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

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COSPAS SARSAT

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

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to define the minimum requirements to be used for the development and manufacture of 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 A provides a list of acronyms used in this document.

e) Appendix B provides a sample Bose-Chaudhuri-Hocquenghem error-correcting code calculation.

f) Appendix C provides an example of beacon encoded location coding.

g) Appendix D provides an example of the first 64 bits of a Linear Feedback Shift Register (LFSR) Implementation.

h) Appendix E provides a map of the BIT assignment numbers.

i) Appendix F provides an M_{offset} calculation and CRC code sample.

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 up to three Classes of operating temperature range for 406 MHz beacons as follows:

Class 0:	-55°C to +70°C
Class 1:	-40°C to +55°C
Class 2:	-20°C to +55°C

Any type of beacon can be supplied with a Class 0, 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)), Automatic Deployable (ELT (AD)), and Distress Tracking ELT (ELT (DT)).

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 categories of ELT(S) Category A which is buoyant and designed to operate when floating in water and Category 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 should float in water and is intended to aid SAR teams in locating the crash site.

Distress Tracking (ELT (DT))

This is a specific type of ELT designed to be activated prior to a crash and to function in compliance with the ICAO GADSS[*] requirements for the Location of an Aeroplane in Distress, aimed at establishing, to a reasonable extent, the location of an accident site within a 6 NM radius. It may be activated automatically upon detection of a distress condition while in flight or it may also be activated manually.

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.

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 (DT) devices intended for in-flight automatic activation the inclusion of a GNSS capability is mandatory.

All types of beacons (except currently ELT(DT)s) may also be provided with the Return Link Service capability.

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

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

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.

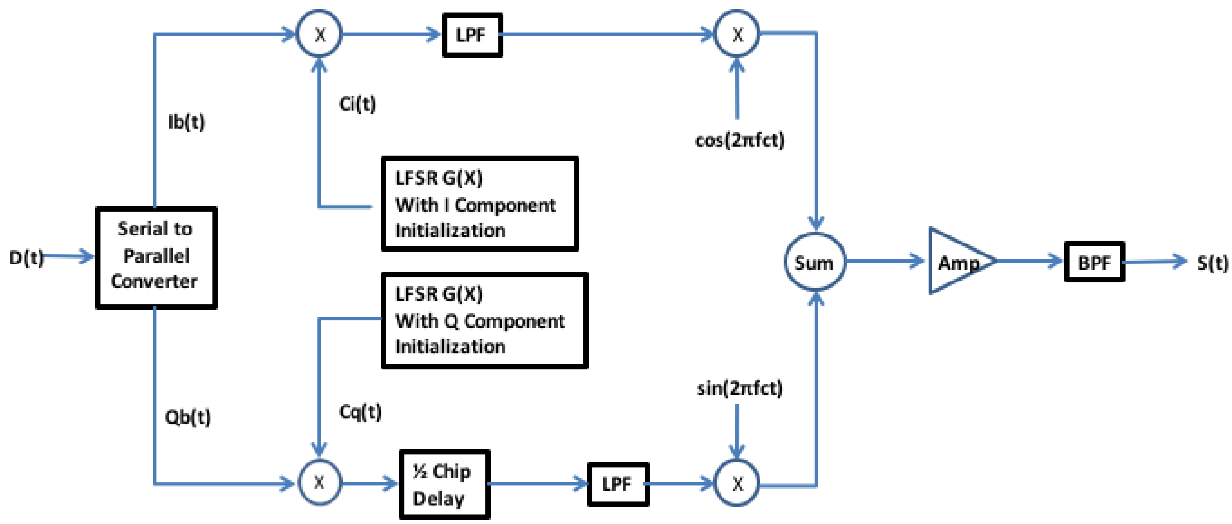
2.1.1 Transmitter Notional Functional Block Diagram

This section contains a notional functional diagram which describes the features which are described in greater detail by later sections of this document.

Figure 2-1 illustrates a notional Direct Sequence Spread Spectrum - Offset QPSK (DSSS-OQPSK) high level transmitter functional block diagram which may be used to better understand one possible implementation of the beacon signal design. In this figure:

- D(t) is the linear bit stream for each beacon burst running at 300 bits/second.
- D(t) is split into parallel bit streams Ib(t) and Qb(t) made up of odd and even bits from D(t) running at 150 bps each
- A Linear Feedback Shift Register (LFSR) function produces the two different chipping segments Ci(t) and Cq(t) using the common generator polynomial G(X). Each chipping segment runs at 38,400 chips/second. Each of Ci(t) and Cq(t) is produced by the LFSR function using the specified unique I or Q channel LFSR initialization, and is reproduced identically for each beacon burst for a given beacon mode of operation.
- Ib(t) and Qb(t) are separately mixed with their respective different chipping segments. The resultant on each channel can change state every chip period.
- The resultant of the mixing on the Q component is then delayed by ½ chip period.
- Both I and Q channels may then be low pass filtered (if necessary) and modulated onto cosine and sine sinusoids.
- The two modulated sinusoids are then summed.
- The summation resultant is amplified, band pass filtered (if necessary), and then transmitted as the outgoing beacon burst signal S(t).

Because the I and Q resultants are offset by ½ chip period from each other, when summed, the resulting signal S(t) is bounded to a maximum phase shift of 90 degrees to help minimize amplitude envelope variation.



D(t) = digital message bit stream (300 bps)
Ib(t) = I component (odd) bit stream (150 bps)
Qb(t) = Q component (even) bit stream(150 bps)
LFSR = Linear Feedback Shift Register Function
G(x) = generator polynomial
Ci(t) = I component chipping stream generated by LFSR using I channel initialization (38,400 cps)
Cq(t) = Q component chipping stream generated by LFSR using Q channel initialization (38,400 cps)
fc = carrier frequency
LPF = low pass filter (if needed)
BPF = band pass filter (if needed)
S(t) = transmitted signal

Figure 2-1: Notional DSSS-OQPKS Transmitter Functional Block Diagram

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 Burst Transmission Interval

From beacon activation a total of 6 initial transmissions shall be made separated by fixed[*] 5s +0 /-0.2s intervals. The first transmission shall commence within 5 seconds of beacon activation[†], except for EPIRBs, where it shall commence within 8 seconds of beacon activation.

The beacon shall then transmit 59 bursts at nominally 30 second intervals. The time between the start of two successive transmissions shall be randomized with uniform distribution around the stated nominal value, so that intervals between the start of two successive transmissions are randomly distributed over ± 5 seconds.

[*] In this context, "fixed" refers to a repetition period which may vary within the tolerances allocated, and that no deliberate randomization within this range is required.
[†] Beacon activation is defined as the point in time at which the initiation of the activation event of the beacon occurs. E.g., the activation events include pressing of the "ON" button, water sensor immersion, the start of a shock, or deformation.

Transmissions shall then occur at nominally 120 second intervals. The time between the start of two successive transmissions shall be randomized with uniform distribution around the stated nominal value, so that intervals between the start of two successive transmissions are randomly distributed over ± 5 seconds.

For ELT DT transmission the first transmission shall commence within 5 seconds of beacon activation. From beacon activation a total of 24 initial transmissions shall be made separated by fixed[*] 5 seconds + 0.0 / - 0.2 intervals. These transmissions shall be followed by 18 transmissions separated by fixed 10 seconds + 0.0 / - 0.2. After the first 300 seconds ELT (DT) transmissions shall continue at nominal intervals of 28.5 seconds until the end of the ELT (DT) operating lifetime. The time between the start of two successive transmissions shall be randomized with uniform distribution around the stated nominal value, so that intervals between the start of two successive transmissions are randomly distributed over ± 1.5 seconds.

The transmission schedule is summarised in the table below.

Table 2.1: Transmission Schedule

IAMSAR Stage	Nominal Time from Activation	Transmission Nominal Repetition Interval	Randomization
Initial	0 to 30[†] Seconds	5 Seconds	0
Action / Planning	30[†] Seconds to 30 minutes	30 Seconds	± 5 Seconds
	30 minutes +	120 Seconds	± 5 Seconds
ELT (DT)	0 to 120 Seconds	5 Seconds	0
	120 to 300 Seconds	10 Seconds	0
	300 Seconds +	28.5 Seconds	± 1.5 Seconds

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 shall be spread using two truncated segments of a common PRN (Pseudo-Random Noise) maximum length sequence (m-sequence) producing symbols known as "chips". These sequence segments shall be deterministic and must be known by the receiver.

The two truncated spreading PRN segments shall:

[*] In this context, "fixed" refers to a repetition period which may vary within the tolerances allocated, and that no deliberate randomization within this range is required.

[†] For EPIRBs this value is 33 seconds.

a) be applied separately to the full duration of each beacon burst transmission with one segment applied to the in-phase (I) component and the other applied to the quadrature (Q) component of the signal;

b) be transmitted as separate odd and even bits, starting with 1 as the first bit. Odd bits are transmitted through the I channel and even bits the Q channel. For each bit, 256 chips are taken from the PRN sequence such that a 0 bit is represented by the non-inverted sequence and a 1 by the inverted sequence, equivalent to an exclusive-OR operation (XOR). The I and Q signal components are spread separately, each by a factor of 256 (with half-chip offset as shown in section 2.3.3). Then when the I and Q channels are combined the overall spreading factor is 128 chips/bit.

c) be generated by a method equivalent to a Linear Feedback Shift Register (LFSR) using the same generator polynomial G(x) = X23 + X18 +1 (see Figure 2-2);

d) be generated in matched pairs for the I and Q components defined in Table 2.2 for each beacon mode;

e) be truncated to the first 38,400 chips of the m-sequence generated using the prescribed initialization values for each of the I and Q components with a 1/2 chip period delay imposed on the Q component relative to the I component (refer to section 2.3.3);

f) be applied to both I and Q components for the full one second duration of each beacon burst transmission including preamble, information bits, and error correction bits, to give a chipping rate of 38,400 chips/second for each component (see 2.3.1.2 for further details); and

g) be identical for each beacon burst transmission for any given burst mode.

Note that this spreading scheme method in fact allows for multiple possible non-overlapping matched I and Q component chipping segment pairs, with each segment in each pair truncated to 38,400 chips. The number of possible segments, 218, is determined by dividing the full m-sequence length for the generator polynomial, by the truncated segment length, $((2^{23})-1)/38{,}400 = 218$ segments. Non-overlapping pairs of segments can be selected from this set of 218 segments.

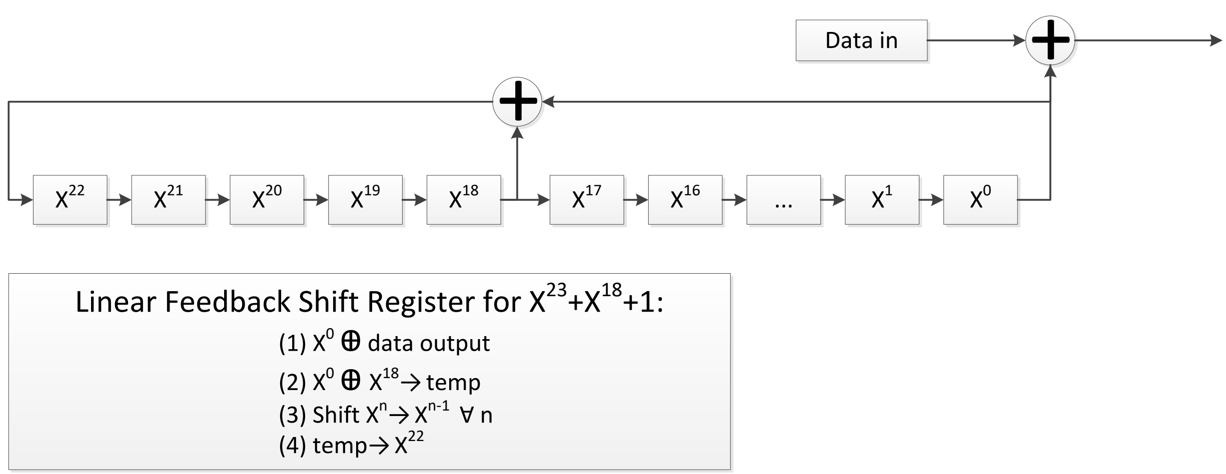


Figure 2-2: Linear Feedback Shift Register

The beacon shall be able to generate multiple PRN sequences segments, such as normal mode and self-test mode, according to Table 2.2. In order to generate these PRN sequences segments, the beacon may use a LFSR with multiple initialization values for PRN sequence segment generation. Table 2.2 provides the generator polynomial initialization LFSR values for I and Q components for beacon normal mode operation and for beacon self-test mode operation. In this table, registers are labelled from 0 to 22. The registers shift from left to right the output from register 0. For clarity, the feedback taps to be XOR'd are indicated in the table and match with the characteristic polynomial. The output chip is taken from register 0. The table also provides the first 64 chips in the order of generation from the LFSR. The 64 chip binary sequence has been displayed in hexadecimal format as demonstrated in the example below the table with the leftmost chip in sequence being the first output. The LFSR implementation (with associated initialization) leads to the correct generation of the whole 38 400 chips sequence, which can be verified to a high degree of confidence by confirming a perfect match of the first 64 chips given in Table 2.2.

Table 2.2: PRN Sequence Initialization Values

Register	*22*	*21*	*20*	*19*	*18*	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*					
XOR					1																		1		**Output *chip* sequence**			
	Register Initial Setting																								*1st*			*64th*
Normal I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	→	8000	0108	4212	84A1
Normal Q	0	0	1	1	0	1	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	0	0	→	3F83	58BA	D030	F231
Self Test I	1	0	1	0	0	1	0	1	1	0	0	1	0	0	1	1	1	1	1	0	0	0	0	→	0F93	4A4D	4CF3	028D
Self Test Q	0	1	1	1	1	0	0	1	1	1	0	1	0	0	1	0	0	1	0	1	0	0	0	→	1497	3DC7	16CD	E124

An example of the generation of the 64 first chips of the normal I-component is given in Appendix D.

The correspondence between the logic level of the chips used to modulate the signal and the signal level is given in Table 2.3:

Table 2.3: Logic to Signal Level Assignment

Logic Level	Signal Level
1	-1.0
0	+1.0

2.2.4 Preamble

The initial 166.7 ms of the transmitted signal shall consist of the combination of the first 6400 chips of the two PRN code segments (each segment 38,400 chips long for the entire burst) used to spread the I and Q message components as illustrated in Figure 2-3. There will be no useful information encoded on either the I or Q components during the preamble. I and Q component information bits shall all be set to '0' during the preamble.

2.2.5 Digital Message

The remaining 833.3 ms of the transmitted signal shall contain a 250-bit message and will be at a nominal bit rate of 300 bps.

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.

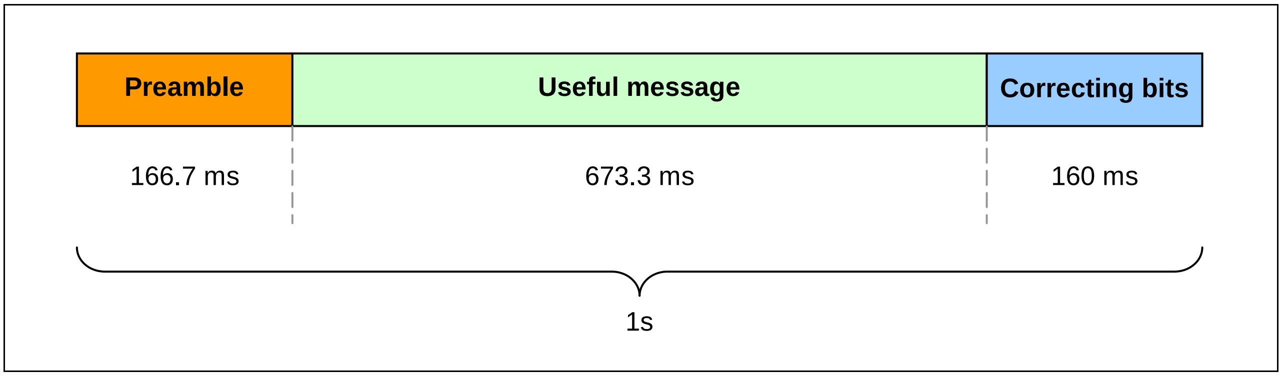


Figure 2-3: Burst general structure

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 bit rate for each channel will nominally be 150 bits/sec.

Each component starts with a 6400 chip preamble described in section 2.2.4 and is spread with the PRN code segment described in section 2.2.3 as shown in Figure 2-4.

The preamble and any bits allocated as ‘0’ are represented by the PRN sequence, and bits allocated as ‘1’ are sent as the PRN sequence inverted for the duration of the bit as shown in Table 2.4. This is the method of modulating data onto the PRN sequence.

Table 2.4: Bit to PRN Sequence Assignment

Bit	PRN Sequence
1	Inverted
0	Normal

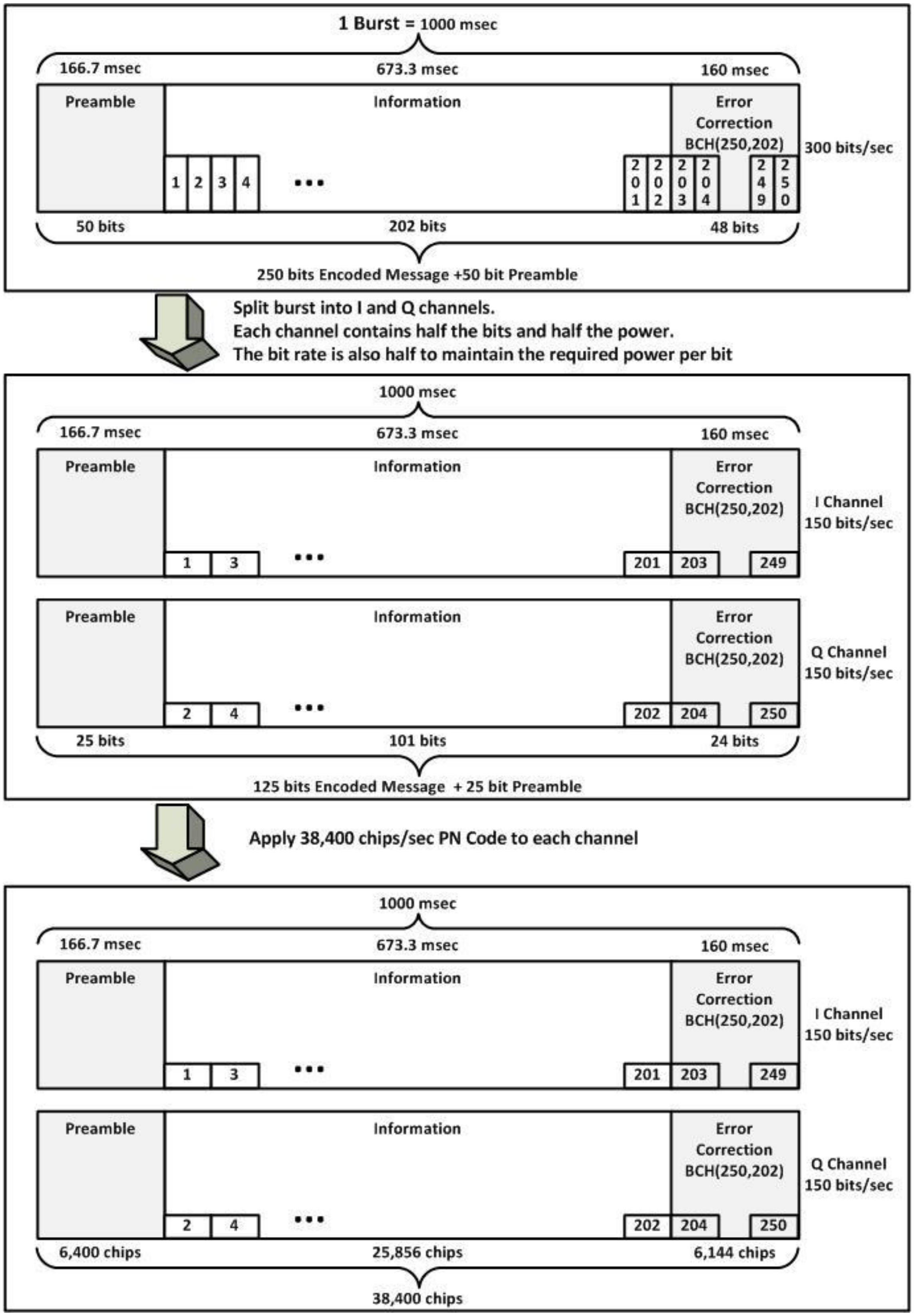


Figure 2-4: I and Q Component Message Structure*

* The 50 bits included in the preamble contain no data and are set to "0"

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. The specifications for the carrier frequency and the chip rate may be decoupled by using separate oscillators.

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

a) Long Term Stability Requirement

The carrier frequency tolerance shall be 406.05 MHz ±1200 Hz over 5 years or the manufacturers' declared beacon maintenance period*, whichever is greater; and

b) Short Term Stability Requirement

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

The maximum allowable carrier frequency variation shall be 7.4 ppb when measured over 166.7 msec within the burst.

2.3.1.2 Chip Rate Accuracy and Variation

The average chip rate shall be 38 400 ± 0.6 chips/s.

The variation of the chip rate shall be ± 0.6 chips/s^2.

These values shall be met both when measuring over the preamble and on the entire burst.

* The beacon maintenance should include validation of the frequency stability of the beacon.

2.3.2 Spurious Emissions

The in-band spurious emissions shall not exceed the levels specified by the signal mask in Figure 2-5, when measured in a 100 Hz resolution bandwidth.

Acceptable types of output filters that may be used, if necessary, to meet the spurious emissions mask include [filtered rectangular, half-sine (i.e., IEEE 802.15.4-2015, Section 12.2.6), root-raised cosine, and triangular]. If other output filters are being considered for use, the Cospas-Sarsat Secretariat must be notified so that they can consult with the Parties regarding their acceptability.

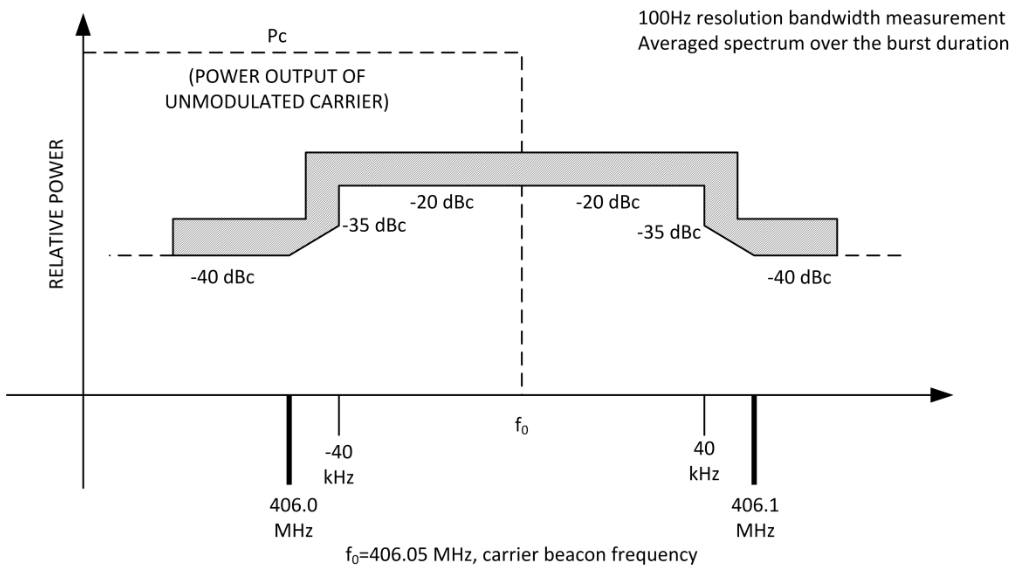


Figure 2-5: Spurious emission mask

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

2.3.3 Modulation

The RF modulation is Offset Quadrature Phase Shift Keying (OQPSK). The PRN sequences for the in-phase (I) and quadrature (Q) components of the signal are defined in section 2.2.3. The chips of the I and Q components shall have an average offset of half a chip period ± 1% of the chip period over the entire burst with I leading Q by one-half a chip period. 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 peak to peak amplitude of the I and Q components shall be on average within 15% of each other over the entire burst. The Error Vector Magnitude (EVM) of the constellation points away from ideal shall be less than 15 % when measured over any 150 millisecond portion of the entire burst.

The figure below illustrates the OQPSK modulation mid-burst including the one-half chip delay on the Q channel. In this figure, T represents the chip period.

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

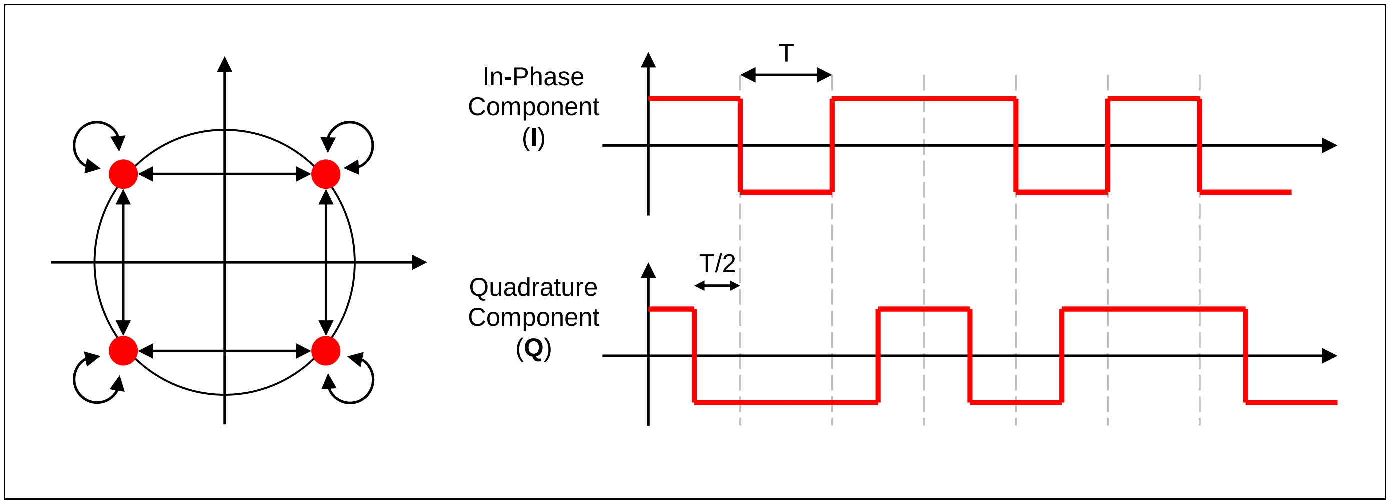


Figure 2-6: OQPSK modulation illustration

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 -10 dBm prior to 25 ms 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. Preamble content shall be transmitted during the power rise time. Power output fall time shall be less than 0.5 ms between the 90% and the 10% power points.

Between 25 ms after the end of any 406 MHz burst until 25 ms before the commencement of the next 406 MHz burst the power level in the 406.0 to 406.1 MHz frequency band shall not exceed -10 dBm.

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 65% of measured EIRP values shall meet the limits shown. In addition, 90% of the measured EIRP values shall meet the limits shown at elevation angles below 55 degrees, except for ELT(DT)s, or ELTs used in combination with automatic deployable flight recorders.

Table 2.5: Required EIRP

Elevation (°)	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
Max dBm	45	45	45	45	45	45	45	45	45	44	44	44	44	44	44	44
Min dBm	34	34	34	34	34	34	34	34	34	34	34	33	33	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 2.4.2 (effective isotropic radiated power). An ideal antenna pattern is shown below for illustration purposes.

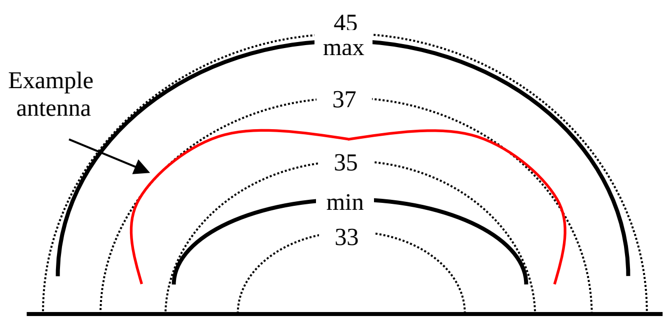


Figure 2-7: Ideal Antenna Pattern

Remote antennas or detachable antennas shall always be approved with a beacon.

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

<u>External Antenna</u>
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.

Detachable antennas when measured directly at the antenna feed point shall achieve a VSWR not greater than 1.5:1 referred to 50Ω.

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 (in this case the type and length of the antenna cable is fixed and is as supplied by the beacon manufacturer) or one or both parts (antenna or cable) may be varied by the user or the installer (in this case the type and length of the antenna cable may vary).

In either case, remote antennas, when measured directly at the antenna feed point, shall achieve a VSWR not greater than 1.5:1 referred to 50Ω.

Remote Antenna without an Integrated Cable

In this configuration (e.g. an ELT installed in an aircraft) there may be more than one type of approved antenna and the length and type of cable between the antenna and beacon may vary.

The characteristic impedance and minimum and maximum loss of the antenna feed cable shall be specified by the beacon manufacturer. The combined beacon, antenna and cable shall meet the EIRP requirements in section 2.4.2 (effective isotropic radiated power) when operating with the minimum and maximum stated cable loss between the antenna and the beacon.

Remote Antenna with an Integrated Cable

In this configuration (e.g. a military PLB with a body worn antenna) the antenna and cable combination is fixed and supplied by the beacon manufacturer (although there maybe more than one approved combination for different applications) and the length and type of cable between the antenna and beacon cannot be changed.

This combination utilising a specific manufacturer supplied integrated antenna cable shall be tested with that cable.

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*. However ELT (DT)s are not required to provide a 406-MHz homing signal.

- END OF SECTION 2 -

* A CW unmodulated 406-MHz homing and on-scene locating signal is under development with details to be provided in a future update to T.018 and will be centered at 406.050 MHz, ± 2 kHz, at a power level, repetition rate, and pulse width to be determined.

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><th colspan="10">202 information bits</th><th colspan="5">48 error correction bits</th></tr>
<tr><td colspan="6">154 bit main field</td><td colspan="5" rowspan="2">48 bit rotating field</td><td colspan="5" rowspan="2">48 bit BCH field</td></tr>
<tr><td colspan="3">Main Message</td><td colspan="3">Spare</td></tr>
<tr><td>1</td><td>…</td><td>140</td><td>141</td><td>…</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	Bit numbers in message	Content
3.7.1a	TAC Number	16	1-16 (MSB=1)	16-bit TAC # (0 to 65,535)[*†]
3.7.1a	Serial Number	14	17-30	14-bit serial number (0 to 16,383)[†††]
3.7.1a	Country code	10	31-40 (MSB= 31)	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 the ITU website: (www.itu.int/cgi-bin/htsh/glad/cga_mids.sh).
3.7.1d	Status of homing device	1	41	On beacon activation a '1' indicates that the beacon is equipped with at least one homing signal and a '0' indicates that the beacon is not equipped with any homing signals or that they have been deliberately disabled. Once the homing signal in the beacon has been activated, a '1' indicates that at least one homing device is functional and transmitting. A '0' indicates that no homing device is functional, or it has been deliberately disabled.
	RLS function	1	42	A '0' indicates a beacon without RLS capability or with this capability disabled. A '1' beacon with RLS capability enabled.
N/A	Test Protocol	1	43	A '0' indicates normal beacon operation. A '1' indicates a Test Protocol message for non-operational use. Selection of test protocol is not an end-user capability.

[*] The TAC and serial number combination shall be unique (see section 3.6).

[†] TAC value range 65,521 - 65,535 is reserved for System beacons (e.g., reference and QMS beacons, calibration beacon, simulators, etc.) – See document C/S T.022.

C/S G.008 reqmt Para.	Description	Number of bits	Bit numbers in message	Content
3.7.1g	Encoded GNSS location	 1 7 15 1 8 15	(MSB= 45, 52, 68, 76) 44 45-51 52-66 67 68-75 76-90	Location* is provided to 3.4 m 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). If the beacon does not have encoded location capability, then these bits shall be set to the following default value: Bits = 1 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). If the beacon does not have encoded location capability, then these bits shall be set to the following default value: Bits = 1 11111111 111110000011111.
3.7.1h	Vessel ID	3	91-93	A three-digit binary field identifier is first transmitted to identify the following message content: 000 - No aircraft or maritime identity (may be defined for national use; default content for bits 94-137 is all 0's); 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 – Spare; 111 – Reserved for System Testing (may contain additional information; default content for bits 94-137 is all 0's)†. This is followed by the vessel or aircraft identity. The

* 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.

† This value is invalid when the test protocol flag, bit-43, is set to '0'.

C/S G.008 reqmt Para.	Description	Number of bits	Bit numbers in message	Content
	Vessel ID (continued)			following coding schemes are permitted:
		30	94-123	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 as a 9-digit number in binary format. If no MMSI is available, then insert the default decimal number 000111111.
		14	124-137	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 ($Y_6Y_7Y_8Y_9$) 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	94-137	2 - Radio call sign: Is encoded using the modified-Baudot code shown in Table 3.2. 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	94-137	3 - Aircraft Registration Marking: Is encoded using the modified-Baudot code shown in Table 3.2. 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	94-137	4 – Aviation 24 Bit Address: Shall either be encoded as a 24-Bit Binary Number,

C/S G.008 reqmt Para.	Description	Number of bits	Bit numbers in message	Content
	Vessel ID (continued)	44	94-137	followed by 20 spare bits all of which are coded as 0 or shall be encoded as a 24-Bit Binary Number, followed by the 3-letter aircraft operator designator*. The 3 letters are encoded using the modified-Baudot code shown in Table 3.2† (3x5 = 15 Bits) followed by 5 spare bits both of which are coded as 0. 5 - Aircraft operator and serial number: A 3-letter aircraft operator designator*. The 3 letters are encoded using the modified-Baudot code shown in Table 3.2† (3x5 = 15 Bits). Followed by a serial number (in the range of 1 up to 4095) as designated by the aircraft operator, encoded in binary, with the least significant bit on the right (12 Bits). The remaining 17 Bits are spare and shall follow the above 27 Bits and be encoded all as 1's.
	Beacon Type‡	3	138-140	"000" ELT (excludes ELT(DT)); "001" EPIRB; "010" PLB; "011" ELT(DT); "111" System beacon; and "100", "101", "110" spare.
	Spare bits	14	141-154	These bits are all set to binary 1. For a cancellation message, these bits are all set to 0.
	TOTAL BITS IN EACH BURST	154		To be transmitted in each burst.

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

‡ These bits always indicate the type of beacon (ELT, EPIRB, PLB, ELT(DT)), as certified, or a System beacon, regardless of the vessel ID coded into the beacon.

Table 3.2: Modified Beaudot Code

Letter	Code[*] MSB LSB	Letter	Code MSB LSB	Letter	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. ELT(DT) In-flight 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. Cancellation Message

Detailed content of rotating fields #0 through #3, and #15 are shown in the tables below.

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: C/S G.008 Objective Requirements Rotating Field (#0)

C/S G.008 Section	Sub-field Description	Number of bits	Bit numbers in message	Content
	Rotating field Identifier	4	155-158 in message (1-4 in rotating field)	0000 – G.008 Objective Requirements.
4.3.1a	Elapsed Time since activation	6	159-164 in message (5-10 in rotating field)	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. If the time is greater than 63 hours, the value shall be set to 63.
4.3.1b	Time from last encoded location	11	165-175 in message (11-21 in rotating field)	0 to 2046 minutes (34 hours and 6 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 2046 minutes, the value shall be set to 2046. If the beacon has not yet obtained a location from the GNSS receiver or is not equipped with encoded location capability, then this field should be set to 2047 as a default value.
4.3.1c	Altitude of Encoded location	10	176-185 in message (22-31 in rotating field)	Altitudes of ≤-400 metres to 15952 metres in steps of 16 metres (where altitudes ≤-400m are encoded as all zeros, -384 metres is encoded as 0000000001 and sea level would be encoded as 0000011001). Heights shall be rounded to the nearest 16 metre step, not truncated. If the height is greater than 15952 metres, the height shall be considered as 15952 metres and encoded as 1111111110. 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	186-193 in message (32-39 in rotating field)	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;

C/S G.008 Section	Sub-field Description	Number of bits	Bit numbers in message	Content
				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	194-195 in message (40-41 in rotating field)	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; and 11 Spare.
4.3.1g	Remaining battery capacity	3	196-198 in message (42-44 in rotating field)	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; and 111 Battery Capacity Not Available or Not Provided.
Not in C/S G.008	GNSS status	2	199-200 in message (45-46 in rotating field)	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; and 11 Reserved for future use.
	Spare	2	201-202 in message (47-48 in rotating field)	00.
TOTAL	Bits in Rotating Field	48		

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

C/S G.008 section	Sub-field Description	# Bits	Bit numbers in message	Content
	Rotating field Identifier	4	155-158 in message (1-4 in rotating field)	0001 In Flight Emergency.
4.3.1b	Time of last encoded location	17	159-175 in message (5-21 in rotating field)	Time rounded to nearest second (17 bits): Time 'sssss' where '00001' indicates a time of 00:00:01 UTC and '86399' indicates a time of 23:59:59 UTC). If UTC time is not available or the time is more than 24 hours old, then this field shall be encoded as all ones.
	Altitude of Encoded Location	10	176-185 in message (22-31 in rotating field)	Altitudes of ≤-400 m to 15952 meters in steps of 16 meters (where altitudes ≤-400 m is encoded as all zeros, -384 metres is encoded as 0000000001 and sea level as 0000011001). Heights shall be rounded to the nearest 16 metre step not truncated. If the height is greater than 15952 metres, the height shall be considered as 15952 metres and encoded as 1111111110. 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 ones.
	Triggering event	4	186-189 in message (32-35 in rotating field)	0001 – Manual activation by the crew; 0100 – G-switch/Deformation Activation; 1000 – Automatic Activation from Avionics or Triggering System*. If multiple triggers occur these bits shall always indicate the latest event. All other bit combinations – spare.
	GNSS Status	2	190-191 in message (36-37 in rotating field)	This field reports the status of the GNSS receiver used to provide the encoded location as follows: 00 Not Fix; 01 2D location only; 10 3D location; and 11 Spare.
	Remaining battery capacity	2	192-193 in message (38-39 in rotating field)	The remaining battery capacity in the beacon compared to its initial capacity shall be reported as follows: 00 ≤ 33% remaining; 01 > 33% and ≤ 66% remaining; 10 > 66% remaining; and 11 Battery capacity not available or Not Provided
	Spare	9	194-202 in message (40-48 in rotating field)	All 0's.
	TOTAL	**48**		

* Trigger in compliance with EUROCAE document ED-237.

Table 3.5: RLS Rotating Field (#2)

C/S G.008 section	**Sub-field Description**	**# Bits**	**Bit numbers in message**	**Content**
	Rotating field identifier	4	155-158 in message (1-4 in rotating field)	**bit 1-4:** "0010".
	Unassigned	2	159-160 in message (5-6 in rotating field)	**bit 5-6:** All 0's.
	Beacon RLS Capability	6	161-166 in message (7-12 in rotating field)	**bit 7** - Capability to process automatically generated Acknowledgement RLM Type-1: "1": Acknowledgement Type-1 (automatic acknowledgement) accepted by this beacon; and "0": Acknowledgement Type-1 not requested and not accepted by this beacon. **bit 8** - Capability to process manually generated RLM (e.g. Acknowledgment Type-2): "1": Manually generated RLM (such as Acknowledgement Type-2) accepted by this beacon; and "0": Manually generated RLM (such as Acknowledgement Type-2) not requested and not accepted by this beacon. Note: The condition bit 7 = "0" and bit 8 = "0" is an invalid condition; at least one of these two bits must always be a "1". **bit 9-12** – Reserved for future use and to be set to all "0's".
	RLS Provider Identification	3	167-169 in message (13-15 in rotating field)	**bit 13-15:** "001": GALILEO Return Link Service Provider; and "010": GLONASS Return Link Service Provider. Other combinations: Spares (for other possible RLS providers)
	Beacon Feedback (acknowledgement of RLM reception)	22	170-191 in message (16-37 in rotating field)	If RLS Provider Identification = 001 (bit 13-15) **bit 16 – RLM Type I Feedback:** "0": Type 1 not (yet) received; and "1": Type 1 received. **bit 17 – RLM Type 2 Feedback:** "0": Type 2 not (yet) received; and "1": Type 2 received. **bit 18-37 – RLM:** if (bit 16 = 1 and bit 17=0): Copy of bits 61-80 of the short RLM in the Open Service Signal in Space (section 5.2 of OS

C/S G.008 section	Sub-field Description	# Bits	Bit numbers in message	Content

				SIS ICD* and section 3.2.1 of Galileo SAR SDD†).
				
				if (bit 16 = 0 and bit 17=1):
				Reserved for future use, currently an invalid condition.
				
				if (bit 16 = 0 and bit 17 = 0):
				Then bits 18-37 all = “0”.
				
				if (bit 16 = 1 and bit 17 = 1):
				Reserved for future use, currently an invalid condition.
				
				If RLS Provider Identification is not 001:
				Reserved and bits 16-37 shall all be set to “0”.

	Unassigned	11	192-202 in message (38-48 in rotating field)	All 0’s
	TOTAL	**48**		

Table 3.6: National Use Rotating Field (#3)

C/S G.008 section	Sub-field Description	# Bits	Bit numbers in message	Content
	Rotating field identifier	4	155-158 in message (1-4 in rotating field)	0011.
4.3.1.i	National use	44	159-202 in message (5-48 in rotating field)	As defined by national administrations Default content all 0’s.
	TOTAL	**48**		

* European GNSS (Galileo) Open Service Signal In Space Interface Control Document (OS SIS ICD v1.3), December 2016.

† European GNSS (Galileo) SAR/GALILEO Service Definition Document (GALILEO SAR SDD Issue 2.0), January 2020.

Table 3.7: Spare Rotating Fields (for future use) (#4 - #14)

C/S G.008 section	Sub-field Description	# Bits	Bit numbers in message	Content
	Rotating field identifier	4	155-158 in message (1-4 in rotating field)	0100 to 1110 inclusive.
4.3.1.h	Spares	44	159-202 in message (5-48 in rotating field)	Default content all 0's.
	TOTAL	**48**		

Table 3.8: Cancellation Message Rotating Field (#15)

C/S G.008 section	Sub-field Description	# Bits	Bit numbers in message	Content
	Rotating field Identifier	4	155-158 in message (1-4 in rotating field)	1111.
	Fixed	42	159-200 in message (5-46 in rotating field)	Set to all 1's.
	Method of deactivation	2	201-202 in message (47-48 in rotating field)	00 Spare; 10 Manual De-Activation by user; 01 Automatic De-Activation by external means; and 11 Spare.
	TOTAL	**48**		

3.4 Beacon Transmission Scheduling of Rotating Fields

Unless dictated otherwise by national or international regulations beacons shall transmit the rotating fields indicated below when making the following transmissions:

Table 3.9: Rotating Field Transmission Conditions

Type of Beacon	Self-Test Transmission	Normal Transmission	Cancellation Message
All Beacons except ELT(DT)s, Beacons with RLS Functionality and National Use Beacons	G.008 Objective Requirements Field #0	G.008 Objective Requirements Field #0	Cancellation Message Field #15
ELT(DT)s (see Note 2)	In-Flight Emergency Field #1	In-Flight Emergency Field #1	Cancellation Message Field #15
Beacons with RLS Functionality (see Note 3)	RLS Field #2	RLS Field #2 alternating with G.008 Field #0	Cancellation Message Field #15
National Use Beacons (see Note 4)	National Use Field #3	Field #3 and Field #0 on a schedule set by the relevant national authority	Cancellation Message Field #15

Notes
1. All beacons always transmit the Main 154 Bit Message Field in every burst before transmitting a Rotating Field as defined above.
2. ELT(DT)s cannot include RLS functionality and therefore always transmit Rotating Field #1
3. Beacons with RLS Functionality always transmit Field #2 in the first and subsequent odd numbered bursts and Field #0 in the second and subsequent even numbered bursts
4. National Use ELT(DT) Beacons shall transmit Field #3 and Field #1 on a schedule set by the relevant national authority. National Use Beacons with RLS Functionality shall transmit Field #3, Field #2 and Field #0 on a schedule set by the relevant national authority. During a self-test all types of National Use beacons always transmit Field #3.

3.5 Beacon Message Content – Error Correcting Field

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

3.6 Beacon Coding and Hex ID

The manufacturer shall program a unique combination of TAC Number and Serial Number into every beacon before it leaves their factory. The TAC Number and Serial Number shall not be capable of being deleted from that beacon. Only approved devices shall be allowed to temporarily modify the TAC and Serial Number in the transmitted message (e.g., a programming adapter (see section 3.7)). If a unit is destroyed or recycled at the end of its life, the unique combination of TAC Number and Serial Number used in that beacon shall not be used in another beacon.

Beacon coding methods are defined in section 3.1 of this specification. Specific operational requirements that impact beacon coding, such as 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 Hex ID is composed as follows:

Table 3.10: Hex ID Contents

23 Hex ID Bit	No Bits	Reference to Bits in Message	Data Content
1	1	n/a	Fixed Binary ‘1’
2 to 11	10	31-40	C/S Country Code
12	1	n/a	Fixed Binary ‘1’
13	1	n/a	Fixed Binary ‘0’
14	1	n/a	Fixed Binary ‘1’
15 to 30	16	1-16	C/S TAC No
31 to 44	14	17-30	Beacon Serial Number
45	1	43	Test Protocol Flag
46 to 48	3	91-93	Aircraft / Vessel ID Type
49 to 92	44	94-137	Aircraft / Vessel ID
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, Test Protocol Flag, 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.

3) When the Vessel ID identifier in bits 91-93 is set to “100” to indicate an aircraft 24-bit address then, solely for the purpose of compiling the 23 Hex ID, bits 118 to 137 of the Vessel ID shall be considered to be all “0’s” regardless of their actual content.

3.7 Programming Adapters

If a manufacturer chooses to offer an optional Programming Adapter with a particular Beacon Model (as defined in C/S T.021 section 1.3) then it shall comply with the requirements in this section.

A Programming Adapter shall only be capable of functioning with one particular Beacon Model; separate Beacon Models shall require the use of a different Programming Adapter.

Each Programming Adapter shall be given its own unique Serial Number by the beacon manufacturer.

The manufacturer shall program a unique combination of TAC Number and Serial Number into every Programming Adapter before it leaves their factory. The TAC Number and Serial Number shall not be capable of being deleted from that Programming Adapter or being overwritten by any means. If a unit is destroyed or recycled at the end of its life, the unique combination of TAC Number and Serial Number used in that Programming Adapter shall not be used in another Programming Adapter.

All data stored in a Programming Adapter shall be in non-volatile memory.

A Programming Adapter shall be capable of having a Country Code and Vessel ID programmed into it, which may be capable of being changed and overwritten.

When a beacon connected to a Programming Adapter is activated, it shall continue to transmit in its message the ID supplied from the Programming Adapter for the duration of the beacon activation, even if the adapter subsequently becomes disconnected/disassociated from the beacon. When next activated (unless the Programming Adapter or another Programming Adapter has been reconnected / connected to the beacon in the meantime), it shall transmit the beacon’s own unique TAC Number and Serial Number and the Country Code and Vessel ID. If a Programming Adapter is connected to an activated beacon, then the beacon shall ignore the Programming Adapter and continue to transmit the beacons own identity, until the beacon is deactivated and subsequently reactivated with the Programming Adapter connected, at which time it will then transmit the identity in the Programming Adapter.

- END OF SECTION 3 -

4. ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS

4.1 General

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

4.2 Thermal Environment

4.2.1 Operating Temperature Range

Three standard classes of operating temperature range are defined, inside which all of the requirements within this specification shall be met:

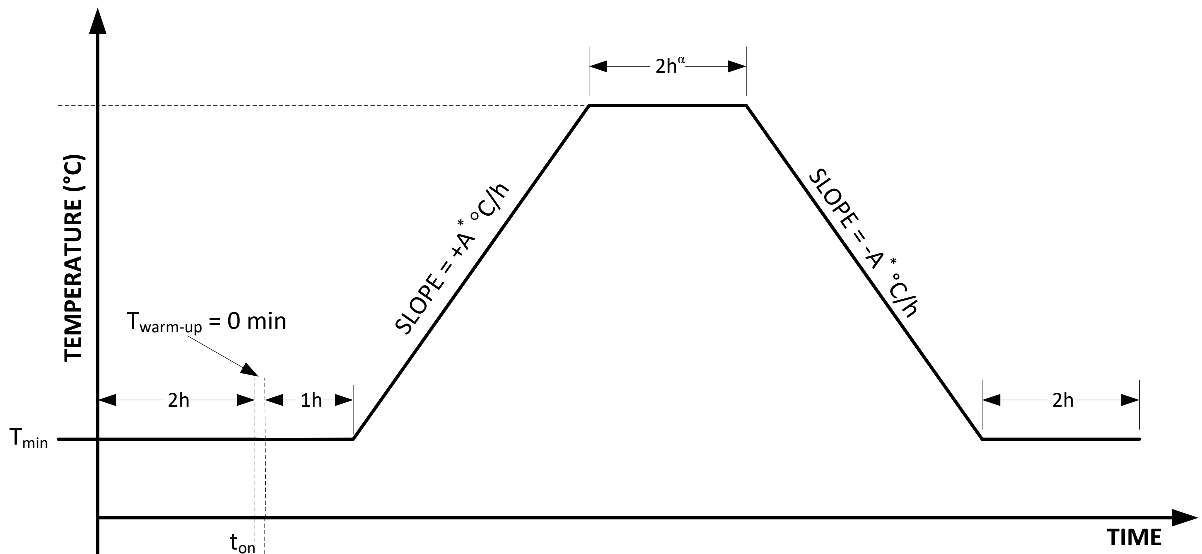
Class 0: -55°C to +70°C
Class 1: -40°C to +55°C
Class 2: -20°C to +55°C

4.2.2 Temperature Gradient

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

4.2.3 Thermal Shock

All of the requirements within this specification shall be met, for measurements beginning 5 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.



NOTES:

T_{max} = + 70°C (Class 0 beacon)
T_{max} = + 55°C (Class 1 & 2 beacons)

T_{min} = - 55°C (Class 0 beacon)
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)

A^* = 7°C/hour for Class 0 (45°C/hour for ELT(DT))
A^* = 5°C/hour for Class 1 and Class 2 (33°C/hour for ELT(DT))
α = For ELT(DT)s this time is reduced on the down-ramp test to one (1) hour.

Figure 4-1: Temperature Gradient

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* at any temperature throughout the specified operating temperature range.

4.5.1.1 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, except the loss due to self-discharge.

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 Radio-Locating signal as defined in section 2.5. ELT(DT)s are not required to provide a Radio-Locating signal.

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

The distress beacon may transmit other radio-locating signals in compliance with appropriate national or international standards. The inclusion of any Radio-Locating Signals within a beacon and the prioritization of these Radio-Locating Signals is the responsibility of the appropriate national or international bodies. The status of the radio-locating transmissions (e.g., operational or non-operational) shall be monitored before each beacon satellite transmission and shall be 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 not begin transmissions for at least 30 seconds (in order for the as equipped status to be transmitted) but shall begin transmission within 5 minutes maximum after

* For installations meeting IMO GMDSS requirements, a minimum operating lifetime of 48 hours (EPIRB) and 168 hours (for Float Free VDR capsules) at any temperature throughout the specified operating temperature range is necessary. The minimum operating lifetime for an ELT (DT) to meet the ICAO GADSS requirement at any temperature throughout the specified operating temperature range shall be 370 Minutes. This duration is based on the ICAO standards for Extended Diversion Time Operations (EDTO) and the maximum diversion time capability of existing aircraft types, as of April 2018.

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

4.5.4.1 Nominal 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 406-MHz signal with 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 be spread by a specific sequence defined in section 2.2.3.

The self-test mode (or GNSS self-test as described hereafter) shall not be used for the purposes of repetitive automated interrogation of the beacon status. A beacon (e.g., ELT(DT)) may contain a different test mode that can be used for repetitive automated interrogation of its status, but operation of the beacon in this different test mode shall not result in the transmission of a 406-MHz signal or other radio locating signals (if applicable) nor interfere with the normal operation of the beacon.

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

ELT(DT) beacons shall include a GNSS self-test mode resulting in a single burst transmission.

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 regardless of the duration of activation of the GNSS self-test control;

b) provide for that in the case of internal GNSS receivers powered by the primary[*] beacon battery the number of GNSS self-tests shall be limited by the beacon design to prevent inadvertent battery depletion;

c) provide a distinct indication 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[†]

4.5.5.1 General

Beacon position data, obtained from a navigation device internal, integral[‡] 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 all the appropriate parts of section 4.5.5.

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

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

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

- Section 4.5.5.2 applies to all beacons with an internal navigation device except ELT(DT)s
- Section 4.5.5.3 applies only to ELT(DT)s which must always include an internal navigation device
- Section 4.5.5.4 applies to all beacons (including ELT(DT)s) which include an external navigation device input.

Thus, for example if an EPIRB has an internal navigation device and an external navigation device input then it shall comply with both sections 4.5.5.2 and 4.5.5.4.

All times are measured since beacon activation unless specified otherwise.

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

ELT (DT)s shall incorporate an internal navigation device and may incorporate an interface to an external navigation device. The initial position transmitted in the first burst may be obtained from either the internal navigation device or from the external navigation device input. Subsequently all future positions shall only be obtained from the internal navigation device.

The transmission in the beacon message of this external source of position is only subsequently allowed if the internal GNSS receiver is not able to produce a valid encoded position less than 1 second before the burst. If position data is available from both sources, within 1 second before the burst, then the location produced by the internal GNSS receiver has the priority over the external source of data*.

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 Internal Navigation Device

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

An internal navigation device shall incorporate self-check features to ensure that erroneous position data is not encoded into the beacon message. The self-check features shall prevent position data from being encoded into the beacon message unless minimum performance criteria are met. These criteria could include the proper internal functioning of the device, the presence of a sufficient number of navigation signals, sufficient quality of the signals, and geometric dilution of precisions below 50.

* The internal navigation device or even the entire ELT(DT) may be powered by an external source prior to its activation in order to comply with this requirement, but must be powered solely by the ELT(DT)'s internal power source immediately after activation of the ELT(DT). The ELT(DT) shall have its own integral or internal power source. However, when available, the ELT(DT) may use aircraft electrical power source during transmission after its activation. ELT(DT) system minimum duration of continuous operation shall however be demonstrated with the ELT(DT) own internal/integral power source.

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.

With a clear view of the sky the distance between the static horizontal position provided by the navigation device, at the time of the position update, and the actual navigation device static position shall not exceed 30 m 95% of the time. The distance between the static vertical position (altitude) provided by the navigation device, at the time of the position update, and the actual navigation device static position shall not exceed 50 m 95% of the time.

The objective should be to provide a position with low geometric dilution of precision, however if the only position available (whether this be 2D or 3D) has a high dilution of precision then this position should be provided rather than being discarded in favour of not providing a position at all.

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 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 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. 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. In this instance when the location changes from 3D to 2D (or No Fix) the altitude shall be reset to the default value until such time as a 3D fix with altitude is available.

First provision of encoded location within a transmitted message shall occur no later than the first burst after 2 minutes from beacon activation with a 95% probability, with a clear view of the sky.

The Internal navigation device shall operate continuously during the initial 30 minutes period following beacon activation. During this period 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. This applies even if the quality of the location has become worse. The navigation device 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 subsequent attempts to obtain an initial location, or an updated location, as applicable, at least every 15 minutes from the end of the last update attempt, for the remainder of the manufacturer declared minimum operating lifetime of the beacon*. Whenever an updated location is obtained, it shall be encoded into the next available beacon message to be transmitted.

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 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.

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.

4.5.5.3 Internal Navigation Device ELT(DT)s only

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

An internal navigation device shall incorporate self-check features to ensure that erroneous position data is not encoded into the beacon message. The self-check features shall prevent position data from being encoded into the beacon message unless minimum performance criteria are met. These criteria could include the proper internal functioning of the device, the presence of a sufficient number of navigation signals, sufficient quality of the signals, and geometric dilution of precisions below 50.

The ELT (DT) navigation system shall be cold-started on initial power-up (ELT(DT) in ARMED mode see section 4.5.6.1) but shall not be cold started if the ELT(DT) is subsequently activated or between ELT(DT) transmissions. Cold start refers to the absence of time dependent or position dependent data in memory, which might affect the acquisition of the GNSS position.

With a clear view of the sky the distance between the static horizontal position provided by the navigation device, at the time of the position update, and the actual navigation device static position shall not exceed 30 m 95% of the time. The distance between the static vertical position (altitude) provided by the navigation device, at the time of the position update, and the actual navigation device static position shall not exceed 50 m 95% of the time. The objective should be to provide a position with low geometric dilution of precision, however if the only position available (whether this be 2D or 3D) has a high dilution of precision then this position should be provided rather than being discarded in favour of not providing a position at all.

* For EPIRBs used as the float-free recording medium for VDRs, after at least 48 hours, the update rate can be extended to a maximum of once every 60 minutes for the remainder of the operating lifetime if required.

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 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. 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. In this instance when the location changes from 3D to 2D (or No Fix) the altitude shall be reset to the default value until such time as a 3D fix with altitude is available.

First provision of encoded location within a transmitted message shall occur within 5 seconds* after ELT(DT) activation with a 95% probability, with a clear view of the sky.

The Internal navigation device shall operate continuously during the initial 30 minutes period following beacon activation, subsequently each location update attempt prior to every 406 MHz transmission shall require the navigation device to be operational for a period of at least 15 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 25 seconds scheduled immediately prior to the next planned location update. After the first hour following beacon activation, the internal navigation device shall also be operational for a period of at least 180 seconds once every hour thereafter, to ensure that the device can download any necessary navigation message updates.

ELT(DT)s shall attempt to acquire fresh position information prior to every 406 MHz transmission (unless this becomes impractical due to navigation signal constraints) for the entire operating lifetime of the ELT (DT) and shall encode the latest position obtained within less than 1 second prior to each burst into that transmission. If an updated position is not available within 1 second immediately prior to every 406 MHz transmission, then the ELT(DT) shall transmit the latest position that it has, unless this position is more than 24 hours old, in which case it shall revert to transmitting the default position until such time as an updated position is available.

ELT (DT)s shall provide the UTC time of the last encoded location to an accuracy and resolution of 1 second and provide this in the transmitted message as required by section 3.3, Table 3.5. If UTC is not available for an encoded location, or if the time of the last encoded location is over 24 hours old then the ELT(DT) shall transmit default data.

4.5.5.4 External Navigation Device Input

It is recommended that beacons, which are designed to accept data from an external navigation device, be compatible with an applicable international standard, such as the IEC Standard on Digital Interfaces (IEC Publication 61162) and that any difference between the ITRS and the

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

datum employed by the receiver should be less than 10 cm. 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. The beacon user manual shall include details of the acceptable interfaces.

In addition to providing horizontal position and altitude the external navigation input 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 external navigation input shall indicate for each provided position whether it has no Fix or was operating in 2D or 3D Mode and the beacon shall encode this data in the message in accordance with section 3.3. 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.

In static conditions the distance between the horizontal position provided by the external navigation input, at the time of the position update, and the position transmitted by the beacon shall not exceed 20 m. The distance between the vertical position (altitude) provided by the external navigation input, at the time of the position update, and the position transmitted by the beacon shall not exceed 40 m.

First provision of encoded location within a transmitted message shall occur within 5 seconds with navigation data available at the external navigation device input.

During the first 30 minutes after beacon activation the location transmitted by the beacon shall always be the latest information provided by the external navigation input. This applies even if the quality of the location has become worse. The external navigation input 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 beacon shall access the external navigation input prior to every transmission and shall encode the position, if available, into the next transmitted burst. 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 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.

4.5.6 Beacon Activation

Beacons shall have a means of manual activation and deactivation and may optionally also include means of automatic activation (for ELT (DT)s see section 4.5.6.1 below).

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 (except ELT(DT)s) 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.

After activation the beacon shall commence transmissions in accordance with section 2.2.1, thereafter the beacon shall not transmit more frequently than the minimum burst transmission interval (as defined in section 2.2.1) regardless of the duration of activation of any controls or the activation of any combination of controls. Once activated and transmitting, the activation of any control other than the ‘Off’, ‘Reset’ or ‘Cancellation’ controls shall not stop the beacon from transmitting.

4.5.6.1 ELT(DT) Modes of Operation

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

Consequently:

- If the ELT(DT) has been automatically activated by the triggering system*, it shall only be de-activated by the same means.
- If the ELT(DT) has been automatically activated by the beacon sensors†, it shall only be deactivated by manually resetting the beacon.
- If the ELT(DT) has been manually activated (i.e., from the cockpit), it shall only be manually de-activated.
- If the ELT(DT) has been activated by any combination of activation means, it can only be de-activated once each activation means has been deactivated.
- Bits 186 to 189 of the ELT(DT) message shall indicate the most recent means of activation. If one means of activation is removed but others remain then Bits 186 to 189 shall revert to indicating the previous most recent means of activation.

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

* For example, triggered by an external source in compliance with EUROCAE ED-237.
† For example, triggered by G-switch / deformation.

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

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

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

RESET – The ELT(DT) is deactivated and ceases transmitting distress alerts and instead transmits a sequence of cancellation messages as defined by Section 4.5.7. Upon completion of the cancellation message sequence, the ELT(DT) reverts to the ARMED condition. The ELT(DT) can only be deactivated as defined above.

4.5.7 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 for all beacons except ELT(AD), ELT(AF), and ELT(DT). 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.

For ELT(AD), ELT(AF), and ELT(DT) beacons, the cancellation function shall be enabled whenever a beacon is deliberately deactivated or reset provided no other activation sources are present.

For ELT(AP) beacons, when connected to the remote control and indicator panel (i.e., when mounted in the aircraft), the cancellation message sequence shall be enabled whenever a beacon is deliberately deactivated or reset provided no other activation sources are present (thus overriding the cancellation function on the ELT unit itself). For ELT(AP) beacons, when not connected to the remote control and indicator panel (i.e. when external to the aircraft), the cancellation message sequence shall only be enabled when the cancellation function on the ELT unit is enabled.

For ELT (DT)s the cancellation function shall include a means of automatic cancellation from the same source(s) as the aircraft automatic activation.

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

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

When the beacon activation cancellation function is enabled it shall comply with section 3.4, Table 3.1 and Table 3.8.

4.5.8 Verification of Registration

See footnote.*

4.5.9 RLS Function

If a beacon is equipped with a Return Link Service (RLS) functionality and is configured to transmit the RLS Rotating Field, it shall meet the following additional requirements.

4.5.9.1 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 or an equivalent proprietary RLM sentence defined by the GNSS receiver manufacturer.

If the GNSS receiver is capable of processing signals from only one GNSS constellation, this shall be the associated RLS provider’s constellation, and satellites should be tracked above 5 degrees of elevation.

If the GNSS receiver is capable of processing signals from several GNSS constellations (multi-constellation GNSS receiver), such a receiver shall prioritize the reception from satellites of the GNSS constellation associated with the RLS provider above 5 degrees of elevation over other GNSS constellations.

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.

* 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.

4.5.9.2 RLS GNSS Receiver Operation

4.5.9.2.1 Operation Cycle

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

a) when encoded with RLS functionality (i.e., transmitting an RLS Rotating Field) maintain the GNSS receiver in an active mode of operation such that it can continuously check for receipt of an RLM message and UTC, for a minimum period of 30 minutes after beacon activation, or until a valid RLM message is acquired, 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 at least 6 hours from the time the beacon was first activated, to an accuracy of better than three seconds (once UTC has been acquired) or until the beacon is deactivated (if UTC is not acquired see (e) below);

c) if an RLM message has not been received within the first 30-minute period, then at the end of this time, utilize UTC time to next activate the GNSS receiver at the next occurrence of UTC M_{offset} minutes to check for receipt of an RLM, for a minimum period of 15 minutes, or until an RLM message is acquired (e.g., if the first 30-minute period ended at 02:29 and M_{offset} is 15 minutes, then next activate the GNSS receiver at 03:15, or if M_{offset} is 44 minutes, then next activate the GNSS receiver at 02:44);

d) then during each subsequent hour reactivate the GNSS receiver to check for receipt of an RLM for a minimum period of 15 minutes at M_{offset} minutes, with $0 \leq M_{offset} \leq 59$, past the hour until either an RLM message is received or 6 hours has elapsed since the beacon was activated;

e) if UTC 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. If UTC is then established the beacon shall continue as per c) and d) above from the next occurrence of UTC M_{offset} minutes; and

f) once an RLM message is received, or after 6 hours has elapsed since beacon activation, whichever is sooner, the beacon shall revert to the GNSS timings in sections 4.5.5.2.

For instance, if the beacon is activated at 03.17h UTC, then the GNSS receiver would remain active until at least 03.47h UTC or until an RLM message is acquired if sooner, or the beacon is deactivated if it is deactivated before that time. If an RLM message is acquired within this period, then the beacon reverts to the GNSS timings in section 4.5.5.2. If an RLM message is not acquired then it would reactivate at the next occurrence of M_{offset} past the hour and remain active until at least M_{offset}+15, or until an RLM message is acquired, or the beacon is deactivated and it would then reactivate again during the next hour at M_{offset} until M_{offset}+15, etc. The scheme continues as above until an RLM message is acquired, or 6 hours has elapsed since beacon activation, that is in this example until 09.17h UTC, at which time if an RLM wasn't acquired earlier the GNSS Receiver reverts to the GNSS timings in section 4.5.5.2. If the beacon is deactivated, then the entire operation cycle commences again from the beginning when the beacon is next activated.

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

The RLS beacon may contain an internal GNSS receiver capable of receiving and decoding other types of acknowledgment RLM following the same operation cycle as the one described.

4.5.9.2.2 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}. A sample of a M_{offset} calculation and CRC code is shown in Appendix F.

4.5.9.3 RLS Indicator

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

a) be readily visible to the user when the beacon is operated in all its normal operational configurations as declared by the manufacturer;
b) be clearly visible to the user in direct sunlight;
c) provide a distinct unique indication;
d) remain inactive at all times when the beacon message is encoded with any message content other than the RLS Rotating Field;
e) within 5 seconds of the beacon transmitting an initial RLS request, commence indication of an RLS request until either a valid RLM Type 1 message is received, or the beacon is deactivated, or the beacon battery is expired;
f) within 5 seconds of the beacon receiving a valid RLM Type 1 message acknowledgement, commence a distinct indication until either the beacon is deactivated or the beacon battery is expired; and
g) only provide the indication of receipt of an RLS request acknowledgment when the received RLM Type 1 message contains the unique 15 Hex ID subset of the 23 Hex ID programmed into that beacon and the beacon has validated that this matches its own 15 Hex ID subset of its 23 Hex ID.

4.5.9.4 Confirmation of a Return-Link Message Receipt

Upon receipt of an Acknowledgement Type-1 RLM or a Test RLM associated with the beacon 15 HEX ID, the beacon shall, within 4 minutes and 14 seconds, acknowledge the RLM receipt by changing the coding of its message as defined in the RLS rotating field, as described in section 3.3. Once changed, the RLM beacon feedback field shall no longer be changed until a different RLM message is received or beacon is switched off or the beacon battery is depleted.

Once the beacon has received an Acknowledgement Type-1 RLM or a Test RLM and has acknowledged the RLM receipt, the GNSS Receiver shall continue to function as required by section 4.5.9.2.1 unless the beacon is coded as a "Type-1 only capable" RLS beacon as defined in Table 3.5. In this specific case only, the GNSS receiver may revert to operating as defined within sections 4.5.5.2 and 4.5.5.4, taking into account the time elapsed between the moment of activation and the moment when the Type-1 RLM message is received, until either the beacon is deactivated or the beacon performance ceases to meet specification due to battery depletion.

Example

A beacon is activated at 9:00. It transmits emergency signals for 2 hours and 30 minutes. During the period from 11:00 to 11:15, it receives a Type-1 RLM Acknowledgement. The GNSS receiver could then revert to operating in accordance to the requirements for internal GNSS receiver without the RLS capability which specifies that, the navigation device shall attempt location update at least once every 15 minutes, for a period of at least 90 seconds, or until an updated location is obtained, if sooner.

4.5.9.5 RLS Beacon Documentation

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

4.5.10 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.

4.5.11 Beacon Labelling

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

1) Beacon 23 Hex ID (the 23 Hex ID shall be displayed as:
NNNNNN NNNNNN NNNNNN NNNNN (i.e., a space after every 6 characters))
2) The beacon operating temperature range

3) The minimum duration of continuous operation

4.5.12 Beacon Instruction Manual

An End User instruction manual shall be made available with all beacons, it shall include the information as outlined in the data item description (Annex H.1.10 of document C/S T.021).

4.5.13 Beacon Data Requirements

The manufacturer shall make available for the purposes of supporting the type approval review the information as outlined in the data item description (Annex G-3 and Annex H.1 of document C/S T.021).

4.5.14 External Power Source for ELT(DT)s

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

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

4.5.15.1 Introduction

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

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

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

4.5.15.2 Beacon Hex ID

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

4.5.15.3 Burst Transmission Interval (with Crash Detection)

If the ELT(DT) includes a crash detection function, within 5 seconds of a crash the ELT(DT) shall restart the transmission schedule for an ELT(DT) as if the ELT(DT) had just been activated and maintain this transmission schedule for the 30 minutes after the crash detection.

Beyond 30 minutes, transmissions shall then occur at nominally 120 second intervals. The time between the start of two successive transmissions shall be randomized with uniform distribution around the stated nominal value, so that time intervals between successive transmissions are randomly distributed over ± 5 seconds.

4.5.15.4 GNSS Update Rate (after Crash Detection)

During a 30-minute period after a crash detection, the GNSS encoded location shall be updated before each transmitted burst, as per section 4.5.5.3.

Beyond 30 minutes, the GNSS encoded location shall be updated in accordance with section 4.5.5.2.

4.5.15.5 Duration of Continuous Operation

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

4.5.15.6 Homing and Locating Signals

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

4.5.16 ELT(DT)s Combined with Automatic ELTs

4.5.16.1 Introduction

Potentially there may be ELT(DT)s that have combined functionality, that is they function as an ELT(DT) during a flight, but on detection of an incident perform as an Automatic ELT (either an ELT(AD), ELT(AF) or ELT(AP)), such a combined ELT would be required to meet the regulatory requirements set by National Administrations and/or Aviation Authorities, for both an ELT(DT) and the type of Automatic ELT that it is combined with.

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

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

4.5.16.2 Beacon Coding and Beacon Hex ID

The combined ELT(DT) and Automatic ELT shall transmit the ELT(DT) In-Flight Emergency Rotating Field #1 at all times and shall not change to transmitting the Objective Requirements Rotating Field #0 when the combined device transitions to or is activated as an Automatic ELT.

The 23 Hex ID shall remain the same regardless of whether the device is operating as an ELT(DT) or as an automatic ELT.

Bit 42 in the combined device message shall remain as “0” indicating that the device is not equipped with the RLS capability and shall not change to “1” when the combined device transitions to or is activated as an Automatic ELT.

Bits 138 to 140 in the combined device message shall remain as “011” indicating that the device is an ELT(DT) and shall not change to “000” when the combined device transitions to or is activated as an Automatic ELT.

4.5.16.3 Burst Transmission Interval

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

4.5.16.4 System Requirements

The combined ELT(DT) and Automatic ELT shall meet the more stringent requirements, that apply to either part of the device (except where stated otherwise below), specifically:

a) the combined ELT(DT) and Automatic ELT does not have to meet the requirement for 90% of measured EIRP values to meet the limits shown at elevation angles below 55 degrees (but does have to meet the other requirements in section 2.4.2);

b) the combined device shall comply with both the Temperature Gradient requirements for an ELT(DT) and the Temperature Gradient requirements for a regular 406 MHz beacon, based upon the declared temperature classes for each part of the device (section 4.2.2);

c) the combined ELT(DT) shall not be required to track time since activation (since it will not be transmitting Rotating Field #0) (section 4.5.6); and

d) the combined ELT(DT) shall comply with the modes of operation for an ELT(DT) (section 4.5.6.1).

4.5.16.5 Cancellation Message

The cancellation message shall function as defined in section 4.5.7 while operating as an Automatic ELT as well as while operating as an ELT(DT).

4.5.16.6 Encoded Position Data and Navigation Device Performance

While operating as an ELT(DT) the navigation device shall comply with the requirements of sections 4.5.5.1 and 4.5.5.3. When operating as an Automatic ELT, that is automatically activated, the navigation device shall comply with the requirements of sections 4.5.5.1 and 4.5.5.2. When operating as an Automatic ELT, that is manually activated, the navigation device shall comply with the requirements of sections 4.5.5.1 and 4.5.5.3, for a period of at least 6 hours and 10 minutes, after which time it shall comply with the requirements of sections 4.5.5.1 and 4.5.5.2.

4.5.16.7 Duration of Continuous Operation

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

4.5.16.8 Class of Operation

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

4.5.16.9 Homing and Locating Signals

The inclusion or otherwise of one or more homing signals in the combined device and the activation and duration of any homing signal transmissions are the responsibility of national administrations. The status of the homing signals in the transmitted beacon message shall comply with Table 3.1.

- END OF SECTION 4 -

APPENDIX A - LIST OF ACRONYMS

A full list of all Acronyms can be found in document C/S S.011 – Glossary.

- END OF APPENDIX A -

APPENDIX B - SAMPLE BOSE-CHAUDHURI-HOCQUENGHEM ERROR-CORRECTING CODE AND 23 HEX ID CALCULATIONS

NOTE: The information in the Appendix is not aligned with the current text in the main body of this document and requires an update.

B.1 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

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

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 and b_{202} - is the last bit of the digital 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 the digital message in the Minimum Requirement main field consists of the following data (decimal notation):

Digital Message	Decimal Data	Binary Data	Bits in Message
TAC number	230	0000000011100110	1 to 16
Serial Number	573	00001000111101	17 to 30
Country code	201	0011001001	31 to 40
Status of homing device	1	1	41
RLS function	0	0	42
Test protocol	0	0	43
Encoded GNSS Location	See below	See below	44 to 90
Vessel ID	0	47 Bits all 0’s	91 to 137
Beacon Type	0	000	138 to 140
Spare bits	16383 (all 1’s)	11111111111111	141 to 154

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

Encoded GNSS location in binary notation (converted in accordance with Appendix C):

Current latitude 0 0110000 110010110000110
Current longitude 0 01000101 000000100011111

In this example Rotating Field 1 (C/S G.008 Objective Requirements) is used, containing the following data:

Digital Message	Decimal Data	Binary Data	Bits in Message
Rotating Field Identifier	0	0000	155 to 158
Elapsed Time since activation	1 hour 27 mins	000001	159 to 164
Time from last encoded location	6 mins 24 sec	00000000110	165 to 175
Altitude of encoded location	430,24 metres	0000110100	176 to 185
Dilution of precision	HDOP<1 VDOP <2	00000001	186 to 193
Activation notification	Manual	00	194 to 195
Remaining battery capacity	>75%	101	196 to 198
GNSS status	3D	10	199 to 200
Spare bits	0	00	200 to 202

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

Bits 1-202	0000 0000 1110 0110 0000 1000 1111 0100 1100 1001 1000 0110 0001 1001 0110 0001 1000 1000 1010 0000 0100 0111 1100 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 1111 1111 1111 1100 0000 0001 0000 0000 1100 0001 1010 0000 0000 1001 0110 00
Hex Message From 202 bits	00E608F4C986196188A047C000000000000FFFC0100C1A00960
Cospas-Sarsat Ground Segment Representation* (MF #90 Ref. C/S A.002)	0039823D32618658622811F0000000000003FFF004030680258 (two leading 0 bits plus bits 1-202)

* As the length of the message in bits is not divisible by 4, the message is augmented, for ground processing purposes, with two leading binary ‘0’s, which results in this revised hexadecimal message.
The division * described above is shown in Figure A1, and results in a 49-bit remainder of:

0010010010010101001001111110001010111101001001001

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:

* Modulo 2 division prohibits a "borrow" in the subtraction portion of the long division.

010010010010101001001111110001010111101001001001

REFERENCE

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

```
       5 “0”                                      Bits 0-202                                                  Bits (203-250)
                                                 (Data bits)                                                      48 «0»
m(x)=  00000 000000001110011000001000111101001100100110000110000110010110000110001000101000000100011 1   …   01000000000001001011000 000000000000000000000000000000000000000000000000
g(X)=               1110001111110101110000101110111110011110010010111

                    0000010111111101001101100010011000011000010100101111000
                         1110001111110101110000101110111110011110010010111

                         0101110001010011000001100010110010010100000101111 0
                          1110001111110101110000101110111110011110010010111

                          01011011010100111100111010110110101101100110010011
                           1110001111110101110000101110111110011110010010111

                           01010101010100100101111110000010111100101000001001
                            1110001111110101110000101110111110011110010010111

                            01001001010100010111110111101010011110110100111100
                             1110001111110101110000101110111110011110010010111

                             01110001010101110011100100111011011010001101010110
                              1110001111110101110000101110111110011110010010111

                              0000000101011011101100001001100101001111111000001010 0010
                                     1110001111110101110000101110111110011110010010111

                                     01001110001011011000111001001000011011100001101011
                                      1110001111110101110000101110111110011110010010111

                                      01111111101011101101111001111111010000100111111000
                                       1110001111110101110000101110111110011110010010111

                                       0001110010101000011111100001000100011010101101111000
                                          1110001111110101110000101110111110011110010010111

                                          000001101011011000110010011001110100101111110111100100
                                               1110001111110101110000101110111110011110010010111

                                               00110101001100111000111000000110111000000101110011 01
                                                 1110001111110101110000101110111110011110010010111

                                                 0011011100111011111110101111010000011100101011010 11
                                                                                                  …                …

                                                                                                        01110000011000011010000011010100110011001010010110
                                                                                                         1110001111110101110000101110111110011110010010111

                                                                                                         0000001100110110100000110100011000000111000000001000000
                                                                                                               1110001111110101110000101110111110011110010010111

                                                                                                               00101110010101010001001101101110010111100110101110 0
                                                                                                                 1110001111110101110000101110111110011110010010111

                                                                                                                 01011010101000011000111101010110111001111110010110
                                                                                                                  1110001111110101110000101110111110011110010010111

                                                                                                                  01010110101101101101110001000010010100011000000010
                                                                                                                   1110001111110101110000101110111110011110010010111

                                                                                                                   01001110100110000111101001101011001111010100101010
                                                                                                                    1110001111110101110000101110111110011110010010111

                                                                                                                    01111110110001010011011000111001111001001101111010
                                                                                                                     1110001111110101110000101110111110011110010010111

                                                                                                                     0001111001111111101011101001110001010111111101101000
                                                                                                                        1110001111110101110000101110111110011110010010111

                                                                                                                        0001000000000100010110110000011010010000111111111000 
                                                                                                                           1110001111110101110000101110111110011110010010111

                                                                                                                           01100011101100000111001010000110100100011011011110
                                                                                                                            1110001111110101110000101110111110011110010010111
                                                                                     49 bits remainder =                    0010010010010101001001111110001010111101001001001
                                                                                                                           |←--------  BCH Code (last 48 bits)  -------→|
```

Figure B-1: Sample 48-Bit BCH Error-Correcting Code Calculation
(for easier viewing the calculation is reduced and divided into 2 parts)

B.2 Sample 23 Hex ID Calculation

Using the same data as above the 23 Hex ID can be generated as shown below. It should be noted that the 23 Hex ID cannot be formed directly from the transmitted message as additional bits have to be added to it and the order of the digital message data has to be changed.

Referring to T.018 Section 3.6 and Table 3.9 and using the digital message data from above results in the following:

23 Hex ID Bit	No Bits	Data Content	Message Content
1	1	Fixed Binary ‘1’	1
2 to 11	10	C/S Country Code ‘201’	0011001001
12	1	Fixed Binary ‘1’	1
13	1	Fixed Binary ‘0’	0
14	1	Fixed Binary ‘1’	1
15 to 30	16	C/S TAC No ‘230’	0000000011100110
31 to 44	14	Beacon Serial Number ‘573’	00001000111101
45	1	Test Protocol Flag	0
46 to 48	3	Aircraft / Vessel ID Type ‘N/A’	000
49 to 92	44	Aircraft / Vessel ID	44 Bits all ‘0’s

1001 1001 0011 0100 0000 0011 1001 1000 0010 0011 1101 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

Which in turn gives a final 23 Hex ID of:

23 Hex ID **9934039823D000000000000**

Which it can be seen is very different to the first 23 Hex characters of the Digital Message Data

00E608F4C986196188A047C

Finally, for completeness it can be noted that the unique 15 Hex ID for the same beacon is obtained by simply truncating the 23 Hex ID, which would give a 15 Hex ID of

9934039823D0000

- END OF APPENDIX B -

APPENDIX C - BEACON ENCODED LOCATION CODING

C.1 ENCODED LOCATION PROTOCOL

This section defines the encoded location protocol which can be used with the 406 MHz beacon message formats for encoding beacon position data in the digital message transmitted by a 406 MHz distress beacon.

C.2 Summary

Encode location is represented differently in second generation beacons. In first generation beacons, degrees, minutes and seconds were used. For second generation beacons, degrees and decimal part of the degrees are used. Moreover, there is no coarse and fine offset fields: all information appears in one field. Moreover, there is no separate return link location protocol. Instead, RLS data is contained in one of the rotating fields.

C.3 Default Values in Position Data

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

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

b) the bits in the decimal parts of the degrees are set to the following patterns:
i. Latitude: 000001111100000 (Note the first five decimal parts of degrees bits are set to “0”s, the middle five bits are set to “1” s and the last 5 bits are set to “0”s)

ii. Longitude: 111110000011111 (Note the first five decimal parts of degrees bits are set to “1”s, the middle five bits are set to “0” s and the last 5 bits are set to “1”s)

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

This default bit pattern is different from first generation beacons. The degree bits are all set to “1”s as in first generation beacons. But it is not easy to set the minutes bit to “0”s and the seconds bits to “1”s as the decimal parts do not fall on integer minute or second boundaries.

C.4 Definition of Location Data Fields

The general structure of encoded location data is illustrated below.

C.4.1 Encoded Location field

The 47 bits available in the main digital message are defined as follows:

a) bits 44-66: latitude data (23 bits), including:

- bit 44: N/S flag (N=0, S=1)
- bits 45-51: degrees (0 to 90) in 1 degree increments
- bits 52-66: decimal parts of degrees

b) bits 67-90: longitude data (24 bits), including:

- bit 67: E/W flag (E=0, W=1)
- bits 68-75: degrees (0 to 180) in 1 degree increments
- bits 76-90 decimal parts of degrees

C.4.2 Encoded Location Data (1)

All position information is encoded as degrees, and decimal parts of latitude or longitude. Latitude and longitude data are rounded off (i.e., not truncated) to the available resolution. All rounding shall follow normal rounding conventions, for example with a resolution of 4, 0.000 to 1.999 shall be rounded down to 0 and 2.000 to 3.999 shall be rounded up to 4. In each location field the Most Significant Bit (MSB) is the lowest numbered bit in the message which is not a N/S, or E/W flag bit.

The following table illustrates the bit assignments for the degrees portion of the encoded location field.

Latitude Bit assignment	Longitude Bit assignment	Bit value in degrees
N/A	68 (MSB)	128
45 (MSB)	69	64
46	70	32
47	71	16
48	72	8
49	73	4
50	74	2
51	75	1

The following table illustrates the bit assignments for the decimal parts of the degrees portion of the encoded location field. The equivalent in minutes and seconds is also provided. The resolution in meters of each bit of longitude at the equator is also given, with the resolution of each latitude bit 0.169% less than for the longitude bit (at the equator). This reflects the fact that the circumference around the earth at the equator is 40,075.16 Km and 40,008 Km for each meridian.

Latitude bit assignment	Longitude Bit assignment	Bit value of decimal parts in degrees	Bit value of decimal parts in minutes	Bit value of decimal parts in seconds	Resolution in meters (equator)
52	76	0.5	30	1800	55566.67
53	77	0.25	15	900	27783.33
54	78	0.125	7.5	450	13891.67
55	79	0.0625	3.75	225	6945.833
56	80	0.03125	1.875	112.5	3472.917
57	81	0.015625	0.9375	56.25	1736.458
58	82	0.0078125	0.46875	28.125	868.2292
59	83	0.00390625	0.234375	14.0625	434.1146
60	84	0.001953125	0.1171875	7.03125	217.0573
61	85	0.000976563	0.05859375	3.515625	108.5286
62	86	0.000488281	0.029296875	1.7578125	54.26432
63	87	0.000244141	0.014648438	0.87890625	27.13216
64	88	0.00012207	0.007324219	0.439453125	13.56608
65	89	6.10352E-05	0.003662109	0.219726563	6.78304
66	90	3.05176E-05	0.001831055	0.109863281	3.39152

C.5 Instructions for converting Latitudes and Longitudes to a Binary Number

Global Navigation Satellite System receivers (e.g. GPS, Glonass, Galileo etc.) normally output position data using an IEC 61162-1 (NMEA 0183) formatted sentence. This will provide a position in decimal degrees, minutes and parts of a minute as a decimal fraction in a defined format for example “3546.295, N, 14821.291, W”. That is 35 degrees and 46.295 minutes North by 148 degrees and 21.291 minutes West. The size of the decimal fraction is not defined In IEC 61162-1, but in order to ensure adequate accuracy initially and during subsequent rounding processes the number of digits after the decimal point should not be less than 3.

In order to transmit this as a part of a Second Generation Beacon message it is necessary to convert the position into a binary number expressed as degrees and a decimal fraction of a degree. The following text provides an example of how this can be achieved.

Referring to C/S T.018 Table 3.1 Encoded GNSS Location we can see that the required message format is as follows:

No of Bits	Content
1	N/S flag (N=0, S=1)
7	Degrees (0 to 90) in 1 degree increments
15	Decimal parts of a degree (0.5 to 0.00003)
1	E/W flag (E=0. W=1)
8	Degrees (0 to 180) in 1 degree increments
15	Decimal parts of a degree (0.5 to 0.00003)

The use of the bits for the N/S or E/W flags and the encoding of Degrees is straightforward and no further explanation is deemed necessary. But converting minutes and a decimal fraction of a minute to decimal parts of a degree and then to binary is less obvious, so an example of this is provided below.

Using the example above “3546.295, N” in binary would appear as follows:

N/S	Degrees							Decimal Parts of a Degree														
0/1	64	32	16	8	4	2	1	1/2	1/4	1/8	1/16	1/32	1/64	..	..	..	..	..	..	..	..	..
0	0	1	0	0	0	1	1	1	1	0	0	0	1	0	1	1	0	0	0	0	1	1

Initially the minutes and decimal fraction of minutes must be converted into a decimal fraction of a degree, this is achieved by simply dividing the whole number by 60 e.g. 46.295 Minutes divided by 60 equals 0.77158333 Degrees. Again in order to maintain accuracy this number should be rounded to no less than [5] decimal places e.g. [0.77158]. So 35 Degrees and 46.295 Minutes becomes [35.77158] Degrees.

Two procedures for converting decimal parts of a degree to binary are provided below, the first uses the Successive Multiplication Method while the second uses the Integral Number Conversion Method.

<u>Successive Multiplication Method</u>

1) Start with the decimal fraction part and multiply it by 2 (add it to itself)
2) If the result is greater than 1 then the first decimal fraction is a 1, if the result is less than 1 then the first decimal fraction is a 0
3) If the result was greater than 1 then subtract 1 from the result
4) Multiply the remaining number by 2

5) Repeat step 2) to obtain the second decimal fraction and then repeat steps 3) and 4)
6) Repeat step 5) for all the remaining decimal fractions
7) On completing the final step to obtain the fifteenth digit again repeat step 3), if the remainder is 0.5 or greater then increase the computed binary number by one to round to the closest possible number, or if the remaining number is less than 0.5 then use the binary number as computed

The above example is provided below:

1) 0.77158 x 2 = 1.54316 thus the first digit is a 1
2) 1.54316 – 1 = 0.54316
3) 0.54316 x 2 = 1.08632 thus the second digit is a 1
4) 1.08632 – 1 = 0.08632
5) 0.08632 x 2 = 0.1728 thus the third digit is a 0
6) 0.17264 x 2 = 0.34528 thus the fourth digit is a 0
7) 0.34528 x 2 = 0.69056 thus the fifth digit is a 0
8) 0.69056 x 2 = 1.38112 thus the sixth digit is a 1
9) 1.38112 – 1 = 0.38112
10) 0.38112 x 2 = 0.76224 thus the seventh digit is a 0
11) Keep going as above
12) 0.78336 x 2 = 1.56672 thus the fourteenth digit is a 1
13) 1.56672 – 1 = 0.56672
14) 0.56672 x 2 = 1.13344 thus the last digit is a 1
15) 1.13344 – 1 = 0.13344
16) If the remaining number is 0.5 or greater then increase the computed binary number above by one to round to the closest possible number, or if the remaining number is less than 0.5 then use the binary number computed above
17) In this example, one computed 110001011000011, applying the rounding rule above means that in this instance the actual binary number to use is the same

<u>Integral Number Conversion Method</u>

1) Start with the decimal fraction part and multiply it by 2^{15} (2 to the power of 15)
2) Round the result to the nearest whole number
3) Convert this number to binary
4) The result is the binary fraction of the decimal fraction

The above example is provided below:

1) 0.77158 x 2^{15} = 25283.13344
2) Rounding gives us 25283
3) Converting 25283 to binary gives 110001011000011

- END OF APPENDIX C -

APPENDIX D - EXAMPLE OF LINEAR FEEDBACK SHIFT REGISTER (LFSR) IMPLEMENTATION

The spreading PRN sequences are generated by a method equivalent to a Linear Feedback Shift Register (LFSR) using the generator polynomial G(x) = X23 + X18 + 1. The generator polynomial initialization values for I and Q components for beacon normal mode operation and for beacon self-test mode operation are given in Table 2.2.

This appendix details the generation of the 64 first chips of the normal I-component using the LSFR implementation described in section 2.2.3 with the initialization value 000 0000 0000 0000 0000 0001 (see Table 2.2).

The last column gives the result of the PRN sequence generation (here 8000 0108 4212 84A1, as per Table 2.2).

Figure D-1: Example of LSFR with the generation of the 64 first chips of the normal I-component

22	21	20	19	**18**	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	**0**	Out
0	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	8
1	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	1	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	0	1	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	0	0	1	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
1	0	0	0	**0**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	1	0	0	**0**	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	0	1	0	**0**	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
0	0	0	1	**0**	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	0	0	0	**1**	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
1	0	0	0	**0**	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**0**	
0	1	0	0	**0**	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**0**	0
0	0	1	0	**0**	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**0**	
0	0	0	1	**0**	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**0**	
0	0	0	0	**1**	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**0**	
1	0	0	0	**0**	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	**0**	0
0	1	0	0	**0**	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	**0**	
0	0	1	0	**0**	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	**0**	
0	0	0	1	**0**	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	**0**	
0	0	0	0	**1**	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	**0**	1
1	0	0	0	**0**	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	**0**	
0	1	0	0	**0**	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	**0**	
0	0	1	0	**0**	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	**1**	
1	0	0	1	**0**	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	**0**	0
0	1	0	0	**1**	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	**0**	
1	0	1	0	**0**	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	**0**	
0	1	0	1	**0**	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	**0**	
0	0	1	0	**1**	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	**1**	8
0	0	0	1	**0**	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	**0**	
0	0	0	0	**1**	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	**0**	
1	0	0	0	**0**	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	**0**	
0	1	0	0	**0**	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	**0**	4
0	0	1	0	**0**	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	**1**	
1	0	0	1	**0**	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	**0**	

0	1	0	0	**1**	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	**0**	
1	0	1	0	**0**	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	**0**	2
0	1	0	1	**0**	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	**0**	
0	0	1	0	**1**	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	**1**	
0	0	0	1	**0**	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	**0**	
0	0	0	0	**1**	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	**0**	1
1	0	0	0	**0**	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	**0**	
0	1	0	0	**0**	0	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	**0**	
0	0	1	0	**0**	0	0	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	**1**	
1	0	0	1	**0**	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	1	0	**0**	2
0	1	0	0	**1**	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	1	**0**	
1	0	1	0	**0**	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	**1**	
1	1	0	1	**0**	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	**0**	
0	1	1	0	**1**	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	**1**	8
0	0	1	1	**0**	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	**0**	
0	0	0	1	**1**	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	**0**	
1	0	0	0	**1**	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	0	**0**	
1	1	0	0	**0**	1	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	1	**0**	4
0	1	1	0	**0**	0	1	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	**1**	
1	0	1	1	**0**	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	1	0	**0**	
0	1	0	1	**1**	0	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	1	**0**	
1	0	1	0	**1**	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	**1**	A
0	1	0	1	**0**	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	1	**0**	
0	0	1	0	**1**	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	**1**	
0	0	0	1	**0**	1	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	**0**	
0	0	0	0	**1**	0	1	0	1	1	0	0	0	1	1	0	1	0	0	1	0	0	**0**	1
1	0	0	0	**0**	1	0	1	0	1	1	0	0	0	1	1	0	1	0	0	1	0	**0**	
0	1	0	0	**0**	0	1	0	1	0	1	1	0	0	0	1	1	0	1	0	0	1	**0**	
0	0	1	0	**0**	0	0	1	0	1	0	1	1	0	0	0	1	1	0	1	0	0	**1**	

- END OF APPENDIX D -

APPENDIX E - BIT ASSIGNMENT NUMBERS

Bits 1 to 43 of 202 Information bits
1 to 43 of 154 bit Main Field

Bit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Field	TAC Number (16 bits) (Part of 23 HEX ID)																Serial Number (14 bits) (Part of 23 HEX ID)														Country Code (10 bits) (Part of 23 HEX ID)										Homing Status	RLS Function	Test Protocol
23 HEX ID bit numbers	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	2	3	4	5	6	7	8	9	10	11			45

Bits 44 to 90 of 202 Information bits
44 to 90 of 154 bit Main Field

Bit	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Field	Encoded Location (47 bits)																																														

Bits 91 to 137 of 202 Information bits
91 to 137 of 154 bit Main Field

Bit	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137
Field	Vessel ID (47 bits) (Part of 23 HEX ID)																																														
23 HEX ID bit numbers	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92

Bits 138 to 154 of 202 Information bits
138 to 154 of 154 bit Main Field

Bit	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154
Field	Beacon Type (3 bits)			Spare Bits (14 bits)													

Bits 155 to 202 of 202 Information bits
Rotating Field Information (48 bits)

Bits 203 to 250 of message bits (Error Correction Code)
48 bits

Bit	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250
Field	BCH (250,202)																																															

Bits 155 to 202 of 202 Information bits

Rotating Field #0 (C/S G.008 Requirements) (48 bits)

155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	
Rotating Field ID "0000" (4 bits)				Elapsed Time since Activation (6 bits)						Time from last encoded location (11 bits)											Altitude of encoded location (10 bits)										Dilution of Precision (8 bits)								Activation (2 bits)		Remaining Battery (3 bits)			GNSS Status (2 bits)		Spare (2 bits)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Rotating Field bit number

Bits 155 to 202 of 202 Information bits

Rotating Field #1 (ELT(DT)) (48 bits)

155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	
Rotating Field ID "0001" (4 bits)				Time of last encoded location (11 bits)																	Altitude of encoded location (10 bits)										Triggering Event (4 bits)				GNSS Status (2 bits)		Remaining Battery (2 bits)		Spare (9 bits)									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Rotating Field bit number

Bits 155 to 202 of 202 Information bits

Rotating Field #2 (RLS) (48 bits)

155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	
Rotating Field ID "0010" (4 bits)				Unassigned (2 bits)		Beacon RLS Capability (6 bits)						RLS Provider ID (3 bits)			Beacon Feedback (acknowledgement of RLM reception) (22 bits)																						Unassigned (11 bits)											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Rotating Field bit number

Bits 155 to 202 of 202 Information bits

Rotating Field #3 (National Use) (48 bits)

155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	
Rotating Field ID "0011" (4 bits)				National Use (44 bits)																																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Rotating Field bit number

Bits 155 to 202 of 202 Information bits

Rotating Field #15 (Cancellation Message) (48 bits)

155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	
Rotating Field ID "1111" (4 bits)				Fixed (all 1's) (42 bits)																																										Method of Deactivation		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Rotating Field bit number

NOTE: When displaying a message as 63 hex characters, one bit is inserted at the beginning of the message to indicate the PRN sequence (0 = Normal, 1 = self-test), followed by one zero, to form the 63 hexadecimal representation (2 bits + 250 bit message) for processing by the Cospas-Sarsat ground segment.

- END OF APPENDIX E -

APPENDIX F - MOFFSETT CALCULATIONS AND CRC CODE SAMPLE

```
1 0 0 1 1 1 0 0 1 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 0 0 0 0 0 1 0 0 0 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0   <- 15 Hex ID: 9934039823D8000
1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1   <- CRC-polynomial: x16+x15+x2+1
0 1 0 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0
 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
 0 1 1 1 0 0 1 0 0 1 1 0 1 1 1 1 1 0
  1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
  0 0 1 0 0 1 0 0 1 1 0 1 1 1 0 1 1 0 0
    1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
    0 1 0 1 0 0 1 1 0 1 1 1 0 1 0 0 1 0
     1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
     0 1 1 0 0 1 1 0 1 1 1 0 1 0 1 1 1 1
      1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
      0 0 0 0 1 1 0 1 1 1 0 1 0 1 0 1 0 1 1 0 0
          1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
          0 0 0 1 1 1 0 1 0 1 0 1 0 1 0 0 1 1 1 0
             1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
             0 0 1 0 1 0 1 0 1 0 1 0 0 1 0 1 1 0 0
               1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
               0 1 1 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0
                1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                0 0 0 1 0 1 0 1 0 0 1 0 1 0 1 1 1 0 1 0
                   1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                   0 1 1 0 1 0 0 1 0 1 0 1 1 1 1 1 1 0
                    1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                    0 0 0 1 0 0 1 0 1 0 1 1 1 1 0 1 1 0 1 1
                       1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                       0 1 0 1 0 1 0 1 1 1 1 0 1 1 1 1 0 1
                        1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                        0 1 1 0 1 0 1 1 1 1 0 1 1 1 0 0 0 1
                         1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                         0 0 0 1 0 1 1 1 1 0 1 1 1 0 1 0 0 0 1 1
                            1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                            0 1 1 1 1 1 0 1 1 1 0 1 0 0 1 1 0 0
                             1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                             0 0 1 1 1 0 1 1 1 0 1 0 0 1 0 0 1 0 0
                               1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                               0 0 1 0 1 1 1 0 1 0 0 1 0 0 0 0 1 0 0
                                 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                 0 1 1 1 1 0 1 0 0 1 0 0 0 0 0 0 1 0
                                  1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                  0 0 1 1 0 1 0 0 1 0 0 0 0 0 1 1 1 0 0
                                    1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                    0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0
                                       1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                       0 1 0 1 0 0 0 0 0 1 1 0 0 1 1 0 1 0
                                        1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                        0 1 1 0 0 0 0 0 1 1 0 0 1 1 1 1 1 0
                                         1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                         0 0 0 0 0 0 0 1 1 0 0 1 1 1 0 1 1 0 0 0 0 0 0 0
                                                1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                0 0 0 0 1 1 1 0 1 1 0 0 0 0 1 0 1 0 0 0 0
                                                    1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                    0 0 1 0 1 1 0 0 0 0 1 0 1 0 1 0 1 0 0
                                                      1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                      0 1 1 1 0 0 0 0 1 0 1 0 1 0 0 0 1 0
                                                       1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                       0 0 1 0 0 0 0 1 0 1 0 1 0 0 1 1 1 0 0
                                                         1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                         0 1 0 0 0 1 0 1 0 1 0 0 1 1 0 0 1 0
                                                          1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                          0 1 0 0 1 0 1 0 1 0 0 1 1 0 1 1 1 0
                                                           1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
                                                           0 [1 0 1 0 1 0 1 0 0 1 1 0 1 0 1 1]
```

CRC-16(9934039823D8000) = 0xAA6B
and Moffset=BIN2DEC(CRC-16(9934039823D8000)) mod 60 = 7

Figure F-1: Example of calculation of M_{offset}

- END OF APPENDIX F -

APPENDIX G - EXAMPLES OF RLS GNSS RECEIVER TIMING

The operation of the RLS GNSS Receiver is defined in section 4.5.9.2 of this document. A set of examples of RLS operation are provided in Table G.1, which cover a range of conditions to clarify the interpretation of the M_{offset} timing, and are summarized below:

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

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

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

Table G.1: Example Scenarios for RLS GNSS Timing

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

Note that interleaved with the GNSS Receiver timings, the GNSS receiver also turns on in accordance with section 4.5.5.2, as well in Examples 1, 3 and 4, but these GNSS 'on' periods are omitted for clarity in the tables.

[*] Timing reverts to schedule per document C/S T.018, section 4.5.5.2.
[†] UTC acquired, back to RLS schedule
[‡] Last ‘on’ period, 1-minute duration, as 6 hours have elapsed from beacon turn-on.
[§] With no UTC reference, receiver reverts to document C/S T.018 section 4.5.5.2 timing, until UTC is obtained.

Table G.1 (Continued): Example Scenarios for RLS GNSS Timing

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

– END OF APPENDIX G –

– END OF DOCUMENT –

* GNSS only 'on' for 4 min until RLM received, M_{offset} never needed.
† GNSS only 'on' for 9 min, until RLM received.
‡ 6 hours up at 6:58, so no seventh attempt is initiated for this case.

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