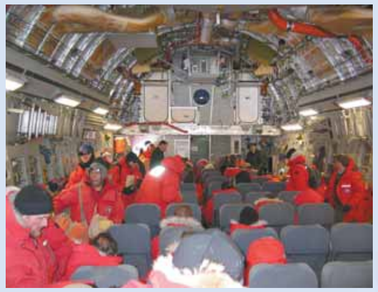
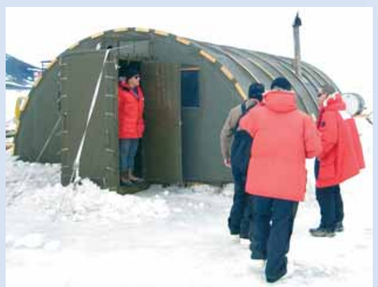
Mission: Antarctica

Sandia team tests new modified MiniSAR sensor that could detect buried or bridged crevasses

Story by Michael Padilla
Photos by the Antarctic team





In one of the coldest parts of the world, four Sandia researchers recently took advantage of what is considered to be one of the warmest time of the year in Antarctica late last year.

At peak temperatures of 35 degrees outside with the sun shining continuously, the researchers worked diligently on a highly planned project. There was no room for error or equipment failures because there is no overnight express to Antarctica.

The goal of the mission was to test a Sandia-modified miniaturized synthetic aperture radar (MiniSAR) prototype sensor that could detect buried or bridged crevasses for the New York Air National Guard (NYANG). Flying for the National Science Foundation, the Air Guard must land planes safely in this remote area of Antarctica. The use of the Sandia sensor would augment or replace the present method of manually finding the crevasses.

"We were highly successful in demonstrating our ability to detect snow-covered crevasses in Antarctica using Sandia's MiniSAR crevasse detection radar," says Tim Mirabal (5341), project manager.

The Antarctica team, led by Grant Sander (5342), included Jeff Bradley (5338), Doug Bickel (5354), and Jeffrey Bach (5345). The team left on Thanksgiving Day 2006 and stayed there for nearly three weeks.

Technical homework

Sandia began working on the crevasse detection radar (CDR) in March 2006 when funding was received from New York Air National Guard to create a system using Sandia's existing MiniSAR technology.

The first step was to change the normal KU-band frequency to X-band. KU-band frequency is 12 to 18 GHz and X-band frequency is 8 to 12 GHz. A lower frequency was needed to penetrate the snow. The snow in Antarctica is unique in the world as it is very dry; whether the radar would perform as well in other climates would need to be investigated, says Tim.

The team built an external X-band converter and changed the front-end components as well. New engineering had to be done in order to accommodate the X-band frequency.

A gimbal arm and electronics were redesigned to allow free movement and antenna balance. The design had to allow for easy assembly and disassembly, says Grant.

"We were able to grow the gimbal assembly and make it perform better," says Tim. "This included rerouting the wiring."

In addition, the team developed specifications for data formats, mechanical and electrical components for installation on the plane, and software tools to review the data.

The technical design team, consisting of more than 30 Sandians, worked for 10 months to meet the objectives of the project. The team built two systems, with one serving as a backup.

"Being that far away, it was good to have a complete spare in your back pocket," says Grant.

Jeffrey Bach, who served as hardware specialist on the trip, says there also was a potential interference problem from the radar system, but the solution didn't arrive in time to apply it before shipping the radar.

"Luckily, my skills weren't needed, as the hardware performed well," says Jeffrey. "I made myself useful in other ways, such as helping to retrieve radar targets from the field at midnight, with the sun still shining brightly."

Road to Antarctica

The hidden crevasse problem was first brought to Sandia's attention in 1999 when the Guard needed assistance in locating deep cracks in the ice. The crevasses made it difficult and dangerous to land airplanes. Historically, millions of dollars have been lost due to crevasse-related incidents. Not until Sandia developed the MiniSAR could the Guard afford to demonstrate CDR technology.

The NYANG uses the LC-130 aircraft, which has special landing gear, to operate off the snow and ice at McMurdo Station, Antarctica's largest community. McMurdo is built on the bare volcanic rock of Hut Point Peninsula on Ross Island, the farthest south solid ground accessible by ship. McMurdo, established in 1956, has grown from an outpost of a few buildings to more than 100 structures including a harbor, an outlying airport with landing strips on sea ice and shelf ice, and a helicopter pad. There are above-ground water, sewer, telephone, and power lines linking buildings. During the winter about 200 to 400 people work at McMurdo, swelling to some 1,500 people in the summer.

The team flew commercial airlines from Los Angeles to Auckland, New Zealand, then on to Christchurch, New Zealand. From Christchurch they took an eight-hour military LC-130 flight to McMurdo.

Before arriving at McMurdo the researchers underwent numerous and extensive physical and dental exams. Each team member had a backup who also went through the rigorous exams as if they were going. They included Marty Thompson (5348), Mike Pedroncelli (5338), Tim Bielek (5342), Steve Reber (5342), Phil Kahle (5334), and Mike Taylor (5342).

At Christchurch they were fitted for extreme cold-weather gear and upon arrival at McMurdo they participated in a two-day "Snow Craft 1" boot camp — also known as "happy camper school." The camp prepared the team on what to expect and taught them various safety and survival techniques.

The hunt for crevasses

"Most people don't realize how large Antarctica is because of it being at the bottom of the globe," says Grant. "This is the area that the Guard is dealing with when it comes to the remote sites that they need to supply."

The crew collected data in several locations including McMurdo Station, Pegasus Wreck, Shear Zone (Mina Bluff Area), Shear Zone Traverse, and Taylor Dome.

"First we mapped McMurdo, Scott Base, and the nearby pressure ridge. Then we flew the Pegasus Wreck site, where our corner reflector array and junk pile were located, says Jeff, who served as test planner, motion measurement operator while flying on the aircraft, morale officer, and snow shovel operator.

Data was sent from the detection radar to an office at McMurdo where Doug served as on-ground support analyst.

Doug pieced the data together to create coherent maps of the surveyed areas. "Piecing the data together using software was a difficult task," Doug says. "But the software was able to receive high volumes of data."

On one day, the researchers were able to conduct two flights while mapping two 5- by 5-nautical mile areas. The 5- by 5-mile area was a goal set by the Guard to find a suitable spot to land in the vicinity of a remote camp.

"We saw crevasses from the first patch of radar data onward," Jeff says. "The first area was at the Shear Zone, an area where multiple glaciers come together and flow in parallel. There is a road bladed into it, an attempt to build a road to the South Pole. It has not been maintained this year, but we think we saw it anyway in the radar data. This couldn't be seen by the naked eye."

The "Tres Hermanas" crevasses, selected by Guard customers Maj. Mark Armstrong and Maj. Walter Hallman, were studied closely. The three crevasses are difficult to visualize from the air and are located in a fairly flat area that represents a possible location to land LC-130 aircraft. The Tres Hermanas are relatively narrow — around four meters wide — and are covered with a snow bridge. Loose snow blows across and camouflages the crevasse, making it look like all the other terrain, especially from the air. The bridge in these crevasses is very loose snow and only a couple meters deep.

"Maj. Armstrong, who is also an LC-130 pilot, was thrilled that we could detect these crevasses using the CDR, especially because of their size and the difficulty in seeing them from the air," says Tim.

CDR outcomes

"The Antarctica MiniSAR CDR can identify hidden threats, clearly show hazards, and effectively covers large areas," says Tim.

"The efficacy of the sensor for this application has now been proven," Jeff says. "I hope the project has the opportunity to carry forward to a fully fieldable system that the Guard can use to make its job of supplying the remote camps and conducting emergency operations safer and more efficient."

Another successful part of the trip was gathering radar imagery of Antarctica, says Jeff.

"We experienced excellent weather, infinite visibility, and fantastic scenery," Jeff says. "And of course cool SAR imagery."

CDR outlook

Since Sandia has successfully demonstrated the ability to see buried crevasses, the team continues to work to sell the capability and secure funding to begin the integration of the CDR on the LC-130 aircraft.

Funding has been set aside to begin analyzing the data obtained in Antarctica and start addressing the integration activity.

"Integration will be a challenge as a lot of work is still necessary to make the CDR ruggedized and user friendly, but we're up for the task," says Tim. "The MiniSAR CDR has other applications, such as day or night search and rescue, a capability the Guard needs. And we will continue to assist them."

TRES HERMANAS — The image below left shows an X-band synthetic aperture view of Tres Hermanas (three sisters). The three crevasses are located in a fairly flat area that would superficially appear to be a possible location to land LC-130 aircraft. From the air and with the unaided eye, however, the crevasses are hard pick out (especially in unfavorable lighting conditions) making landings in unfamiliar areas a bit uncertain. The MiniSAR imagery gives a new level of confidence to pilots. The image below right gives a ground-level view of one of the Tres Hermanas crevasses.