



Understanding Search & Rescue:  
The Ecosystem Behind Saving Lives

*“Cospas-Sarsat has helped to save more than 40,000 lives (6 lives per day) since 1982.”*

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# Cast Away. All Is Lost. 127 Hours. Alive.



Each of these movies has a similar story—a disaster occurs on the sea, on land or in the air resulting in a search and rescue effort for survivors. In *Cast Away*, Tom Hanks' character is stranded on an uninhabited island for four years after his aircraft crashes in the South Pacific. *All is Lost* sees Robert Redford lost at sea after his yacht collides with a shipping container leaving his navigation equipment and radio disabled. *127 Hours* depicts the true story of canyoneer Aron Ralston, a young man trapped for over 5 days by a boulder in an isolated canyon. And, *Alive* relives the dramatic 72-day ordeal of a Uruguayan rugby team when their plane disappears in the Andes Mountains.

Every day, search and rescue teams are dispatched to help find survivors in emergency situations similar to those mentioned above. In many cases, rescue efforts are hampered by the simple inability to pinpoint the location of the emergency resulting in valuable time wasted. In the various movie scenarios, the remote locations and technology breakdowns—a mobile phone has no coverage, a radio is out of range, a navigation system is inoperable—simply add to the challenge. In a world where every second counts, understanding the search and rescue ecosystem becomes critical. Had the individuals or vessels in the movie scenarios been equipped with emergency beacons, for example, the outcomes may have been different.

This document is intended to provide an overview of the search and rescue ecosystem—products, technologies and processes—that has helped to save over 40,000 lives since 1982.<sup>1</sup>

## WHAT IS SEARCH AND RESCUE?

Search and rescue (also referred to as SAR) is a term often used to describe the “search” for people in distress or imminent danger and the associated “rescue” by emergency response agencies. There are actually several categories of SAR, depending primarily on geography or terrain (e.g. mountain rescue, air-sea rescue over water, terrestrial rescue), but the general concept is the same—emergency teams are dispatched to locate, assist and rescue people in crisis situations. And, while there are some very well-known methods used to broadcast or

1. *Cospas-Sarsat Programme Update, January 28, 2015*

communicate an emergency—mobile phone calls, mayday radio signals, flares and even smoke signals—these are not always reliable or available as evidenced by the aforementioned movie examples.

One of the keys to SAR is determining the smallest possible search area. Figure 1 below shows actual photos of search areas from the U.S. Air Force and U.S. Coast Guard. As shown, it can be quite difficult to pinpoint distress sites. Distress beacons help to identify and isolate emergency locations to facilitate and accelerate rescue.

*Figure 1: Actual U.S. Air Force and U.S. Coast Guard search area photos*



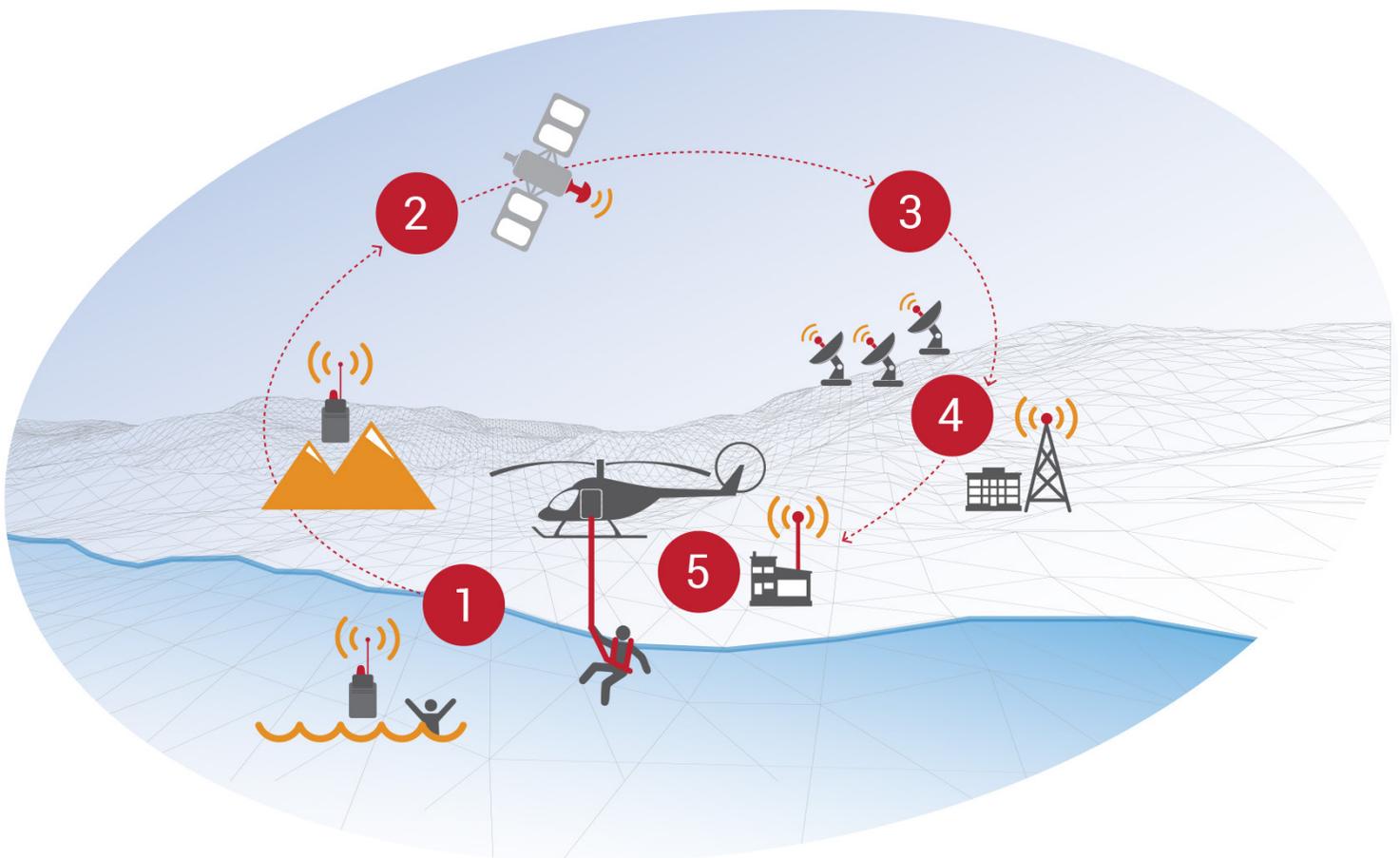
## THE SEARCH AND RESCUE ECOSYSTEM: AN OVERVIEW

While the term “search and rescue” is fairly self-explanatory, the actual process—what occurs between initial distress signal and the actual rescue—is quite complex.

For this paper we will focus on the international satellite system for search and rescue, Cospas-Sarsat<sup>2</sup>, the program behind the 40,000 lives saved since 1982. In a recent year, Cospas-Sarsat helped to rescue over 2,100 people in 720 incidents globally. Of these rescues, 48 percent were maritime, 30 percent on land and the remaining 22 percent were in aviation. So, despite other methods for detecting and locating seafarers, aviators and recreational adventurers in distress situations, Cospas-Sarsat has established itself as the foremost global search and rescue system due to its wide adoption (over 40 countries worldwide), expansive satellite coverage and its proven alert detection and information distribution process (6 people saved daily since 1982).

The diagram in Figure 2 below shows a typical Cospas-Sarsat satellite-based search and rescue process. As shown, there are 5 stages of the process from activation to detection to response.

Figure 2: Satellite-Based Search & Rescue Ecosystem



2. COSPAS is a Russian acronym for *Cosmicheskaya Sistema Poiska Avariynyh Sudov* (Space System for the Search of Vessels in Distress). SARSAT is an acronym for *Search And Rescue Satellite-Aided Tracking*.

*“Beacon registration ensures that search and rescue authorities have crucial information about the beacon owner, the vessel and emergency contacts.”*

STAGE	ACTION
1	A distress beacon is activated in an emergency
2	The signal is transmitted to a satellite
3	The satellite relays the signal to a satellite ground station (also referred to as a LUT or local user terminal)
4	The LUT sends critical positioning data to a Mission Control Center (MCC)
5	An alert is then sent from a Rescue Coordination Center (RCC) to the appropriate emergency response teams (e.g., Coast Guard for maritime emergencies)

The Cospas-Sarsat system today consists of the following:

- ▶ 7 LEOSAR (Low Earth Orbiting Search and Rescue) satellites
- ▶ 5 GEO (Geostationary Earth Orbiting Search and Rescue) satellites
- ▶ 56 LEOLUTs (Low Earth Orbiting Local User Terminal)
- ▶ 22 GEOLUTs (Geostationary Earth Orbiting Local User Terminal)
- ▶ 31 Mission Control Centers (MCC)
- ▶ 236 Rescue Coordination Centers (RCCs) or Search and Rescue Points of Contact (SPOCs)
- ▶ 1.3 Million 406MHz beacons (from 40 active manufacturers)

Let's take a closer look at the various stages of the SAR ecosystem.

## STAGE 1: DISTRESS BEACONS

In the event of an emergency, a distress beacon signal is activated either manually or automatically depending on beacon type. There are several beacon variations—a few of the main types are listed below. For Cospas-Sarsat systems, beacons operate in the 406MHz frequency range.

406MHZ BEACON TYPE	TYPICAL INDUSTRY	ACTIVATION METHOD
EPIRB <i>(Emergency Position-Indicating Radio Beacon)</i>	Maritime	Manual or Automatic <i>(Hydrostatic Release)</i>
ELT <i>(Emergency Locator Beacon)</i>	Aviation	Manual or Automatic <i>(G-Switch)</i>
PLB <i>(Personal Locator Beacon)</i>	Recreation/Outdoor	Two-Process Manual



An **EPIRB (Emergency Position-Indicating Radio Beacon)** is a beacon typically associated with the maritime industry and can be installed on a boat, integrated into a life-jacket or used by individual crew or passengers. In an automatic EPIRB activation, water triggers a hydrostatic release mechanism that allows the beacon to release from its mounting bracket, float to the surface and begin transmitting. Manual activation requires the user to flip a switch to begin transmission.



An **ELT (Emergency Locator Beacon)** is often built into aircraft and is activated either manually or automatically in a crash. ELTs that activate automatically typically have an impact-sensing switch (or “G” switch) that is triggered when a crash has occurred.



A **PLB (Personal Locator Beacon)** is, as the name implies, used by individuals often when participating in outdoor, recreational activities such as hiking, kayaking or boating. PLBs, roughly the size of a mobile phone, are typically carried by the individual and are manually activated in an emergency situation.

There are several beacon features that further help to aid in rescue operations. Every beacon has a unique 15-digit hexadecimal identification number that allows the registration of owner or vessel information with proper authorities. Most beacons also have integrated GPS functionality thereby sending critical GPS positioning data via the Cospas-Sarsat system to further accelerate location detection. Several PLBs also have built-in strobe lights for enhanced visual aids.

*“MEOSAR is an emerging next-generation satellite-based search and rescue system that will revolutionize Cospas-Sarsat.”*

## STAGE 2: SATELLITE COMMUNICATIONS

In each beacon example, a distress signal is sent at regular intervals and captured by Cospas-Sarsat satellites. This distress signal includes key positioning data such as GPS location (if available), beacon identification information, transmit time and other information. For Cospas-Sarsat, the satellites used today are either GEOSAR (Geostationary Earth Orbiting Search and Rescue) or LEOSAR (Low Earth Orbiting Search and Rescue). MEOSAR (Medium Earth Orbiting Search and Rescue) is an emerging next-generation satellite-based SAR system that will be fully available in the coming 2-3 years.

The chart below summarizes some of the key differences between the various satellite constellations:



	LEOSAR	GEOSAR	MEOSAR
COVERAGE	Global	GlobalExceptPoles	Global
DISTANCE FROM EARTH	850km	35,000km	20,000km
NUMBER OF SATELLITES	5	7	72 (Planned)
BEACON DETECTION TIME	45+ Minutes	Near Instantaneous	Near Instantaneous
LOCALIZATION TECHNIQUE	Doppler (Frequency) Processing	GPS (if Encoded)	TDOA FDOA
LOCALIZATION ACCURACY	2–5km	100m (if GPS)	100m (if GPS)
AVAILABILITY	Now	Now	2-3 Years

Rather than get into the specific differences of the various satellite technologies, it’s important to remember that distress signals received by the satellites are processed differently resulting in differences in timing and location determination.

For example, the five Cospas-Sarsat LEOSAR satellites orbit the earth north pole to south pole and make one complete orbit every 45 minutes. Therefore, it can take on average 45 minutes for beacon detection due to this satellite orbital period. LEOSAR determines location by using Doppler processing techniques which use beacon signal frequencies and satellite velocity calculations.

*“One of the keys to SAR is determining the smallest possible search area... Emergency beacons help to identify and isolate distress locations to facilitate and accelerate rescue.”*

The seven GEOSAR satellites, on the other hand, orbit in synchronization with the earth and therefore appear (from Earth) as remaining in the same place in the sky. GEOSAR satellites can have near immediate beacon detection assuming the beacon signal is within the “geostationary” coverage area (between 70° North and 70° South) and that GPS data is encoded in the beacon transmission.

MEOSAR, once available, will combine the best operational qualities of LEOSAR and GEOSAR with regards to coverage area and timeliness in detecting distress signals. The use of 72 planned satellites ensure global coverage while advanced localization techniques using Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA) will result in highly accurate positioning (within 5km, 95% of the time within 10 minutes of beacon activation).

### STAGE 3: GROUND STATION, OR LOCAL USER TERMINAL (LUT)

The beacon positioning data is then relayed back to Earth through satellite ground stations, or LUTs (GEOLUT for GEOSAR, LEOLUT for LEOSAR, MEOLUT for MEOSAR). Depending on the satellite type, these stations either simply relay the beacon data to SAR Mission Control Centers (MCCs) or further translate the beacon data into more specific location information before sending alerts to the appropriate MCCs for further processing.

If a beacon position is known, the alert will be routed to the closest MCC. In the U.S., for example, the MCC is located in Suitland, Maryland, a suburb of Washington DC. In the United Kingdom, the MCC is located in Kinloss, Scotland. If the position is not known, because there is no GPS for example, then the alert is routed to the MCC of the host country based on beacon registration. If there is no position and no registration, then the MCC has to wait for more information from satellite passes to try and approximate a position—which extends the waiting period before a rescue effort.





## STAGE 4: MISSION CONTROL CENTER (MCC)

A Mission Control Center is used to collect, store and sort the data received from LUTs and other MCCs and to distribute this information in the form of alerts to associated Rescue Coordination Centers (RCC) or Search and Rescue Points of Contact (SPOC). MCCs typically include a variety of hardware products, software platforms and information databases that give personnel the ability to monitor and track emergency situations. And although MCCs are manned 24 hours a day, 365 days a year, the vast majority of alert data distribution is handled automatically without human intervention.

## STAGE 5: RESCUE COORDINATION CENTER (RCC)

Rescue Coordination Centers (or SPOCs) collect, store and sort the Cospas-Sarsat distress alerts and location data sent by the MCC and are responsible for coordinating the rescue response to the distress location. RCCs are responsible for a geographic area, known as a “Search and Rescue Region of Responsibility” or SRR. In the United States, for example, the RCCs are operated by the U.S. Coast Guard and the U.S. Air Force. In the United Kingdom, the maritime RCC is part of Her Majesty’s Coastguard operations.

## THE CHALLENGES FACING COSPAS-SARSAT SEARCH AND RESCUE

Despite its successes in search and rescue efforts for the past 30+ years, the existing Cospas-Sarsat system has its challenges. Some of the more common issues are listed here:

**Beacon Registration:** Registering a beacon using its unique 15-digit beacon identification number costs nothing and takes only a few minutes to complete, yet many owners do not take this simple step. Beacons can be registered via the Cospas-Sarsat website at [www.Cospas-Sarsat.org](http://www.Cospas-Sarsat.org). Beacon registration ensures that search and rescue authorities have crucial information about the beacon owner, the vessel and emergency contacts. This information helps rescuers locate an emergency position and quickly limits the search area once a distress signal is received.



**False Alarms:** A false alarm is the activation of an emergency beacon in a non-distress situation. A beacon can be activated accidentally by inadvertent use, improper testing, incorrect mounting or a number of reasons. False alerts are one of the biggest issues facing Cospas-Sarsat today because they take up SAR resources and can impede legitimate rescue efforts.

**Satellite Coverage and Location Accuracy:** LEOSAR and GEOSAR have their pros and cons as discussed earlier. MEOSAR, the next-generation Cospas-Sarsat system, will help to maximize global coverage area while enhancing beacon location accuracy by using over 10 times as many satellites as LEOSAR and GEOSAR today.

**Rescue Times:** The typical time for a satellite to receive the first beacon alert is 5 minutes but this can be delayed. As we mentioned earlier, LEOSAR satellites orbit the earth once every 45 minutes to calculate an approximate beacon position it takes one to two passes to gather accurate information, which can take 45 to 90 minutes. GEOSAR satellites pick up the signal almost immediately, but they cannot calculate a position unless GPS is encoded in the signal. After a beacon alert is received by an MCC/RCC, response times will vary depending on whether there is a position received with the alert. Without GPS information the search area will be broader and response time longer simply because the position calculation and validation process takes more time. A beacon with GPS will always result in a faster response time and smaller search area.

## THE FUTURE OF SAR: MEOSAR, TECHNOLOGY INTEGRATION AND INDUSTRY INITIATIVES

A system that has helped to save 40,000 lives should be considered a proven success. But, there is always room for improvement.

As highlighted, **MEOSAR**, the next generation in Cospas-Sarsat, will offer all the advantages of existing LEOSAR and GEOSAR systems and more including near-instantaneous detection, identification, and location determination of 406MHz beacons. This position accuracy will help reduce rescue response times. In addition, MEOSAR will add an optional “return link service” that will allow SAR professionals to send messages back to the distress site confirming that their alert was received.

MEOSAR is a revolutionary development for Cospas-Sarsat but will not be completely rolled out until 2018 at the earliest.

Another emerging trend is the **convergence** of SAR technologies with a variety of industry-specific applications especially in the Maritime Domain Awareness (MDA) and mobility fields. Fleet management and vessel monitoring software platforms now incorporate SAR-related functionality to streamline operations while saving lives. Beacons incorporating Automatic Identification Systems (AIS) technology, for example, are being used in man overboard situations to notify nearby vessels that assistance is required a rescue effort. Cospas-Sarsat rescue procedures are also being integrated into the operational training and simulation systems used by captains and vessel operators. And, mobile SAR applications are becoming more commonplace on mobile devices such as smartphones, tablets and GPS navigation systems.

As a result of recent high profile incidents, several emerging **industry initiatives** are underway to further enhance the search and rescue process. The International Civil Aviation Organization (ICAO) is working with the aviation industry to develop a new aviation emergency management system also known as the Global Aeronautical Distress and Safety System or GADSS. The International Maritime Organization (IMO) is coordinating efforts for several new Global Maritime Distress and Safety System (GMDSS) solutions. HELIOS is a European Commission program tasked with building next-generation EPRIBs, ELTs and beacon-enabled clothing and wearable devices. Several military solutions are also being developed to leverage the functional benefits of MEOSAR in covert SAR operations

## CONCLUSION

The world of search and rescue is a complex ecosystem of products, technologies and personnel with one common goal—to save lives. The existing Cospas-Sarsat satellite-based SAR system is a great example of this SAR ecosystem in action having saved 5 lives per day over the past 30 years. As the awareness and understanding of this ecosystem—from beacons to satellite connectivity to rescue coordination software—increases, we will see the emergence of new applications, innovations and procedures emerge that will save even more time, more costs and, ultimately, more lives.

## France

Bât. D,  
Office D204 (2nd floor)  
2405 Route des Dolines  
06560 VALBONNE Sophia-  
Antipolis  
Phone: +33 (0)4.92.90.70.40  
Fax: +33 (0)4.92.38.09.75

Z.I. des 5 Chemins BP 23  
56520 Guidel, France  
Phone: +33 (0)2 97 02 49 49  
Fax: +33 (0)2 97 65 00 20

## UK

Silver Point, Airport  
Service Road  
Portsmouth PO3 5PB, UK  
Phone: +44 (0)23 9262 3900  
Fax: +44 (0)23 9262 3998

## USA

4296 Forbes Boulevard  
Lanham, MD 20706  
United States  
Phone: +1 240 790 0600  
Fax: +1 240 790 0605

11610 Iberia Place, Suite 100  
San Diego, CA 92128  
United States  
Phone: +1 877 468 8722

[www.mcmurdogroup.com](http://www.mcmurdogroup.com)

## ABOUT MCMURDO

McMurdo is a global leader in emergency readiness and response including search and rescue and maritime domain awareness solutions. At the core of these solutions are resilient positioning, navigation and tracking products, technologies and applications that have helped to save over 40,000 lives since 1982. A division of Orolia, McMurdo brings together nearly 150 combined years of experience by consolidating proven Boatracs, Kannad, McMurdo, SARBE and Techno-Sciences, Inc. brands into the industry's first end-to-end emergency readiness and response ecosystem (distress beacons, satellite connectivity infrastructure, monitoring/positioning software and emergency response management solutions). Airbus, Boeing, the British Royal Navy, the U.S. Coast Guard, NASA and others are among the hundreds of aviation, fishing, and government, marine and military customers around the world that trust McMurdo to prevent emergencies, protect assets and save lives. Established in January 2014, has offices in France (Guidel and Sophia Antipolis), the U.K. (Portsmouth) and the U.S. (San Diego and Washington D.C.).



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