees (0 to 90) in 1 degree increments Decimal parts of a degree (0.5 to 0.00003) (Default value of bits = 0 1111111 000001111100000 E/W flag (E=0, W=1) Degrees (0 to 180) in 1 degree increments Decimal parts of a degree (0.5 to 0.00003) (Default value of bits = 0 11111111 111110000011111)
3.7.1h	Vessel ID	 3 30	A three digit binary field identifier is first transmitted to identify the following message content: 000 - No aircraft or maritime identity (in which case the following 44 binary bits shall all be 0) 001 – Maritime MMSI 010- Radio call sign 011 – Aircraft Registration Marking (Tail Number) 100 – Aircraft aviation 24 Bit Address 101 – Aircraft operator and serial number 110 and 111 Spare This is followed by the vessel or aircraft identity, the following coding schemes are permitted: 1 - Maritime Mobile Service Identity A unique ship station identity in the format $M_1I_2D_3X_4X_5X_6X_7X_8X_9$ where MID indicates the flag state of the vessel and XXXXXX is the unique vessel number in accordance with ITU-R M.585-6 encoded

C/S G.008 reqmt Para.	Description	Number of bits	Content
		14	as a 9 digit number in binary format. If no MSI is available then insert the default decimal number 000111111 Followed if applicable by the Maritime Mobile Service Identity for the EPIRB-AIS system in the format $9_1 7_2 4_3 X_4 X_5 Y_6 Y_7 Y_8 Y_9$ in accordance with ITU-R M.585-6 where only the last 4 digits ($Y_6 Y_7 Y_8 Y_9$) are encoded here as a number in binary format, If there is no EPIRB-AIS device, then insert the default binary number 10101010101010 (10922)
		44	2 - Radio call sign Is encoded using the modified-Baudot code shown in Table 3.1a. This code enables 7 characters to be encoded using 42 bits (6x7=42). The two highest bits (43 and 44) are spare and shall be coded as 00. This data will be left justified with a modified-Baudot space (100100) being used where no character exists. If no Radio call sign is available then insert a series of 7 spaces (100100)
		44	3 - Aircraft Registration Marking Is encoded using the modified-Baudot code shown in Table 3.1 a. This code enables 7 characters to be encoded using 42 bits (6x7=42). The two highest bits (43 and 44) are spare and shall be coded as 00. This data will be right justified with a modified-Baudot space (100100) being used where no character exists. If no Aircraft Registration Mark is available then insert a series of 7 spaces (100100)
		44	4 – Aviation 24 Bit Address Shall be encoded as a 24 Bit Binary Number, followed by 20 spare bits all of which are coded as 0
		44	5 - Aircraft operator and serial number 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) as document 8585. The 3 letters are encoded using the modified-Baudot code shown in Table 3.1a (3x6 = 18 Bits). Followed by a serial number (in the range of 1 up to 4095) as designated by the aircraft operator,

C/S G.008 reqmt Para.	Description	Number of bits	Content
			encoded in binary, with the least significant bit on the right (12 Bits). The remaining 14 Bits are spare and shall follow the above 30 Bits and be encoded all as 1's.
	Spare bits	17	These bits are all set to binary 1
	TOTAL BITS IN EACH BURST	154	To be transmitted in each burst

NOTES
All position information is encoded as degrees and decimal parts of a degree, or as fractions of these units to be as close as possible to the actual position.
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.

Table 3.2 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

3.3 Beacon Message Content – Rotating Fields

The objective requirements of document C/S G.008 are provided in rotating fields as detailed below. During every transmission burst the beacon shall transmit 1 of the 16 types of rotating field content. The type of field content selected for transmission shall be in accordance with the rotating field scheduling requirements – see section 3.4. The 16 types of rotating field content are listed below.

0. C/S G.008 Objective Requirements (except national use and spares)
1. Inflight Emergency (to allow more accurate time parameters)
2. RLS (for RLS messages)
3. National Use (to allow national administrations to define for their use)
4. Spare (for future use)
5. Spare (for future use)
6. Spare (for future use)
7. Spare (for future use)
8. Spare (for future use)
9. Spare (for future use)
10. Spare (for future use)
11. Spare (for future use)
12. Spare (for future use)
13. Spare (for future use)
14. Spare (for future use)
15. Spare (for future use)

Detailed content of rotating fields #0 through #3 are shown in Tables 3.3 through 3.6 below. [Note: Requirements, contents, and scheduling are still being evaluated.]

Unless stated otherwise all sub-fields of every rotating field are separately binary encoded, with the Least Significant Bit to the right (i.e., the highest numbered bit in that particular message field).

Table 3.3: G.008 Objective Requirements Rotating Field (#0)

C/S G.008 Section	Sub-field Description	Number of bits	Content
	Rotating field Identifier	4	0000 – G.008 Objective Requirements
4.3.1a	Elapsed Time since activation	6	0 to 63 hours in one hour steps (actual time since activation shall be truncated, not rounded e.g. between 1 hour and 2 hours after activation shall be encoded as 1 hour). If the beacon is turned off and on again (even quickly) this field shall be reset to zero.
4.3.1b	Time from last encoded location	11	0 to 2047 minutes (34 hours and 7 minutes) in one minute steps (actual time since last location shall be truncated, not rounded e.g. between 34 minutes and 35 minutes after activation shall be encoded as 34 minutes). Every time that a new / updated encoded location is obtained this field shall be reset to zero. Time is calculated from when the location was obtained not when it was transmitted. If the time is greater than 2047 minutes, the value shall be set to 2047.
4.3.1c	Altitude of Encoded location	10	-400 metres to 15968 metres in steps of 16 metres (where -400m is encoded as all zeros and sea level would be encoded as 0000011000). Heights shall be rounded to the nearest 16 metre step not truncated. If altitude is not available (e.g. there is no location data or only a 2D fix is available) then this field shall be encoded as all 1's
4.3.1d	Dilution of Precision	8	The value of HDOP of the encoded location shall be reported (first 4 bits) followed by the value of VDOP on the following basis: 0000 = DOP <= 1 0001 = DOP > 1 and <= 2 0010 = DOP > 2 and <= 3 0011 = DOP > 3 and <= 4 0100 = DOP > 4 and <= 5 0101 = DOP > 5 and <= 6 0110 = DOP > 6 and <= 7 0111 = DOP > 7 and <= 8

			1000 = DOP > 8 and <= 10 1001 = DOP > 10 and <= 12 1010 = DOP > 12 and <= 15 1011 = DOP > 15 and <= 20 1100 = DOP > 20 and <= 30 1101 = DOP > 30 and <= 50 1110 = DOP > 50 1111 = DOP Not Available
4.3.1f	Automated/Manual Activation notification	2	Report the activation method of the beacon as follows: 00 Manual Activation by user 01 Automatic Activation by the beacon 10 Automatic Activation by external means 11 Spare
4.3.1g	Remaining battery capacity	3	The remaining battery capacity in the beacon compared to its initial capacity shall be reported as follows: 000 <= 5% remaining 001 > 5% and <= 10% remaining 010 > 10% and <= 25% remaining 011 > 25% and <= 50% remaining 100 > 50% and <= 75% remaining 101 > 75% and <= 100% remaining 110 Reserved for future use 111 Battery Capacity Not Available
Not in C/S G.008	GNSS status	2	This field reports the status of the GNSS receiver used to provide the encoded location as follows: 00 No Fix 01 2D location only 10 3D location 11 Reserved for future use
	Spare	2	00
TOTAL	Bits in Rotating Field	48	

Table 3.4: In Flight Emergency Rotating Field (#1)

C/S G.008 section	Sub-field Description	# Bits	Content
	Rotating field Identifier	4	0001
4.3.1b	Time of last encoded location	26	Date (4+5 bits) and time to nearest second (17 bits) Date 'mmdd' where month is a 4 bit binary number from 1 to 12 and day is a 5 bit binary number from 1 to 31 (e.g. January 17 would be 000110001) Time 'sssss' where '00001' indicates a time of 00:00:01 UTC and '86399' indicates a time of 23:59:59 UTC)
	Unassigned	18	All 0's
	TOTAL	**48**	

Table 3.5: RLS Rotating Field (#2)

C/S G.008 section	Sub-field Description	# Bits	Content
	Rotating field identifier	4	0010
4.5.1	RLS data	6	100000 = RLM Request Type 1 only (default) 010000 = RLM Request Type 2 only 110000 = RLM Request Type 1 and Type 2 (From paper JC-24/8/6; C/S T.001 section A3.3.7.1b)
	Unassigned	38	All 0's
	TOTAL	**48**	

Table 3.6: National Use Rotating Field (#3)

C/S G.008 section	Sub-field Description	# Bits	Content
	Rotating field identifier	4	0011
4.3.1.i	National use	44	As defined by national administrations Default content all 0's
	TOTAL	**48**	

Table 3.7: Spare Rotating Fields (for future use) (#4 - #15)

C/S G.008 section	Sub-field Description	# Bits	Content
	Rotating field identifier	4	0100 to 1111 inclusive
4.3.1.h	Spares	44	Default content all 0's.
	TOTAL	**48**	

3.4 Rotating field – Transmission scheduling

Default: By default field type #0 (G.008 data) shall be sent unless dictated otherwise.

ELT in-flight emergency: TBD

Time since beacon activation	Rotating Fields to be Transmitted
0 to 30 seconds	
30 seconds to 30 minutes	
30 minutes +	
Other	

RLS: TBD

Time since beacon activation	Rotating Fields to be Transmitted
0 to 30 seconds	
30 seconds to 30 minutes	
30 minutes +	
Other	

National use: Administrations shall define their own rotation schedule for field type #3. Such schedules shall include regular transmission of field type #0.

3.5 Beacon Message Content – Error Correcting Field

A sample of the BCH Error-correcting Code Calculation is provided in Appendix 3.

3.6 Beacon Coding and Hex ID

Beacon coding methods are defined in section 3.1 of this specification. Specific operational requirements that impact beacon coding, such as the self-test mode and the encoding of position data, are defined in section 4 of this specification.

The 23 hexadecimal characters that uniquely identify each 406 MHz beacon are called the beacon 23 Hex ID. This is never transmitted by the beacon as such, rather it is generated locally by the SAR ground segment hardware and generated during beacon manufacture in order to apply identity labels to the beacon by extracting the bits shown below from the beacon data.

The 23 HexID is composed as follows:

Table 3.8: Hex ID Contents

23 Hex ID Bit	No Bits	Data Content
1	1	Fixed Binary ‘1’
2 to 11	10	C/S Country Code
12	1	Fixed Binary ‘1’
13	1	Fixed Binary ‘0’
14	1	Fixed Binary ‘1’
15 to 34	20	C/S TAC No
35 to 44	10	Beacon Serial Number
45 to 47	3	Aircraft / Vessel ID Type
48 to 91	44	Aircraft / Vessel ID
92	1	Spare Bit – Fixed Binary ‘1’
Total	**92**	**23 Hex**

Notes

1) Fixing bits 1, 12, 13 and 14 of the 23 Hex ID to ‘1101’ ensures that the 23 Hex ID cannot duplicate a First Generation Beacon 15 Hex ID.

2) The first 60 bits of the 23 Hex ID comprising the C/S Country Code, C/S TAC Number, Beacon Serial Number, Fixed Bits 1, 12, 13 and 14 and the first part of the Aircraft / Vessel ID together form a unique subset of the 23 Hex ID which form an SGB 15 Hex ID which is required for certain services, such as the Return Link Service. That is a unique SGB 15 Hex ID which may be obtained by simply truncating the 23 Hex ID and ignoring the last 8 Hex characters.

- END OF SECTION 3 -

4. ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS

4.1 General

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

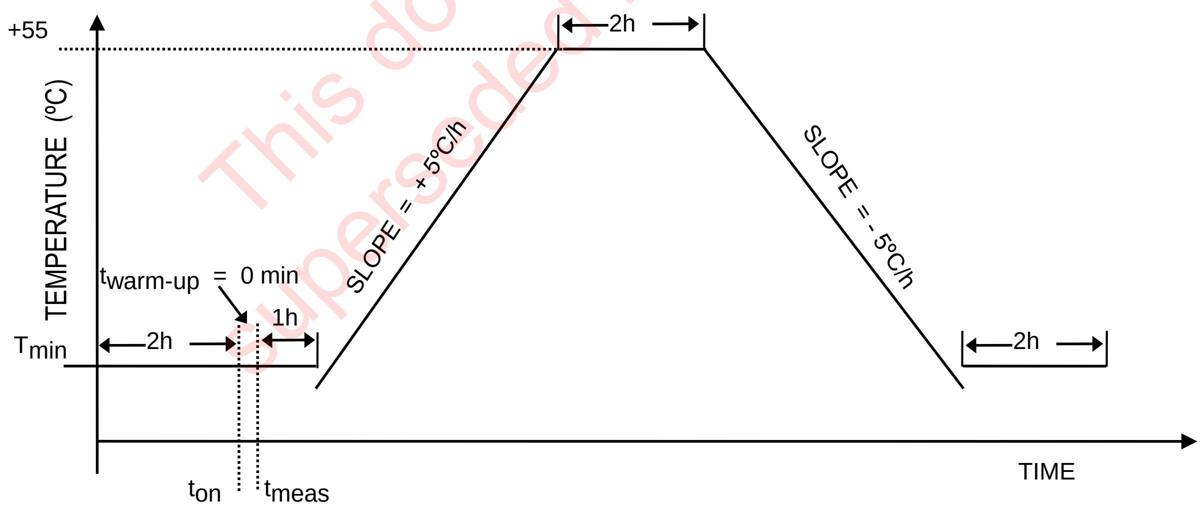
4.2 Thermal Environment

4.2.1 Operating Temperature Range

Two standard classes of operating temperature range are defined, inside which all of the requirements within this specification shall be met:
Class 1: -40°C to +55°C
Class 2: -20°C to +55°C

4.2.2 Temperature Gradient

All of the requirements within this specification, shall be met when the beacon is subjected to the temperature gradient shown in Figure 4.1.



NOTES: T_{min} = - 40°C (Class 1 beacon)
T_{min} = - 20°C (Class 2 beacon)
t_{on} = beacon turn-on time after 2 hour "cold soak"
t_{meas} = start time of frequency stability measurement (t_{on} + 0 min)

Figure 4.1: Temperature Gradient

4.2.3 Thermal Shock

All of the requirements within this specification shall be met, for measurements beginning [3] seconds after simultaneously activating the beacon and applying a rapid thermal shock of [50] °C within the specified operating temperature range of the beacon within [1] minute. Subsequently, all requirements shall continue to be met for a minimum period of two hours.

4.3 Mechanical Environment

Beacons should be submitted to vibration and shock tests consistent with their intended use. These requirements should be defined by national authorities, preferably using internationally-recognized standards such as RTCA/DO-204 for ELTs.

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[2] at any temperature throughout the specified operating temperature range.

4.5.1.2 Battery Replacement Interval

The beacon battery replacement interval shall be declared by the beacon manufacturer. At the end of the battery replacement interval the beacon shall continue to meet the required duration of continuous operation as defined in 4.5.1 after accounting for all losses in battery capacity over the declared battery replacement interval at ambient temperatures plus a safety factor of 65% applied to all losses.

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 Radio-Locating Signal (for Homing and on-Scene Locating)

The distress beacon may transmit a 406 MHz Homing signal as defined in section 2.5.

The distress beacon may transmit other radio-locating signals in compliance with appropriate national or international standards. The status of the radio-locating transmissions (e.g.,

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

operational or non-operational) shall be monitored and encoded in the beacon message as indicated in Section 3.2.

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

Radio-Locating Signals shall begin transmission within 5 minutes maximum after beacon activation, except (if applicable) AIS signals which shall not be delayed for longer than 1 minute after beacon activation.

4.5.4 Beacon Self-Test Mode

All beacons shall include a self-test mode of operation, which shall include a Verification of Registration function as detailed in Section 4.5.8.

In the self-test mode beacons shall transmit a digital message encoded in accordance with Section 3. The content of the self-test message shall always provide the beacon ID as defined in Section 3.6. The transmitted message shall contain an identifier to indicate that the message is a self-test transmission as specified in Section 3.2 [and shall be spread by a specific sequence defined in section 2.2.3].

The complete self-test transmission shall be limited to one 406 burst at full power and one burst of each radio-locating signal at full power with a maximum duration of 3 sec each. The radio-locating signals shall be transmitted first in order of ascending frequency followed lastly by the 406 MHz satellite signal.
The self-test mode shall be activated by either a separate switch to that used to activate the beacon or cancel transmissions; or a separate switch position of the beacon activation switch.

The duration of the self-test cycle shall not exceed [15] seconds.

The self-test function shall perform an internal check and provide a distinct indication:

a) that the self-test mode has been initiated within [2] secs of activation;

b) that RF power is being emitted at 406 MHz and the radio locating frequencies, if applicable; and

c) that the internal check has passed successfully within [15] secs of activation; or

d) that any of item a), b) or c) has failed the self-test within [15] secs of activation

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 beacons without valid location data, the content of the encoded position data field of the self-test message shall be the default values specified in Section 3. Additionally, beacons may optionally also provide for the transmission of a self-test message encoded with a GNSS position.

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 GNSS self-test activation, and shall not result in more than a single self-test burst;

b) provide for that in the case of internal GNSS receivers powered by the primary[3] 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 that the GNSS self-test is underway and to register successful completion or failure of the GNSS self-test;

d) provide, for beacons with internal navigation devices powered by the primary beacon battery, a separate distinct indication that the limited number of GNSS self-test opportunities have been attained;

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 (or before the time limit is reached), indicate a GNSS self-test pass and transmit a single self-test burst containing the [valid] location data.

4.5.5 Encoded Position Data[4]

4.5.5.1 General

Beacon position data, obtained from a navigation device internal or external to the beacon, shall be encoded in the beacon message, if available. Beacons that do not provide encoded position data shall indicate this within the message and shall transmit default location data as defined in Section 3. Beacons capable of encoding position data shall comply with the appropriate parts of Section 4.5.5.

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

4.5.5.2 Message content and timing

Encoded position message content shall be as defined in Section 3.

First provision of encoded location within a transmitted message shall occur within the following times after beacon activation, with a 95% probability

[3] The primary battery is the battery which is powering the 406 MHz function.
[4] ELTs carried to satisfy the requirements of ICAO Annex 6, Parts I, II and III shall operate in accordance with ICAO Annex 10.

[Note: conditions need to be defined for the navigation signal and environment].

a) Within [3] seconds for any beacon with an external navigation input.
b) Within [2] minutes for beacons with an internal navigation device.

If a valid 3D location (including height) is available then this shall be transmitted, however if a 3D location is not available but a valid 2D location is then this shall be transmitted instead.

The first [30] minutes after beacon activation is a 'rapid tracking' period, during this time the beacon shall acquire fresh position information immediately prior to every transmission burst unless this becomes impractical due to navigation signal constraints.

During the first [30] minutes after beacon activation the location transmitted by the beacon shall always be the latest information provided by the navigation device (or external input). This applies even if the quality of the location has become worse. Navigation devices (or external inputs) shall provide an updated location at least every [1] second and the update immediately prior to the next scheduled transmission burst shall be encoded and transmitted by the beacon within [1] second of receipt.

After the first 30 minutes, the navigation device shall make at least one attempt every 15 minutes to obtain an initial location until an initial location is obtained or 2 hours has passed since beacon activation.

After the first 30 minutes once an initial location is obtained or 2 hours has passed since beacon activation, the navigation device shall attempt location updates following the regime set out below:

- In the first 6 hours the navigation device shall attempt at least one location update every 30 minutes

- Beyond 6 hours a location update shall be attempted at least every 60 minutes for the life of the battery

Whenever the beacon has fresh encoded location data at the start of a burst, this shall be indicated within the message by zeroing the "time from last encoded location" field as required by section 3.3.

If the beacon is capable of transmitting a position from a navigation device (internal or external) but no position is available then the beacon shall transmit either default position data (if it has no position) or the last received position until such time as a fresh position is available. In addition the beacon shall compute the elapsed time since the last position update (or since activation) to an accuracy of [10] seconds and provide this in the transmitted message to a resolution of the [nearest minute] as required by section 3.3.

4.5.5.3 Navigation Performance

With a clear view of the sky the distance between the horizontal position provided by the navigation device, at the time of the position update, and the actual navigation device position shall not exceed 30 m 95% of the time. The distance between the vertical position (altitude) provided by the navigation device, at the time of the position update, and the actual navigation device position shall not exceed 50 m 95% of the time. The encoded position data shall be provided in a format compatible with the International Terrestrial Reference System (ITRS) and its reference frames (ITRF) such as the WGS 84 or GTRF. The difference between the chosen format and the ITRF shall not exceed [10] cm.

The navigation device (internal or external) shall provide an indication of the potential error of each provided position in terms of Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP) and shall encode the respective DOP values in the message in accordance with Section 3.3

The (internal or external) navigation device shall provide the following additional information for each provided position whether it has no Fix or was operating in 2D or 3D Mode and shall encode this data in the message in accordance with Section 3.3.

Any 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.

4.5.5.4 Internal Navigation Device

An internal navigation device shall be capable of global operation and should conform to an applicable international standard.

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.

Internal navigation devices shall operate continuously during the initial [30] minutes period following beacon activation.

Internal navigation devices shall be enabled prior to 406 MHz transmissions as required by Section 4.5.5.2. Each location update attempt shall require the navigation device to be operational for a period of at least [90] seconds or until a valid location has been obtained whichever is shortest.

[If the internal navigation device fails to provide a location during the two location update attempts immediately previous to the current location update attempt, then the current update attempt shall be extended to a minimum duration of [3] minutes scheduled immediately prior to the next planned location update.]

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). The input must be able to provide all relevant position data as required by Sections 3.2 and 3.3, this includes horizontal position, vertical position (altitude), time of this position to an accuracy of 1 second, HDOP, VDOP and, No Fix or 2D or 3D operating. Examples of suitable Maritime IEC 61162-1 sentences to achieve this objective include GNS and GSA and Aviation ARINC 429 labels to achieve this objective include Label 101, 102, 310, 311 etc.

4.5.6 Beacon Activation

Beacons shall have a means of manual activation and deactivation and may optionally also include means of automatic activation.

The beacon shall be designed to prevent inadvertent activation.

Within [1] second after activation, the beacon shall provide a visual indication that it has been activated.

For beacons which can be remotely activated, there shall be an indicator on both the remote activation device and the beacon.

The beacon shall track time since activation to an accuracy of [10] minutes and provide this in appropriate transmitted messages to a resolution of the nearest [one hour] as required by Section 3.3.

4.5.7 Beacon Activation Cancellation Function

The beacon shall include a beacon activation cancellation function. This shall be a separate function from the on/off capability of the beacon. The cancellation function shall be protected from inadvertent activation and shall be triggered by two simple and independent actions that provide confidence in intentional cancellation action by the user.

[When the beacon activation cancellation function is enabled the beacon shall transmit a cancellation message [3 times at intervals of 10 seconds ±2 seconds] as required by section 3.2 after which time it shall cease transmitting and return to an off / ready state.
Note: To be reviewed in light of recent changes to G.008 3.11.1, see also Table 3.1 Section 3.7.1.f.]

4.5.8 Verification of Registration

See footnote.[5]

4.5.9 ELT Triggered In-Flight Operation

The in-flight triggered ELT operation should be activated by a means outside of the ELT.

[5] C/S G.008 Section 3.13 describes an operational beacon requirement to design the beacon such that the registration status of the beacon is displayed to the beacon user. The registration status shall remain valid for a period of two years and the beacon shall be designed such that the self-test function indicates by default that the beacon is not registered. National Administrations have a variety of registration renewal requirements and methods for registration verification. The lack of a common approach makes it difficult to identify a specific specification to achieve the requirement at this time. It's possible that in the future that a common approach would be identified, but until such time, compliance with this requirement is not met by SGBs in C/S T.018.

ELTs with this capability shall also transmit encoded location data as available in the beacon message as specified in the appropriate parts of Section 4.5.5.

4.5.10 RLS Function

If a beacon is equipped with a Return Link Service (RLS) functionality, it shall meet the following additional requirements.

4.5.10.1 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 RLM compliant sentence.

The following Return Link Message has been defined by Cospas-Sarsat to date:

- Type-1 An automated response that simply acknowledges receipt of the RLS request.

The definition of the Type-1 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.

4.5.10.2 RLS GNSS Receiver Operation

4.5.10.2.1 Operation Cycle

In addition to the beacons normal GNSS receiver operating cycle as defined in 4.5.5.2 and 4.5.5.4 or as defined by the beacon manufacturer if in excess of this requirement, the RLS beacon shall:

a) within 5 seconds of the beacon transmitting its first RLS Rotating Field message maintain the GNSS receiver in an active mode of operation such that it can continuously check for receipt of an RLM message for a minimum period of 30 minutes or until the beacon is deactivated if this occurs first;

b) as soon as possible determine Coordinated Universal Time (UTC) from the GNSS receiver and maintain a clock for the operating lifetime of the beacon to an accuracy of better than one second or until the beacon is deactivated;

c) After the first 30 minutes, utilise UTC time to activate the GNSS receiver with the following schedule until the beacon is deactivated or the beacon battery has expired:

   At M_{offset} minutes, with $0 \leq M_{offset} \leq 59$, past the next natural hour since the GNSS receiver was last activated to check for receipt of an RLM for a minimum period of 15 minutes; and

d) If UTC is not available after the first 30 minutes the beacon shall attempt to establish UTC using the timings detailed in sections 4.5.5.2 and 4.5.5.4. If UTC is then established the beacon shall continue as per c) above.

The GNSS receiver in the beacon continues with this operation mode until the expiration of the battery even if a Type 1 RLM has been received.

For instance, if the beacon transmitted an RLS protocol at 03.17h UTC, then the GNSS receiver would remain active until at least 03.47h UTC or until the beacon is deactivated if it is deactivated before that time. It would then re-activate at 04:00+Moffset and remain active until at least 04.00+M_{offset}+15 or until the beacon is deactivated and it would then reactivate again at 05:00+M_{offset} until 05.00+M_{offset}+15. The scheme continues until the battery has expired or the beacon is deactivated.

4.5.10.2.2 Derivation of M_{offset}

The value of M_{offset} for each beacon is computed from the beacon 15 Hex ID subset of the 23 Hex ID (see Section 3.4). More specifically:

M_{offset} = BIN2DEC (CRC16(Beacon 15 Hex ID in Binary)) mod 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}.]

4.5.11 Battery Status Indication

The battery status indication provides the user with an indication prior to beacon activation that the battery may be partially depleted and may not operate for the full specified operating lifetime.

Beacons powered by a Rechargeable battery shall automatically provide an indication when the battery requires recharging. Beacons powered by a Non-rechargeable battery may provide an indication of battery status during a self-test.

If provided this shall be a separate indication to the self-test pass/fail indication and the battery status indicator shall be activated when the battery in the beacon may not have sufficient energy to support beacon operation for the declared operating lifetime.

4.5.12 Beacon Labelling

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

1) The beacon 23 Hex ID

2) The beacon operating temperature range

3) The minimum duration of continuous operation

4.5.13 Beacon Instruction Manual

An End User instruction manual shall be made available with all beacons, it shall include:

1) Instructions on operation of the GNSS self-test 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.

- END OF SECTION 4 -

Appendix 1
Narrowband System-Specific Specification
(For Information Only)

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 Second Generation

- 406 MHz Emergency Locator Transmitters (ELTs),
- Emergency Position-Indicating Radio Beacons (EPIRBs), and
- Personal Locator Beacons (PLBs)

utilizing a narrowband signal that falls within the standard 3 kHz channels defined in C/S T.012.

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.

1.2 Scope

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

a) Section 2 gives the system requirements applicable to all types of narrowband 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 appendix.

c) Annex A deals with the beacon message coding and detailed message structure.

d) Annex B describes the BCH codes used for error correction and error detection.

e) Annex C describes the content and bit allocation for the different data packages transmitted in the PDF-2 field.

- END OF SECTION A1-1 -

2. TECHNICAL REQUIREMENTS

2.2 Digital Message Generator

The digital message generator will key the modulator and transmitter so that the message defined in Section 3 of this Appendix is transmitted. The requirements given below are in addition to those defined in Section 2 of the main specification document C/S T.X01.

2.2.1 Repetition Period

From beacon activation a total of [6] initial transmissions shall be made separated by fixed [5s ± 0.1s] intervals. The first transmission shall commence within [3] seconds of beacon activation.

Transmissions shall then occur at nominally [30] second intervals until [30 ± 1] minutes after beacon activation. The repetition period between the start of two successive transmissions shall be randomised around the stated nominal value, so that intervals between successive transmissions are randomly distributed over ± [5] seconds.

Subsequent transmissions [TBD].

The transmission schedule is summarised in the table below:

Table 2.1: Transmission Schedule

IAMSAR Stage	Time Interval	Transmission Repetition Interval	Randomization
Initial	[0 to 30] Seconds	[5] Seconds	[0]
Action / Planning	[30 seconds to 5 minutes]	[30] Seconds	± [5] seconds
	[5 minutes to 30 minutes]	[30] Seconds	± [5] seconds
	[30 minutes +]	TBD	TBD

2.2.2 Total Transmission Time

The total transmission time, measured at the 90 percent power points, shall be [910] ms ±[0.25] percent for the 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

The final [750] ms ±[0.02] percent of the transmitted signal shall contain a [300]-bit message at a bit rate of 400 bps ±[0.02] percent.

2.2.4.1 Bit Synchronization

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

2.2.4.2 Frame Synchronization

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

A second frame synchronization pattern consisting of [32] bits shall occupy bit position [269-300]. This second frame synchronization pattern shall always be [1ACFFC1D] in hexadecimal format or [0001 1010 1100 1111 1111 1100 0001 1101] in binary format.

2.2.4.3 Format Flag

Bit 25 is a format (F) flag that shall be set to "0" for all messages, except for the legacy long message when it shall be set to "1".

2.2.4.4 Message Content

The content of the remaining [243] bits is defined in section 3.

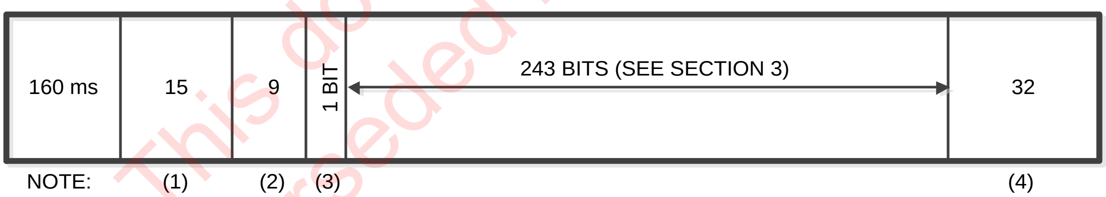


Figure 2.1: Message Format

Notes:
(1) Bit Synchronization : 15 ‘1’ bits
(2) Frame Synchronization 1: 000101111 (except as in section 4.5.4??)
(3) Format flag: ‘0’ except when legacy long message data package in PDF-2 (see Annex A)
(4) Frame Synchronization 2: [0001 1010 1100 1111 1111 1100 0001 1101]

2.3 Modulator and 406 MHz Transmitter

2.3.1 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.

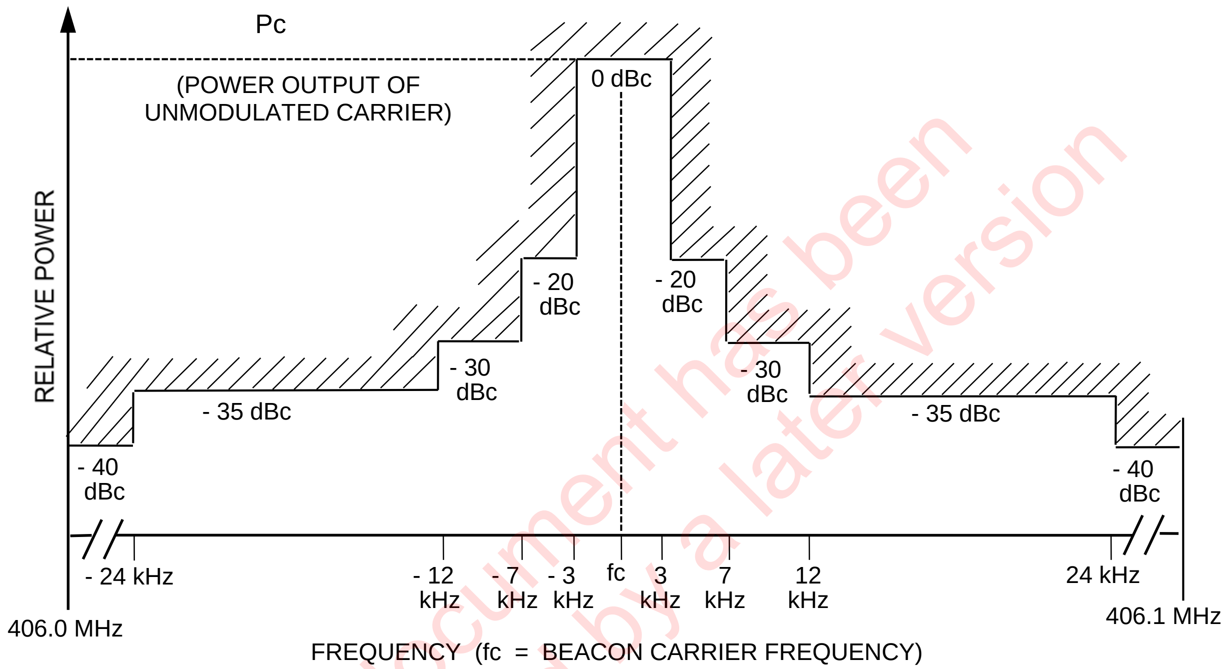


Figure 2.2: Spurious Emission Mask for 406.0 to 406.1 MHz Band

2.3.2 Transmitted Frequency[6]

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.

The carrier frequency of beacons operating in the 406.[050 to 406.080] MHz channels, in accordance with the Cospas-Sarsat 406 MHz Channel Assignment Table, shall be set at 406.[xxx] ± 1 kHz. The carrier frequency shall not vary more than +2 kHz /-5 kHz from 406.[xxx] MHz in 5 years.

[6] 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 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.[7]

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.

Distress transmissions shall commence [5] seconds 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 ±5], 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. [note: this will need to be modified in accordance with new repetition rates]

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.

2.3.3 Transmitter Power Output

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

2.3.4 Data Encoding

The data shall be encoded bi-phase L, as shown in Figure 2.4.

[7] See document C/S G.008, 3.4.3 e) for dependencies, also consider enhanced performance in first "x" minutes after beacon activation.

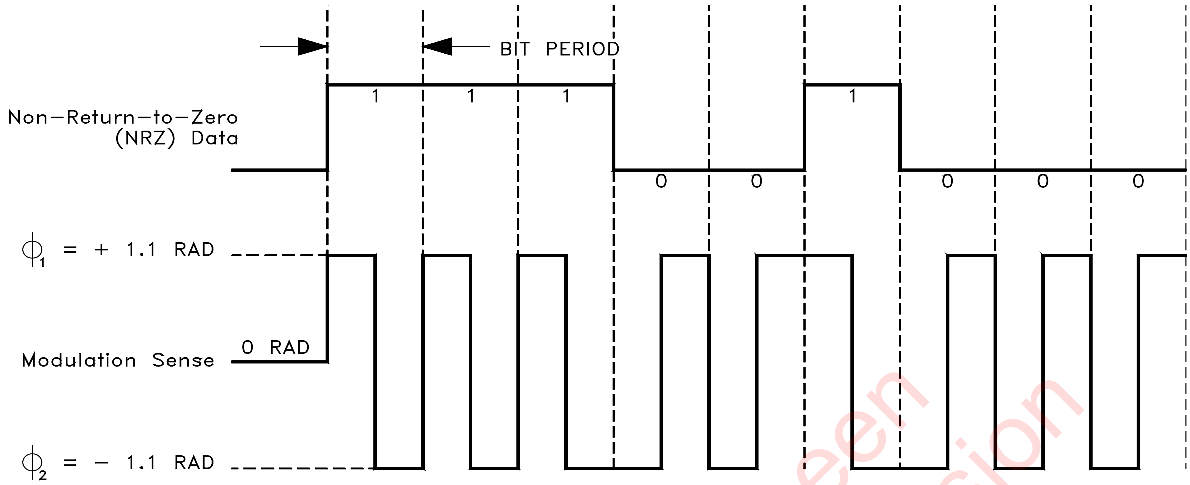


Figure 2.3: Data Encoding and Modulation Sense

2.3.5 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 ± 100 µs].

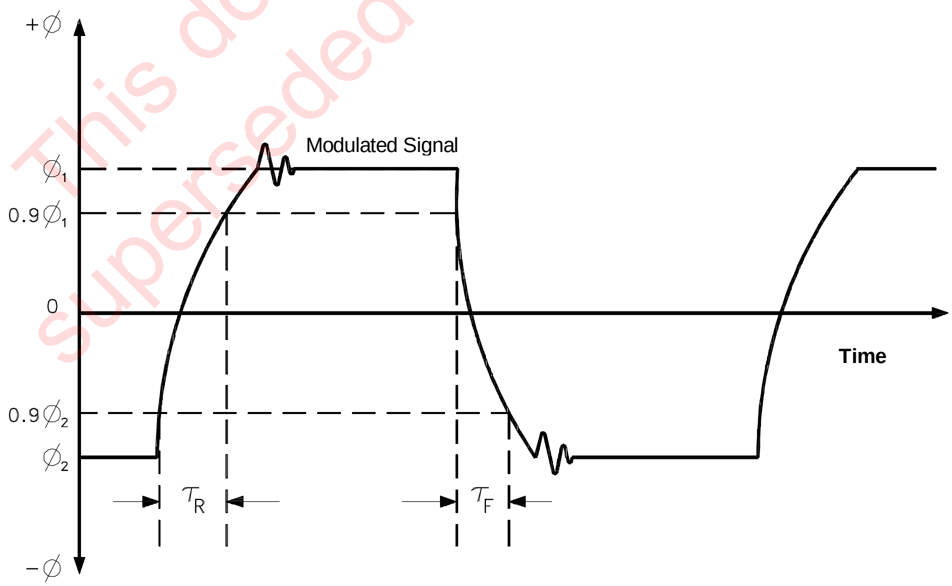


Figure 2.4: Definition of Modulation Rise and Fall Times (figure not to scale).

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

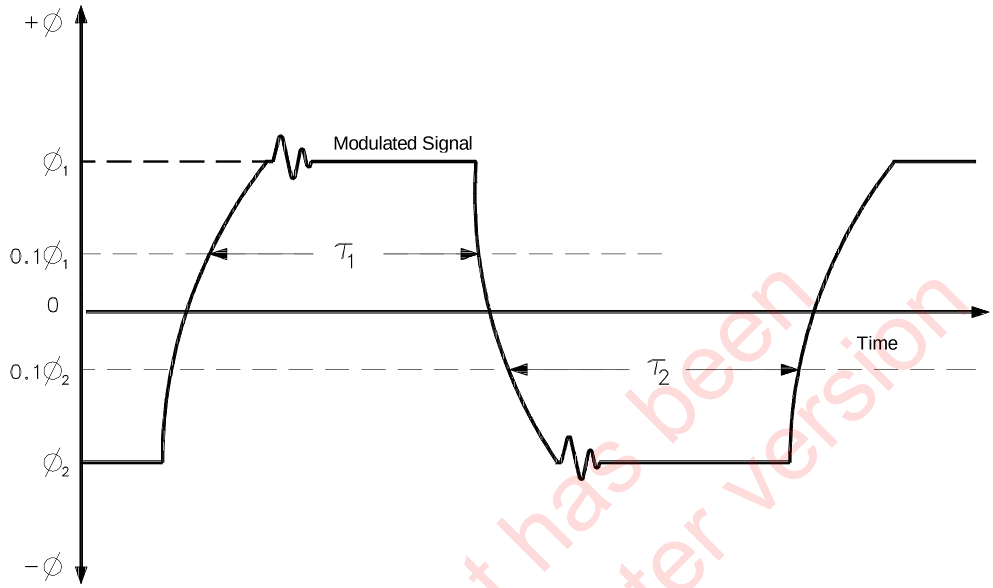


Figure 2.5: Definition of Modulation Symmetry (figure not to scale).

2.3.6 Voltage Standing-Wave Ratio

The requirements of paragraph 2.3.2 (transmitter power output) are not subject to the VSWR requirement of Section [xxx] of the main specification document.

- END OF SECTION A1-2 -

3. DIGITAL MESSAGE STRUCTURE

3.1 Basic Structure

The beacon message content will contain 202 bits of information, with 154 bits of essential information in main field, and objective information in a rotating field of 48 bits.

Currently defined rotating fields to meet operational objective requirements, in addition to that in Section 3 of the main document, are shown in the tables below.

Table 3.1 – In Flight Emergency Rotating Field

C/S G.008 section	TITLE-in flight emergency rot field	# Bits	
	Rotating field Identifier	4	
4.3.1b	Time from last encoded location	25	Date (9 bits) and time to nearest second (16 bits)
	Unassigned	19	
	TOTAL	**48**	

Table 3.2 - RLS Rotating Field

C/S G.008 section	TITLE: RLS rotating field	# Bits	
	Rotating field identifier	4	
4.5.1	Return link national ID number	16	From paper JC-24/8/6; C/S T.001 section A3.3.71a
	RLS data	6	From paper JC-24/8/6; C/S T.001 section A3.3.7.1b
	unassigned	22	
	TOTAL	**48**	

Table 3.3 – National Use Field

C/S G.008 section	TITLE: National Use	# Bits	
	Rotating field identifier	4	
4.3.1.i	Reserved for National use	44	Number of bits not defined by JC or C/S G.008. JC-25 OWG splinter felt it was technical matter to define. Current C/S T.001 specifies 72 bits in National Serial User Protocol (A2.8). This 44 bits can be doubled to 88 bits using an unassigned rotating field as another national use rotating field.
	TOTAL	**48**	

Table 3.4 – Spares/Unassigned Rotating Fields

C/S G.008 section	TITLE: Spares	# Bits	
	Rotating field identifier	4	
4.3.1.h	Spares or unassigned	44	e.g., 132 bits spread over three rotating fields to meet RTCM suggestion of 100 bits
	TOTAL	**48**	

The complete digital message which is transmitted by the 406 MHz beacon will be approximately [1000 msec] and consists of [330] bits:

[TBD – The total message will adhere to section 3.1 with additional BCH and synchronisation bits.]

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).

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

(4) The following [70] bits of the message, positions 107 through [176], is referred to as the second protected data field (PDF-2).

(5) The following 92 bits of the message, positions [177] through [268], are a Bose-Chaudhuri-Hocquenhem or BCH (244,152) error-correcting code and a second parity bit. This bit group is referred to as the second BCH error-correcting field (BCH-2). This code can detect and correct up to 12 bit errors in the 244 bits of (PDF-1, BCH-1, PDF-2 and BCH-2). The combination of PDF-2 and BCH-2 is referred to as the second protected field.

(6) The last [32] bits of the message, positions [269] through [300], are system bits; they are defined in section 2 and are used for frame synchronization.

3.2 Beacon Coding

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

The 15 hexadecimal characters that uniquely identify each 406 MHz beacon are called the beacon identification or beacon 15 Hex ID. This beacon identification comprises 60 bits of PDF-1 (bits 26 to 85). It is required that the beacon 15 Hex ID be permanently marked on the exterior of the beacon.

- END OF SECTION A1-3 -

4. ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS

4.5 Operational Requirements

4.5.4 Beacon Self-Test Mode

In the self-test mode beacons shall transmit a digital message encoded in accordance with Annex A of Appendix 1 to this specification. The content of the self-test message shall always provide the beacon 15 Hex ID.

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.

4.5.5 Encoded Position Data

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 [92]-bit BCH code protects the data of the first and second protected fields (PDF-1 and BCH-1 and PDF-2 and BCH-2). The BCH codes shall always match the message content. The beacon shall recompute these codes each time the message content is changed.

The beacon shall commence transmissions upon activation even if no valid position data are available. Until valid data is available, the content of the encoded position data field of the message shall be the default values specified in Annex A. The first input of position data into the beacon message shall occur as soon as valid data is available. If the beacon has the capability to provide updated position data, subsequent transmissions of the updated position shall not occur more frequently than every [5] minutes.

If, after providing valid data, the navigation input fails or is not available, the beacon message shall retain the last valid position for 4 hours (± 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.

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.

- END OF SECTION A1-4 -

Annex A to Appendix 1
Narrowband 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:

Message Format (see Figure A1)

Bit Field Name	Bit Field Location
1. Bit synchronization field	bit 1 through bit 15
2. First frame synchronization field	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 176
6. Second BCH error-correcting field (BCH-2)	bit 177 through bit [268]
7. Second frame synchronization field	bit [269] through bit [300]

The bit synchronization and frame synchronization fields are defined in sections 2.2.4.1, 2.2.4.2, and 2.2.4.3, respectively.

The first protected data field (PDF-1) and the second protected data field (PDF-2) of the message are defined in sections [*TBD*] of this Appendix, and shown in Figures [*TBD*]. .

The BCH error correcting fields BCH-1 and BCH-2 fields are defined in section 3.1 and the corresponding 21-bit and 92-bit BCH error-correcting codes are described at Annex B. The 12-bit BCH error-correcting code associated with the legacy long message data package is also described in 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 message as follows:

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

A1.2.1 Format Flag

The format flag (bit 25) shows whether or not the message includes the legacy long message format data package using the following code:

F=0	message does not include the legacy long format data package
F=1	message includes the legacy long format data package

A1.2.2 Protocol Flag

The protocol flag (bit 26) is included for interoperability with the existing Cospas-Sarsat system and is always set to 1, i.e., P=1 for all bursts.

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 (www.itu.int/cgi-bin/htsh/glad/cga_mids.sh). National administrations allocated more than one MID code may opt to use only one of these codes. However, when the 6 trailing digits of a MMSI are used to form the unique beacon identification, the country code shall always correspond to the first 3 digits of the MMSI code.

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

A1.3 Protocol Codes

Each coding protocol is identified by a unique protocol code defined by a 3-bit code in bits 37-39.

Table A1 shows the combinations of the format flag and the protocol flag and the corresponding configurations of the message. The protocol codes assignments are summarized in Table A3.

Table A1: Format Flag and Protocol Flag Combinations

Format Flag (bit 25) → **Protocol Flag (bit 26) ↓**	**0** **(no legacy long message data package)**	**1** **(legacy long message data package)**
1 **(protocol code: bits 37-39)**	• User Protocols (PDF-1) • Data packages aside from legacy long message data package (PDF-2)	• User Protocols (PDF-1) • Legacy long message data package (PDF-2)

Table A2: Data Fields of the Narrowband Message Format

	Bit Synchro-nization	Frame Synchro-nization 1	First Protected Data Field (PDF-1)				BCH-1	Second Protected Data Field (PDF-2)	BCH-2	Frame Synchro-nization 2
Unmodulated Carrier (160 ms)	Bit Synchro-nization Pattern	Frame Synchro-nization Pattern	Format Flag	Protocol Flag	Country Code	Identification Data	21-Bit BCH Code	Supplementary Data	92-Bit BCH Code	Frame Synchro-nization Pattern
Bit No.	1-15	16-24	25	26	27-36	37-85	86-106	107-176	177-268	269-300
	15 bits	9 bits	1 bit	1 bit	10 bits	49 bits	21 bits	70 bits	92 bits	32 bits

Table A3: Protocol Code Assignments (Bits 37 – 39 with F=0/1, P=1)

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.	TAC and serial number Protocol	101

- END OF SECTION A1-A1 -

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 (non-legacy data packages=0, legacy long message data package=1)
26	protocol flag (=1)
27-36	country code
37-39	protocol code
40-83	identification data
84-85	spare

Bits 37-39 in the protocol code field designate one of the user protocol codes as listed in Table A2, 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.

The bit assignments for user protocols in PDF-1 of the 406 MHz beacon digital message are summarized in Figure A2.

Table A4: Bit Assignment for the First Protected Data Field (PDF-1)

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	S	S
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	S	S

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	S S

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	S S

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)

8a. TAC/SERIAL NUMBER ID PROTOCOL

Bits	25	26	27 36	37 39	40 41	42 61	62 85
......	F	1	Country Code	1 0 1	0 0	TAC Number (20 bits)	Serial Number per TAC Number (24 bits)

Notes:

S = Spare

TTT = 000 - ELT with serial number
011 - ELT with 24-bit aircraft address
001 - ELT with aircraft operator designator and serial number
010 - float free EPIRB with serial number
100 - non float free EPIRB with serial number
110 - personal locator beacon (PLB) with serial number
101 – Additional protocols:
00: Type-approval certificate (TAC) No. / Serial No. ID Protocol
01: Spare
10: Spare
11: Spare

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)

Table A5: 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 Protocol

The maritime 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	spare

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

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

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

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

A2.3 Radio Call Sign Protocol

The radio call sign 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 protocol has the following structure:

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

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 Protocol

The aviation user protocol has the following structure:

Bits	Usage
25	format flag (=0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=001)
40-81	aircraft registration marking
82-83	specific ELT number
84-85	spare

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 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;

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

If bit 43 is set to 0:

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

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

A2.5.1 Serial Number

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

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

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	spare

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

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

A2.5.2 Aircraft 24-bit Address

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

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

Bits	Usage
25	format flag (= 0)
26	protocol flag (=1)
27-36	country code
37-39	user protocol code (=011)
40-42	beacon type (=011)
43	flag bit for Cospas-Sarsat type approval certificate number
44-67	aircraft 24-bit address
68-73	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	spare

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 or default to "0" when only one ELT is carried; 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:

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

Bits	Usage
25	format flag (=0)
26	protocol flag (=1)
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	spare

Bits 44-61 are a 3-letter aircraft operator designator from the list[8]* of "Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services" published by the International Civil Aviation Organization (ICAO). The 3 letters are encoded using the modified-Baudot code of Table A3.

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

A2.6 Test User Protocol

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

The test user protocol has the following structure:

Bits	Usage
25	format flag (= 0)
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 contained within PDF-1 or within PDF-1 plus the legacy long message data package, 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 legacy long message package is transmitted.

[8] 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.

The national user protocol has the following structure:

```
Bits  25 26 27         36 37    40                                                   85
  ---+--+--+------------+------+-----------------------------------------------------------+
     ¦  ¦  ¦ Country    ¦      ¦                  National Use                             ¦
     ¦0 ¦1 ¦ Code       ¦1 0 1 ¦                   (46 bits)                               ¦
   ----------------------------------------------------------------------------------------
```

Bits	Usage
25	format flag (= 0, except legacy long message data package = 1)
26	protocol flag (=1)
27-36	country code
37-39	national user protocol code (=100)
40-85	national use
86-106	21-bit BCH code
107-268	national use + 12-bit BCH code (if legacy long message data package transmitted)

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

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

A2.9 C/S Type-Approval Certificate (TAC) / Serial Number User Protocol

The C/S type-approval certificate (TAC) / serial number user protocol permits individual beacons to be identified via a concatenation of the appropriate TAC number and a device serial number corresponding to that TAC number.

The TAC number / serial number user protocol has the following structure:

```
Bits  25 26 27         36 37    40  42                   61 62                     85
  ---+--+--+------------+------+------+-----------------------+--------------------------+-
     ¦  ¦  ¦ Country    ¦      ¦      ¦    C/S Cert. No.      ¦  Serial No.              ¦
     ¦0 ¦1 ¦ Code       ¦1 0 1 ¦ 0 0  ¦     (TAC No.)         ¦                          ¦
   --------------------------------------------------------------------------------------
```

Bits	Usage
25	format flag (=0)
27-36	country code
37-39	user protocol code (=101)
40-41	sub-identifier code (=00)
	codes 01, 10, 11 are spare
42-61	C/S type-approval certificate (TAC) number
62-85	Serial number per TAC number

Table A6: Summary of User Protocols Coding Options

<table>
<tr><td>b 25:</td><td>Message format flag:</td><td colspan="4">0 = short message, 1 = long message</td></tr>
<tr><td>b 26:</td><td>Protocol flag:</td><td colspan="4">1 = User protocols</td></tr>
<tr><td>b 27 - b 36:</td><td>Country code number:</td><td colspan="4">3 digits, as listed in Appendix 43 of the ITU Radio Regulations</td></tr>
<tr><td>b 37 - b 39:</td><td>User protocol code:</td><td colspan="4">000 = Orbitography
001 = Aviation
010 = Maritime
011 = Serial
110 = Radio call sign
111 = Test
100 = National
101 = Spare</td></tr>
<tr><td colspan="2">b 37 - b 39: 010 = Maritime user</td><td>110 = Radio call sign user</td><td>011 = Serial user</td><td>001 = Aviation user</td><td>100 = National use</td><td>101=</td></tr>
<tr><td colspan="2">b 40 - b 75: Trailing 6 digits of MMSI or radio call sign (modified-Baudot)

b 76 - b 81: Specific beacon (modified-Baudot)

b 82 - b 83: 00 = Spare</td><td>b 40 - b 63: First four characters (modified-Baudot)

b 64 - b 75: Last three characters (binary coded decimal)

b 76 - b 81: Specific beacon (modified-Baudot)

b 82 - b 83: 00 = Spare</td><td>b 40 - 42: Beacon type
000 = Aviation
001 = Aircraft Operator
011 = Aircraft Address
010 = Maritime (float free)
100 = Maritime (non float free)
110 = Personal

b 43: C/S Certificate flag
b 44 - b 73: Serial No. and other data

b 74 - b 83: C/S Cert. No. or National use</td><td>b 40 - b 81: Aircraft Registration Marking (modified - Baudot)

b 82 - b 83: Specific ELT number</td><td>b 40 - b 85:
National use</td><td>b 40 - b 41:
Sub-identifier=00
TAC No./Serial No. ID scheme

b 42 - b 61:
TAC number

b 62 - b 85:
Serial number per TAC number

b 40 - b 41:
Sub-identifier=
01: Spare
10: Spare
11: Spare</td></tr>
<tr><td>b 84 - 85:</td><td colspan="4">Spare</td><td></td><td></td></tr>
<tr><td>b 86 - b 106:</td><td>BCH code:</td><td colspan="5">21-bit error-correcting code for bits 25 to 85</td></tr>
<tr><td>b 107 - b 176:</td><td>PDF-2:</td><td colspan="5">Supplementary data via multiple data packages (see Annex C)</td></tr>
<tr><td>b 177 - b 268:</td><td>BCH code:</td><td colspan="5">92-bit error-correcting code for bits 25 to 176</td></tr>
</table>

- END OF SECTION A1-A2 –

- END OF ANNEX A TO APPENDIX 1 -

ANNEX B TO APPENDIX 1

BOSE-CHAUDHURI-HOCQUENGHEM (BCH)
ERROR-CORRECTING CODE AND SAMPLE CALCULATION

[Insert generators and description of 12-bit and 92-bit BCH codes.]

B1 SAMPLE 21-BIT BCH CODE CALCULATION

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

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

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

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

where LCM = Least Common Multiple.

In the above case:

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

from which,

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

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

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

$$g(X) = 1001101101100111100011$$

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

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

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

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

The above process may be clarified by the following example:

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

for which:

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

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

0001011001010101001001

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

BCH Error-Correcting Code: 001011001010101001001

REFERENCE

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

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

```
   |                                  |           |---->|<------------ Bits  25 - 85 ---------------------------->|<---Bits 86-106---->|
45'0'|          (Data bits)                 |    (21 "0"s)     |
m(X)=010101101110011010000000010000000000001000100000001000000000100000000000000000000
g(X)= 1001101101100111100011
   0011011010101010100011 00
    1001101101100111100011
    0100000111001101101111
     1001101101100111100011
     0001100011111100111100000
        1001101101100111100011
        0101110010000000000110
         1001101101100111100011
         0010001001100111100010100
           1001101101100111100011
           0001001011111001110111000
              1001101101100111100011
              00001100101010010110110001
                  1001101101100111100011
                  0101000111110001010 0100
                   1001101101100111100011
                   0011100010000101000111 00
                     1001101101100111100011
                     0111100101110011111111 1
                      1001101101100111100011
                      0110100110000000001110 00
                       1001101101100111100011
                       0100100000110011101101 10
                        1001101101100111100011
                        0000101110101001010101 0000
                            1001101101100111100011
                            0010000111110010110011 01
                              1001101101100111100011
                              0001110010101100101110 000
                                 1001101101100111100011
                                 0111111000000001001001 10
                                  1001101101100111100011
                                  0110011101100011000101 0
                                   1001101101100111100011
                                   0101010110100001101001 0
                                    1001101101100111100011
                                    0011000000010010011000 100
                                      1001101101100111100011
                                      0101101111110100100111 0
                                       1001101101100111100011
                                       0010110010001110101101 10
                                         1001101101100111100011
                                         0010100101011101010101 00
                                           1001101101100111100011
                                           0011111000010010110111 00
                                             1001101101100111100011
                                             0110001100101100111111 0
                                              1001101101100111100011
                                              0101110100111110011101 0
                                               1001101101100111100011
                                               0010000100011011011001 00
                                                 1001101101100111100011
                                                 0001111100001010000111 000
                                                    1001101101100111100011
                                                    0110001100110111011011 0
                                                     1001101101100111100011
                                                     0101110100001001010101 0
                                                      1001101101100111100011
                                                      0010000101110101001001 00
                                                        1001101101100111100011
                                                        0001111010110011000111 000
                                                           1001101101100111100011
                                                           0110111011111111011011 0
                                                            1001101101100111100011
                                                            0100011010011001010101 0
                                                             1001101101100111100011
                                           22-bit remainder  =  0001011001010101001001
                                                                      |<------ BCH ------>|
                                                                      |  (last 21 bits)   |
```

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

- END OF ANNEX B TO APPENDIX 1 –

ANNEX C TO APPENDIX 1

BIT FIELD DESCRIPTIONS AND BIT ALLOCATIONS FOR PDF-2 DATA PACKAGES

All data packages contain the same number of bits, equal to the size of the PDF-2 field (70 bits). Additional data packages may be developed to include additional data.

Note that the content identifier code is not a fixed-width field. This is intentional and stems from the observation that the encoded location data package ("00") has the largest information-payload requirement. Though the content identifier codes are of different lengths, a shorter-length ID code is never a prefix to a longer-length ID code, and this means that LUTs can clearly distinguish the data packages being received.

Table C1: Bit allocation for the encoded-location data package (70 bits).

Bits	***Description***	***G.008 Requirement***
1	*Self-test flag*	*3.10*
2	*Content identifier code "00"*	
22	*Latitude (N/S 7.14 format)* • *Gives a step size of approximately 6.8m* • *Rounding shall be used to reduce quantization error*	*4.1, 4.2, 4.3.1(a)*
23	*Longitude (W/E 8.14 format)* • *Gives a step size of approximately 6.8m at the equator (smaller step sizes at larger latitudes)* • *Rounding shall be used to reduce quantization error*	*4.1, 4.2, 4.3.1(a)*
10	*Altitude (metres/16)* • *0-960: Positive altitudes from 0m to 15360m (16m step size)* o *0 ⇒ 0m, 1 ⇒ 16m, 2 ⇒ 32m, etc.* • *1023,1022,1021, … , 999: Negative altitudes from -16m to -400m* o *1023 ⇒ -16m, 1022 ⇒ -32m, etc.* • *992: only 2D lock has been achieved (i.e., default value - no altitude information available)* • *961-998 excluding 992: Reserved for future use* *Comments:* • *16m step size (division by 16 is easy in a microcontroller)* • *Close match to latitude/longitude step size* • *Rounding shall be used to reduce quantization error*	*4.1, 4.2, 4.3.1(c)*
11	*Time delta from GNSS fix (minutes)* • *0-2040: 0-2040 minutes in one-minute steps* • *2041-2046: Reserved for future use* • *2047: Time delta not available*	*4.3.1(b)*

	Comments: • *Field saturates at 2040 (34 hours)* • *Transmitted value is the time delta truncated to an integer number of minutes (i.e., no rounding)*	
1	*Spare / future use*	*4.3.1(j)*

Table C2: Bit allocation for the mixed-content data package (70 bits).

Bit Index	***Bits***	***Description***	***Operational Requirement***
bit 107	1	Self-test flag	G.008-3.10 (minimum)
bits 108-111	4	Content identifier code "0100"	
bits 112-114	3	Activation information • 0=Manual activation • 1=Manual activation - ELT in-flight (i.e., high velocity) • 2=Reserved for future use • 3=Manual de-activation (i.e., "turn-off", *not* "user cancel")[1] • 4=Automatic activation 1 (ELT G-switch or EPIRB water activation) • 5=Automatic activation 2 (ELT in-flight auto-triggered) • 6=Reserved for future use (e.g., ELT in-flight automatic de-activation) • 7=Reserved for future use	G.008-4.3.1(g) (objective)
bits 115-120	6	Elapsed time since activation in hours • 1-hour increments saturating at 63 hours • The value does not increment until the next full hour has been reached; for example, for the first hour of operation this field will contain '0'.	G.008-3.7.1(b) (minimum)
bits 121-123	3	Remaining battery capacity • 0=0-5% capacity • 1=5-10% capacity • 2=10-25% capacity • 3=25-50% capacity • 4=50-75% capacity • 5=75-100% capacity • 6=Reserved for future use • 7=Feature not available	G.008-4.3.1(i) (objective)
bits 124-131	8	Homing capabilities that are active (set of 8 toggle switches) • 406 MHz beacon burst with pure carrier (i.e., 160ms of CW followed by data, 5W EIRP, ~50s rep. period) • [TBD] • [TBD] • [TBD] • 121.5 MHz • AIS • [TBD] • [TBD]	G.008-3.7.1(d) (minimum)
bits 132-133	2	GNSS (encoded location) equipment[2] • 00=No GNSS	

Bit Index	***Bits***	***Description***	***Operational Requirement***
		• 01=Internal GNSS • 10=External navigation system (i.e., "hot-fed" capability) • 11=Reserved for future use	
bits 134-137	4	RLS system indicator[3] • 0=No RLS • 1=Galileo • 2=Japan QZSS • 3-15=Reserved for future use	G.008-4.5.3, par.2 (objective)
bits 138-141	4	RLS data field[3] Usage defined by the RLS service provider indicated in the previous field.	G.008-4.5.3, par.2 (objective)
bits 142-161	20	Type Approval Certificate (TAC) number	G.008-4.3.1(e) (objective)
bits 162-165	4	Horizontal accuracy (or other specialty uses)[4] • 95% confidence, threshold levels TBD • This accuracy value is associated with the last latitude/longitude/altitude information transmitted, i.e., the last data package "00" message transmitted.	G.008-4.3.1(d) (objective)
bits 166-169	4	Vertical accuracy (or other specialty uses)[4] • 95% confidence, threshold levels TBD • This accuracy value is associated with the last latitude/longitude/altitude information transmitted, i.e., the last data package "00" message transmitted.	G.008-4.3.1(d) (objective)
bits 170-172	3	Interpretation code for accuracy fields • 0=Accuracy estimates not available • 1=Horizontal accuracy estimate as 2·HDOP·10m, vertical accuracy estimate as 2·VDOP·10m (factor of 2 is for 95%)[5] • 2=Horizontal accuracy estimate as 2·stddev of lat/long (use max), vertical accuracy estimate as 2·stddev of altitude (factor of 2 is for 95%)[6] • 3=[unassigned] • 4=[unassigned] • 5=[unassigned] • 6=[unassigned] • 7=Accuracy fields used instead to indicate "Type of Emergency" (coding TBD)[7]	G.008-4.3.1(d) (objective)
bits 173-176	4	Spare / future use	G.008-4.3.1(j) (objective)

[1]"User Cancel" is a separate function handled by a separate data package.
[2]This differs from "GNSS Lock Status".

Table C3: Bit allocation for the user-cancel data package (70 bits).

Bit Index	***Bits***	***Description***	***Operational Requirement***
bit 107	1	Self-test flag (always 0)	G.008-3.10 (minimum)
bits 108-171	64	Content identifier code: • Binary - 1111 0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 • Hexadecimal - F0123456789ABCDE	G.008-3.11 (minimum)
bits 172-175	4	Cancel-burst counter	
bit 176	1	Spare / future use	G.008-4.3.1(j) (objective)

Table C4: Bit allocation for the spare data package (70 bits).

Bits	***Description***	***Operational Requirement***
1	*Self-test flag*	*3.10*
4	*Content identifier code "0110"*	
65	*Spare/future use*	*4.3.1(j)*

Table C.5: Bit allocation for legacy long message data package (70 bits).

Bits	***Description***	***Operational Requirement***
26	*T.001 PDF-2 (User-location protocol)*	
12	*T.001 BCH-2 (User-location protocol)*	
32	*Spare / future use*	*4.3.1(j)*

- END OF ANNEX C TO APPENDIX 1 –

- END OF APPENDIX 1 -

APPENDIX 2 [to be revised]

LIST OF ACRONYMS [note: to be further developed]

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

- END OF APPENDIX 2

APPENDIX 3

SAMPLE BOSE-CHAUDHURI-HOCQUENGHEM ERROR-CORRECTING CODE CALCULATION

Sample 48-Bit BCH Code Calculation

The error-correcting code used in 406 MHz messages is a shortened form of a (255,207) Bose-Chaudhuri-Hocquenghem (BCH) code. The shortened form (250,202) consists of 202 bits of data followed by a 48-bit sextuple error-correcting code. The code is used to detect and correct up to six errors in the entire 250-bit pattern (bits 1 through 250 of the 406 MHz message).

Note: For the purpose of error correction, all calculations shall be performed with the full 255 length code. Therefore, 5 zeros are placed before the 202 data bits to form the 207 bit pattern of the (255,207) BCH code. These padding zeros do not affect the generation of the BCH code as described below.

For the (250,202) BCH code, a generator polynomial g(X) (the same as for (255,207) BCH code) is defined as follows:

$$g(X) = LCM(m_1(X), m_3(X), m_5(X), m_7(X), m_9(X), m_{11}(X))$$

where LCM = Least Common Multiple.

In the above case:

$$m_1(X) = X^8 + X^4 + X^3 + X^2 + 1$$

$$m_3(X) = X^8 + X^6 + X^5 + X^4 + X^2 + X + 1$$

$$m_5(X) = X^8 + X^7 + X^6 + X^5 + X^4 + X + 1$$

$$m_7(X) = X^8 + X^6 + X^5 + X^3 + 1$$

$$m_9(X) = X^8 + X^7 + X^5 + X^4 + X^3 + X^2 + 1$$

$$m_{11}(X) = X^8 + X^7 + X^6 + X^5 + X^2 + X + 1$$

from which

$$
\begin{aligned}
g(X) \quad &= m_1(X), m_3(X), m_5(X), m_7(X), m_9(X), m_{11}(X) \\
&= X^{48} + X^{47} + X^{46} + X^{42} + X^{41} + X^{40} + X^{39} + X^{38} + X^{37} + X^{35} + X^{33} + X^{32} + X^{31} \\
&+ X^{26} + X^{24} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{17} + X^{16} + X^{13} + X^{12} + X^{11} + X^{10} + X^{7} + X^{4} + X^{2} \\
&+ X + 1
\end{aligned}
$$

a determination of g(X) results in the following 49-bit binary number

$$g(X) = 1110001111110101110000101110111110011110010010111$$

To generate the BCH code, an information polynomial, m(x) is formed from the 202 data bits as follows:

$$m(X) = b_1X^{201} + b_2X^{200} + \cdots + b_{201}X + b_{202}$$

where b_1 - is the first bit (i.e. fixed binary ‘1’ or the first bit of 23-HEX ID), and b_{202} - is the last bit of the message.

m (X) is then extended to 250 bits by filling the least significant bits with 48 "0". The resulting 250-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. Suppose, that digital message consists of the following data (decimal notation):

Country code	201
TAC number	230
Serial Number	573
Type of Vessel	6
Vessel ID	0
Status of homing device	1
Self-Test function	1
User cancellation	0

Message also contains encoded GNSS location. This example uses the following values of position data:

Current latitude	48,793153539336956 °N
Current longitude	69,00875866413116 °E
Altitude	430,24 м

Encoded GNSS location in binary notation:

Current latitude	00110000011001110100011
Current longitude	001000101000000000010010010

In this example Rotating Field 1 (C/S G.008 Objective Requirements) is used. Suppose, that 1 hour 27 minutes and 24 seconds (1 hour after truncation) had passed since radiobeacon activation, and 6 minutes and 24 seconds had passed since last encoded location (6 minutes after truncation), then the content of rotating field will be the following (binary notation):

Rotating field identifier	0000
Elapsed time since activation	000001
Time from last encoded location	00000000110
Altitude of encoded location	0000110011
Dilution of precision	00000001
Automated/Manual activation notification	00
Remaining battery capacity	101
GNSS status	10

Thus, digital message in hexadecimal and binary notation will be the following:

23 HEX ID	99340039A3DC0000000001 (bits 1-92)
Message*	99340039A3DC0000000001C60CE8C8A024BFFC0100C198096C (bits 1-202)
Bits 1-202	1001 1001 0011 0100 0000 0000 0011 1001 1010 0011 1101 1100 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0001 1100 0110 0000 1100 1110 1000 1100 1000 1010 0000 0010 0100 1011 1111 1111 1100 0000 0001 0000 0000 1100 0001 1001 1000 0000 1001 0110 11

* As the length of the message in bits is not divisible by 4, message was supplemented with two binary ‘0’, which gave in hexadecimal notation symbol ‘C’ at the end of the message.

The division [9] described above is shown in Figure A1, and results in a 49-bit remainder of:

00011100000101111100000000111010001001100000010110

The most significant bit position of the remainder will always be a "0" and is deleted to obtain the 48-bit BCH code.

Thus BCH Error-Correcting Code:

0011100000101111100000000111010001001100000010110

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

REFERENCE

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

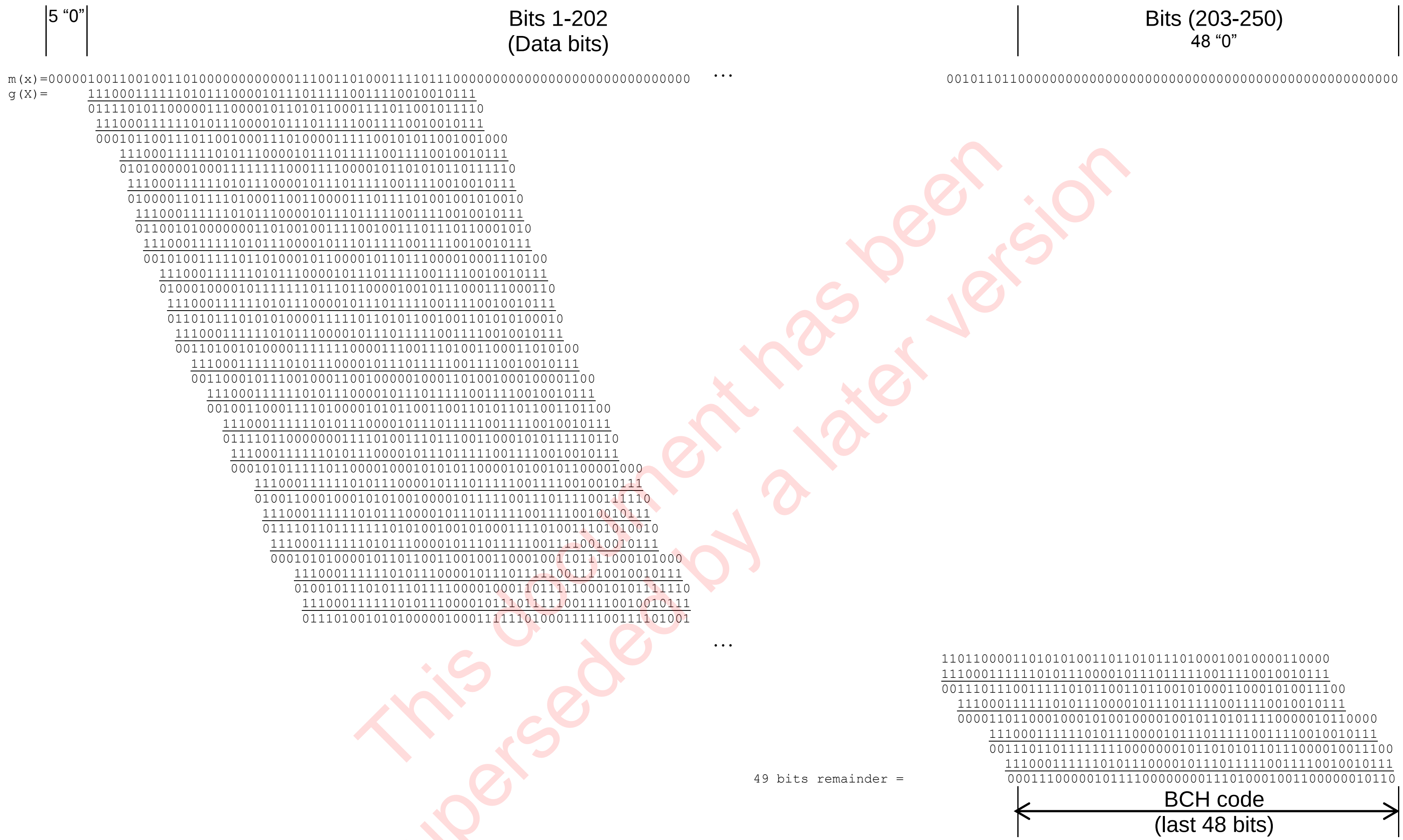


Figure X: Sample 48-Bit BCH Error-Correcting Code Calculation
(for easier viewing the calculation is reduced and divided into 2 parts)

- END OF APPENDIX 3 -

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