Cessna C-GIIY's crash site as viewed from the air by 442 Squadron's Buffalo 458, the aircraft which spotted the downed aircraft and parachuted in medical help. The crash site is in the very centre of the frame.

SARSAT proven in mountain rescue

Canada's Armed Forces respond to more than 9,000 distress calls each year and log thousands of flight hours in search and rescue duties. Now, an international search and rescue satellite program, SARSAT/COSPAS, is offering increased coverage, faster response, better accuracy and lowered search and rescue costs. Although the system is not yet fully operational, it proved its worth in September when it located the three survivors of a light aircraft crash in the mountains of British Columbia.

The effectiveness of emergency locator transmitters (ELTs) and earth satellites as major tools for locating downed aircraft has been confirmed by the successful completion of a search and rescue mission in western Canada with crash site data relayed by a Russian navigation satellite.

The mission was mounted within the framework of an international search and rescue satellite program known in western countries as SARSAT and in the Soviet Union as COSPAS. Cosmos 1,383, the Russian satellite which picked up the signals from the downed airplane, was launched on June 30 this year and began a period of joint technical evaluation by the four SARSAT/COSPAS members (Canada, the U.S., France and the U.S.S.R.) on September 1. The Canadian rescue mission was the first operational evaluation of the ELT/satellite system and its success is expected to advance the program substantially.

The accident

On September 9, a Cessna 172 with three persons aboard departed Dease Lake, British Columbia, on a VFR flight for Dawson Creek, also in B.C., via Ingenika. The three persons aboard were John Zeigelheim, Gary Van Amelsvoort and George Heemskerk. This flight was itself a search mission; the three men were looking for Heemskerk's son, Jim, who had disappeared July 19, on a flight from Dawson Creek to Dease Lake. The search for the younger Heemskerk was placed on a reduced status by the Department of National Defence on August 10, after 1,780.9 flying hours.

At about 1100 hrs, the aircraft flew into a blind valley, stalled and crashed in a heavily wooded area surrounded by mountains, some of which topped 8,000 ft. (2,438 m). The three survived, but with significant injuries: a broken leg (Zeigelheim); broken ribs (Van Amelsvoort); and, a broken arm (Heemskerk). The aircraft ended up in a nose-down position, with the tail in the trees. The ELT's antenna broke off in the impact.

At about 1500 hrs the survivors, recognizing the seriousness of their situation, removed the ELT from the aircraft and climbed to the top of a hill (despite their injuries) to improve the beacon's range. Here, the broken antenna was stuck straight into the ELT's connector slot, again in an effort to improve their chances.

At 1515 hrs the Rescue Coordination Centre (RCC) at Victoria, British Columbia, was informed that the flight was overdue, and the RCC began a communications check of the area along the planned flight path. At 1659 hrs, the Canadian Forces' 442 (Search and Rescue) Squadron, based at Canadian Forces Base Comox, was alerted and at 1757 hrs, a de Havilland DHC-5 Buffalo aircraft was airborne to make an ELT search of the area (15 nm either side of the planned track (24 km)) and a night visual search was also performed. These were completed without success.

That evening, the possibility of acquiring an ELT signal by satellite was discussed, but it was discovered that the next two orbits would not place the spacecraft close enough to the crash to "see" the signal. However, a pass beginning at 0120 hrs on September 10 (the next day) was thought possible.

At 0120 hrs the next day, the SARSAT ground station at Ottawa, Ontario, began tracking the 17.5 minute pass over central Ontario, and, by 0200, had re-

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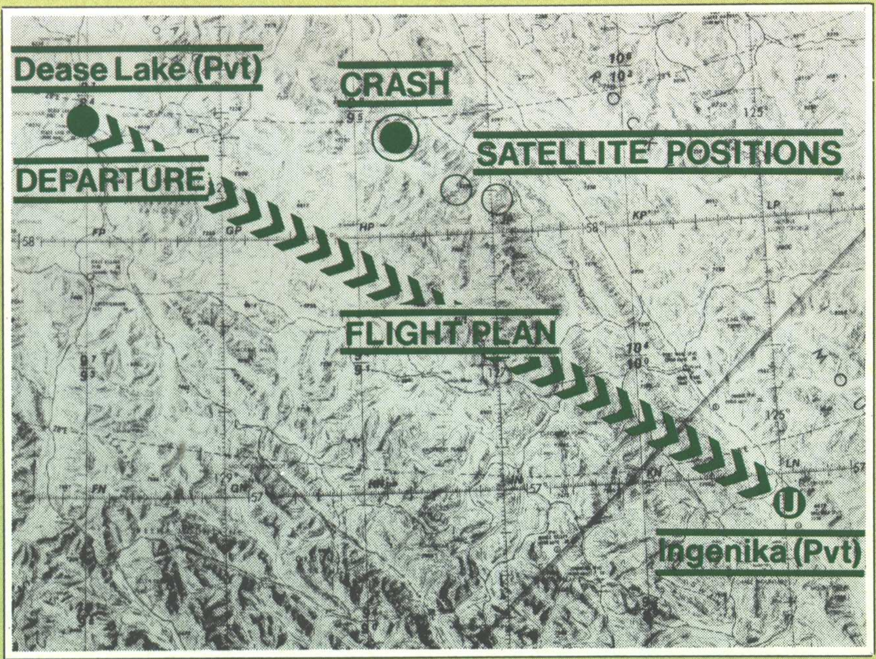
Continued from previous page
ceived ELT signals and identified two possible locations. The two sites were automatically passed to the Mission Control Centre at CFB Trenton, Ontario, which in turn passed the data to Victoria. A further processing of the satellite transmission narrowed the possibilities to one site, and a 442 Squadron Buffalo was directed to the area identified by the satellite system.

No ELT signal was received until the aircraft circled the area at greater altitude, where an ELT transmission was picked up, directing the aircraft to a position 14 nm (22 km) northwest of the satellite-derived site, where the downed airplane was found. Search and rescue technicians were parachuted into the site at 1330 hrs to begin medical treatment and at 1600 hrs a CAF search and rescue helicopter arrived overhead and lifted out the survivors and the SAR technicians.



The downed Cessna was located about 31 mi. (50 km) north of its planned flight path. Although the SARSAT system identified two possible crash sites, the ambiguity was resolved with enough precision to place rescuers close to the scene.

Off planned track

Canadian Forces personnel at the Victoria RCC have concluded that since the aircraft was found about 32 mi. (50 km) north of its intended route, three or four days could have elapsed before the area was searched, had the satellite information not been available. Further, the search crews at the scene concluded that the survivors would have gone into shock and that the pilot might not have survived beyond three or four days without medical attention.

Reception of the ELT signal itself was uncertain because of the crash site's extreme distance from the satellite ground track. Michael Stott, vice-president of Canadian Astronautics Ltd. (CAL), the Ottawa-based firm which designed, developed and built all the SARSAT ground stations in use in western countries, noted that both the crash site and the ground station (known as the Local User Terminal, or LUT) must be "visible" to the satellite.

The CAL system calculates the ELT's location by measuring the transmission frequency doppler shift, as received by the moving satellite. Since the satellite's precise position is known, the ELT's location can be derived very accurately.

Statistically, the SARSAT system will be able to determine location to within a four to six mile (7 to 10 km) range, although its most conservative rating is about 12 miles (20 km).

"Ideally," said CAL president Jim Taylor, "we like to have the middle point on the doppler curve (when the satellite is broadside to the ELT) and a couple of minutes on either side to determine the curve." The computer processing in the SARSAT system generates a curve which is similar to that received from the satellite. This curve is used to indicate an initial position fix on the ELT. With additional processing, the computer can smooth out the errors between its own (synthesized) curve and that received from the satellite.

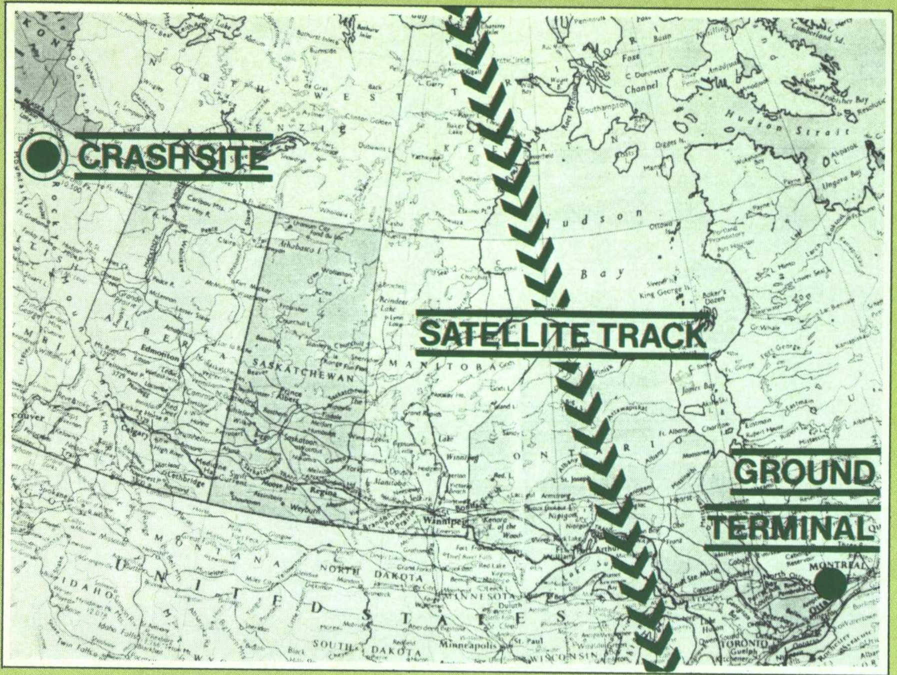
Canadian Armed Forces SAR duties combine both fixed-wing aircraft and helicopters. Shown: Buffalo 458.

Another factor in site determination is right/left ambiguity: when an ELT signal is received and processed, the position is known relative to the spacecraft's track. However, this position could be either to the right or left of the track. As the satellite track shifts slightly on subsequent orbits, one possible location will change, while the genuine target will have the same position indicated. Another way to resolve this problem and increase the coverage of the system would be to employ a network of satellites which would provide a number of fixes, from which the exact position should be readily identifiable.

In the case of the B.C. search and rescue operation, however, the system was only able to acquire the last five minutes of the curve (out of a 17.5 minute satellite pass), but this proved enough to put rescue crews close enough to the scene to pick up the ELT signals directly.

Canadian participation

Canada has been active in the development of the SARSAT system since 1973, when Telesat Canada (the domestic satellite communications system) undertook early feasibility studies. The Canadian government directed CAL to prepare system designs and program plans in 1974. Preliminary experiments with the amateur radio satellites, *OSCAR* 6 and 7,



A comparison of the crash site location and the track of COSPAS satellite orbit 990 on September 10 shows that reception of the downed Cessna's ELT signal was made at the extreme limit of the system's range.

were carried out by the Canadian government at CAL's suggestion, in 1976. The company became involved in the processing research and development work three years ago.

Spar Aerospace Ltd., Toronto, Ontario, will supply the satellite transponders for the SARSAT-equipped western spacecraft. The first of these, the U.S. National Oceanic and Atmospheric Administration/RCA NOAA-E spacecraft, is scheduled for launch in February, 1983. SED Systems Inc., Saskatoon, Saskatchewan is also involved in the program—the company provided the Canadian mission Control Centre at CFB Trenton, a message and traffic exchange facility which works with the regional rescue centres across Canada and, it is expected, eventually will act as an interface with other countries' national search and rescue facilities.

Manager of Canada's effort in SARSAT is the Department of National Defence, which is also responsible for the country's search and rescue efforts, although other departments, including the Canadian Coast Guard, Dept. of Energy, Mines and Resources, R.C.M.P., Dept. of Transport, Dept. of Indian and Northern Affairs and the Dept. of Fisheries and Oceans contribute to the service.

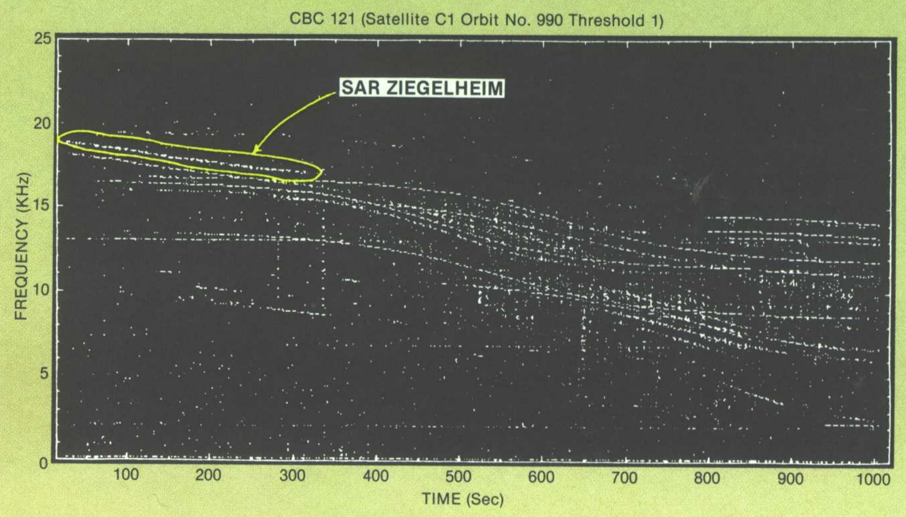
The SARSAT system is designed for both military and civil operations with ELTs that operate on either 121.5 MHz (civil) or 243 MHz (military use). Emergency position indicating radio beacons (EPIRBs), the marine equivalents of ELTs, can also be traced by the SARSAT/COSPAS system. A third, experimental frequency, 406.1 MHz, is under consideration for future ELTs and EPIRBs.

The new channel has been described as offering both more capacity and better accuracy than current channels. The current digital processor is capable of handling up to 10 signals in each of the 121.5 MHz and 243 MHz bands, and, said CAL's Stott, any more signals would probably overload search and rescue forces dramatically. Although the 406.1 MHz frequency would use more power, the experimental ELTs only emit a one-second burst, once per minute, so the system is not really suited to location by antenna direction finding. Finally, while the new frequency would provide a greater absolute degree of accuracy, CAL officials believe current frequencies are accurate enough to guide rescue crews to the immediate areas of a crash or sinking and that final location can be determined visually, or by conventional direction finding.

According to reasonable estimates, there are now about 200,000 ELTs in use in North America. They were legislated into Canadian aircraft in April, 1981, after some earlier regulatory wrangling over the safety of the batteries. ELTs are a proven and reliable method of locating an accident site; shortcomings in their effectiveness were due, as often as not, to the extremes of the Canadian terrain which limited their line-of-sight signals.

Said CAL's Jim Taylor, "It took only hours to accomplish this rescue, whereas traditional methods may take days, risk the lives of search parties and be too late. Time is of the essence because of severe weather conditions and possible injuries to victims of a disaster. In a practical sense, it is also going to save a lot of money in rescue operation costs throughout the world."

Now, with the advent of the SARSAT and COSPAS satellites, the geometry of the situation has been changed to ensure that when an ELT begins transmitting, there will be somebody listening.



A frequency trace of ELT transmissions received from the Soviet COSPAS satellite on September 10. As shown, only about the last five minutes of the desired trace were recorded. This was sufficient to generate a position fix.