THE SPACE REPORT

SPACE FOUNDATION

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NEW SPACE ECONOMY | LAUNCHPAD DESIGN | EUCLID JOINS WEBB | RESCUES FROM SPACE

Introduction | *Satellites have played a pivotal role in search and rescue efforts for more than 40 years. Visionaries from around the world applied space technology to search and rescue efforts on Earth and built an enduring global humanitarian program. Satellite tracking has saved more than 57,000 people worldwide since the system's first rescue in 1982. With new equipment in the marketplace, its role keeps growing.*

An Army UH-60 Black Hawk Helicopter hovers near Washington's Cascade mountains as crews train to locate survivors using satellite beacons.
Credit: Defense Department

Satellite Constellations Weave Growing Global Search and Rescue Safety Net

The outcomes of search and rescue efforts before 1982 too often relied on chance and were more of an arduous search than a successful rescue. A global effort to develop and field a satellite-based search and rescue system changed everything for people in distress and first-responders who answer their calls.

The formal coalescence of international efforts began with the August 1979 signing of a partnership agreement between NASA, and agencies in France and Canada to develop a way to use signals from space to help locate civilians in distress — from mariners to lost hikers. Russia joined the growing consortium in November 1979, adding their powerful research into space systems and giving the group a bigger acronym for a name: Cospas-Sarsat.[1]

The system proved life-changing for Andreas Stabno, a seasoned mountain climber who found himself clinging on a tiny ledge jutting from a sheer mountain face in August 2022. The perch, 3 feet wide by 8 inches deep, was about a vertical mile up the 13,327-foot McHenry's Peak in Colorado's Rocky Mountain National Park. "I looked up and couldn't find a way to go up," he said. "I looked right and left and couldn't find a way there. I looked down and my moves up had been difficult enough that I did not see a safe way to retrace my route down."

Stabno, who often climbs alone, had added a personal locator beacon — which uses space-based technology to identify civilians in distress, notify help, and assist in locating them — to the survival gear he carries. He attributes his survival to his decision to "press that button right away because time really was of the essence."[2]

His precarious location and deteriorating weather meant rescuers needed all the time they could get to reach him and to determine the best way to prise him from the ledge. Stabno waited nearly seven hours for help to arrive, and that may have been in the nick of time. "It wasn't to the point where, any second, I was going to fall off, but I just didn't know."

Stabno's satellite signal for help and others like it in America are received by Florida's Air Force Rescue Coordination Center, commanded by Lt. Col. Matthew "Muddy" Mustain, which works with local authorities to track the location of people in distress and facilitate assistance.

"If that beacon is activated — it depends upon the location — but it's usually single-digit minutes from the time the person pushes the button until the time we see the location information here … so we are able to get a rescue team dispatched in literally minutes to start heading out to the individual's location," he said.[3]

Beacons, Beacons, Everywhere but No Good Way to Find Them

Distress beacons were predominately used by military planes, helicopters, and vessels, before the 1970s. But an Alaska plane crash in October 1972 that claimed the lives of two federal lawmakers, U.S. Reps. Hale Boggs, D-Louisiana, and Nick Begich, D-Alaska, drove Congress to stiffen mandates on the use of emergency beacons by all civil aircraft.[4] That same year ushered in mandated use of distress beacons at sea. Canada, with vast areas of rugged wilderness terrain, soon followed suit, and Europe adopted the technology, too. The total number of beacons deployed worldwide is estimated to have reached 250,000 by the end of the 1970s.[5]

But early distress beacon technology, based on terrestrial radio signals and triangulation, was notoriously unreliable. Malfunction plagued both aviation distress beacons, commonly called Emergency Locator Transmitter or ELT, and maritime beacons, designated Emergency Positioning-Indicating Radio Beacons or EPIRBs. False alerts, caused by either device malfunction or user error, presented another significant complication. The introduction of Personal Locator Beacons, or PLBs, in 1975 exacerbated the issues.

Range limitations of the radio frequencies that carried distress signals, patchy monitoring of those signals, and the lack of a global monitoring system hampered detection of emergency beacons. Even when detected, inability to pinpoint signals resulted in long, costly, and often fruitless searches.[6] Engineers refined radio beacon technology for decades. But solving the overarching problem of how to quickly and accurately locate them remained elusive.

An original partnership of four countries, formally established in 1988 as Cospas-Sarsat, has grown to 45 participating countries.
Credit: Cospas-Sarsat

Building a Better Search and Rescue System for the World

One of those engineers, Canadian Harry Stevinson, designed an improved aircraft beacon known as the Crash Position Indicator in the wake of World War II.[7] As the Space Age blossomed, Stevinson looked to orbit to help solve search and rescue problems. In 1971, he co-authored a report for Canada's National Research Council that pioneered how satellites could locate distress beacons on the planet below.

Jim King, one of the Search and Rescue Satellite pioneers who served in Canada's contingent to the International Cospas-Sarsat Program, believes Stevinson's research was integral to the developing space-based search and rescue technology.

"His ideas were actually quite futuristic because at that time there were still no commercial geostationary satellites in the sky, and this was only 14 years after Sputnik's launch in 1957," King said. "Only 14 years later, he's already saying, 'let's use satellites to find these beacons.'"[8]

NASA began investigating the concept in the early 1970s. Bernard Trudell, study manager in the Applications Group at NASA's Goddard Space Flight Center, was tasked with exploring the application of satellite technology to search and rescue and developed a "Search and Rescue Orbiting Satellite."[9] Soviet researchers, who racked up an impressive list of space industry firsts, were simultaneously investigating the feasibility of using low-altitude satellites to aid search and rescue.

Researchers across the globe inaugurated the Cospas-Sarsat Implementation Plan in May 1980. "It was the cookbook with the formulas to design and build the whole system…," King said. With plans in place, the teams continued development of separate systems — Sarsat in the west and Cospas in the east — while ensuring the two worked together.

The Soviets launched the first satellite, COSPAS-1, in June 1982. The satellite showed its worth three months later. While flying over North America, it picked up an aircraft distress signal in the Stikine Mountains of northern British Columbia. The two pilots, Jonathan Ziegleheim and Gary VanAmelswoort, and their passenger, George Heemskerk, crashed as they were searching the mountainous area for George's 24-year-old son, Jim, and his downed aircraft, which crashed only weeks before the Cospas-1 launch. Neither Heemskerk's son nor his plane was ever located.[10]

Despite suffering injuries, facing hash elements, and crashing more than 50 miles off their planned flight path, Heemskerk and his pilots were found within hours. Additional successful search and rescue efforts followed in quick succession. Media coverage of the rescues secured public support and additional government money, driving program development.

When testing finished in May 1985, the satellite system had located 194 distress signals around the world and facilitated the rescue of 473 people. The four partner countries agreed to a framework to efficiently operate the system, and the International Cospas-Sarsat Program and its administrative body, the Secretariat, was founded in 1988.[11]

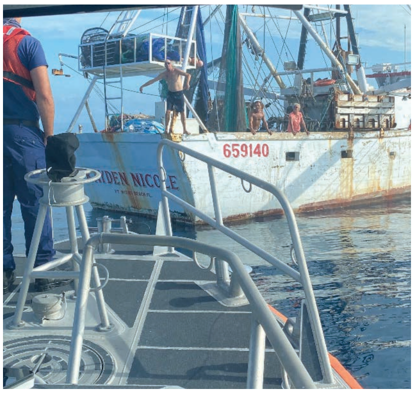
The Cospas-Sarsat team also proposed and developed an improved option to the antiquated distress signal radio frequency while building the satellite search and rescue system. The much stronger, dedicated, digital signal logged its first save in 1984. It was phased in over the next two decades and became the sole frequency used by Cospas-Sarsat in 2009.[12]

The satellite constellations that power the system grew and improved dramatically. On the ground, a global network of government, civil, and volunteer organizations grew to offer the people, planning, and perseverance needed for successful search and rescue under challenging conditions.

How Cospas-Sarsat Works

NOAA's Marisa Gedney, a search and rescue satellite operations support officer, summarized the evolution of the system, explaining that distress signal detection initially depended on the LEOSAR system, which are low-Earth orbiting satellites circling the poles. Data from at least three of these low-Earth orbiting satellites allowed for triangulation of distress signals. But the low-flying satellite travelled too quickly to linger over emergency sites, which could result in an hours-long signal detection delay.

A bigger window on the Earth was opened with the addition of geostationary weather and communication satellites, called the GEOSAR system. These satellites remain stationary to detect signals over wide swaths of the planet, excluding polar regions. While offering nearly instantaneous beacon detection, they could not pinpoint a distress beacon location.



A satellite distress beacon allowed the Coast Guard to quickly reach this sinking fishing vessel off the Florida Coast in 2020, rescuing its crew.
Credit: Coast Guard

The combination of the LEOSAR and GEOSAR constellations' data worked, but search and rescue experts believed the system could be improved. In 2002, feasibility studies began around creating a system utilizing Global Navigation Satellite Systems (GNSS) constellations.

Cospas-Sarsat , starting in 2005, added "MEOSAR" search and rescue payloads to the American Global Positioning System as well as Europe's Galileo and Russia's GLONASS constellations. The first real-world test of the new system occurred May 4, 2016 when a distress beacon led rescuers to the 21 crewmembers who had abandoned their burning ship in the Pacific Ocean within 20 minutes of detection of their signal. The old combination of low- and geo-Earth orbiting satellites produced the same information, but it took more than two hours.

"Our new MEOSAR system overcomes the limitations of the old systems and combines the best of what both have to offer," Gedney said.[13]

But people, not satellites, accomplish the rescues. Mustain praised his Air Force Rescue Coordination Center team along with its military and civilian partners.

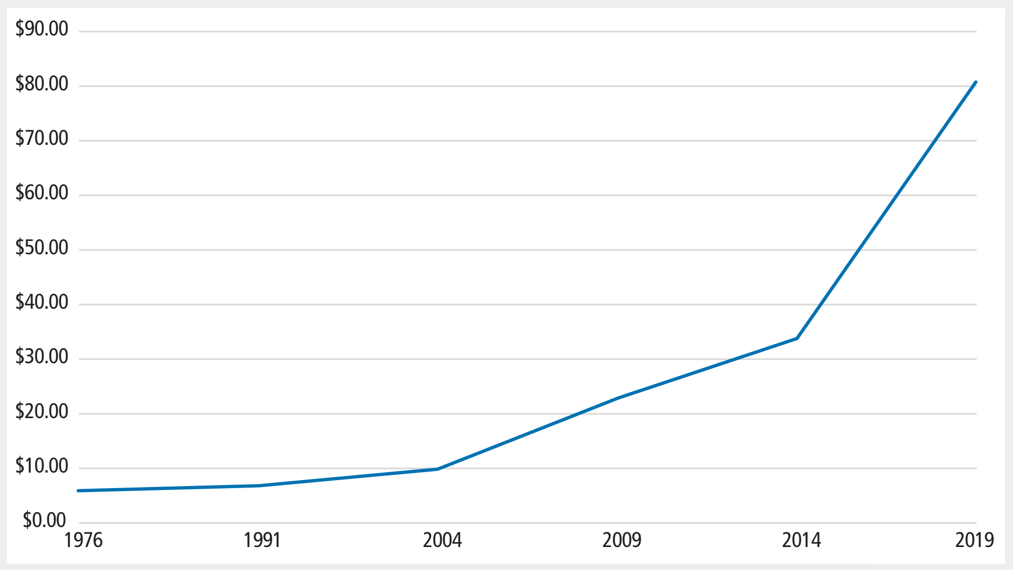
"My airmen and controllers, when they leave for the day, they know they made a difference in people's lives and we're proud to do it. We work with outstanding search and rescue teams in Army, Navy, Marine Corps, Coast Guard, Customs, Border Protection, National Park Service. I have to give huge kudos to the volunteers in Civil Air Patrol. We have direct contact with 48 state Civil Air Patrol Wings and D.C. and Puerto Rico. They are the right and left hand of what we're doing. They are phenomenal people, and I cannot say enough about the great work they do."

Michael McDonald, a Civil Air Patrol volunteer for 40 years, began his service after a personal experience. "I participated in a climbing expedition in the Himalayas and experienced the death of one of the members of our expedition and the death of a member of another group climbing near us. There was also a terrible accident that occurred within a Japanese expedition camping near us one night and we helped provide first aid. Those experiences in a remote area prompted me to get involved with search and rescue."[14]

Increasing Benefits and Inadvertent Costs

Cospas-Sarsat services are provided at no charge to the public, but there is a cost to the global community to provide this humanitarian service. Larger nations with robust search and rescue infrastructure provide coverage and assistance for smaller countries lacking resources.

Benefits per Dollar Spent on Rescue Satellites, 1976-2019



Credit: Space Foundation database

Studies find the benefits outweigh the costs. In 2022, the U.S. Search and Rescue Satellite Program Steering Group found the benefits for every dollar spent on the program rose from an estimated $6 in 1976 to more than $80 in 2019.[15]

Recent enhancements to the already superior MEOSAR system include the January 2020 rollout of Return Link Service, which provides another layer of assurance that assistance is on the way by sending the victim an acknowledgement that their call for help has been received.[16] In November 2022, China signed a Declaration of Intent to add six satellites from their BeiDou system to the more than 50 satellites in the MEOSAR constellation.[17]

New Emergency Locator Transmitter technology, called ELT(DT), adds distress tracking for aircraft. These enhanced transmitters provide proactive data, designed to be manually or automatically activated before a crash when the aircraft exhibits certain distress parameters while still in flight. Cospas-Sarsat approved the operational distribution of ELT(DT) data on Jan. 1, 2023.[18]

The continuing improvements amplified one of the original complications of search and rescue: false alarms, which officials say impede their efforts and drive up costs. Mustain illustrated it this way: "Just ripped from the headlines yesterday, May 23rd, 2023 we had 56 SAR beacon alerts and none of them were somebody actually in distress … and we treat every beacon like it's an actual distress beacon until we can confirm that it is not." Mustain and Gedney said people can reduce the number of false alerts by learning to correctly operate and registering their beacons.

Casting the Earth's Search and Rescue Safety Net Back Out to Space

Aspirations to improve search and rescue now extend beyond Earth. NASA tapped first responders from Colorado's High-Altitude Army Aviation Training Site to provide expertise to astronauts for the Artemis III mission. Seasoned aviator Lt. Col. Scott Tucker the aviation training site's commander, read transcripts from the Apollo landings, reviewed the degraded visual environments that were encountered, and compared one-meter imagery from proposed lunar landing zones with one-meter imagery from difficult, mountainous helicopter landing zones in the Rockies.

Tucker and his team then tailored the training protocol that they typically teach pilots to help them land in hazardous, high-altitude Earth environments to the training needs of astronauts who will attempt to land on the Moon. "It's actually pretty remarkable, the similarities between what we teach and lunar operations." Tucker said. "We put them in a helicopter, and we show them how difficult it is to make an approach to an unimproved area where you really don't know what you are getting into."[19]

NASA's Search and Rescue office is exploring even more ambitious application of Earth search and rescue protocol to the Moon to Mars missions through its Lunar Search and Rescue (LunaSAR) concept, envisioning how search and rescue can be provided to astronauts working on the lunar surface.[20]

Under the umbrella of this project, NASA spearheaded the development of Advanced Next Generation Emergency Locator (ANGEL) beacons that will accompany Artemis astronauts. The increased accuracy of these beacons could be a game-changer for individuals in distress, directing rescuers to within shouting distance of the incident location.[21]

Leaders say international tensions haven't diminished participation in Cospas-Sarsat. In 2020, NASA joined Australia's SmartSat Cooperative Research Center on the Resilient Emergency and Search and Rescue Communications project. The project aims to leverage next-generation satellite and communication systems to improve rescue on Earth and to develop it for future endeavors in space, said Lisa Mazucca, NASA Search and Rescue Mission Manager. "This collaboration has the chance to … pursue bold future augmentations of the search and rescue network."[22]

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Section 3 | Space Products & Innovation

Satellite Constellations Weave Growing Global Search and Rescue Safety Net

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