30th Anniversary Special Issue

COSPAS SARSAT

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Cospas-Sarsat 1979-2009

A 30-year Success Story

By Daniel Levesque, Head of Secretariat, International Cospas-Sarsat Programme

In 1971, responding to a Congressional mandate, the Federal Aviation Agency of the USA adopted new regulations requiring the carriage of 121.5 MHz Emergency Locator Transmitters (ELTs) onboard general aviation aircraft. This action by the US Congress followed a dramatic aircraft accident in California in 1967 when a 16-year-old crash survivor, Carla Corbus, starved to death after being stranded for many days. In another incident, three search aircraft crashed during a long, unsuccessful search, claiming rescuers' lives. ELTs were only the beginning of the solution to the problem of lost aircraft. Although ELTs did assist Search and Rescue (SAR) teams to locate many aircraft crashes and rescue survivors, early ELT models were insufficiently robust and sometimes poorly installed in aircraft. Many would activate unduly when no situation of distress existed, generating numerous false alerts and a heavy burden on SAR forces. Too often they would fail to reliably deliver the expected alerting and locating function. On 16 October 1972, a Cessna 310 flying from Anchorage to Juneau, Alaska, disappeared while carrying passengers Hale Boggs, Majority Leader of the US House of Representatives, and Representative Nick Berish of Alaska. The U.S. Coast Guard, Navy and Air Force planes searched for the party for 39 days with no success.

The early days of East-West cooperation, Leningrad, USSR, 1984.
Standing: D. Levesque, T. McCunigal, Y. Zurabov, B. Dagenais.
Seated: D. Ludwig, F. Flatow, A. Selivanov, J. Robinson.

Following an in depth analysis of failures, revised standards were issued, particularly in respect of the automatic G-switch activation mechanism and the ELT installation in aircraft. Performance of second generation ELTs significantly improved, but a global monitoring system for 121.5 MHz transmissions was still missing. Specifically, serious difficulties remained in detecting and locating ELT signals using overflying aircraft. The Cospas-Sarsat System was developed to address these shortcomings.

1975-1979: THE PIONEERS

In the mid-seventies, more than 250,000 ELTs had been deployed in commercial and general aviation aircraft and carriage of 121.5 MHz distress beacons was spreading to recreational boats. Canada and the USA began investigating the use of satellites in low-altitude Earth orbit to detect 121.5 MHz beacon transmissions and locate the source of emissions using the Doppler location technique. The principles of the technique were known and used in the US Transit navigation satellite system. This technique had also been demonstrated in 1971 with the French EOLE satellite system, tracking meteorological balloons drifting through the atmosphere. In Canada, proof-of-concept tests were carried out using modified distress beacons and an amateur radio satellite, OSCAR-6, in 1975. However, reliably detecting and locating an analogue 121.5 MHz low power transmission relayed through an orbiting satellite was still a challenge and many doubted this could be effectively accomplished. 121.5 MHz ELTs had not been designed for Doppler processing, their frequency did not have the desired stability. The spectrum was not always clean, with a nice stable carrier component, and often showed asymmetrical side-bands which significantly compli-

(story continued on p. 2)

cated the required signal processing on the ground. The Communications Research Centre (CRC) of the Department of Communications of Canada (DOC) pioneered the Doppler processing technique for 121.5 MHz beacons and embarked, with NASA and NOAA in the USA, on the first leg of the SARSAT project: the 121.5/243 MHz SAR repeater system.

At the time, the French national space centre (CNES) was cooperating with NOAA and NASA in the USA on the development of the Argos system. Argos, as a successor to EOLE, aimed to provide environmental data collection using NOAA's polar-orbiting satellites. Argos, still in operation to this day, was capable of locating moving objects, from large ships to animals, anywhere in the world using low power transmitters at 401 MHz. The transition to a 406 MHz distress alerting system was a logical step which would offer, in the long-term, far better performance than could be expected from the 121.5 MHz system. In particular, onboard processing of 406 MHz transmissions would provide global coverage which clearly could not be achieved with a repeater system on low-altitude polar-orbiting satellites. The 406 MHz Search and Rescue Processor, with onboard store-and-forward processing capability, would form the second leg of the Search and Rescue Satellite Aided Tracking (SARSAT) experiment associating NASA, DOC and CNES.

In these cold-war times, after the end of the race to the moon (1969-1972) and the success of the Apollo-Soyuz mission in 1975, international cooperation and the peaceful use of space technology were attractive to policy makers eager to show the benefits of space applications to ordinary citizens. A joint East-West search and rescue satellite experiment with a humanitarian purpose, no exchange of funds and no technology transfer was an ideal vehicle for cooperation. Morflot, the USSR Ministry of Merchant Marine, and Morsviazsputnik, its agency responsible for maritime mobile satellite communications, were considering a satellite concept also using the 406 MHz frequency reserved by the ITU for low-power Emergency Position-Indicating Radio Beacons (EPIRBs). The COSPAS project, coordinated by the Space Research Institute of the USSR Academy of Sciences, aimed to detect and locate ships in distress, worldwide.

The marriage of the two projects was celebrated with the adoption of the first Memorandum of Understanding (MOU) between CNES of France, the DOC of Canada, Morflot of the USSR and NASA in the USA, in Leningrad[1], USSR on 23 November 1979. The COSPAS-SARSAT Project was officially established the following year, in 1980, after the official ratification of the MOU by the four partners, despite international tensions resulting from the Soviet intervention in Afghanistan[2]. The objective was to ensure that both systems would be fully "interoperable". All distress beacon transmissions, whether at 121.5 MHz or 406 MHz would be relayed by all available satellites and their signals would be received by ground receiving stations anywhere in the world[3].

The stage was now set for the challenges and successes of the 30-year Cospas-Sarsat saga.

1982: FIRST SATELLITE LAUNCH AND FIRST SAVES

The first satellite (Cospas-1) was launched on 30 June 1982. On 10 September 1982, a few days after the satellite repeater was activated and made available in orbit, a 121.5 MHz signal was detected by an experimental ground station in Ottawa, Canada, leading to the first successful rescue of three survivors of a light airplane crash in British Columbia, Canada. This very early success and the ensuing media coverage were enough to convince doubters that satellite detection and location was valuable in distress situations. It also

Morflot Delegation (USSR) in Leningrad, USSR, November1979.

proved the value of associating the processing of "old" analogue 121.5 MHz signals with the development of "new" digital 406 MHz beacons in the same experimental programme, as a successful demonstration of the 406 MHz technology would not have had the impact of a real rescue among policy makers and regulators. The first actual rescue using a 406 MHz beacon was not achieved until December 1984, when a car racer in an automobile rally in Somalia seriously injured himself. The fourth 406 MHz real SAR event and first rescue at sea involving a 406 MHz EPIRB was registered in March 1987. However, it would take another 22 years to achieve a full transition from the 121.5 MHz technology to 406 MHz distress beacons.

1985: THE SYSTEM IS DECLARED OPERATIONAL

After a thorough demonstration and evaluation of the system over two and a half years (1982-1984), the formal approval of the Project Report by the Cospas-Sarsat Coordinating Group and, by mid-1984, more than 255 persons rescued in over 90 distress incidents using Cospas-Sarsat data, the partners were eager to declare the system "operational". A second Memorandum of Understanding was signed on 5 October 1984 between the Department of National Defence (DND) of Canada, CNES in France, NOAA in the USA and Morflot in the former USSR to reflect the transition of responsibilities and the system was declared operational at the first meeting of the newly established Steering Committee, in July 1985 in Seattle, Washington, USA. However, full international recognition required more than a formal declaration by the founding partners that the system was ready for use and would be maintained "at least until the year 2000". The coordination of a worldwide operational satellite system was already over-stretching the capabilities of the four operating agencies. Four other countries had participated in the system demonstration and evaluation phase (Bulgaria, Norway, the UK and Venezuela). Other countries were ready to join in the use of the system or the installation of ground receiving stations, including Australia, Brazil, Chile, Denmark, India, Italy, Japan, the Netherlands, Spain, Sweden and Switzerland. The required coordination was now expanding from technical to regulatory issues, and from development work to operational matters and world-wide alert data distribution. Moreover, this evolution required coordination of operations with new stakeholders, the Search and Rescue authorities who were the actual "customers" of Cospas-Sarsat alert data.

1988: SIGNING OF THE INTERNATIONAL COSPAS-SARSAT PROGRAMME AGREEMENT

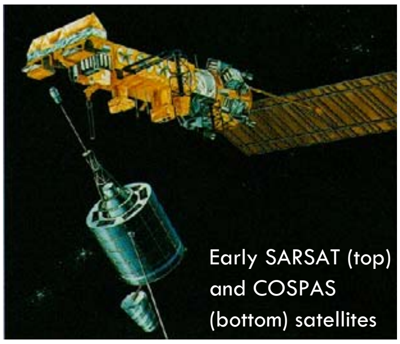
The need for a permanent administrative body was accepted by all partners, but the desired international secretariat could not be implemented without establishing the principles of long-term institutional arrangements guaranteeing funding and system continuity. Furthermore, IMO could not officially accept the 406 MHz system as part of the "Future Global Maritime Distress and Safety System" (FGMDSS) without a formal commitment by the provider States to ensure free and continuous availability of the satellite system. A formal international instrument was needed to define the management structure of the system and the roles and responsibilities of providers, operators and users. All possible options for a specific Cospas-Sarsat organisation and the associated international policy constraints were considered[4] and three years of intense negotiations were required to develop, agree and sign on 1 July 1988 the International Cospas-Sarsat Programme Agreement (ICSPA) between the governments of Canada, France, the USA and the USSR. The ICSPA, with the force of a full treaty, ensured the continuation of the system and its availability to all States on a non-discriminatory basis, free of charge for users in distress. It also defined the means and procedures by which other States could associate with the Programme and contribute to the System and/or participate in its management.

(story continued on p. 6)

SARSAT Delegation (Canada, France, USA) in Leningrad, USSR, November 1979.

Cospas-Sarsat 1979-2009:

1979 The Cospas-Sarsat System was initially developed under a Memorandum of Understanding (MOU) among Agencies of the former USSR (Morflot, Ministry of Merchant Marine), USA (NASA), Canada (Dept of Communications) and France (CNES, Centre National d'Etudes Spatiales), signed in 1979 in Leningrad.


Early SARSAT (top) and COSPAS (bottom) satellites

1982 The first Cospas-Sarsat LEO satellite (Cospas-1) was launched by the USSR on 30 June 1982 and on 10 September, a few days after the satellite repeater was first activated, a 121.5 MHz signal was detected by an experimental ground station in Ottawa, Canada, leading to the first successful rescue of three survivors of a light airplane crash in British Columbia, Canada.

1984 After completion of a successful Demonstration & Evaluation phase, a second Memorandum of Understanding was signed on 5 October 1984 by CNES of France, the Department of National Defence (DND) of Canada, Morflot of the former USSR and the National Oceanic and Atmospheric Administration (NOAA) of the USA. By mid-1984, more than 255 persons had been rescued in over 90 distress incidents with the assistance of Cospas-Sarsat data.

1985 The Cospas-Sarsat System was declared operational.

1987 The Cospas-Sarsat Secretariat was established in London, U.K., under a specific Arrangement between the Cospas-Sarsat partners (Canada, France, the USA and the USSR) and Inmarsat.

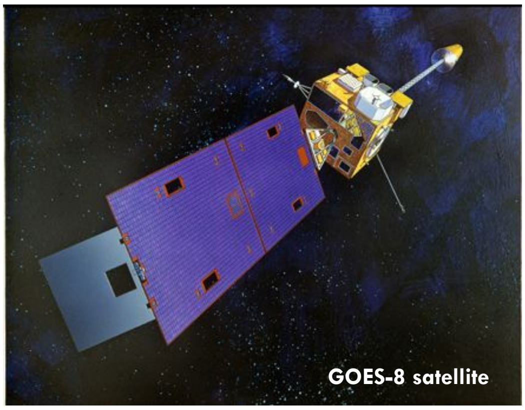
1988 On 1 July 1988, the four States providing the space segment (Canada, France, USA, USSR) signed the International Cospas-Sarsat Programme Agreement which ensures the continuity of the System and its availability to all States on a non-discriminatory basis.


Photo: Signing of the International Cospas-Sarsat Programme Agreement, Paris, 1988. From left to right: C.P. Srivastava, Secretary General of IMO; William Evans, USA; O.A. Savine, USSR; Gilbert Perol, France; David Wright, Canada; ICAO Representative, Paris Office.

Major Milestones

1993 Satellite EPIRBs became mandatory equipment for all ships operating under the IMO Safety of Life at Sea (SOLAS) convention.

1998 A GEOSAR demonstration and evaluation (D&E) was performed during 1996 and 1997 with the participation of Canada, Chile, France, India, Spain, the UK and the USA. The D&E clearly showed the significant time advantage provided by the GEOSAR system for the prosecution of SAR cases. In 1998, the GEOSAR system, comprising two GOES satellites (USA) and the Indian INSAT-2A satellite, was formally declared part of the Cospas-Sarsat System.


GOES-8 satellite

2005 In 2005, the Cospas-Sarsat Parties decided to accept Canada's invitation to establish the Programme and its Secretariat in Montreal, with the legal status of a body corporate in Canada and all the privileges of an international organisation. A new international agreement was signed in April 2005, complementing the 1988 Agreement.

2005 Montreal, Canada becomes the new home of the Cospas-Sarsat Programme office.

2009 In accordance with the 2000 Council decision, satellite processing of 121.5/243 MHz distress signals was terminated on 1 February 2009. The System operates with only the superior digital 406 MHz beacon, whose stronger signals are

more verifiable and traceable. In 2009, more than 900,000 406 MHz beacons were in use. Since September 1982, more than 27,000 persons have been rescued with the assistance of Cospas-Sarsat distress alert data.

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The ICSPA did not establish a new international organisation but did define the management structure of the Programme with a Council and a permanent administrative body: the Secretariat. For the provision of secretariat services, the Cospas-Sarsat partners decided to contract with the International Maritime Satellite Organisation (Inmarsat) based in London, UK. This urgent step was actually achieved in August 1987, before the signature of the ICSPA, and these arrangements continued until 1999 at which time Inmarsat was privatised and the Cospas-Sarsat Secretariat transferred to Inmarsat's successor: IMSO (International Mobile Satellite Organization).

The ICSPA proved to be the cornerstone of success of the International Cospas-Sarsat Programme. In particular it allowed Cospas-Sarsat to overcome many political hurdles in the four countries providing the space segment and survive substantial international changes resulting from the disappearance of the USSR in 1991. In January 1992, Russia formally assumed responsibility for the obligations of the former Soviet Union under the ICSPA.

For the original partners, the main benefit of the ICSPA was to ease political pressures that would periodically reappear when the time would come to approve a budget for new satellite payloads or to fund ground segment equipment and operations. For users, the commitment to System continuity and non-discriminatory availability was fundamental to passing regulations mandating the carriage of ELTs on aircraft or EPIRBs on merchant vessels and fishing boats. For those States who wished to contribute to the management of the Programme and eventually procure and operate ground receiving stations, the ICSPA provided a stable and clear foundation for their role and status as associated participants.

Meeting in Paris, France, July 1988. From left to right: D. Hodgson (Canada), Y. Zurabov (USSR), J. Bailey (USA).

1993: EPIRBS MANDATORY ON SOLAS SHIPS

The entry into force of the ICSPA in 1988 opened the door to full international acceptance of Cospas-Sarsat and IMO soon decided to adopt 406 MHz satellite EPIRBs, in parallel with another competing design, the L-band satellite EPIRB relayed through Inmarsat's geostationary satellites. On 1st August 1993, satellite EPIRBs became mandatory on all ships subject to the SOLAS convention, prior to the 1999 deadline for the GMDSS implementation. Many States had already made 406 MHz float-free beacons mandatory equipment on large fishing vessels. Sales of 406 MHz EPIRBs boomed and, by mid-1993, with over 2,000 persons rescued in about 560 distress incidents at sea, the device quickly became popular with sailors, overcoming earlier scepticism. The L-band EPIRB design required an integrated location device to provide the vessel's position in the distress message. The development of EPIRBs with integrated GPS receivers was successfully completed, but with some delays which impacted marketing opportunities. Ultimately, in 2004, Inmarsat, recognising the limited appeal of L-band EPIRBs in a market already captured by 406 MHz beacons, decided to discontinue the Inmarsat-E service by December 2006 and offered to replace about 1,300 L-band beacons in use worldwide with an equivalent 406 MHz type.

1995: FIRST GEOSAR PAYLOADS IN OPERATION

The participation of SAR authorities, the recipients of Cospas-Sarsat alert data, in the management of the System provided the incentive for its constant evolution, technically as well as operationally. Quasi-real-time alerting, identified by IMO as a desired requirement for EPIRBs, could not be provided by the Cospas-Sarsat LEOSAR system, comprised of a limited number of low-altitude polar orbiting satellites. In 1984, the USA, in conjunction with Canada and France, conducted an experiment on NOAA's geostationary satellite GOES-7 which showed the feasibility of detecting 406 MHz signals from existing Cospas-Sarsat beacons in quasi-real-time. This type of processing was not feasible for 121.5 MHz very low power analogue transmissions.

However, much more work was still required to demonstrate reliable availability and benefits of 406 MHz GEOSAR processing. The challenge was considerable, as 406 MHz beacons were designed for LEOSAR operation, with satellites flying at about 850 km altitudes instead of the 36,000 km altitude of geostationary spacecraft. Position determination in the LEOSAR system was provided using a Doppler technique, which was not possible with the GEOSAR alerting system. The benefits of GEOSAR alerting for beacons without a location capability were unclear and much debated amongst Cospas-Sarsat participants. The feasibility of adding a GNSS receiver to the beacon and encoding the GNSS position in the beacon message had to be investigated. New beacon coding protocols compatible with the LEOSAR onboard processor had to be developed together with special alert processing requirements.

Finally, by 1995, three geostationary satellites equipped with a 406 MHz repeater were available for comprehensive evaluation: the USA satellites GOES-8 and 9, and the Indian satellite INSAT-2A. The beacon specification had been modified to accommodate new coding schemes with an encoded location, and processing requirements had been defined and implemented in a number of ground receiving stations. Finally the Cospas-Sarsat MCC communication network was enhanced to distribute the new alerts on a worldwide basis. The GEOSAR demonstration and evaluation (D&E) was performed during 1996 and 1997 with the participation of Canada, Chile, France, India, Spain, the UK and the USA. The D&E clearly showed the significant time advantage provided by the GEOSAR system for the prosecution of SAR cases, even when no encoded location data was available in the alert message received from the beacon. Furthermore, subsequent developments showed that GEOSAR beacon frequency data could be combined with LEOSAR data processing to enhance the Doppler location capability of the LEOSAR system.

The GEOSAR D&E Report was approved by the Cospas-Sarsat Council in October 1998 and the GEOSAR system was formally declared part of the Cospas-Sarsat System, fourteen years after the very first experiment.

2005: COSPAS-SARSAT AS AN INDEPENDENT ORGANISATION

Although the Cospas-Sarsat relationship with IMSO remained at all times excellent and fruitful, the privatisation of Inmarsat in 1999 had revealed a serious limitation of the arrangements made in 1988. The Secretariat of the Programme had no independent legal status in the host country, the UK. The management of the Programme was in practical terms dependent on temporary contractual arrangements with an organisation which was not under the control of the founding partners and had no direct stake or responsibility in maintaining the Programme. A more stable environment was required for long-term development. After investigating various options, the Cospas-Sarsat Parties decided to accept Canada's invitation to establish the Programme and its Secretariat as an independent organisation in Montreal, with the legal status of a body corporate in Canada and all the privileges of an international organisation. A new international agreement was needed, complementing the 1988 ICSPA. This was achieved in record time and the new Arrangement was signed in April 2005. The Order in Council giving legal status to the organisation was issued by the Federal Government of Canada in May 2005, allowing the Secretariat to move from London to Montreal in July of the same year.

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Inauguration of the Secretariat Headquarters in Montreal, Canada, April 2005. From left to right: M. Hucteau (France), J. Murray (Canada), D. Levesque (C-S Secretariat), A. Kushev (Russia), A. Mehta (USA).

2009: TERMINATION OF SATELLITE PROCESSING FOR 121.5/243 MHz BEACONS

The Cospas-Sarsat Council decision, in October 2000, to terminate satellite processing of 121.5/243 MHz distress signals on 1 February 2009 was well publicised by Cospas-Sarsat and carefully coordinated with IMO and ICAO [see Information Bulletin No 20 (Feb. 2008) and 21 (Feb. 2009)] . The rationale for the decision and the timing of its implementation were extensively documented in the Cospas-Sarsat 121.5/243 MHz Phase-Out Plan. However, despite thorough preparations by Cospas-Sarsat and a number of countries, many users remained unconvinced of the need to take action and replace their soon to become obsolete analogue 121.5 MHz devices. One particular issue was the impossibility to accurately determine the number of 121.5 MHz beacons still in service. In 2007, 222 SAR events were associated with 121.5 MHz alert and location data provided by Cospas-Sarsat. In 2008, this number dropped to 135, which would correspond to a potential 121.5 MHz beacon population of 275,000, assuming a similar activation rate as for 406 MHz beacons.

The reluctance of certain categories of users, particularly general aviation aircraft owners in North America to "switch to 406" was offset by the considerable growth of the 406 MHz beacon population worldwide during the last few years, which proved that determined efforts by administrations could also be successful.

The February 2009 deadline to "switch to 406" has now passed. For Cospas-Sarsat providers, almost 30 years after the launch of the Cospas-Sarsat project, this event was a clear sign of the Programme's maturity and the Programme participants are now focussing their efforts on the next stage, the development of the MEOSAR system with enhanced services to users and SAR authorities, which should pave the way for another 30 years of successful operations.

Acronyms:

CNES: Centre National d'Études Spatiales (France)

COSPAS (КОСПАС) = Космическая Система Поиска Аварийных Судов (*Cosmicheskaya Sistema Poiska Avariynyh Sudov*) - satellite system for the search of vessels in distress

DOC: Department of Communications (Canada)

GEOSAR: Geostationary Earth Orbiting satellite system for Search and Rescue

GMDSS: Global Maritime Distress and Safety System

GNSS: Global Navigation Satellite System (e.g. GPS, Glonass, Galileo)

ICAO: International Civil Aviation Organization

IMO: The International Maritime Organization

IMSO: The International Mobile Satellite Organization

ITU: International Telecommunication Union

LEOSAR: Low-altitude Earth Orbiting satellite system for Search and Rescue

MCC: Cospas-Sarsat Mission Control Center responsible for alert data distribution

MEOSAR: Medium-altitude Earth Orbiting satellite system for Search and Rescue

MORFLOT: Ministry of Merchant Marine of the Soviet Union

MORSVIAZSPUTNIK: Russian agency for maritime navigation and mobile satellite communications at sea and on land

NASA: National Aeronautics and Space Administration (USA)

NOAA: National Oceanic and Atmospheric Administration (USA)

SARSAT: Search and Rescue Satellite Aided Tracking

SOLAS: International Convention for the Safety of Life at Sea, 1974

Notes:

1. Now Saint Petersburg, Russia.

2. See "Cospas-Sarsat: a quiet success story" (Richard J H Barnes & Jennifer Clapp) in Space Policy 1995 11 (4) P.266.

3. The 243 MHz frequency, used in distress beacons similar to 121.5 MHz ELTs was also relayed by repeaters on Sarsat satellites. However, these beacons being mostly used by NATO countries in military aircraft, the 243 MHz satellite system was not considered for inclusion in the Cospas-Sarsat project. Consequently, Cospas spacecraft did not carry 243 MHz repeaters.

4. See "The Development of an Institutional Structure for the Future Global Satellite System for Search and Rescue" (D. Levesque, K. Hodgkins, P. Drover) in Satellite Search and Rescue - Experimental Results and Operational Prospects, CNES-Toulouse 1984.

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