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COSPAS-SARSAT
DEMONSTRATION AND EVALUATION RESULTS
IN CANADA

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ABSTRACT

The Search and Rescue community in Canada has been making operational use of COSPAS-SARSAT data since September 1982. This paper will summarize the Canadian operational experiences with an emphasis on the aeronautical environment.

Canadian COSPAS-SARSAT Demonstration and Evaluation results are discussed in terms of the operational impact of the system in support of Search and Rescue activities. The involvement of the COSPAS-SARSAT system in the "Real World" environment is described in relationship to its contribution to the resolution of both the real distress and false alarm events.

INTRODUCTION

Although the COSPAS-SARSAT Demonstration and Evaluation did not formally start until February 1983, for Canada, the demonstration really began on the 9 September 1982. On that date COSPAS-SARSAT recorded its first involvement in support of a real distress incident. This incident, referred to in Canada as SAR ZEIGELHEIM, involved the crash of a small airplane in rugged mountaineous terrain in north central British Columbia. Three people were on board and all were rescued with the aid of locating data provided by COSPAS-SARSAT.

Since that date, COSPAS-SARSAT has continued to demonstrate its utility as a very positive adjunct supporting the efforts of the Canadian Search and Rescue (SAR) community.

The purpose of this paper is to provide an overview perspective on the Canadian operational experience using the COSPAS-SARSAT facilities. As will be illustrated later, this experience relates primarily to the aeronautical environment since there are very few Emergency Position Radio Indicating Beacons (EPIRB) in use in Canada.

In order to put this discussion in a Canadian context, the COSPAS-SARSAT facilities available to the Canadian Search and Rescue community are briefly described.

THE CANADIAN COSPAS-SARSAT SYSTEM

The mandate of the Canadian COSPAS-SARSAT project was that of demonstrating the capability of the satellite system to reduce the time to detect and locate an emergency beacon transmitting from an aircraft or vessel in distress. Hence, it was a Research and Development activity with very obvious and strong operational overtones. To make it a viable activity, the project solicited and received overwhelming operational support in the definition, operations and evaluation of the COSPAS-SARSAT concept and the developed facilities.

The Canadian Department of National Defence, with its lead role in the coordination of Search and Rescue, undertook the major sponsorship of COSPAS-SARSAT through the Chief, Research and Development Branch. A project office located at the Defence Research Establishment Ottawa (DREO) managed the Canadian aspects of COSPAS-SARSAT with the support of a Technical Office managed and staffed by the Communications Research Centre (CRC) of the Department of Communications (DOC).

Although COSPAS-SARSAT was developed as a prototype activity, every effort was made to incorporate as many operational facilities as could be accommodated under project constraints. Before the developed facilities are described, the SAR environment into which COSPAS-SARSAT was incorporated is briefly discussed.

The COSPAS-SARSAT Operational Environment

The Canadian Search and Rescue environment is very active, involving in excess of 8500 logged events a year. Canada has a very large land mass, much of it very sparcely populated. Furthermore, Canadians are a flying population with in excess of 20,000 small privately owned aircraft. Under existing regulations, these aircraft are required to carry Emergency Locator Transmitters or ELTs. Corresponding legislation does not exist for the marine communities. Therefore, within the COSPAS-SARSAT context, the SAR problem exists in the aeronautical environment for which in general the Department of National Defence has the primary operational responsibility.

Of these 8500 SAR incidents, about 2000 are air incidents. Correspondingly, of these 2000 air incidents, about 800 are initiated by ELTs and it is these events which COSPAS-SARSAT was developed to support. As an interesting aside, the ELT false alarm rate is 98%, or about 16 incidents a year involve true distress in which a beacon played a significant role. Only about 44% of the non-distress beacon activations are actually ever traced.

To support Search and Rescue operations, the Department of National Defence has established four Rescue Coordination Centres across Canada located at: Victoria, British Columbia; Edmonton, Alberta; Trenton, Ontario; and Halifax, Nova Scotia. These centres are manned 24 hours a day seven days a week by both military and Canadian Coast Guard controllers. In general the military controllers handle air/land incidents and the Coast Guard controllers handle marine related incidents.

In addition to the marine resources available through the Canadian Coast Guard and other government departments, each RCC has associated with it a dedicated Search and Rescue Squadron. Each squadron consists of a mixed fleet of fixed wing aircraft and helicopters of a type suitable to the environment of the particular RCC. Over the years, on average, these craft fly about 7000 hours each year in support of Search and Rescue cases.

It was into this environment that COSPAS-SARSAT facilities were incorporated to support the Canadian Search and Rescue community.

The Canadian
COSPAS-SARSAT Facilities

Operationally, the Canadian COSPAS-SARSAT facilities consist of the Canadian Mission Control Centre (CMCC), the Local User Terminal (LUT) and the communication lines which join these facilities together and provide the link between the Mission Control Centre and the aforementioned RCCs.

The Canadian Mission Control Centre, located at Canadian Forces Base (CFB) Trenton, Ontario has been in operation since July 1982. Late in August 1982, it began receiving COSPAS I data from the Canadian Local User Terminal, processing these data and distributing them to the Rescue Coordinating Centres. This centre which operates 24 hours a day, 7 days a week has two primary functions: it is a computer based receiver and distributor of COSPAS-SARSAT data; and, in addition, being manned by Search and Rescue personnel, it is a SAR unit and hence provides a first level screening of the COSPAS-SARSAT data before passing it on to the RCCs. In Canada, this operational filtering of the data is considered very important.

The Canadian LUT, located at Shirley Bay, Ottawa, was installed in the spring, 1981. It was the subject of a detailed technical checkout until August 1982 when it first began tracking COSPAS I. With the launch of COSPAS II and SARSAT I in the spring, 1983, the LUT began supporting tracks of all three satellites. Obviously a single LUT does not provide full national coverage nor is the location of the LUT ideal. This was a constraint on the R&D project to demonstrate the utility of the concept before commitments were made towards full national coverage.

The CMCC and the LUT are linked electronically via dedicated communication lines. The CMCC in turn is linked to the four Canadian RCCs via the Advanced Defence Data Network and to the USMCC via the ADDN/AUTODIN. All the data links have worked well, and, as will be discussed later, they have managed to handle the large volumes of COSPAS-SARSAT data.

With this background discussion provided on COSPAS-SARSAT in Canada, attention is now focussed on operational experiences gained to date and initial assessments of performance observed.

OPERATIONAL EXPERIENCES

With the launch of COSPAS I in June 1982, Canada upon handover of the satellite in August 1982, began using the data provided by the COSPAS-SARSAT system to support the operational SAR agencies. Even though the system was undergoing technical checkout, all alert data generated were being reviewed and where appropriate, operational data were being distributed.

Therefore, while the formal commencement of the COSPAS-SARSAT D&E phase was not until 1 February 1983, operations in Canada really began in early September 1982 with the previously noted SAR ZEIGELHEIM incident.

Operational experiences involving the use of COSPAS-SARSAT are now considered in terms of:

- Distress Incident Summary
- The False Alarm Problem
- Operational Impact
- Accuracy and Coverage
- Identified Deficiencies

Distress Incident Summary

The operational experience with COSPAS-SARSAT began with SAR ZEIGELHEIM. As of February 1984, when the last coordinated list was put together, COSPAS-SARSAT has supported 69 significant SAR events involving 206 people of which 186 were rescued. While it may not be a meaningful statistic, these numbers equate to COSPAS-SARSAT involvement on average in one distress incident a week, contributing to the rescue of 2-3 people per incident.

In the subject time frame Canadian incidents consisted of 20 events involving 46 people of which 37 were rescued. Significantly, all incidents except one were in the air environment. Time is not available to discuss these events in detail. However, three are briefly summarized to give an indication of how COSPAS-SARSAT data is being used. The three considered are:

- ZEIGELHEIM
- BARRY
- POTVIN

Aside from being the first recorded event, SAR ZEIGELHEIM had some very interesting aspects to it. It involved a plane crash, with injuries in a remote region. Significantly, the SAR Forces had just finished a unsuccessful search in the same region for the crash site of the son of the occupant of the ZEIGELHEIM craft. In this unsuccessful search over 2000 hours of flight time had been logged. Under slightly different circumstances and without the aid of COSPAS-SARSAT the ZEIGELHEIM incident could have suffered the same fate.

SAR BARRY is another interesting incident. It involved 2 people who lost their canoe while running rapids in a remote region of north central Ontario. Stretching a point, this could be considered Canada's first marine incident. These people were on a wilderness trek and were approximately 70 miles from civilization when the incident occurred. Furthermore, because they had just started out on their adventure and were not expected back for a month, their predicament could have gone unnoticed for weeks before a search would have started. Fortunately they had an ELT which alerted the SAR Forces and directed the latter right into the incident site. Without COSPAS-SARSAT and the ELT, these people would have had a definite problem.

Finally, SAR POTVIN was an incident which occurred in January 1984, and involved the crash of an airplane in a wooded area on Anticosti Island. Four people, with injuries, were involved. COSPAS-SARSAT data alerted the SAR Forces well before the conventional overdue notices. As a result, RCC Halifax was able to react quickly and get search aircraft into the area just before darkness set in on the day of the incident. Significantly, just after the rescue, a snow storm hit the area. The resulting weather would have made it impossible for search aircraft to operate in the area the whole of the next day and definitely would have made it very uncomfortable for the injured people.

The False Alarm Problem

Historically, Canada has had an ELT/EPIRB false alarm problem. Not all SAR ELT related events are of the spectacular nature of those just described. Over the years there has been a consistent false alert rate of 97-98%.

The reasons for this high false alarm rate are many and varied. A sample of some reasons include:

- ELT accidently activated on commercial aircraft.
- ELT activated by hard landing.
- Aircraft blown over by wind activating ELT.
- ELT traced to closet in private home.
- ELT accidently set off when pilot swept aircraft off.
- Badly corroded ELT began transmitting.
- ELT traced to aircraft in hangar, wiring was faulty.
- ELT accidently turned on during installation.

COSPAS-SARSAT data is contributing to the resolution of ELT false alarms. In fact all those traced ELT events just mentioned involved the use of the satellite data.

As part of the evaluation, the reasons for ELT activations for non distress incidents have been categorized from a sample provided through incident reports, see Table 1. Assuming that this sample represents the total population of reasons for the occurrence of non-distress incidents, then the conclusion drawn is that 70% of such incidents need not occur. They relate to poor maintenance or operating procedures, or to basic design shortcomings in the ELT which, therefore, necessitate overly stringent maintenance attention. It is interesting to note that 8% of the alerts involve ELT/EPIRBs in the non air/marine environment, i.e. in homes, in transit, etc.

TABLE 1

REASONS FOR
NON DISTRESS ELT/EPIRB INCIDENTS

Reasons	% of Cases
Maintenance	15
Parked Aircraft (No Particular Reason)	39
Poor Operating Procedures	8
Airborne	2
Non Air/Marine Environment	8
Hardland/Minor Incidents	11
Weather	6
Transmitters, FSS, etc.	5
Unknown	5

Weather or minor incidents account for 17% of the cases. In most of these cases, the ELT was activated for justifiable reasons.

In summary, the false alarm rate is high and a number of causes for these alarms have been quantified. It is also evident that through a combination of a more resiliently designed ELT and better operations and maintenance procedures, the false alarm case load would be greatly reduced.

Operational Impact

In terms of operational impact, two points are noted. Firstly, the trend of involvement of COSPAS-SARSAT in ELT incidents is described. Secondly, the general assessment of the utility of COSPAS-SARSAT as an alerting tool is discussed.

During the period Jan-Oct 1983 COSPAS-SARSAT data was involved in the resolution of 190 ELT/EPIRB incidents, the vast majority of which were obviously false alerts. In terms of percentage involvement, COSPAS-SARSAT started the year being involved in about 30% of the incidents. With the launch of COSPAS II and SARSAT I in March 83, this percentage has climbed to the 60-70% range, see Figure 1. Considering the source of many of the incidents, i.e. in or near airports where incident resolution is very quick, this is more than an acceptable involvement record. The important fact is that COSPAS-SARSAT is playing a role in the major incidents, i.e. the SAR ZEIGELHEIM, BARRY AND POTVIN's , where the potential exists for expending large amounts of resource effort in expensive searches.

Alert categorization data are available for the months August 1983 through January 1984. During the period in question 340 ELT/EPIRB events were logged.

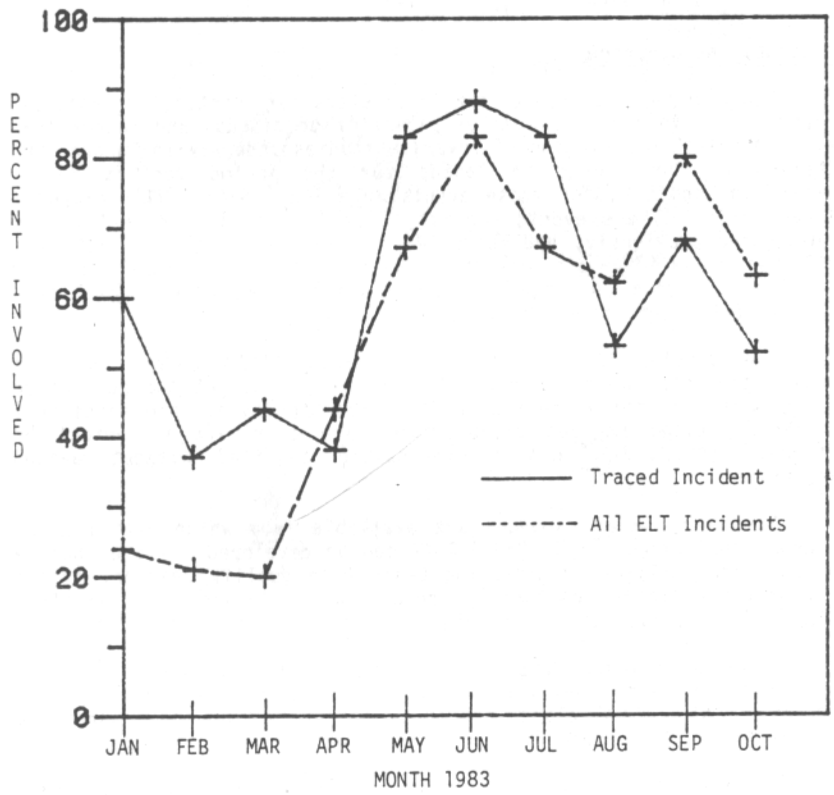
For each of these 340 incidents, the four RCCs categorized the alert mechanism in terms of COSPAS-SARSAT involvement. In the first instance it was noted whether COSPAS-SARSAT was involved or not. In the second instance for those cases involving COSPAS-SARSAT data, the RCCs identified whether satellite data was the only alerting data, whether it was the first alert source, or whether it was confirming information.

The percentage of cases for each of these categories for the period in question are as illustrated, in Table 2.

TABLE 2

SUMMARY
ALERT CATEGORIZATION
PERCENTAGE OF TOTAL CAES
August 1983 - January 1984

ALERT CATEGORIZATION	PERCENT CASES
COSPAS-SARSAT INVOLVED	
Satellite Only	18
Satellite First	23
Other First	24
Total	65
COSPAS-SARSAT NOT INVOLVED	35



COSPAS-SARSAT INVOLVEMENT LEVEL
IN ELT/EPIRB EVENTS

FIGURE 1

As noted in the previous involvement studies, these data indicate that COSPAS-SARSAT data is involved in 65% of the ELT/EPIRB events. Furthermore, in 41% of the cases, it was the first alert mechanism. It is also quite significant that COSPAS-SARSAT was the sole alerting device in 18% of the cases. COSPAS-SARSAT played a supporting or "assist" role in 24% of the cases and played no role in 35%. These latter percentages would seem acceptable considering the number of ELT activations in and around airports and populated areas.

In summary, available data indicates that COSPAS-SARSAT is playing a significant role in 60-70% of the Canadian ELT/EPIRB cases. It is a first alert facility in 41% of the cases and, significantly, in 18% of the cases now being recorded, it is the only alerting mechanism.

Accuracy and Coverage

Accuracy and coverage are parameters of particular interest operationally. Coverage is a complex parameter to discuss and rather than get into a detailed description of coverage studies underway in Canada, the distribution of SAR events in Canada for the period Jan-Oct 83 is illustrated in Figure 2, for those events in which COSPAS-SARSAT played a significant role. These events consist of real distress incidents, i.e. those discussed previously, and ELT/EPIRB traced transmissions which were set off for a variety of reasons. Note that these data are only illustrative of system coverage, not LUT coverage. Furthermore, it does not indicate SAR events missed, i.e. lack of coverage.

The distribution of SAR events using COSPAS-SARSAT data as illustrated presented no surprises. In general it follows the population belts of Canada. As noted previously, the important events are those that occur in the remote regions because they are difficult to detect by conventional methods and can be impossible to find without beacon information.

A number of data sources are available from which estimates of the accuracy performance of COSPAS-SARSAT can be developed. These include controlled signal uplinks, engineering tests with quality beacons, system tests, operational tests and finally operational incidents. In the final analysis, it is the operational incident data which determines performance.

Accuracy estimates are available for the previously described SAR events. This data base consists of 190 SAR cases in which the ELT was located, and COSPAS-SARSAT played a role by detecting them and providing a location estimate, see Figure 3.

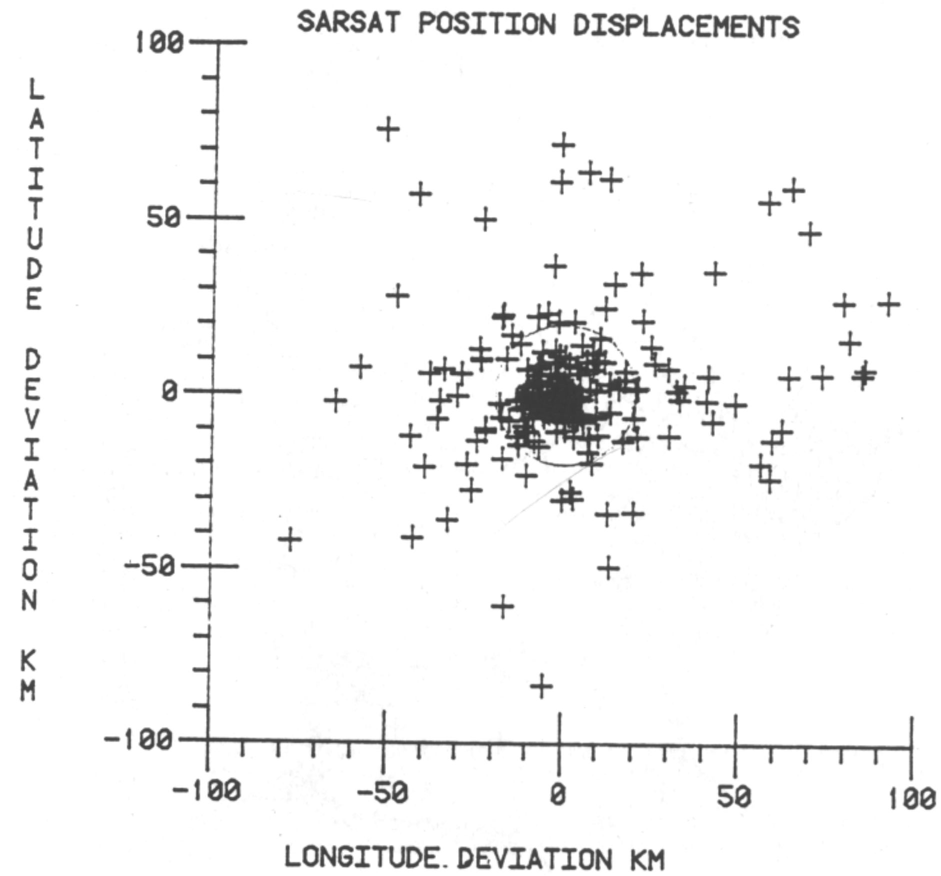
The summary conclusions arising from an analysis of these data include:

- The mean radial error (the 50 percentile) for the 190 cases, considering all detections, was 13.9 kilometers;
- the one sigma error or 67 percentile was 27 kilometers;
- 60.5% of the detections were within 20 kilometers.

The system specification requirement is a one sigma error of 20 kilometers. The data being considered suggest that 60% of these detections are achieving the required specification. The combination of this

DISTRIBUTION OF SAR EVENTS IN CANADA
USING COSPAS-SARSAT

FIGURE 2



ERROR ESTIMATES
CANADIAN SAR INCIDENT DATA (JAN-OCT 83)

FIGURE 3

parameter and the mean error of 13.9 kilometers indicates excellent performance. Two additional comments are made. Firstly, the variety of conditions under which these beacons are being detected are enormous, ranging from being found in a burning garbage dump, to closets in houses, to actual crashes. It is surprising that in many cases these beacons are detected at all. Secondly, technical studies are indicating that, particularly in the data processing and handling areas, improvements in location accuracy can be made.

Identified Deficiencies

As noted in the introductory remarks, COSPAS-SARSAT was viewed in Canada as a prototype development activity, necessarily with strong operational overtones. As such, the intention of the demonstration and evaluation was to identify deficiencies in the COSPAS-SARSAT system and facilities. The comment here is that for a prototype system, COSPAS-SARSAT has worked phenomenally well. However, improvements can be made.

Consider first the Canadian Mission Control Centre. It has worked very well. The Canadian project totally underestimated the volume of data it had to handle. An example period is the fifteen weeks between 24 July and 5 November 1983. During that period 29,000 messages were received and 15,000 transmitted. This amounts to the handling of 3000 messages a week. While the facilities can handle the data, CMCC operators have had to devote too much time just distributing the data with little time left over to put a SAR perspective on it. A major effort is underway to provide better facilities to manage the COSPAS-SARSAT data.

The Local User Terminal has proven itself to be a very resilient and technically sophisticated facility. Solution accuracy is presenting some problems operationally. However, as a counter to this problem, instances are documented in which COSPAS-SARSAT is providing good location data; but, when SAR Forces investigate, they cannot find the source. In other words, under some conditions the COSPAS-SARSAT system is more sensitive than local homing equipments. Another comment being made by Canadian operators is that they are not being provided with adequate quantitative information about the quality of the detected signal. RCC controllers are provided with location data with very little quidance concerning how to action it. Technical studies underway suggest that the LUT can provide meaningful confidence indicators to operational elements so that they can better establish procedures for handling the COSPAS-SARSAT data. Finally, as with the CMCC, the LUT is having problems managing the volume of data in terms of getting the most out of the available information.

These deficiencies, and others not discussed are seen as normal shortcomings in a prototype development activity, and, while they do not significantly degrade the performance of COSPAS-SARSAT, they make it a hard facility to operate and maintain. Identified deficiencies are being quantified in preparation for the conversion of COSPAS-SARSAT into an interim operational system.

SUMMARY COMMENTS

COSPAS-SARSAT Demonstration and Evaluation Results in Canada have been summarized. In general the Canadian elements of the COSPAS-SARSAT continue to work well and are contributing in a positive manner to the Canadian Search and Rescue community.

During its short period of existence the COSPAS-SARSAT system has met with overwhelming success. Both nationally and internationally COSPAS-SARSAT has demonstrated its capability to contribute to the rapid detection and location of people in distress. And, while the detailed evaluation of the performance of the COSPAS-SARSAT search and rescue satellite is not yet complete, some of the following anticipated benefits of the system are being realized:

- Quick reaction to distress alarms
- Respond to ship and aircraft distress signals
- Saving of lives
- More efficient use of SAR resources

In conclusion, COSPAS-SARSAT has now become an important and an enthusiastically accepted tool by the Canadian SAR community. The only challenge left will be to make it truly operational and user responsive.