Synthetic Aperture Radar and Search and Rescue

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Abstract - Scientists at the Canada Centre for Remote Sensing have explored the uses of remotely sensed imagery to assist Search and Rescue in Canada. Studies concentrated on the uses of SAR imagery for the detection and classification of crashed aircraft and have shown the feasibility of using such imagery for these purposes, although current spaceborne systems are proving limited in their capabilities. With further development in technologies, improved coverage of the Canadian land-mass of future systems, and further development of techniques it will be possible to assist in Search and Rescue for land targets. This is expected to bear fruit for RADARSAT-2 and other future satellite SAR systems.

INTRODUCTION

Most of the Canadian landmass is sparsely populated, and there are significant northern areas that are in total darkness for prolonged periods each year. Airplane traffic over these areas continues to increase. The need to reach crash sites (often of airplanes carrying less than half a dozen passengers) and to assist the victims is served by Search and Rescue (SAR) in Canada, which is the responsibility of the Department of National Defence [1] .

A major improvement in capabilities to save lives of crash victims was the development of the COSPAS-SARSAT program [2] which makes it possible to detect Emergency Locator Transmitters (ELTs). The current Canadian Search and Rescue procedure, well detailed in the National Search and Rescue Manual [3], involves listening for ELTs and visual searches from spotter aircraft. Unfortunately, although systems have been improving, the functioning of ELTs has been problematic. Statistics (obtained for the United States, and expected to be similar in Canada) indicate that ELTs function only about 25 percent of the time [4]: In most cases, the ELT does not operate and other methods of finding the crash site are required.

The possibility of using imagery from spaceborne systems to assist in search and rescue has been considered previously; indeed such possibilities were initially considered many years ago. (e.g. [5])). The need to find such crash sites in inclement weather and darkness provides the opportunity for scientists to assist in the development of techniques that make use of microwave remote sensing systems. These can provide imagery during periods when both visual searches and optical imaging systems are not able to help.

Fortunately, in recent years, there have been active initiatives in this area, in particular at the Search and Rescue Mission at NASA Goddard Space Flight Center, which launched a project in 1988 to investigate the feasibility of using space and airborne remote sensing technology to aid in beaconless searches [6]. The SAR^2 Project, has carried out experiments beginning in 1989 with several systems for a variety of test targets and locales in the United States [7]. A Canadian initiative at the Royal Military College examined the use of SAR and optical imaging (from spaceborne and other systems) in Search and Rescue [8]. Furthermore, Search and Rescue has been identified as an opportunity for RADARSAT-2 [9].

SAR is particularly useful for the location of crashed airplanes because of the microwave scattering by the dihedrals formed by parts of the airplane structure. It has been found that these often survive the crash: If the orientation between the SAR system and the target makes it possible to image these dihedral structures, it can be easier to find the crashed aircraft (e.g. [10]).

In these studies at CCRS, various techniques, including interferometric coherence and polarimetric signatures, have been examined for detection and, where possible, classification of targets as crashed aircraft.

INTERFEROMETRIC COHERENCE

Interferometric coherence can be used to locate non-changing, man-made targets within regions of natural targets. The location of crashed aircraft has been examined in coherence analyses performed with three RADARSAT-1 F5 images acquired in 1998 (July 4, July 28, and October 8).

The target was a Fairchild-27 that crashed in Northern Canada in 1968 (Figure 1).

Figure 2 is a colour composite of July 28, 1998 – October 8, 1998 coherence, July 4, 1998 – October 8, 1998 coherence, and the July 28 1998 intensity image as background. Close scrutiny of Figure 2 indicates that only one target was highlighted (i.e. the Fairchild-27). This is a consequence of the crashed aircraft having high backscatter and there being high coherence in both image pairs (resulting in a white composite sample). The number of false alarms detected would be less than .03 per square km.

POLARIMETRY

The distinctive polarimetric signatures of man-made targets provide an aircraft detection and classification opportunity. We used a methodology based on work at NASA GSFC SAR^2 [10]. Our testing used data acquired by the C-SAR on board the Environment Canada Convair-580 operating in polarimetric mode [11][12].

For test data over Carp, Ontario, a number of aircraft parked for the winter (Figure 3) were imaged on March 18, 1999. Signal data were acquired and processed at CCRS to calibrated imagery in each of the four polarimetric Scattering Matrix components (S_{HH}, S_{HV}, S_{VH}, and S_{VV}) at resolutions of 6 m (slant range) by 1 m. (azimuth).

These results shown in Figures 4 and 5 indicate that man-made targets including the aircraft, were detected, and all of the aircraft were correctly classified: In these figures, the small aircraft have been identified (as expected) and classified by their polarimetric signatures (as dihedrals or narrow dihedrals). This study was complicated by the proximity of other man-made targets (buildings) which would not be present in an actual search.

CONCLUSIONS

These examples show successful use of SAR for detection of man-made targets, in particular, crashed aircraft. As there will soon be an increase in available spaceborne SAR and operating modes, the possibility of saving lives and mitigating the effects of aircraft crashes will improve. Further work in the development and testing of such remote sensing methodologies is essential to enable this to become operational.

ACKNOWLEDGEMENTS

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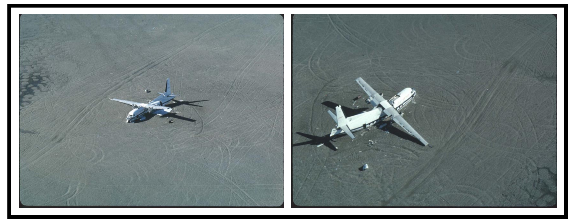

Figure 1. Crashed Fairchild-27, Cornwallis Island, Canada. (Courtesy of P. Budkewitsch, CCRS).

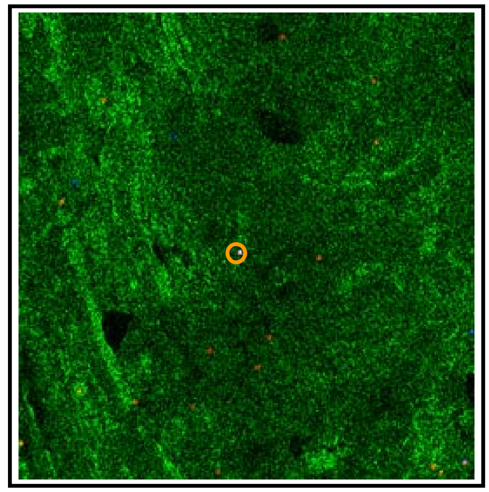

Figure 2. Colour composite of RADARSAT-1 F5 images over the Fairchild-27 on Cornwallis Island. Red channel: July 28, 1998 – October 8, 1998 coherence; Green channel: July 28, 1998 intensity; and Blue channel: July 4, 1998 – October 8, 1998 coherence. Orange circle indicates the airplane location.

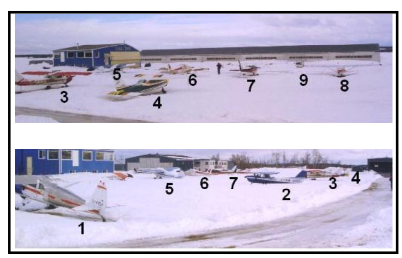

Figure 3. Aircraft at Carp Airport, March 19, 1999

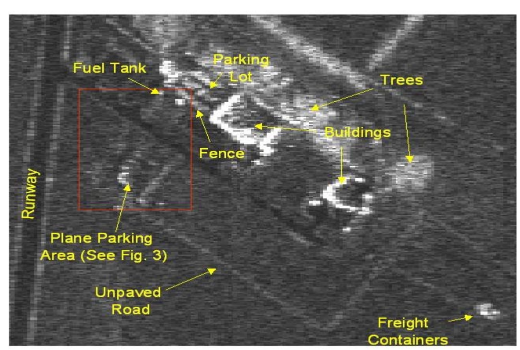

Figure 4. Annotated SAR image of Carp Airport.

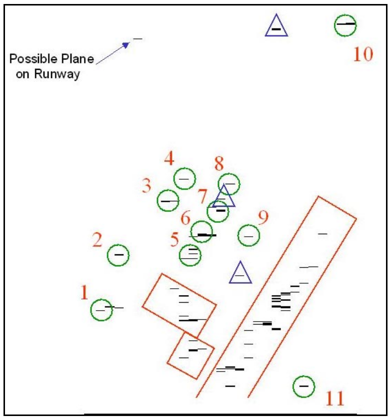

Figure 5. Classification of Carp Airport showing the 11 airplanes. O Detected and classified airplanes; Δ Storage box or fuel tank; □ Buildings

K. Murnaghan, A. Wind, and R. Jean contributed to the processing and calibration of these data.

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