OPERATIONAL REQUIREMENTS FOR COSPAS-SARSAT SECOND-GENERATION 406-MHz BEACONS

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OPERATIONAL REQUIREMENTS FOR COSPAS-SARSAT SECOND GENERATION 406 MHz BEACONS

History

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1. INTRODUCTION

1.1 Purpose of the Document

The purpose of this document is to capture the high-level operational requirements for second generation 406 MHz beacons designed to operate with the Cospas-Sarsat System. These requirements will be used by Cospas-Sarsat to develop and manage detailed specifications and type approval procedures for a second generation of 406 MHz distress beacons designed to operate with the planned Cospas-Sarsat systems. The operational requirements describe what functionality, performance or information the distress beacon is expected to provide; however, they do not describe how the beacon must provide it.

In addition to the high-level operational requirements, the rationale for each requirement and the dependencies associated with meeting that requirement are provided in this document. Furthermore, where appropriate, a minimum level of performance is provided along with a desired performance level. These requirements are not intended for use by manufacturers as specifications to design, develop or manufacture distress beacons. Cospas-Sarsat specifications and type approval procedures for the second generation of 406 MHz beacons will be provided in separate documents (new System documents C/S T.101 and C/S T.107). National Administrations may have additional requirements and approval standards applicable to specific types of beacons.

1.2 Background

The International Cospas-Sarsat System has been successfully operating since 1982 and has achieved world-wide recognition as a provider of satellite distress alerts to search and rescue (SAR) authorities. The carriage of Cospas-Sarsat distress beacons on board aircraft[1] and ships[2] is mandated by Administrations in accordance with the recommendations of the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO). Their use on board fishing vessels, pleasure craft and general aviation aircraft is also a requirement in numerous countries. Furthermore, non-mandated usage of distress beacons is becoming increasingly popular among individuals at risk in difficult or dangerous environments[3].

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1 Emergency Locator Transmitters (ELTs) are carried onboard aircraft.
2 Emergency Position Indicating Radio Beacons (EPIRBs) are carried onboard ships.
3 Distress beacons used by individuals in various environments are called Personal Locator Beacons (PLBs).

The LEOSAR and GEOSAR systems comprise the current operational Space Segment. Cospas-Sarsat is now developing a new satellite alerting capability, the MEOSAR system, which is planned to begin operating in the 2012 - 2015 timeframe. The MEOSAR system will be backward compatible and will accommodate the operation of first-generation Cospas-Sarsat beacons as specified in document C/S T.001. The MEOSAR system is also expected to provide enhanced performance for all 406 MHz beacons, to include global, near-instantaneous alerting and locating capabilities and greater resilience to beacon-to-satellite obstructions, and allow for a return link to the beacon. Detailed information on MEOSAR system development is available in the document C/S R.012 "Cospas-Sarsat 406 MHz MEOSAR Implementation Plan".

1.3 Scope

This requirements document describes the high-level interface between Cospas-Sarsat 406 MHz distress beacons (hereafter referred to as "beacon") and the planned Cospas-Sarsat Space and Ground Segments. It applies to all beacon types including Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs), Personal Locator Beacons (PLBs), but excluding Ship Security Alerting System (SSAS) transmitters. These requirements do not preclude the development and integration of additional auxiliary functions and features.

As part of Strategic Goal 1 (Continuous and effective System operations) defined in document C/S P.016, the Cospas-Sarsat Strategic Plan, Objective 7 calls for the implementation of the MEOSAR space and ground segments. Objective 7 includes the following actions:

- Action 2: "consider possible new or revised specifications and type approval standards for beacons operating with the MEOSAR system that would enhance performance, provide new capabilities and/or allow lower beacon costs"; and

- Action 5: "plan for the implementation of a return link capability".

Strategic Goal 5 in document C/S P.016 (a robust industrial base to support system operations) includes Objective 3 to "consider opportunities to lower beacon costs and improve beacon capabilities and performance" and specifically an action aiming to "provide timely review of new technology developments and investigate proposals that could lower the cost or increase the functionality of 406 MHz beacons".

Document C/S G.008 provides the background for undertaking the actions of Strategic Goal 1, Objective 7 and Strategic Goal 5, Objective 3 quoted above. In particular, it defines and analyses users' and customers' requirements that should guide the development of new or revised specifications. The GEOSAR, LEOSAR and MEOSAR system characteristics are also considered in the trade-off of performance versus costs, in a deliberate effort to maximise cost effectiveness and System performance, taking advantage of new technologies while ensuring the affordability of beacons for various categories of users.

1.4 Methodology of Operational Requirements Development

These operational requirements were developed based on performance requirements established by the Fourteenth Session of the International Civil Aviation Organization (ICAO) / International Maritime Organization (IMO) Joint Working Group on Search and Rescue and reported at the IMO COMSAR 12 Meeting as document COMSAR 12/6. The performance requirements established by the ICAO/IMO JWG on SAR are also listed at Annex C to document C/S P.016, Cospas-Sarsat Strategic Plan, and used as performance criteria to illustrate existing and future capabilities of the Cospas-Sarsat System.

In addition, input from Rescue Coordination Centres, System users, beacon manufacturers, and standards organisations was used to generate these operational requirements.

These operational requirements will be presented to ICAO and IMO for their review. Cospas-Sarsat will ensure that each of these requirements is used to develop detailed specifications which can be traced back to this document.

The description of these requirements, their application to second generation beacons operating with the Cospas-Sarsat satellite system and their translation into specifications and type approval standards are managed by the Cospas-Sarsat Council.

- END OF SECTION 1 -

2. ASSUMPTIONS AND CONSTRAINTS

2.1 Assumptions

First generation 406 MHz beacons were designed to operate with the Cospas-Sarsat LEOSAR system which includes on board Search and Rescue Processor (SARP) and Search and Rescue Repeater (SARR) instruments. SARP instruments allow on-board processing, storage and rebroadcast of beacon message contents and frequency measurement results, and provide global coverage with independent location capability.

First generation 406 MHz beacons are also compatible with the Cospas-Sarsat GEOSAR system. The MEOSAR system is being designed to ensure full backward compatibility with these beacons and accommodate their operation. However, beacons designed to meet document C/S T.001 specifications and document C/S T.007 type approval standards may not achieve some of the minimum or objective requirements for second generation beacons provided in this document.

The LEOSAR SARP on board processing constraints limit the possible evolution of first generation beacon specifications. Second generation beacons designed to revised specifications aiming to meet the requirements of this document may not be interoperable with the LEOSAR SARP processing. If second generation beacons are not interoperable with LEOSAR SARP instruments, the LEOSAR system will not provide the alerting and locating functions for these beacons on a global basis.

Second generation beacon operational requirements have been developed assuming operation with the Cospas-Sarsat GEOSAR and MEOSAR systems comprising only on orbit SARR instruments, with all signal and data processing performed by ground receiving stations called Local User Terminals or LUTs. It is assumed that a complete network of MEOLUTs will be available to provide the alerting and locating functions on a global basis for both first and second generation 406 MHz beacons, albeit with different performance levels.

New processing software will be required and eventually implemented in existing GEOLUTs to provide the alerting service for second generation beacons. Existing LEOLUTs may be upgraded to process second generation beacon signals relayed via LEOSAR satellite repeaters (SARR).

Some Participants have developed MEOLUTs in support of the MEOSAR system development. These MEOLUTs could require upgrades if warranted by the second generation beacon design.

Finally, software upgrades will also be implemented in Cospas-Sarsat Mission Control Centres (MCCs) to forward and distribute distress alerts originating from second generation beacons to Rescue Coordination Centres (RCCs) and SAR Points of Contact (SPOCs).

2.2 Constraints

The current GEOSAR space segment is in operation and the planned MEOSAR space segment has already been designed. Requirements for second generation beacons will be constrained by the characteristics of these constellations and the design of their Search and Rescue instruments.

The GEOSAR and MEOSAR constellations will consist of various satellite systems which could introduce variations of performance levels due to system design differences. Minimum interface requirements[4] have been established to minimise such variations and ensure full interoperability with commissioned space and ground segment equipment in the Cospas-Sarsat System.

The minimum interface requirements and performance characteristics of satellite repeaters and ground segment processing equipment in the GEOSAR and MEOSAR systems are the basic constraints to be taken into consideration in the cost and benefit trade-offs for the development of second generation beacon requirements.

Another aspect of the above constraints is to ensure that beacon technology is available at reasonable cost, allowing second generation beacons to meet requirements when operating with the MEOSAR and GEOSAR systems. Requirements addressing the timeliness and accuracy of alert data, or desirable new features associated with the distress alerting function must be assessed in terms of affordability for various categories of users as well as in terms of technical feasibility. For example, the size of the beacon will be the result of a trade-off between users' needs, manufacturer's cost and battery size, thus affecting the length of time the beacon can operate.

2.3 System Background and Definitions

2.3.1 MEOSAR System

The MEOSAR system is designed to provide:

a. baseline performance for existing first generation beacons, as described in document C/S R.012 "Cospas-Sarsat 406 MHz MEOSAR Implementation Plan", and

b. enhanced performance with use of second generation beacons.

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[4] See the "Minimum Performance Requirements for MEOSAR Compatibility with the 406 MHz Cospas-Sarsat System" and the "MEOSAR Space Segment Interoperability Parameters" provided at Annexes E and F of document C/S R.012 (MIP), respectively.

2.3.2 Minimum and Objective Operational Requirements

Minimum Operational Requirements are applicable to all second generation beacons. They provide for effective and efficient detection and location of a beacon which facilitate the rescue of the persons in distress. Although current technology may not allow meeting some minimum operational requirements in a cost effective fashion, these requirements are targets which will drive future innovation and specifications.

Objective Operational Requirements may not apply to all beacons operating within the Cospas-Sarsat System. Objective operational requirements provide beacon enhancements and allow for desired additional features that may be required for specific categories of beacons to meet particular needs and enhance performance in specific applications.

- END OF SECTION 2 -

3. MINIMUM OPERATIONAL REQUIREMENTS

The following requirements are the minimum operational requirements applicable to all types of second generation beacons operating in the Cospas-Sarsat System. These minimum operational requirements are consistent with appropriate international regulations. However, additional requirements may be applicable to certain types of beacons in accordance with international regulations. Competent Administrations are responsible for the enforcement of requirements applicable to beacons under their jurisdiction.

3.1 Compatibility with the Cospas-Sarsat System

3.1.1 Requirement

Beacons transmitting in the 406.0 - 406.1 MHz frequency band and operating in the Cospas-Sarsat System shall not cause harmful interference or degrade the nominal system performance.

3.1.2 Rationale

The Cospas-Sarsat System already accommodates over one million users. At a minimum, second-generation beacons must be compatible with the operational Cospas-Sarsat System, as its use is mandated internationally by ICAO and IMO.

3.1.3 Dependencies

Second generation beacon signals received in the LEOSAR SARP channel and the LEOSAR and GEOSAR SARR channels shall not cause harmful interference that impact these channels' performance with existing first generation 406 MHz beacons.

Second generation beacon signals received in the LEOSAR and GEOSAR SARR channels shall meet applicable performance requirements outlined in documents C/S T.002, C/S T.005, C/S T.009 and C/S T.010 when processed by suitably upgraded LEOLUTs and GEOLUTs. Operational LEO and GEOLUTs will require software changes to accommodate second generation beacons. The more extensive the changes required, the higher the cost will be to Ground Segment Providers.

At a minimum, LEOLUT and GEOLUT SARR channel processing will have to be upgraded to recover valid beacon messages. Depending on the desired degree of backward compatibility/interoperability of second generation beacons with the

LEOSAR system, LEOLUT SARR channel processing might also be upgraded to perform Doppler location computations.

While interoperability with the LEOSAR SARP channel may be achieved, second generation beacons are not required to be interoperable with the LEOSAR SARP channel. Second generation beacons that are not interoperable with the LEOSAR SARP channel will not satisfy the requirement for independent location capability and will not be accepted for use in the Cospas-Sarsat System until an operational MEOSAR system becomes available.

However, these interoperability capabilities with the LEO and GEO systems should not necessarily be the primary consideration in the definition of second generation beacon characteristics. Appropriate changes to documents C/S T.002 and C/S T.009 might be required to reflect these limited interoperability capabilities.

Second generation beacons shall meet all applicable performance requirements when processed in the MEOSAR system.

3.2 Independent Location Capability

3.2.1 Requirement

The beacon signal shall allow the computation of a location independently of the content of the message.

3.2.2 Rationale

Even though many beacons can provide a GNSS location, the primary method of location shall be an independent computation by the Cospas-Sarsat System. Having an independent location provides secure and reliable location information that can be forwarded to the responsible search and rescue authorities.

3.2.3 Dependencies

This requirement will drive beacon signal characteristics and ground segment processing specifications.

An adequate number of satellites must be available in proper orbital positions to ensure permanent visibility of a minimum of 3 satellites from any location on Earth and MEOLUTs must be available with an appropriate geographic distribution to avoid coverage gaps in the 2D location capability and provide redundancy.

3.3 Independent Location Accuracy

3.3.1 Requirements

The beacon shall have first burst transmission characteristics to allow for independent location computation.

The operational performance requirement is for first burst 2D independent location accuracy within 5 km, 90% of the time.

The beacon shall have transmission characteristics to allow for improved accuracy of independent location computation over time.

The operational performance requirement is for 2D independent location accuracy of:

- 5 km, 95% of the time, within 30 seconds after beacon activation,
- 1 km, 95% of the time, within 5 minutes after beacon activation, and
- 100 m, 95% of the time, within 30 minutes after beacon activation.

After the first 30 minutes of beacon activation the 2D independent location accuracy computation shall provide a location within 100m, 95% of the time within 30 minutes of receiving any burst.

3.3.2 Rationale

Timely, accurate and reliable location information is crucial to SAR authorities. Survival rates at sea or on land are dependent on the time required to reach the scene of the accident. In the first 5 minutes after a beacon is activated, a distress location with a coarse accuracy is sufficient to allow rescue forces to send assets to the general area of the alert. As the SAR operation progresses, more accurate location data is required to better assist the response effort.

3.3.3 Dependencies

This requirement will drive beacon signal characteristics and ground segment processing specifications.

Parts of this requirement may be difficult to achieve. The cost benefit trade-off between the performance requirement and beacon and MEOLUT costs needs to be investigated. There is a cost trade-off in terms of waveform characteristics and specified location accuracy requirements. This could also lead to strict constraints on LUT processing algorithms, making them less flexible.

If the requirement also pertains to moving objects in distress, the maximum velocity of the object, the need for three dimensional location data and associated location accuracy requirements must be investigated further.

Space Segment:	-	number of satellites
	-	satellite performance
Ground Segment:	-	LUT performance
	-	TOA and FOA measurement accuracy

3.4 First Burst Transmission Timeliness

3.4.1 Requirement

The beacon shall transmit a valid message within [3] seconds after activation. The transmission shall meet appropriate signal characteristics.

3.4.2 Rationale

This requirement supports the need for detection and location immediately after activation. The objective is to reduce the overall system latency from activation to delivery to the search and rescue forces. In particular, it provides a better chance that a valid alert message will actually be transmitted in a catastrophic event with minimal time for transmission, e.g. an aviation crash incident.

3.4.3 Dependencies

a. The cost benefit trade-off between performance and beacon/MEOLUT costs must be investigated.

b. The beacon cost could increase substantially if some environmental conditions, i.e. extreme temperatures, thermal shock, are to be met on first burst transmission.

c. This requirement may be technically very difficult to achieve even if beacon size and cost increases were acceptable.

d. Mitigation of the potentially large increase in the false alarm rate is dependent on the "Cancellation Function" detailed in requirement 3.11. However, this will cause additional operational traffic, even if the alert is effectively cancelled.

e. Consideration should be given to the timing of float-free EPIRB automatic activation under water, noting that the EPIRB may not have reached the surface 3 seconds after activation.

3.5 Increased Performance in First Thirty Seconds of Distress Alert Transmission

3.5.1 Requirement

The beacon shall have transmission characteristics to allow for enhanced performance within the first thirty seconds of activation.

The operational performance requirement is for a 99.9% probability of detection of at least one valid beacon message within 30 seconds after activation and independent location accuracy as defined in section 3.3.

3.5.2 Rationale

Analysis of previous incidents has shown that some beacons fail within the first 30 seconds of a distress situation. It is also important to detect and locate a beacon as soon as possible in all distress cases. By improving the characteristics of the beacon performance in the first 30 seconds it is possible to increase the probability of receiving an alert. It may not be practical to sustain this level of performance beyond a certain timeframe so that other requirements may be met, such as the operating life time.

3.5.3 Dependencies

Enhanced detection and independent location performance may be achieved by higher repetition rate of the message or increased power of the transmitted signal. However, trade-offs in terms of global system performance will be required as illustrated below.

a. Risks associated with increased repetition rates are burst collisions, increased false alarm rates. Longer protocols may also increase the possibility of message collisions in time.

b. Increased power may not be a practical proposition, since it has an impact on beacon cost and size.

3.6 Beacon Unique Identification

3.6.1 Requirement

Each beacon must be uniquely identified.

3.6.2 Rationale

This requirement is essential to preclude possible confusion of alert data processing, confusion of measurements for independent location calculations and for the purpose of MCC, RCC, and SPOC operations and registration database lookup.

By ensuring that beacons have unique identifications, situations where a rescue response is delayed or cancelled due to the investigation of conflicting beacon registration information will be avoided. Most beacon registration databases prevent a second registration for the same identifier, which may result in at least one beacon not being registered. Duplicate registrations or absence of registration could put lives at risk and expend SAR resources needlessly.

3.6.3 Dependencies

A level of compliance already exists. However, SAR authorities and national Administrations should specify what types of unique identification will be required in the future, i.e. serial, MMSI, etc.

3.7 Beacon Message Content

3.7.1 Requirement

The beacon shall transmit a message providing at least the following information. This information is considered essential and shall be transmitted within every message burst.

a. Identification (ID): To be used for MCC, RCC, and SPOC operations and for Registration Database lookup. The identification shall include:

   - a country code,
   - additional information that uniquely identifies the beacon when combined with the country code, and
   - Type Approval Certificate (TAC) number.

b. Beacon type: Identifier of the beacon type (ELT, EPIRB, PLB, SSAS, Test, Orbitography, Multi-Environment, plus nine spares). *

c. Type of homing/locating device: Identifier for the technology supported by the beacon for on-site location (121.5 MHz homer, 9 GHz SART, AIS, 406 MHz homer, plus four spares). *

d. Homing device activation: Confirmation of homing device status.

e. Self-Test: Used to reduce false alerts and allow service functionality tests.

f. User cancellation: Positive confirmation of non-distress or false alert.

g. Encoded location: Location data derived as defined in section 4.1, with the accuracy required per section 4.2.

h. Vessel (MMSI)/Aircraft ID: Identification of the vessel or aircraft on which the beacon is carried, to be used for the MCC, RCC and SPOC operations and for Registration Database lookup.

i. Spare bits: Allows for future requirements.

* Provided in alert message from MCC with information derived from TAC database.

3.7.2 Rationale

Alert messages must contain sufficient information to aid SAR authorities' response to a distress situation. The minimum requirements are listed above and provide mandatory data fields. However, there may be other data fields in the message to further assist rescue forces. Such additional fields could provide secondary information about the beacon and parent craft when registration data is not available. The rationale for each of the fields specified above is summarised below:

a. ID: Required to ensure correct processing of data. Allows RCCs and SPOCs to obtain information on parent craft and user that helps SAR response planning or false alert resolution.

b. Beacon type: Support SAR response planning by RCCs and SPOCs.

c. Type of homing device: Support SAR response planning by RCCs and SPOCs and on scene response by SAR forces.

d. Homing device activation: Provides confirmation to SAR response that the homing device activated and allows for planning and on scene response.

e. Self-Test: Used to reduce false alerts and allow service functionality tests.

f. User Cancellation: Positive confirmation of non-distress or false alert allowing SAR response to terminate mission in a timely manner.

g. Encoded Location: Provides confirmation of independent location data and a geographic location through the GEO system (if data is available from an external of integrated GNSS receiver).

h. Vessel (MMSI)/Aircraft ID (transmitted with equal priority and availability as the beacon ID): Provides essential identification for beacons, so that RCCs and SPOCs can obtain information that helps SAR response planning or false alert resolution, which may reduce time for a SAR response.

i. Spare Bits: Allows for future expansion and growth.

3.7.3 Dependencies

a. Existing beacon protocols and equipment constrain future flexibility. Duplicate IDs must be avoided to ensure successful alert processing.

b. A common format must be internationally agreed.

3.8 Operating Life Time

3.8.1 Requirement

The beacon shall operate at specified temperature extremes and meet all required signal characteristics for a minimum of 24 hours.

3.8.2 Rationale

The beacon must be able to operate for a length of time to support the response of search and rescue forces and recovery of survivors to places of safety.

The value of 24 hours has historically been used by Cospas-Sarsat as the minimum requirement. National Administrations and intergovernmental organisations may have more stringent requirements for beacon operating life time.

3.8.3 Dependencies

A trade-off between performance requirements and beacon characteristics (battery capacity, beacon size and cost) is required. While longer operating life time may be required at sea, the lowest operating temperature (-40ºC) is rarely met by EPIRBs. Furthermore, the continuous, worldwide capability of the MEOSAR system to provide near real-time alerting and locating functions limits the need for a longer operating life time. A trade off may be possible between the repetition rate of transmissions and the operating life time.

3.9 Temperature Range of Operation

3.9.1 Requirement

The temperature range is defined by the maximum and minimum temperatures at which the beacon shall be able to operate and meet all required signal characteristics.

Two classes of beacon have been defined, which correspond to the following ranges of operating temperatures:

Class 1: -40°C to + 55°C.

Class 2: -20°C to + 55°C.

The beacon shall be able to withstand a thermal-shock range of 50°C.

3.9.2 Rationale

Cospas-Sarsat is a global system and its beacons can be operated in varying environmental extremes. A range of operating temperatures is required to properly design and power a Cospas-Sarsat beacon and ensure minimum performance requirements are met.

3.9.3 Dependencies

a. Thermal shock has an impact on performance, especially during initial burst transmissions.

b. The requirement to operate at minimum temperature and meet all signal characteristics for the minimum operating life time has a major impact on beacon design and battery capacity requirements, hence the beacon cost, size and weight.

3.10 Self-Test Function

3.10.1 Requirement

The beacon shall include a self-test function which shall provide to the user a confirmation that the core functionalities of the beacon are working properly and that a self-test message has been emitted in accordance with Cospas-Sarsat requirements.

The self test message transmission shall meet all applicable Cospas-Sarsat requirements and shall not impact the performance of the operational system. In particular, the self-test transmission shall not be confused with an operational distress transmission when processed by any Cospas-Sarsat satellite channel (i.e. LEO, GEO and MEO).

The number of self test transmissions should be limited to avoid possible abuses, such as tracking applications.

3.10.2 Rationale

The self-test function will allow the user and/or service inspectors to test the functionality of the beacon without impacting the system operation and SAR services, thus reducing the number of false alerts. For some users it is mandatory to test the beacon regularly.

3.10.3 Dependencies

A more specific definition is required in terms of functionality and impact on performance.

Several self-test transmission types may be required to test the various beacon functionalities (e.g. with or without encoded location data).

In accordance with Requirement 3.13 (Verification of Beacon Registration), the self-test function will be used to display the registration status of the beacon.

3.11 Cancellation Function of False Alert by User

3.11.1 Requirement

In case of an inadvertent activation, the beacon shall be capable of transmitting a message indicating that previous transmissions were a false alert. The protocol and transmission sequence of false alert cancellation messages shall be standardised. This should be a separate function from the on/off capability.

The beacon shall have characteristics to ensure that a cancellation message is valid 100% of the time. A cancellation message shall be received 90% of the time within 5 minutes of the cancellation function being activated.

3.11.2 Rationale

The cancellation function will help reduce the use of SAR assets for non distress situations. SAR services need a positive indication from the user transmitting an alert that a SAR response is not required.

3.11.3 Dependencies

National administrations' acceptance of beacons having a cancellation function will have operational and legal implications. More details on the performance parameters of this function are needed (i.e. probability of receipt within [x] minutes).

Note that this requirement should not be applicable to SSAS beacons.

3.12 Indicator of Beacon Activation

3.12.1 Requirement

Visual indicators shall be provided to alert beacon users that their beacon is activated.

For beacons which can be remotely activated, the indicators should be attached to both the remote activation device and the beacon.

3.12.2 Rationale

The user should be notified that the beacon is in operation. This indication will facilitate recognition of an inadvertent activation and allow notification of SAR responders.

3.12.3 Dependencies

Battery and beacon size and cost trade-offs.

3.13 Verification of Beacon Registration

3.13.1 Requirement

The beacon shall be designed 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.

The beacon shall be designed such that the self-test function indicates by default that the beacon is not registered. When registration in the appropriate national register or the International Beacon Registration Database is accomplished, the self-test function shall indicate that the beacon is registered. The "registered" status shall remain valid for a period of two years. Upon re-coding of the beacon, the self-test function shall indicate the default, non-registered status until proper re-registration is accomplished.

When activated in operational distress mode, the beacon shall send the required distress message regardless of its registration status.

When activated in self test mode, the beacon shall send the required self-test message regardless of its registration status.

3.13.2 Rationale

Registration data is important for supporting lifesaving efforts. MCCs/RCCs/SPOCs use the data to reduce the time required to verify that a distress situation is valid and to gather additional information to determine the response required. Proper registration reduces the time to identify and resolve false alerts.

3.13.3 Dependencies

National administration acceptance of this feature will have legal implications. This requirement may also have procedural and management implications on the Cospas-Sarsat System, including costs to Cospas-Sarsat providers, users and/or Administrations.

Implementation and enforcement of this requirement is to be regulated by a National Administration. However, the case when a national Administration declines enforcing this requirement also needs to be addressed.

3.14 Homing and on-Scene Locating

3.14.1 Requirement

Beacon design shall provide for homing and on scene locating.

3.14.1.1 Homing Performance

Any beacon homing signal shall be suitable for detection and homing by a typical direction finding unit to an altitude of 10,000 feet (3048 metres) above ground at a range of at least 30.0 nautical miles (55.6 kilometres) or the radio line-of-sight horizon (whichever is less). The beacon homing signal shall allow SAR Units travelling at speeds between 0 kts (0 kilometres/hour) and 270 kts (500 kilometres/hour), inclusive, to support a line of bearing accuracy of ± 5 degrees by a typical direction-finding unit.

Note: Homing signal characteristics suitable for detection by a typical direction-finding unit will be addressed in the Specification for Second Generation Cospas-Sarsat 406-MHz Distress Beacons (C/S T.X01).

3.14.1.2 On-scene Locating Performance

Beacon design shall allow suitably equipped SAR units, airports and certain other fixed and mobile facilities to receive and decode beacon identities and GNSS data, if available, encoded in the beacon or homing transmissions sent via 406 MHz to aid SAR units in locating the beacon.

3.14.2 Rationale

Geographic and environmental conditions may require the use of local locating, homing or direction finding to complete the rescue. Locating, homing and direction finding functions allow for non Cospas-Sarsat systems and organisations to provide notification and support for SAR response.

3.14.3 Dependencies

The 406 MHz burst shall take precedence over any homing and/or location signal. Compliance with the Cospas-Sarsat requirements in this section shall not prevent compliance with international and/or national requirements for on-scene locating, homing, or signal transmission(s) for direction finding.

The goal is to implement these requirements with minimum impact to currently fielded aircraft and ground 406 MHz direction finding/homing/local location equipment.

- END OF SECTION 3 -

4. OBJECTIVE OPERATIONAL REQUIREMENTS

The following operational requirements are desirable objectives for second generation beacons which may not be applicable to certain types of beacons operating in the Cospas-Sarsat System. Competent Administrations are responsible for requirements applicable to beacons under their jurisdiction, in accordance with appropriate international regulations. However in order to ensure compatibility and interoperability with the Cospas-Sarsat System, any desired requirements deemed necessary by Administrations shall be in accordance with the Cospas-Sarsat requirements and specifications.

4.1 Encoded Location Data

4.1.1 Requirements

Second generation beacons should be capable of acquiring Global Navigation Satellite System (GNSS) position data after activation, using an external or internal GNSS device, and storing and retransmitting the information encoded in the beacon message in accordance with Cospas-Sarsat Requirements 4.2 and 4.3 (see below).

After acquisition of initial position data, the beacon may continuously or periodically acquire position updates. In the case when position updates are available, the updated position shall be retransmitted in the beacon message at specified time intervals, in accordance with Cospas-Sarsat Requirements 4.2 and 4.3 (see below).

The location data encoded in the beacon message shall be accompanied by information defining the date and time of position acquisition, as specified by Cospas-Sarsat.

4.1.2 Rationale

In the case of GEOSAR alerts, encoded position data is the only method for determining and providing the distress location to SAR authorities. Encoded GNSS position data in the beacon message can be very accurate and, when available, is a valuable substitute or complement to the independent position data provided by the MEOSAR system. Furthermore, when both the independent MEOSAR and encoded GNSS positions are available and match, the “merged” position exhibits a very high degree of reliability which can be relied upon by SAR services to plan and conduct the SAR operation.

In case of conflicting independent positions, an encoded location is useful to confirm the real position and eliminate errors, thus speeding up the rescue operation. As EPIRB actual locations may drift, and portable ELTs’ or PLBs’ positions may change with time, a date and time must be associated with the encoded data transmitted by the beacon.

4.1.3 Dependencies

This special capability must be included at the beacon design stage and impacts the beacon cost.

Ground segment equipment must be capable of processing the beacon message format with encoded location data. Special filtering and routing procedures may be required at the MCC level. Special processing is required in cases where independent and encoded positions do not match.

The coding of an accurate position with associated time requires additional processing logic and a longer message, which may affect the overall performance of the System in terms of capacity, beacon battery size and beacon cost.

4.2 Encoded Location Accuracy

4.2.1 Requirement

Encoded locations shall be provided to an accuracy of 30 m in latitude and longitude, 95% of the time, within 5 minutes of beacon activation.

If available, altitude information shall be provided to an accuracy of 50 m, 95% of the time, within 5 minutes of beacon activation.

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

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

- In the first 6 hours the navigation device shall attempt at least one location update every 30 minutes.
- Beyond 6 hours a location update shall be attempted at least every 60 minutes for the life of the battery.

4.2.2 Rationale

The MEOSAR system is expected to provide accurate independent location information. Encoded location data should be provided with the best accuracy obtainable from GNSS receivers to significantly enhance System performance. The same logic holds for altitude information, if required in some applications.

4.2.3 Dependencies

LUTs and MCCs must have the capability to process encoded location data with the specified accuracy.

High encoded location accuracy may lead to frequent updates, which require special processing and may impact ground segment operation costs and complexity.

4.3 Message Content

4.3.1 Requirement

In addition to the essential data fields for the beacon message content defined in section 3.7 (i.e. Identification (ID), Beacon Type, Type of Homing Device, Homing Device Status, User Cancellation, Encoded Location, and Vessel(MMSI)/Aircraft ID, the beacon message should provide the following information:

a. Elapsed Time: Time elapsed since the beacon was activated (48 hrs. maximum with 1 hr. resolution). 50% probability of detection every two hours after activation.

b. Information providing Time of last encoded location data. 90% probability of detection for the first hour after activation, then 50% probability of detection every two hours thereafter.

c. Altitude of encoded position when applicable. 90% probability of detection for the first hour after activation, then 50% probability of detection every two hours thereafter.

d. Dilution of Precision (DOP) of encoded location. 50% probability of detection every two hours after activation.

e. Automated / manual activation notification. 50% probability of detection every two hours after activation.

f. Remaining battery capacity, as percentage of the battery capacity required to support beacon operation for the required lifetime. 50% probability of detection for the first two hours after activation, 90% probability of detection every two hours thereafter.

g. Spare bits for future use. Detection probability dependent on future capability requirement(s).

h. Reserved spare bits for national use. 90% probability of detection every 30 minutes.

4.3.2 Rationale

High resolution encoded position data should be provided with appropriate data quality indicators (i.e. DOP of the computed position) and the associated time and date of acquisition.

Specific information on the distress situation (type of emergency) can assist SAR authorities in planning the SAR operation.

4.3.3 Dependencies

Additional data in the beacon message impact its length, the system capacity, battery requirements and ultimately the cost of the beacon. In a GEO/MEO system, which provides continuous worldwide coverage, alternate transmissions of data contents could provide a means of reducing the impact of this requirement on beacons.

Specific ground segment equipment processing capabilities may be required.

4.4 ELT Activated in Flight

4.4.1 Requirement

Second generation fixed ELTs should have a capability to be triggered while the aircraft is still in-flight (prior to an anticipated accident). The ELT could be activated automatically (i.e. while in flight and separate from G-switch detection of a crash) and/or be manually activated.

The automatic in-flight activation should be triggered by a signal originated by the aircraft avionics (or its equivalent) after detection of anomalous flight conditions that warrant ELT activation as determined by the triggering algorithm. ELTs with automatic activation capability should also transmit encoded location data in the beacon message[5].

4.4.2 Rationale

In many aircraft accidents, the violence caused by the high speed of impact destroys the ELT or its antenna system, preventing the transmission of an alert. Anomalous flight conditions leading to sudden and rapid loss of altitude resulting in a crash can often be reliably detected by aircraft avionics and used to trigger ELT transmissions within the typical 30-second interval that precedes the crash. Such transmissions would be helpful to SAR authorities, particularly when the ELT does not survive the crash.

4.4.3 Dependencies

ELT transmissions from aircraft in-flight will be affected by likely large Doppler shifts induced by aircraft speed that will impact the LEOSAR system Doppler positioning capability. Such Doppler position information in most circumstances will be unreliable and will need to be appropriately flagged when distributed to SAR agencies or, alternatively, filtered out of the alert data. The impact on independent MEOSAR location data will have to be investigated further to ensure reliability and evaluate the location accuracy achievable.

Automatic in-flight activation capability would be highly desirable for in-flight triggering of second generation ELTs, but the implementation of this capability might be limited in aircraft with less sophisticated avionics (especially small and/or older aircraft).

Encoded location data (if available as per paragraph 4.1) would serve as a complement to and/or confirmation of independent position determination, and as a unique source of precise accident position. However the availability of location data from the avionics is inherently limited by the characteristics of those avionics. It is assumed that, if an aircraft has automatic in-flight activation capability, encoded location data will also be available.

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[5] Second generation fixed ELTs installed in aircraft subject to the “Accident Site Location” provisions of Annex 6 to the ICAO Convention (under development) will be required to have automatic in-flight activation capability and transmission characteristics allowing for the determination of an accident position within 11.1 km (6 NM) (TBC by [5] Second generation fixed ELTs installed in aircraft subject to the “Accident Site Location” provisions of Annex 6 to the ICAO Convention (under development) will be required to have automatic in-flight activation capability and transmission characteristics allowing for the determination of an accident position within 11.1 km (6 NM) (TBC by the pending amendment to Annex 6), 95% of the time, whether the location is determined through independent location computation or by providing an encoded location.

4.5 Return Link Capability

4.5.1 Requirement

Second generation beacons should be capable of receiving return link messages to acknowledge the receipt of the forward link alert transmission and provide ancillary information to the person in distress, or trigger ancillary beacon functions.

The operational performance requirement is for receipt of the RLS message sent by the Return Link Service Provider (RLSP) within 15 minutes, 99% of the time.

4.5.2 Rationale

The return link capability can assist the SAR response. It can potentially provide a variety of services.

4.5.3 Dependencies

The beacon must include a GNSS receiver which accommodates the Return Link Service and the appropriate logic function.

Information on the return link capability of the transmitting beacon must be sent with the forward link alert message and relayed to appropriate contacts (return link service provider and/or SAR authorities). This requires a limited upgrade of Cospas-Sarsat MCCs.

A detailed definition of the various functions which may be supported by the return link capability and a thorough demonstration of the potential benefits are required.

4.6 Battery Status Indicator

4.6.1 Requirement

A battery status indicator should be provided, separate from the self test function, to warn users of depleted batteries which would not meet the expected operation life time requirement.

A battery status indicator should always be incorporated into beacons powered by rechargeable batteries.

4.6.2 Rationale

A visible indication of battery status would enhance the reliability of beacons as prematurely depleted batteries could be replaced. This feature would be essential for beacons powered by rechargeable batteries as it would help ensure that battery charge is properly maintained.

4.6.3 Dependencies

The availability of reliable, cost-effective battery status indicators should be verified and their reliability in the context of Cospas-Sarsat beacon use should be assessed.

A battery status indicator should not supersede the mandated battery replacement date for non rechargeable batteries. Adequate warning to this effect should be attached to the indicator.

- END OF SECTION 4 -

ANNEXES TO DOCUMENT

OPERATIONAL REQUIREMENTS FOR COSPAS-SARSAT SECOND GENERATION 406 MHz BEACONS

C/S G.008

ANNEX A

GLOSSARY/TERMINOLOGY

Alert detection:	At least one valid beacon message is produced by a LUT after receiving one or several bursts from the same beacon through one or several satellite channels.
Alert detection probability:	Probability of achieving an alert detection within a given time period.
Burst detection:	Beacon burst received through a single satellite channel (i.e. a unique path from beacon to satellite instrument to LUT antenna and receiver system) which produces a beacon message and measurements of the appropriate signal characteristics (e.g. TOA/FOA measurements).
Burst detection probability:	Probability of obtaining a burst detection within a given time period.
Compatibility:	A compatible transmission does not create harmful interference that impacts the performance of a satellite channel. Systems are compatible when they can operate simultaneously with no degradation of their respective performance. Compatible systems may operate in a given frequency band with different signals to provide different functionalities.
First burst:	First transmission of a 406 MHz message by a beacon after activation.
First generation beacon:	A beacon which complies with the specifications of document C/S T.001 and is tested against the type approval standards of document C/S T.007.
Interoperability:	Systems are interoperable when the same transmission can be processed by both systems to provide the expected functions with the appropriate performance levels. Interoperable systems may provide either similar or different functionalities.

Independent location: A location computed by the LEOSAR or the MEOSAR system, independently of the data encoded in the beacon message. The LEOSAR system provides independent beacon locations using a Doppler technique based on received beacon burst frequency measurements over a LEO satellite pass. The MEOSAR system provides independent locations using a triangulation technique based on multiple TOA/FOA measurements from burst detections received through a number of MEO satellite channels.

MEOSAR system: The Cospas-Sarsat MEOSAR system will comprise a space segment consisting of several interoperable MEO satellite constellations and a ground segment consisting of a number of MEOLUTs suitably located around the globe to ensure that beacon transmissions, anywhere on the globe, are received by at least one MEOLUT via at least three MEOSAR satellite channels.

Second generation beacon: A beacon which complies with the specifications of document C/S T.101 and is tested against the type approval standards of document C/S T.107.

- END OF ANNEX A-

- END OF DOCUMENT-

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