Antarctic Mapping Mission - 2

RADARSAT-1 Antarctic Mapping Project

Science Requirements Document

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AMM-2 Science Requirements Document

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1.0 Introduction

The Radarsat Antarctic Mapping Project is a collaboration between NASA and the Canadian Space Agency to map Antarctica using synthetic aperture radar (SAR). The first Antarctic Mapping Mission (AMM-1) was successfully completed in October 1997. Data from the acquisition phase of the 1997 campaign have been used to achieve the primary goal of producing the first, high-resolution SAR image map of Antarctica. The limited amount of data suitable for interferometric analysis have also been used to produce remarkably detailed maps of surface velocity for a few selected regions. Most importantly, the results from AMM-1 are now available to the general science community in the form of various resolution, radiometrically calibrated and geometrically accurate image mosaics.

The second Antarctic imaging campaign is planned for the fall of 2000. Modified from AMM-1, the satellite will remain in north looking mode during AMM-2 restricting coverage to regions north of about –80 degrees latitude. But AMM-2 will utilize for the first time RADARSAT-1 fine beams providing an unprecedented opportunity to image many of Antarctica's fast glaciers whose extent was revealed through AMM-1 data. AMM-2 will also attempt to capture extensive data suitable for interferometric analysis of the surface velocity field.

This document defines the science goals, mission objectives, mission requirements and operational requirements to support the second Modified Antarctic Mapping Mission (AMM-2) which is part of the RADARSAT-1 Antarctic Mapping Project (RAMP). The project continues to be supported by the NASA Pathfinder Program. The document includes activities to be conducted by the team members including NASA, Canadian Space Agency, ASF, JPL, Vexcel, GSFC, WFF, OSU, ERIM, and the Antarctic Mapping Planning Group (see appendix 1).

AMM-2 consists of three phases: the planning phase; the second Antarctic Imaging Campaign (AIC-2); and the data processing and delivery phase. The primary acquisitions in support of AMM-2 will occur in September-November, 2000.

2.0 AMM-2 Science Goals

AMM-2 science goals are based on the polar related objectives of NASA's Earth Science Enterprise. These relate to understanding the mass balance of the polar ice sheets and the response of the polar ice sheets to changing climate. Specific science questions were selected whose answers could further progress towards reaching NASA's objectives and which could be addressed using the unique capabilities of RADARSAT-1. Science goals and questions are listed in table 1.

Table 1. AMM-2 Science Goals

Ice Sheet Kinematics and Mass Balance
1) How are the interior ice sheet and ice sheet margin changing?
2) How are internal boundaries, such as the southerly limits of melt facies, changing?
3) What are the velocities and strain rates for different flow regimes (ice streams, interior ice sheet, ice shelves)?
4) What is the mass discharge from major drainage basins?
5) Where are grounding lines located and have they moved?
Ice Sheet Dynamics and Ice Streams
1) What are the morphologies and dynamic properties of Antarctic Ice Streams?
2) What portion of the Antarctic Ice Sheet is drained by ice streams?
3) How are ice sheet properties correlated with the glacier bed?

3.0 AMM-2 Project Goals

The AMM-2 has two project goals that follow from the science objectives and questions. The goals are listed in table 2.

Table 2 Project Goals

1) **Produce high-resolution image mosaics** of Antarctica north of -80 degrees latitude for change detection measurements and studies to understand the response of the ice sheet to climate change
2) **Measure the surface velocity field** over coherent and/or trackable areas of the ice sheet north of -80 degrees latitude for ice dynamics studies and for exploring the time varying nature of dynamical processes

The *operational* risks in AMM-2 are greatly reduced when compared with AMM-1 because no satellite rotation is planned.

AMM-2 *data acquisition and processing* challenges are increased because of the data requirements for interferometric analyses.

4.0 AMM-2 Science Requirements

Science requirements were compiled by estimating measurement spatial densities, accuracies and the need for ancillary data associated with the science questions. The detailed science requirements assessment is presented in the Radarsat: Antarctic Mapping Mission-2 Pathfinder proposal. The Antarctic Mapping Planning Group has reviewed the science goals and corresponding requirements. Requirements are listed in Table 3.

Table 3. AMM-2 Science Requirements

Image Mosaic

Science Product	Accuracy	Spatial Resolution	Contribution to Measurement Objectives
2nd image mosaic of area north of –80 degrees	100 m absolute geolocation 1 dB relative and 2 dB absolute radiometric accuracy	25 m	Flow variations Mass balance Non-steady flow Calving Flux
Coherence mosaic of area north of – 80 degrees	100 m absolute geolocation	200 m	Flow styles surface physical properties

Velocity

Science Product	Velocity Accuracy Requirement	Grid Spacing	Contribution to Measurement Objective
Velocity field over coherent and/or trackable areas north of –80 degrees	1 m/yr (slow flow) 10% (fast flow) speed accuracy, 5 degrees in direction	5 km grid	Flow Styles Flow Variation Balance Velocity
Selected Study Areas (e.g., East and West Antarctic Ice Streams, Lambert Glacier)	5 % in speed, 5 degrees in direction	1 km grid	Mass Balance Ice Dynamics Nonsteady flow Calving Flux
Grounding Line Velocities north of –80 degrees	20% in speed, 10 degrees in direction	500 m grid within 20 km of the estimated grounding line	Grounding Lines

The following requirement pertains to both velocity and image products.

Image mosaics and velocity fields should be **snapshots** of Antarctica. Data acquisitions should be accomplished over a minimum period of time.

5.0 AMM-2 Project Objectives

The science requirements lead to a list of primary and secondary project objectives, which are summarized in tables 4 and 5. The secondary objectives fall outside of the original Pathfinder proposal and were developed subsequent to the detailed evolution of the project concept and mission plan. Nevertheless, they are worthwhile objectives that will be addressed pending availability of time and resources.

Table 4. Primary Objectives

1) Production of a 25 m, image map of the viewable area. 2) Production of 200 m, coherence maps of the viewable area. 3) Production of 5 km post spacing velocity field of coherent or trackable areas. 4) Production of 1 km post spacing velocity field of coherent or trackable areas of fast glaciers. 5) Production of 500 m post spacing velocity field along the grounding line. 6) Delivery of products to the DAACs.

Table 5. Secondary Objectives

1) Production of ascending and descending image mosaics of viewable area. 2) Production of high resolution, F1 ascending and descending image mosaics of fast glaciers. 3) Production of ascending and descending coherence maps of viewable area. 4) Production of high resolution, F1 ascending and descending coherence maps of fast glaciers.

6.0 Acquisition Phase Objectives

The science goals and objectives lead to a set of acquisition phase objectives. These objectives form the basis of the mission requirements, acquisition plan and replanning strategies.

Table 6. Acquisition Phase Objectives

1) 1 complete image coverage of the viewable area for change detection. 2) 1 complete ascending image coverage of the viewable area. 3) 1 complete descending image coverage of the viewable area. 4) 1 complete set of F1 image mini mosaics over high velocity areas. 5) 1 complete set of ascending F1 image mini mosaics. 6) 1 complete set of descending F1 image mini mosaics. 7) 1 F1 image pair for InSAR and feature-retracking velocity over fast glacier polygons. 8) A standard insar ascending and a descending pair for velocity over remaining areas. 9) 3rd cycle of standard and fine images for double differencing and remapping to improve single pair InSAR success rate and velocity coverage.

Acquisition phase success criteria follow from these objectives. The minimum success criteria are:

Table 7. Acquisition Phase Success Criteria

1) data are acquired for production of at least one image coverage map to support the goal of change detection.
2) data are acquired for production of velocity maps and coherence mosaics of the fast glacier areas to support the goal of velocity determination.

Similarly, criteria for proceeding with the mission follow from the objectives. Go/no-go criteria will be used to terminate the mission should complications in either the space or ground segment preclude achieving the minimum success criteria. Go/no-go criteria are:

Table 8. Postponement Criteria

1) abort acquisitions if there is a substantial (50%) loss of image date due to space or ground segment failures or
2) if the repeat orbit baselines exceed by 30% or more of the F1 critical baseline for at least 50% of the acquisitions.

7.0 Mission Requirements

Mission requirements deal with the end-to-end activity from the planning phase to delivery of final products to the DAACs.

Table 9. AMM-2 Mission Requirements

1) Three complete cycles of ascending and descending images.
2) Maximize spatial coverage and spatial coherence.
4) Mapping must occur during the same time period as AIC-1
5) Post-mission satellite ephemeris absolute accuracy of better than 200 m (prior to GCP refinement).
6) Radiometric calibration accuracy 1 dB relative; 2 dB absolute
7) Nominal baseline separation between 0 and 300 m for standard beams. Nominal baseline separation between 0 and 800 m for fine beams.

8) Post mission baseline knowledge better than 1 m (satellite navigation and GCPs)

9) Use beams EL1, ST1, ST2, ST5, ST6 and F1M (F1N/F, ST3, 4, and 7 are contingency options)

10) Acquire pre-mission data to test processors, validate verification tools, evaluate data links, and acquisition strategy

11) Acquire data in AGC mode

12) Ground and velocity control points distributed across Antarctica

13) Near real time verification of acquired data coverage

14) Near real time verification of InSAR success rate.

15) Distribute test data within 1 month of the end of the acquisition phase of the mission

16) Receive first calibrated, Single Look Complex (SLC) data within 6 months of the end of the acquisition phase of the mission and all SLC data within 10 months of the acquisition phase of the mission

17) Process all image and coherence data to a mosaic within 16 months of the acquisition phase

18) Process all SLC data to velocity products within 3 years of acquisition

19) Map products supported by additional data (e.g. projection information, incidence angle, azimuth, and ASF image ID (Vexcel)).

20). The map product will be in the SSMI Polar Stereographic projection (Vexcel).

21) Maintain an archive of valued-added products, (e.g. GCPs, DEM).

22) Coordinate with other complementary programs (GLAS, ENVISAT, GRACE)

23) Finest resolution image products will be available to NASA/CSA approved investigators. 125 m image products and velocity products will be available to any user.

7.1 Pre-mission requirements

Pre-mission requirements include validating data processing algorithms, verifying end-to-end data flow links, signing off of project documentation (Science Requirements, Operations Plans, RAMS Functional Requirements, ASF Requirements, Cal/Val Plan, DSN Acquisition Plan, PSLA, Science Team Plan). Many of these activities require test data as noted below.

Table 10. Pre-mission Test Data Requirements

1. Data to verify assumptions in acquisition plan (EL1, ST1,2,6 and F1 Insar pair, SLC data) and to test InSAR validation tools
2. Data to verify operational readiness of active radar transponder
3. Data to verify data links (e.g. McMurdo to ASF via TDRSS link, GAT/PAS to ASF)
4. Data to verify orbit maintenance plan.

Image test data requirements are further discussed in appendix 2.

One of the most important pre-mission requirements is the development of an acquisition plan and investigation of contingency options. Guidance for these activities is presented in the following table and in appendix 3.

Table 11. AIC-2 Data Acquisition Strategy and Contingency Options

1) September – October 2000 northmode acquisitions
2) Limited September- October 2001 northmode acquisitions for contingency
3) Select and schedule beams to maximize spatial coverage and coherence
4) Complete ascending and descending coverages
5) Maximize fine beam coverage in support of InSAR high priority study areas.
6) Maximize use of ST6, followed by ST5, ST2, ST1 and EL1 to increase the probability of coherent InSAR data over areas not covered under item 5.
7) Develop a satellite navigation plan to optimize baseline
8) AMM-2 data shall be downlinked to North Hemisphere ground receiving stations.
9) McMurdo Ground Receiving Station will be used for downlinking RTM data.
10) One complete image map is the highest priority for cycle 1 (this may be assembled from ascending and descending coverage).

11) Cycle 2 and 3 Acquisitions over important glaciologic features are a higher priority than complete InSAR coverage. 12) Acquisition of gaps in AIC-1 INSAR higher priority than areas already covered during AIC-1 13) Acquisition of gaps in ERS Tandem coverage higher priority than areas covered during the Tandem mission 14) Minimize the complexity of the acquisition plan 15) Minimize the impact on other users while meeting mission objectives.

8.0 Operational Requirements

Science and mission requirements levy a specific set of requirements on the partner organizations. These are

Table 12. RAMP AMM-2 Operational Requirements

1) JPL will create a pre mission, test data acquisition plan 2) ASF must acquire and process test data to support verification of the acquisition strategy and to validate verification tools. This includes at least one InSAR pair each of F1, EL1 and ST1, 2 6 data. Test data will be provided to JPL and OSU for further analysis. 3) ASF shall acquire and process data over the McMurdo Antarctic Transponder to verify operational readiness 4) ASF and JPL shall receive and process test data from McMurdo over the TDRSS link to verify operational readiness in support of data quality verification activities 5) JPL and GSFC will develop a satellite navigation recommendation for optimizing baselines. The plan will be submitted by the Joint Technical Team. 6) GSFC/Wallops and CSA will coordinate DSN satellite tracking activities both pre and during mission. 3 acquisitions per day from a high latitude, southern hemisphere station are required. Results will be used in CSA orbit determination. 7) JPL shall create a mission acquisition plan and provide same to CSA 8) CSA and ASF will develop detailed mission operations plans

9) CSA will provide JPL with mission planning contraints

10) ASF will provide means for User Request File input to the MMO both prior to and during the mission.

11) CSA will manage satellite operations and mission planning activities in accordance with the CSA/NASA approved acquisition plan, provide the science team with information on mission progress, receive replanning information from the science team, and provide ASF with data calibration information complementary to the ASF calibration plan.

12) ASF must acquire, receive, record and duplicate all RAMP raw data either received directly by ASF or other ground receiving stations.

13) ASF must support activities of other ground receiving stations by verifying data transmission linkages (e.g. PAS/GAT data transfer to ASF, supplying expendable products as needed

14) ASF should be prepared to use either ASF receiving antenna in the event of ground station failures

15) ASF shall generate Scan Results Files (or comparable information) within 6 hours of acquisition at ASF; scanning priority is ranked by the oldest data on hand.

16) ASF shall immediately transmit scan results files to RAMP mission planning computers.

17) MGS will transmit Data Quality Monitoring (DQM) results to ASF within 12 hours of acquisition.

18) ASF shall have on site expertise for interpreting scan results and DQM files during AMM.

19) JPL shall request, receive and process select data from MGS via TDRS for verification purposes during the mission.

20) Gatineau and Prince Albert signal data sent to ASF to arrive within 2-days after acquisition.

21) ASF will make available to the science team quick look products of 10% of the data per day within 30 minutes of acquisition.

22) ASF shall write, maintain, and implement a calibration plan for RAMP data

23) ASF will provide science team with a Work area (phones, desks, internet, workstation) to support science team. ASF will also provide image processing tools for

image inspection and interferometric processing and selected AMM full resolution data (high-res display, create histograms, inspect individual pixel values, interpolate geographic location of interior pixels from 4-corner points, inspect coherence maps and interferograms).

24) ASF will process 2 swaths per day with up to 5 minutes per swath to level zero products for distribution to the science team.

25) CSA will provide a work area (desks, phones, internet) to support replanning team activities. CSA will accept replanning requests from the on-site replanning team.

26) JPL will arrange for receipt of two-minutes per day of MGS data via TDRSS and distribute level 0 data and results to OSU and Vexcel.

27) JPL will consult with CSA on orbit maintenance during the pre-mission and acquisition phase of the project.

27) JPL will provide near real time analysis of baseline separations

28) JPL and OSU will be prepared to measure coherence on selected SLC pairs.

29) CSA shall provide JPL and ASF with an updated SPA configuration file optimized for planning over Antarctica

30) CSA Science team will advised CSA and NASA on mission progress towards meeting science objectives.

8.1 Requirements on Canadian Ground Stations

Identified below are requirements, as specified by NASA and CSA, for support at the Gatineau and Prince Albert Satellite Stations. It is anticipated that the requirements will emulate the support provided during AMM-1.

Table 13. Support Requirements for Prince Albert and Gatineau Satellite Stations

1) CCRS will provide on-site resources (desk, telephone, etc.) for one NASA identified staff person. This person will be responsible for data quality assessment, logistics of tape shipments, coordination with NASA for any issues.
    - NASA will be on-site for the duration of the first cycle, plus 7 days (31 days)
    - Additionally, NASA will be on-site for the first week of the third cycle (7 days)
2) CCRS will record data to Sony ID-1 media, for delivery to ASF.
3) CCRS will provide access to the Fast-Scan systems at each station, for use in data quality and coverage assessment.

4) CCRS will support a delivery time of 7 days when NASA staff is not on-site (cycles 2 and 3). Logistics of shipping (account numbers, addresses, etc.) will be provided by NASA.

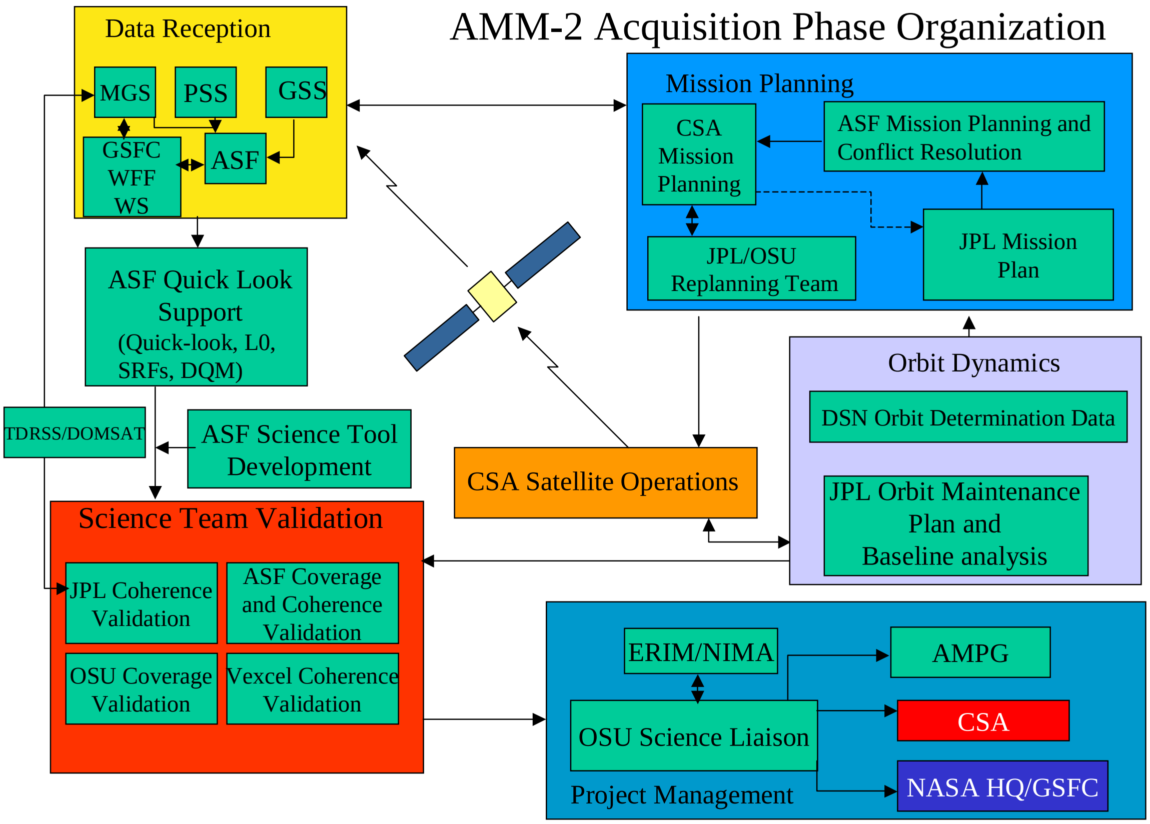
8.2 Requirements on the ASF SAR Processor

ASF SAR processor requirements originate from the plan to create SLC images at ASF. Associated requirements are listed in Table 14 and the Vexcel Functional Requirements Document.

Table 14. RAMP Requirements for ASF Processor
(See also RAMS Functional Requirements Document)

1) single-look complex imagery
2) calibrated data with look up table or equation to convert digital numbers to backscatter coefficient
3) Processor shall not introduce geometric errors greater than 100 m and distortions greater than 50 m in 100 km
4) Data products to be delivered to BPRC on DLT tapes (uncompressed and at highest density allowed by device).
5) Data processed/provided in RAMP requested order.
6) Radiometrically calibrated data (1 dB relative, 2 dB absolute)
7) Process standard, extended low, and fine 1 beams
8) Detailed formatting requirements are contained in the Vexcel functional requirements document

Appendix 1



AMM-2 Mission Responsibilities Chart

Team Member	Pre-mission	Mission	Post Mission
BPRC	Science Team Coordination Compile available velocity, GCP and DEM data Science requirements Mission Requirements Participate in rehearsals	Replanning guidance Support staff deployed to receiving facilities Liaison with CSA and NASA	Mosaic production Velocity Products Science Team Coordination
ASF	Acquisition Scheduling (WOS) repair and deploy transponders Data validation tools Calibration Plan Mission Ops Plan Processor Upgrades Participate in rehearsals	receive and validate all data monitor mission progress by: verify acquisitions against acquisition plan generate demonstration products contingency planning coordinate on-site science team	Calibrated image data in SLC format within 4 months of mission. limited SLC data within 1 month of mission for system validation Final product

			distribution
Vexcel	Functional Requirements Processing system development	replanning guidance	System Delivery System validation Sustaining engineering
JPL	Acquisition Plan Orbit Maintenance Strategy Validate TDRSS/DOMSAT link Participate in rehearsals	Replanning Teams (ASF and CSA) Baseline monitoring Receive and process TDRSS data Coherence verification Science Team (ASF)	Participate in science team validation activities
GSFC/ WFF	Ground Station and DSN Preparations (MGS, ASF)		
ERIM	Velocity Control Point Plan	VCP acquisition	VCP delivery to OSU

Appendix 2

AMM Test Data Plan

1.0 Test Data Objectives

Test data are necessary for the following AMM activities:

1) validate mission planning concepts (e.g. southerly reach)
2) verify coherence-related performance of F1 beams
3) develop InSAR data processing tools
4) verify data links
5) verify feasibility of swath vs frame processing (stability of Doppler centroid)
6) verification of baselines computed dynamically with those computed with interferometry

2.0 Data Requests

The following data can l be used to support those activities. Requests are in priority order:

2.1 Test F1 coherence over a bright region of Antarctica (Wilkes Land)

a) Two acquisitions sets separated by the 24 day repeat cycle for use in interferometric analysis.
b) 3 adjacent F1 swaths which cover the target area, each swath should be at least 3 frames long
c) Target area is: 72.5 S and 155 E

2.2 Test EL1 reach, sensitivity and coherence (WAIS)

a) Two acquisition sets separated by the 24 day repeat cycle for use in interferometric analysis.
b) 3 adjacent EL1 swaths which cover the target area, each swath should be at least 3 frames long.
c) Target area is: 80S 140 W

2.3 Test F1 coherence over a dark region (Law Dome)

a) Two acquisitions sets separated by the 24 day repeat cycle for use in interferometric analysis.
b) 3 adjacent F1 swaths which cover the target area, each swath should be at least 3 frames long
c) Target area is: 70S 120 E

2.4 Test F1 coherence over a medium bright region (QML) (OBR Required)

a) Two acquisitions sets separated by the 24 day repeat cycle for use in interferometric analysis.
b) 3 adjacent F1 swaths which cover target area, each swath should be at least 3 frames long
c) Target area is: 72.5S 5E

2.5 Test El1 reach, sensitivity and coherence (EAIS) (OBR Required)

a) Two acquisition sets separated by the 24 day repeat cycle for use in interferometric analysis.
b) 3 adjacent EL1 swaths which cover the target area, each swath should be at least 3 frames long.
c) Target area is: 80S 20W

Total data volume is estimated to be about 22 minutes over two cycles.

3.0 Data links

A combination of real time downlink data and OBR data are identified. These data can be used to verify the various data links.

4.0 Processing Requirements

Data should be processed to level zero products. Products should be sent to OSU and JPL on DLT tape.

Appendix 3

Mission Planning Requirements

1.0 Acquisition Planning

Acquisition planning procedures follow from the Science Requirements Document. The Science Requirements pertaining to acquisition planning and replanning are summarized in table 1. .

Table 1. AMM-2 Mission Requirements Related to Acquisition Planning
1) Three complete acquisition cycles of ascending and descending images.
2) Maximize spatial coverage and spatial coherence.
3) Mapping must occur during the same time period as AIC-1
4) Use beams EL1, ST1, ST2, ST6 and F1 (ST3, 4, 5 and 7 are contingency options)

These requirements lead to the acquisition strategy designed to reach goals of complete image coverage and robust InSAR coverage. The elements of the acquisition strategy are described in table 2.

Table 2 AIC-2 Data Acquisition Strategy
1) September – October 2000 northmode acquisitions
2) Select and schedule beams to maximize spatial coverage and coherence
3) Complete Ascending and descending coverages
4) Maximize fine beam coverage in support of InSAR high priority study areas (figure 1).
5) Maximize use of ST6, followed by ST2, ST1 and EL1 to increase the probability of coherent InSAR data.
6) AMM-2 OBR data shall be downlinked to North Hemisphere ground receiving stations.
7) McMurdo Ground Receiving Station will be used for downlinking RTM data.
8) Minimize the complexity of the acquisition plan (EL1, ST1, ST2, ST6 and F1 beams)
9) Minimize the impact on other users while meeting mission objectives.

2.0 Acquisition Re-Planning

Re-planning will be carried out in the event of spacecraft or ground segment anomalies. Re-planning may also be carried out if ground segment resource limitations require shifts from RTM to OBR acquisitions and vise versa. Under the nominal mission scenario, re-planning will only be carried out during the first cycle. This is because InSAR acquisitions in cycles 2 and 3 must be spatially identical to cycle 1 and lost data cannot be recovered during cycles 2 and 3 without compromising that objective. If missions goals are restricted to image coverage only, cycle 2 may constitute a series of contingency acquisitions replanned to fill gaps occurring during cycle 1.

Replanning rules for the nominal scenario are listed in table 3. In the event that only partial coverage of the Antarctic north of –80 degrees is possible, the highest priority target areas are shown in figure 3.

Table 3 Replanning Rules

1) Replanning will be limited to cycle 1 under the nominal scenario.

2) One complete image map is the highest priority for cycle 1 (this may be assembled from ascending and descending coverage).

3) If only partial image coverage is possible, the highest priority targets are shown in figure 2.

4) Maximize InSAR acquisition opportunities over important glaciologic features during cycle 1 replanning.

5) Acquisition of gaps in AIC-1 INSAR are higher priority than areas already covered during AIC-1.

6) Acquisition of gaps in ERS Tandem coverage are higher priority than areas covered during the Tandem mission.

7) There will be no cycle 1 replanning of F1 acquisitions north of about -70^{o} latitude.

8) Cycle 1 replanning south of about -70^{o} latitude is permissible if replanning does not result in holes.

9) There will be no cycle 1 replanning south of about -70^{o} latitude if replanning perturbs the F1 nominal plan.

10) Replanning should always opt for a fine beam, or for a standard beam with the largest numerical designation.

2.1 Contingency scenarios

From the science perspective, there are several possible replanning and contingency scenarios. .

1) In the event of random data outages of a few orbits, the replanning rules will be followed so as to *maintain the nominal plan* optimized for science, SAR OnTime, and resource efficiency: Beam priority is F1, ST6, ST2, ST1 and EL1 for use during cycle 1 replanning. No replanning is expected during cycles 2 and 3 under normal operating scenarios.

2) In the event of a systematic failure that preclude any cycle 2 and 3 data acquisitions, replanning will be carried out so as to complete *one image mapping*. Ascending coverage is preferable to descending coverage. In a worst case, the plan should attempt to obtain F1 coverage of fast glacier areas. In either case, the InSAR MAMM acquisitions will be replanned to occur in 2001.

3) In the event of an MGS failure, we will monitor progress on restoring MGS whilst replanning acquisitions to OBR in accordance with the CSA replanning windows (submissions required 29 hours prior to the acquisition). If MGS suffers a catastrophic failure, F1 acquisitions will be replanned to OBR – Standard beam acquisitions will be canceled after consultation with CSA and NASA.

4) Partial failures during either cycle 1 or 2 will be assessed against the probability of acquiring image and InSAR coverage of the high priority areas specified in this document. Failures resulting in more than 25% loss of the high priority areas will trigger discussions to postpone further acquisitions till 2001.

5) In the event of a reduction in available ground and/or satellite resources, we will *limit cycle 3 coverage to high slope areas*: Cycle three coverage will be used as contingency for interferometric coverage and limited double differencing calculations. Contingency planning allows for a reduction of Cycle 3 coverage to high slope areas (figure 3). In low slope areas, the OSU digital elevation model of Antarctica will be used to subtract surface topography effects from the InSAR data in regions where slopes are less than 1 degree.

6) Successful orbit maintenance within the 1 km control band during cycle one will be a criteria for proceeding with cycle 2 (and subsequently cycle 3) acquisitions. Deviations from this plan (more than about 20%) will result in discussions to delay cycle 2 and 3.

Replanning related to specific space or ground segment anomalies will be dealt with during mission rehearsal activities. Based on experience from AMM-1, several technical replanning scenarios can be anticipated including: spacecraft anomalies resulting in one or more orbits of lost data; data reception failures (usually only one orbit); complete ground station failures. In addition, there may be conflicts between RADARSAT and other acquisitions scheduled for MGS. This may result in replanning acquisitions from RTM to OBR.

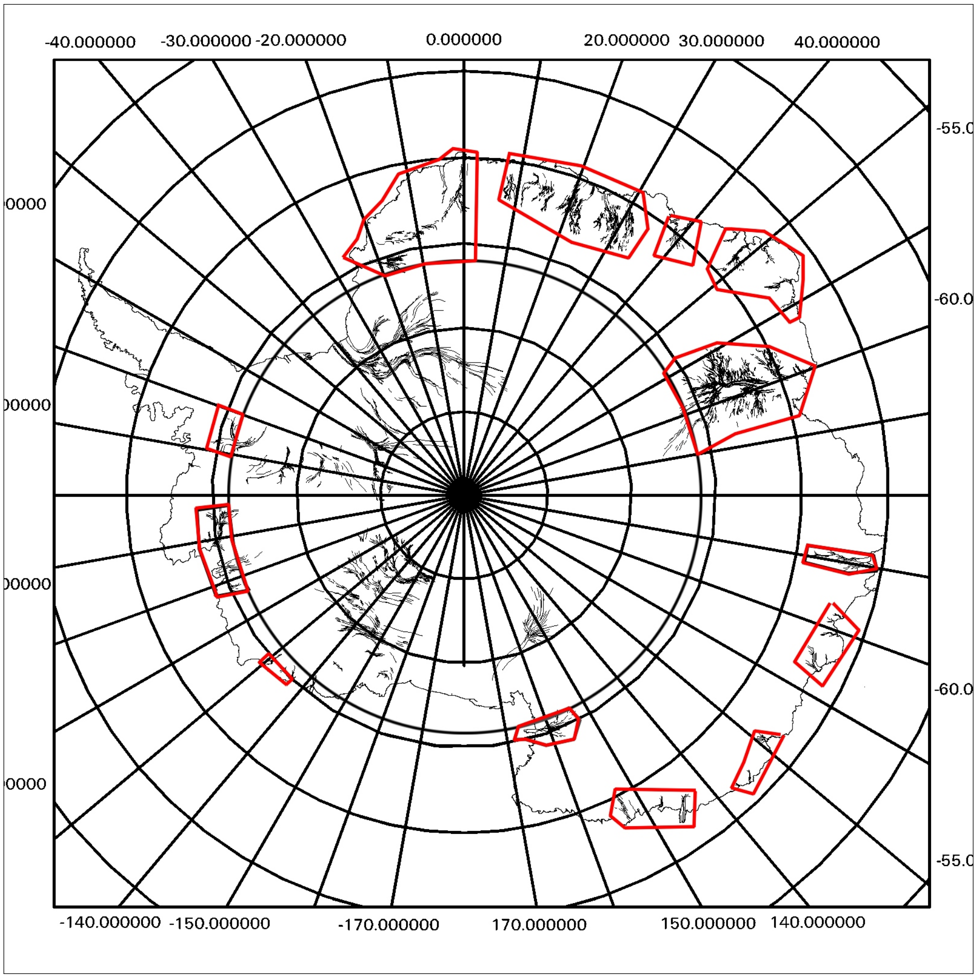


Figure 1. High priority locations for F1 coverage

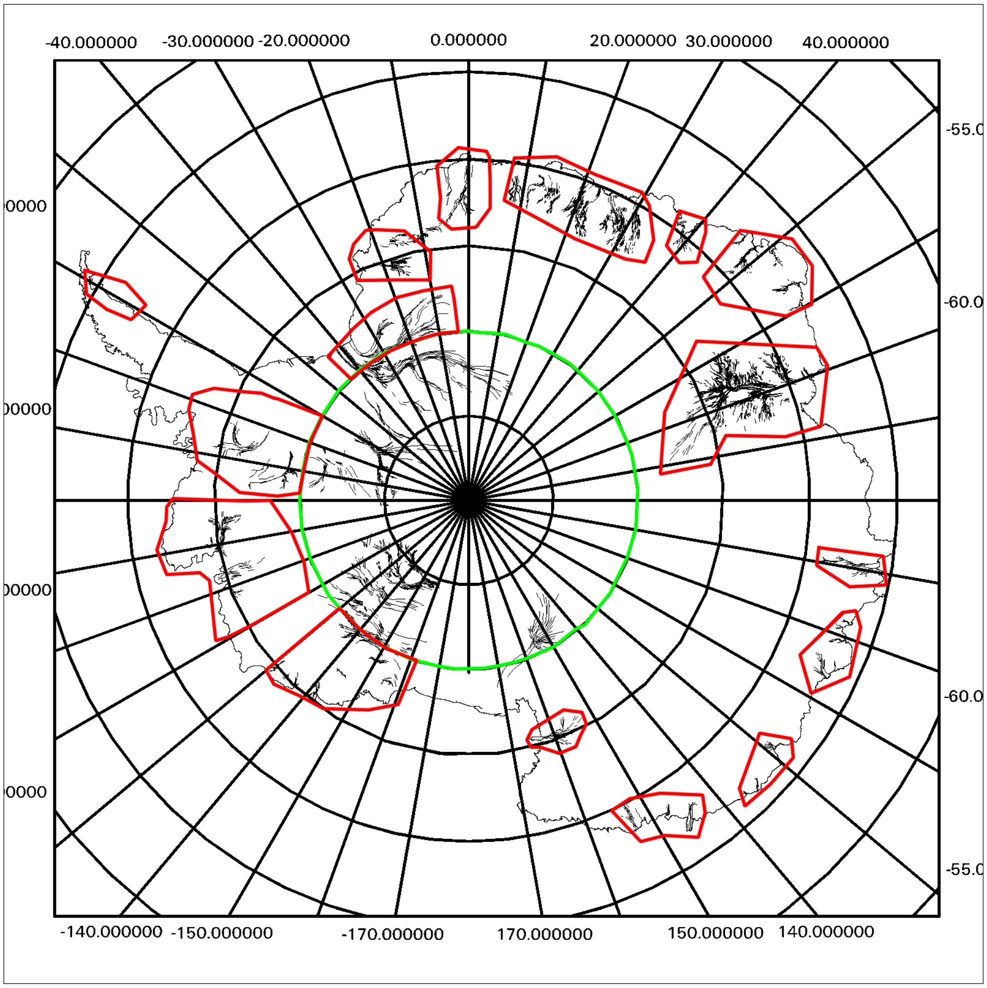


Figure 2. High priority target sites for use in replanning exercises

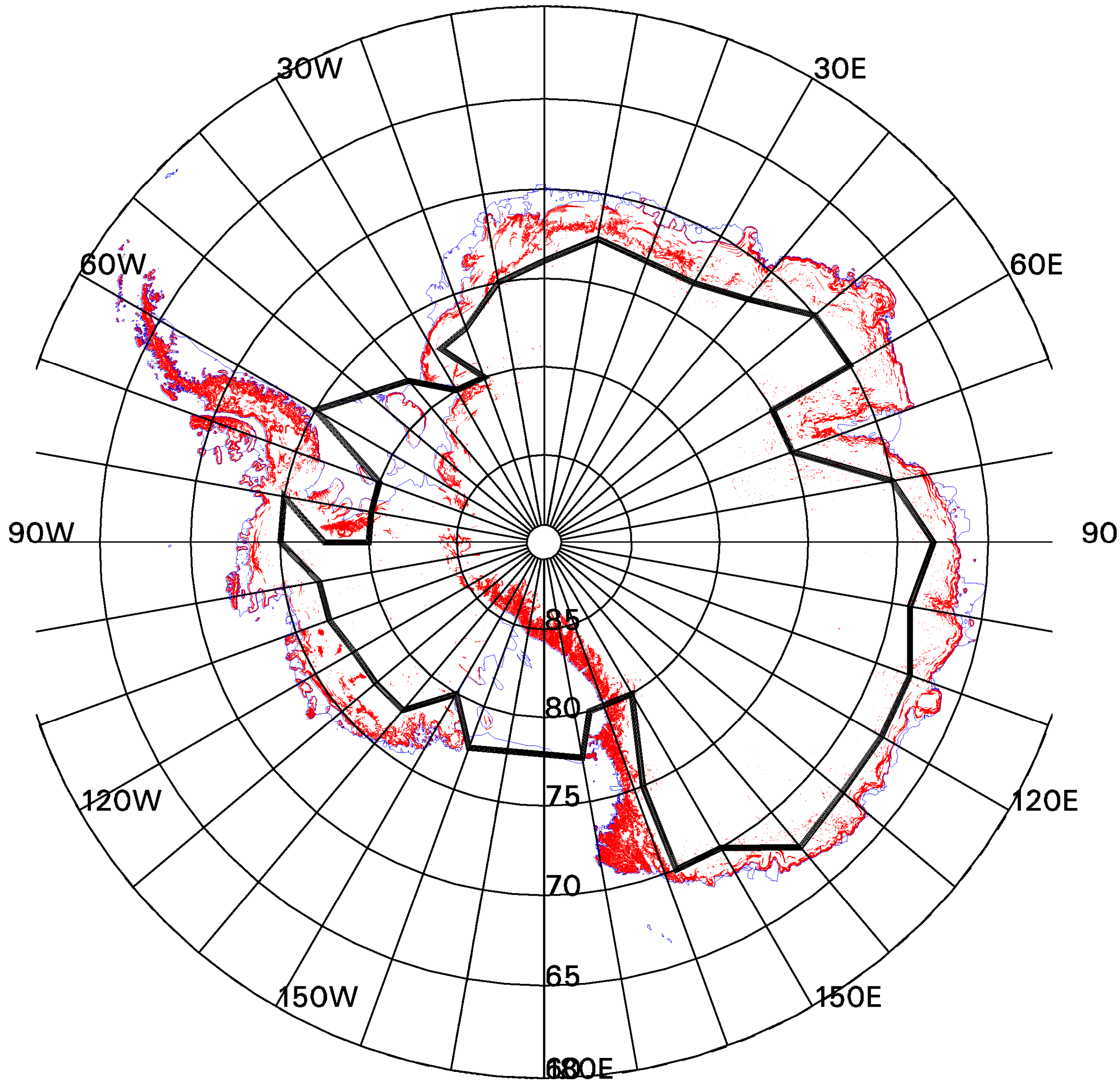


Figure 3. High slope areas.