RADARSAT
Antarctic Mapping Project

ACTIVE RADAR CALIBRATOR
INSTALLATION DOCUMENT

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RADARSAT ANTARCTIC MAPPING PROJECT

- Project Description: South Pole Deployment -

We propose to deploy an active radar calibrator (ARC) at South Pole Station in support of the National Aeronautics and Space Administration and National Science Foundation sponsored second mapping of Antarctica using satellite radar. The ARC is required in the calibration of these radar image data. This active radar calibrator is omnidirectional in azimuth and allows viewing at elevation angles from 20° to 50°. An active radar calibration target provides a known and temporally stable radar scattering cross-section which is large compared to the surrounding clutter. In addition, it will provide a geodetic control point.

The first radar mapping of Antarctica was completed in 1997. The second mapping will also be accomplished using the Canadian RADARSAT synthetic aperture radar (SAR) during a planned 30 day mission during September/October of either 2000 or 2001. The goals of the second mapping are to complete a high-resolution radar mosaic for use in change detection studies and to collect interferometric data to assemble a continent scale map of surface velocity. This activity is driven by national interests in the glaciology, geology, geophysics, oceanography and meteorology associated with this continent. For instance, areal maps of Antarctic are required to answer global and local scale questions about the ice sheet. The orbital pattern of RADARSAT allows the opportunity to obtain complete coverage of the Antarctic continent. These data represent an unprecedented opportunity to study the Antarctic. They also represent a baseline against which future changes will be calculated. The Antarctic image data will be acquired at high resolution and compiled into a geocoded mosaic. The value of these data is dependent on both their geodetic position and radiometric fidelity.

RADARSAT ARC OPERATION SCHEDULE

(Assumes a mission in 2000)

South Pole

Installation and Initial System Test:	January 2000
ARC Placed in Storage	February - September 2000
ARC Reinstallation	September 2000
RADARSAT Mapping Mission	September/October 2000

BACKGROUND

Goal

Provide a known and stable calibration target with a known radar scattering cross section (RCS).

Heritage

Transponders were operated at South Pole Station and McMurdo Station in 1997 to support the first Antarctic Imaging Campaign.

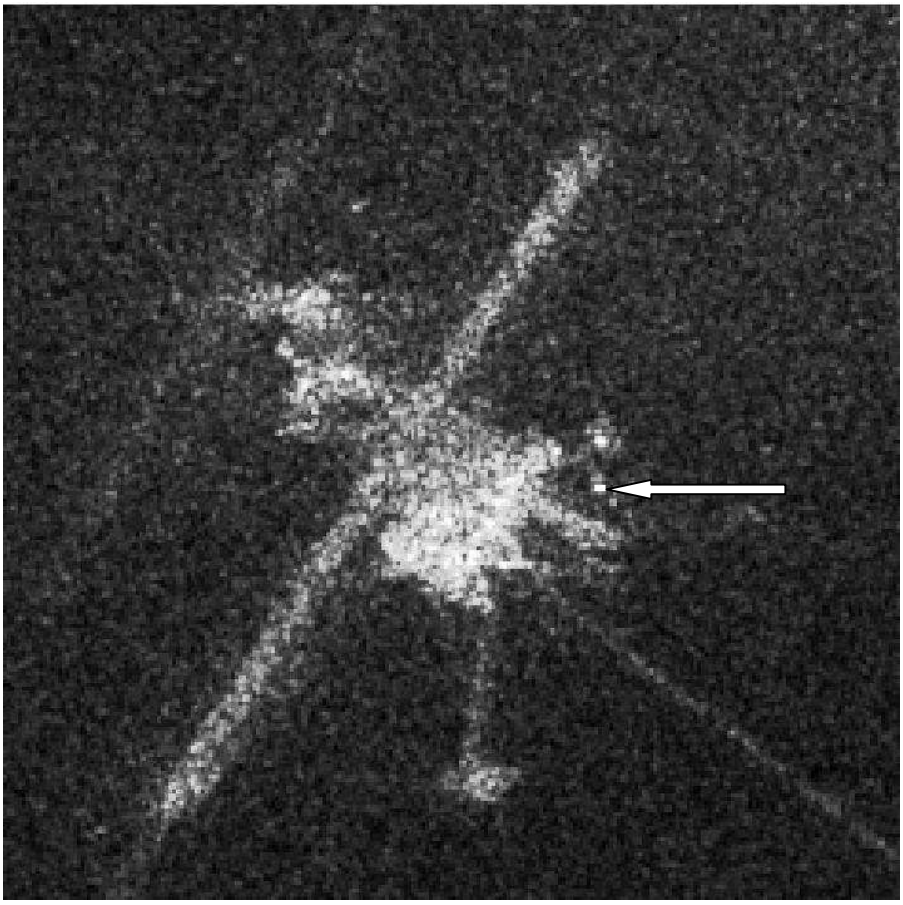

Figure 1. Radarsat Image of South Pole showing transponder location

Approach

Utilize an active radar calibrator (ARC) to obtain a cross-section much greater than that of the surrounding clutter. An ARC samples the signal transmitted by the spaceborne SAR, provides a known gain enhancement, and retransmits back to the satellite.

Design Considerations

- Calibration of RADARSAT SAR must be possible at all radar headings and incidence angles. Incidence angles extend from 20° to 60°.
- A calibration accuracy of ±0.5 dB is desired.
- The environment is hostile and ambient air temperature may be as low as -65°C.
- Power for the transponder will be obtained from station power.

Design Approach

(1) To meet the need to provide a calibration signal independent of azimuth angle, antennas are used which are polarization independent (e.g. circularly polarized) and provide an ominidirectional azimuth response.

(2) To provide calibration at incidence angles as large as 50°, antennas with beamwidths of 100° are used. The gain of an antenna ranges from +4.5 dBic on its optical axis to about -5 dBic when viewed at 60°. Two antennas are used to provide high isolation (e.g. about 77 dB) between the receive and transmit antennas.

(3) Calibration accuracy is dependent on the ARC to clutter ratio and ARC amplifier gain stability. A calibration accuracy better than ± 1dB has been strived for. Factors which impact calibration accuracy include low antenna gain, requirements for low operating power, the extreme temperature operating range, and the limit of system isolation on determining the maximum allowable

amplifier gain. Transponder oscillation will occur if the amplifier gain exceeds the antenna-to-antenna isolation. Shrouds formed from radar absorbing material are placed about each antenna. Isolation also increased with increasing distance between antennas. The ARC package size is set by the requirements of the shroud and spacing between antenna.

(4) The low temperature specification is met by using mil-spec RF components. Mil spec components are tested for operation to -55°C. These devices, however, operate below -55°C. Operation of the system electronics have been tested to -70°C. The ARC will be powered using station power.

(5) The ARC package is designed to provide a stable temperature environment. This is accomplished through the use of insulating foam, a 250 W heating source, and electronic components which self heat.

(6) The ARC mechanical interface is designed to mount to a pair of 3.5" x 4" posts. The ARC is to be mounted at a height of 1.5 to 2 meters above the snow or gravel surface. This mounting method is required to prevent the ARC from becoming buried in snow and snow drifts from forming about the ARC. The ARC package has a length of about 1.2m , a height of about 0.5 m, and a width of about 0.3 m. This is the minimum dimensional cross section possible and allows the ARC to present a low wind cross-section. The weight of the package is less than 30 kgm.

Active Radar Calibrator Testing

(1) Temperature testing have been performed to examine ARC amplifier and

component property stability from +20° to -70°C. A large environmental chamber was used.

(2) The ARC effective radiation pattern have been characterized using an outdoor radar range facility which includes a rotating table. In addition, near field measurements were made in an indoor range facility. The ARC radar scattering cross-section has been calibrated.

INSTALLATION APPROACH

- South Pole Station -

The following represents the proposed deployment of the RADARSAT ARC at the South Pole Station. The deployment would be essentially the same as that which occurred in 1997. A SAR image of South Pole Station is shown in figure 1. The location of the transponder is shown the arrow.

Installation at the South Pole

Station personnel. In 1997 help was received from Jerry Marty and Dave Fisher.

RADARSAT Mapping Activity

The ARC installation will need to be accomplished by the first week of September 2000. The RADARSAT mapping mission will begin approximately on September 9 and will continue for a period of about 30 days.

Description of the ARC Package

The ARC is a single unit with an attachment mount for interfacing with a pair of vertical and square posts with a dimension of 3.5 x 4 inches.

Location of the ARC Package

The ARC will be installed at a site of low radar clutter. The location chosen in 1997 was found to be suitable and could be used again if the station configuration has remained constant. A region of benign clutter but which provides access to station power will be selected. The ARC will then be placed in a region of benign clutter within 150-300 meters from the station power access location. Placement of the ARC in an environment of strong point target scatterers is of great concern. This is because such an environment limits the

accuracy and useability of the ARC signature.

Station Power Requirements

The power required to operate the ARC is 115VAC at 60 Hz and 5 amps. Power is needed to supply the ARC RF amplifiers, provide heat to amplifier cavity to narrow the operating temperature range of the amplifiers, and to supply a temperature sensing module.

RFI Information

The ARC operates at 5.3 GHz. The Active Radar Calibrator is a transponder. It is activated when the RADARSAT synthetic aperture radar illuminates the ARC. The incident power density provided by RADARSAT to the ARC is expected to range from -20 to -25 dBm/m^2. The ARC provides a power amplification of about 70 dB and then retransmit back to the satellite a replica of the received sinal. The illumination pattern of the ARC is a cone which extends from the zenith to 65° from zenith. Extreme care is taken to eliminate radiation from 65° to the horizon because this radiation also acts to limit the performance and calibration accuracy of the ARC.

Table 1. Active Radar Calibrator System Description

Description	Parameter
ARC Frequency	5.3 GHz
ARC Radiation Pattern	Zenith to 65° from Zenith
ARC Peak Power	+33 dBm Watts
RADARSAT Power Density	-20 to -25 dBm/m^2
ARC Power Requirement	5 amps @ 115 VAC and 60 Hz
ARC Physical Size	1.2 m(length) x 0.3 m(width) x 0.5 m(height)
ARC Mount	mounts to a 1.5-2 m high vertical post 3.5" x 4"
ARC Weight	60 lbs (installed), 120 lbs (shipping)
RFI Interference Level	> -70 dBm/m^2 (Station RFI needs to less than this value at 4-8 GHz)

Table 2. RADARSAT Active Radar Calibrator Power Budget

Device	Power Requirement
ARC Transceiver	700mA @ 15VDC, 10 times/day for 15 seconds 100mA @ 15VDC, quiescent
ARC Heater	2.200mA @ 115VAC, steady state
Temperature Monitor	5mA @ 15VDC, average
AC/DC Converter	Power loss due to efficiency is 6 watts peak
Light Indicating ARC Is On	0.9A @ 115VAC, continuous
Design Total	3.25A @ 115VAC, peak 3.2A @ 115VAC, continuous
Request Power Total	5A @ 115VAC, peak 3.25A @ 115VAC, continuous

OPERATION OF TEMPERATURE DATA LOGGER

The purpose of the temperature data logger is to record the temperatures of the plate that the RF amplifiers are attached. This sense of temperature will be used to determine the operating temperature of the amplifiers. Amplifier gain increases with decreasing temperature. The StowAway temperature loggers may be set for a variety of sampling intervals. In addition, a program delay may also be incorporated. If the temperature sampling interval of 1 hour is chosen the data logger may be used to record data for a period of about 1 year. The table below is provided to indicate what the operation parameters are for the South Pole and McMurdo Stations. Since knowledge of the interior temperature is important two data loggers are included to provide redundancy.

Programming Needs During Installation of South Pole ARC

The data logger will be programmed during the system test which will occur January 2000. It will be programmed for operation during the September/October 2000 collection. Data downloading will be needed to retrieve the temperature data upon completion of the October data collection. If the ARC is returned on a reasonable time basis after the October collection, than downloading of these data may be done at ASF.

Table 3. StowAway Temperature Data Logger Parameters

Parameter	South Pole Station	McMurdo Station
Measure	Temperature °C	Temperature °C
Duration Between Samples	1 hour	0.5 hour
Sampling Period	330 days	115 days
Delay	3 months	none