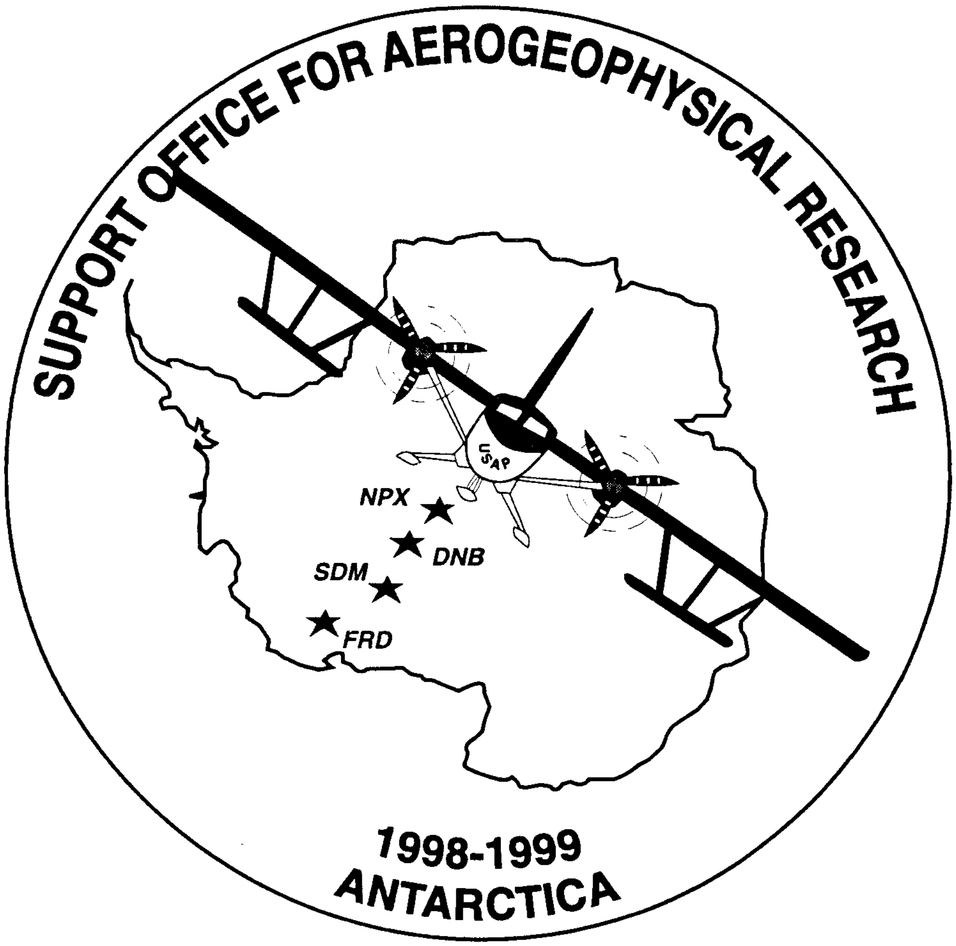
SOAR

Annual Report
1998/99



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Executive Summary

Overview

The Support Office for Aerogeophysical Research (SOAR) is a facility of the National Science Foundation's Office of Polar Programs whose mission is to make airborne geophysical observations available to the broad research community of geology, glaciology and other sciences.

The central office of the SOAR facility is located in Austin, Texas within the University of Texas Institute for Geophysics. Other institutions with significant responsibilities are the Lamont-Doherty Earth Observatory of Columbia University and the Geophysics Branch of the U.S. Geological Survey.

This report summarizes the goals and accomplishments of the SOAR facility during 1998/99, its fifth year of operation, and plans for the next year.

History

This facility grew out of science programs funded by the National Science Foundation to study West Antarctic geology and glaciology beginning in 1989. The instrumented aircraft developed for that program and presently used by SOAR was also used for the site survey at the Taylor Dome drill site in East Antarctica. The support of this science program and the increasing number of requests for aerogeophysical surveys led to the concept of the SOAR facility.

SOAR was chartered on August 1, 1994 via a cooperative agreement between the National Science Foundation and the University of Texas at Austin. The facility goal stated in the agreement is to "develop, maintain and operate a suite of geophysical systems aboard a Twin Otter Aircraft in support of research in Antarctica for five years."

In 1994, SOAR assembled a staff, designed the laboratory areas and deployed personnel and equipment for a thirty-two flight survey 1994/95 field season based out of Byrd Surface Camp. The primary science project supported was a collaborative aerogeophysics program of the University of Texas Institute for Geophysics, Lamont-Doherty Earth Observatory and the United States Geological Survey (CASERTZ/WAIS) over the West Antarctic Ice Sheet. The data acquired during the 1994/95 season also included the preliminary site selection information for the deep ice coring site at the West Antarctic ice divide. For the 1995/96 field season, SOAR completed a successful 88-flight operation, again based at Byrd Surface Camp. The science projects supported were the CASERTZ/WAIS aerogeophysics program and the glaciology program of the University of Wisconsin (UW). For the 1996/97 field season SOAR conducted a 58-flight field season from a field camp at Siple Dome, completing both the CASERTZ/WAIS and the UW programs. In 1997/98 SOAR completed a 36-flight field season in support of five science projects (see Table A.5). Details of the goals, accomplishments, finances and timetables of the first four field seasons can be found in the respective SOAR Annual Reports.

Fifth Year Review

Operations and Experiments

The overall experimental goal of SOAR is to meet the needs of its science projects by providing airborne observations of subglacial topography, ice-surface topography, gravity, and magnetics. Support activities range from initial proposal planning to detailed experiment design, data acquisition (field operations), and data management (data distribution, archiving and reduction). This year SOAR planned to support two projects in the field with investigators from four institutions. B. Luyendyk of the University of California, Santa Barbara and C. Siddoway of Colorado College are the principal investigators for "Air-ground study of tectonics at the boundary between the Eastern Ross Embayment and Western Marie Myrd Land." R. Bell and W.R. Buck of the Lamont-Doherty Earth Observatory, and D.D. Blankenship of the University of Texas Institute for Geophysics are the principal investigators for "Collaborative Research: Contrasting Architecture and Dynamics of the Transantarctic Mountains." SOAR worked with these investigators to refine and finalize experiment designs for both science projects (see Figure A.1).

To meet the science objectives for these projects (nearly 50,000 line-km of geophysical surveying), SOAR estimated that 83 survey flights would be needed with operations from four different bases (Table A.1). Two major intracontinental moves were required in order to configure the aircraft and accomplish the survey goals. These moves, in addition to the large number of survey flights, required complex logistics, contingency planning, and base station portability of a degree never before achieved.

SOAR accomplished 49,617 line-km of geophysical surveying in 96 flights during the 1998/99 season, fulfilling the survey objectives of both major planned projects. This season's success was due to several factors including favorable weather, sustained personnel efficiency, relatively few equipment problems, a newly developed capability to quickly move and reconfigure base stations, and the flexibility afforded by simultaneously operating from multiple bases. The increase in survey coverage beyond what was originally planned was partly due to changes in experiment design implemented in the field by SOAR for logistical and scientific reasons, and partly due to the opportunity to continue surveying from Downstream B while the main base move from South Pole Station to Siple Dome experienced a weather delay. The increase in the *number* of flights was due in part to a delay in the installation of the Ford Ranges Camp which necessitated surveying solely from Siple Dome, increasing the average transit distance per survey flight.

In addition to planned support for the two major science projects, support for a third project was added when the opportunity arose to complete two survey transects left unfinished from the 1997/98 season. These transects were part of the project "West Antarctic Glaciology – V" (Principal Investigators R. Bindschadler and J. Behrendt). The purpose of this particular transect pair was to monitor changes in ice stream morphology by repeating the survey in multiple years. The initial flight was slated for 1997/98 but did not take place; therefore, the opportunity to survey these transects in 1998/99 put this project back on schedule for the planned reflight in 1999/00.

SOAR distributed raw data from the 1997/98 field season to clients on July 21, 1998. Paper QC and field notes to accompany raw data were distributed to UTIG, LDEO, and the LIV project in August, 1998. Time-stamped laser and radar profiles were delivered to WAG investigators on November 20, 1998, and have been available to other clients (WMB, STI, and LIV) via the Internet since January 22, 1999. Potential fields data reduction for 1997/98 surveys was postponed until the completion of data acquisition for those projects in 1998/99. The SOAR data reduction facility at UTIG has developed a web page detailing reduction and distribution events. It can be accessed from the SOAR web page (http://www.ig.utexas.edu/research/projects/soar/soar.html).

Technology

The technical goal of the facility is to prepare, configure and operate the geophysical and positioning systems aboard the survey aircraft and at base stations in order to obtain the highest quality observations consistent with simultaneous operation of all instruments. The aerogeophysical instrument suite consists of an ice-penetrating radar, a laser altimeter, a gravity meter, and a magnetometer. Carrier-phase kinematic differential GPS measurements are critical for the gravity and laser measurements.

Improvements were made to both the ground and aircraft systems since the 1997/98 field season. Achievements during the fifth year of SOAR included the development of three portable base station quality control (QC) data systems which significantly improved SOAR's ability to move quickly between bases of operation. SOAR improved base station logging of magnetometer data through the use of new portable computers and real-time monitoring software, and purchased additional flat-panel (LCD) displays for use in the aircraft and on the ground. SOAR acquired and operated a new cesium base station magnetometer which performed far more reliably and at a higher data rate than proton precession magnetometers.

SOAR developed and tested new real-time data monitoring software on the aircraft and found it to be very useful in evaluating the data acquisition process. SOAR successfully modified the cooling system on the TUD radar power amplifiers so that they would operate at the lower ambient air pressures found above 8,000 feet. SOAR purchased a spare cesium magnetometer and built a spare magnetometer winch which was utilized near the end of the 1998/99 field season. SOAR also purchased a spare True-Time time code generator for the aircraft and returned its laser altimeters to the factory for refurbishment. SOAR worked with Kenn Borek Air, Ltd. in order to modify the second set of radar antennas, bringing them to full operational status as spares.

Logistics

The SOAR facility had large and diverse logistical requirements during the 1998/99 season with its multiple moves and multiple simultaneous bases of operation. In handling these requirements, SOAR was assisted by several organizations. The major needs and assisting organizations were:

- Aircraft Support — operation and maintenance of the Twin Otter survey aircraft. Aircraft and services were contracted by Antarctic Support Associates (ASA) from Kenn Borek Air, Ltd.

- Field Support — provided by Antarctic Support Associates (ASA) on-site at Siple Dome, South Pole Station, Downstream B, and Ford Ranges Camp, and for moves between McMurdo and all of these bases.

- Scientific Equipment Support — the Bell Aerospace BGM-3 airborne gravity meter was supplied by the Naval Oceanographic Office (NAVOCEANO). Six carrier-phase GPS receivers were provided by the Lamont-Doherty Earth Observatory and three were provided by the University of Maryland.

- Cargo Support — provided by a variety of groups involved in the transport of SOAR equipment coordinated by Lee Degalen for the NSF at Port Hueneme, California.

To meet its aircraft support needs, SOAR requires exclusive use of the specially configured Twin Otter from the beginning of instrument installation to the conclusion of flight operations. Field preparation of the aircraft required 20 days this season, including eight test flights prior to regular survey flying. The aircraft and its subsystems critical to SOAR functioned well and were very reliable with the exception of the autopilot. The vertical hold feature of the autopilot was unable to maintain a constant altitude within ± 12m as specified by SOAR, especially when surveying at higher altitudes (above ~ 8,000').

Field support consists of services provided principally for operation of the field camp and support for flight operations (hourly weather updates, fueling assistance, food preparation, etc.). In general, the facilities and staff at Siple Dome, South Pole Station, and the Ford Ranges Camp provided exceptional support. Camp staffing at Downstream B was inadequate to provide SOAR with required weather updates and food preparation, and an initial shortage of berthing at Downstream B was rectified just after the start of survey activities. A special SOAR requirement is voice and data communications with North America. Low bandwidth communications were not established until after the survey aircraft was configured at Siple Dome, and a higher bandwidth GOES link was not established at Siple Dome until just after the Christmas holiday (roughly 25 days after survey operations had commenced). Once established, the GOES link provided adequate communication bandwidth for SOAR to send quality control data products to North America and for the camp to have e-mail and Internet access for several hours each day.

The gravity meter, a Bell Aerospace BGM-3, was supplied by NAVOCEANO. External support supplying this gravity meter is required because of the expense of this instrument. UNAVCO provided precise surveying of a number of critical points early in the field season.

Because of the need to transport a complete systems integration laboratory, multiple computing facilities, and the equipment necessary to operate the survey aircraft, SOAR requires the transportation of a large amount of cargo. A total of 19,475 pounds of cargo was transported to Antarctica in eleven shipments plus six pieces of hand-carried cargo. The shipping effort went very well this season with all items arriving as needed. The gravity meter had special requirements, including an escort and continuous power.

Personnel

SOAR's core staff consists of two scientific directors, a technical coordinator, a science coordinator, two research engineers, an installation engineer, a senior systems analyst, two systems analysts, and an administrative associate. SOAR was without a technical coordinator for much of 1998/99, but hired Dr. Jack Holt to fill the this position in November, 1998. SOAR increased its core systems analyst staff from one to two with the hiring of Steve Terry just prior to the

1998/99 field season. This was done in order to replace support previously provided by an outside contractor.

Eight additional people were temporarily hired for the 1998/99 field deployment, and a ninth person was supplied under the United States Geological Survey subcontract.

Finances

Expenditures for SOAR during its fifth year (May 1, 1998 to April 30, 1999) are estimated to be $1,138K. This compares to $1,168K budgeted.

Plans for 1999/00

This section reviews issues and plans for SOAR in the upcoming year. Each general topic is fully described in the respective appendices.

Operations and Experiments

The objective for SOAR for the 1999/00 field season is to acquire data for five science projects with twelve investigators from nine institutions (See Appendix A, Project Development). Figures A.3 - A.5 show the 1999/00 survey targets (see also Table A.4). An estimated 60 flights will be required from five different operational bases in order to accomplish the 22,317 line-km of planned surveys. A fixed period of time will be dedicated to projects in East and West Antarctica.

After a mid-October arrival for the first contingent of SOAR personnel, the survey aircraft will be configured at Williams Field, McMurdo beginning early in November. Surveying for the TAM/Wilkes Basin and Robb Glacier surveys will begin after configuration and test flights are complete, using Williams Field and the Italian Midpoint as operational bases. The TAM Robb Glacier line will require refueling and a temporary base station at the Moody Glacier camp. After a short time, most personnel will be moved to Midpoint so that both flight crews can operate from a location more central to the survey. Upon completion of the western end of the survey, the small crew and base station at Williams Field will move to Dome C for the remainder of the survey.

Just before Christmas, surveying for the TAM project will cease and the crews will return to

Willy Field to pack and prepare for West Antarctic operations. A main base will then be established at Byrd Surface Camp, with a secondary base at Siple Dome. SOAR will survey lines for four different projects in West Antarctica, some of which are repeat surveys from previous seasons. This phase of work is estimated to require 21 flights and will end in mid January. At that time, SOAR will return to Williams Field, McMurdo to reconfigure the survey aircraft for a field test of the new JPL Europa testbed radar. After SOAR packs much of its equipment for retrograde shipment, a small crew will remain for the radar test. Two engineers from JPL and an engineer from the University of Texas Institute for Geophysics will join SOAR for this activity.

SOAR will continue the reduction of data as requested by the proposals. The data distribution target date for data collected during the 1998/99 season is August 1, 1999 for the raw data sets required by some investigators, and November 1, 1999 for the reduced data products required by other investigators (see Table A.5). SOAR is targeting completion of the reduced data products for the 1999/2000 field season by August 1, 2000, six months after flight operations are complete.

Technology

SOAR was successful in implementing new technology last season, primarily in base station QC systems and geophysical instrumentation. This enabled SOAR to operate at multiple base stations simultaneously and to move efficiently between bases of operation, contributing greatly to last season's success. Some avenues for improvement were noted, however, and will be addressed in the coming year.

A spare cesium magnetometer will be purchased for base stations. Base station carrier-phase GPS logging methods will be evaluated in order to eventually improve their reliability, and rackmount computers will be built to perform GPS logging of Ashtech GPS receivers on the aircraft. The spare Digital Avionics Interface for the aircraft will be made operational, and the existing spare GLONASS/GPS receiver will be modified so that it can replace the primary unit more rapidly. SOAR plans to finalize development of real-time data monitoring software for the aircraft, and year 2000 issues will be addressed for all SOAR-utilized software and hardware before the 1999/00 field season. SOAR will purchase two Iridium satellite telephones for base camps and is requesting that an additional one be installed in the survey aircraft for safety reasons. Primary repair/refurbishment targets include the laser altimeters (one failed during surveying last season) and the proton precession magnetometers.

Due to problems with the gravity meter last season, a complete spare unit including sensor will be requested from NAVOCEANO in order to avoid potentially large delays in surveying.

Logistics

Future plans for SOAR logistics are guided by the desire to enhance existing arrangements and support new SOAR requirements.

Important items planned for aircraft support are improvement of the aircraft's autopilot, redesign of the GPS navigation display mount, early field arrival of the survey aircraft next season (Nov. 1), sufficient staffing and support equipment for aircraft operations away from the main base for five consecutive days, the use of two aircrews, the installation of a satellite telephone and assistance in the development of survey risk assessment procedures and a SOAR safety procedures manual.

The plans for field support include early field arrival (mid October), main base operations from Williams Field, the Italian Midpoint, and Byrd Surface Camp, and secondary base operations at Dome C and Siple Dome. Communication requirements are T1 voice and data links at Williams Field, and ATS (or better) voice and GOES data links at Byrd Surface Camp.

For technical support, the BGM-3 gravity meter will again be needed. A spare gravity meter sensor will be requested and will have the same transportation requirements. Other cargo requirements should be approximately the same as last year.

Personnel

Personnel targets for this year include filling a Lab Manager position and replacing a research engineer who is resigning to attend graduate school. Seven temporary personnel will be hired for the field season.

Finances

SOAR planned expenditures are $1144K for the coming year. Some residual funds (approximately $30K) associated with unspent salaries reduce the requested amount this year to $1115K.

In order to complete the commitments described in this report, SOAR will require approximately

$358K in additional funds for data reduction and other activities.

Cooperative Agreement

A one-year extension to the current Cooperative Agreement must be established to complete the work currently scheduled for the 1999/00 field season

Appendix A: Operations and Experiments

SOAR Annual Report
1998/99

This appendix details SOAR's support for experiments during 1998/99 and SOAR's plans for 1999/00. Facility support is divided into the following sections:

I. Project Development – proposal assistance and experiment design;

II. Data Acquisition – field operations;

III. Data Management – data documentation, distribution, reduction and archiving.

I. Project Development

Goal

SOAR's project development goal is to provide support for developing proposals with accurate estimates of the SOAR resources required to meet the experimental objectives of each science project. SOAR's role in project development also includes the detailed experiment design necessary to mesh the experimental goals of the funded science projects with the NSF logistics constraints.

Plans for 1998/99

Individual Investigators

SOAR was to continue working with individual investigators to clarify SOAR's capabilities for data acquisition and management and to assist them in assessing the SOAR resources needed to meet their science goals. This was to include finalizing experiment designs prior to field deployment.

Project Development and International Collaboration

SOAR planned to continue working toward optimizing the use of its aerogeophysical platform by providing the maximum amount of data to the largest number of investigators. Opportunities for coordinated US and international project development included the Chapman Conference on the West Antarctic Ice Sheet (September 1998) and the Lake Vostok Workshop in the Fall of 1998.

Interagency Coordination

During the previous year (1997/98) a number of discussions were held between SOAR and NASA regarding the development of a next-generation radar system and NASA involvement in Antarctic programs. SOAR was to continue these discussions and work with NASA on the development of a coherent radar to be tested in Antarctica on the SOAR platform.

1998/99 Accomplishments

Individual Investigators

SOAR operations for 1998/99 were to focus on the completion of previously funded projects. SOAR continued to work with these science clients to refine experiment designs:

- B. Luyendyk of University of California, Santa Barbara and C. Siddoway of Colorado College. Modified survey designs for their proposal entitled "Air-ground study of tectonics at the boundary between the Eastern Ross Embayment and Western Marie Byrd Land" (WMB).

- R. Bell and W. Roger Buck of the Lamont-Doherty Earth Observatory of Columbia University, and D.D. Blankenship of the University of Texas Institute for Geophysics. Modified and refined the survey target for their project "Collaborative Research: Contrasting Architecture and Dynamics of the Transantarctic Mountains" (TAM), specifically the Pensacola-Pole transect (PPT).

- E.D. Waddington of the University of Washington, and D.L. Morse and D.D. Blankenship of the University of Texas Institute for Geophysics. Refined the survey target for their investigation "Collaborative Research, Universities of Washington and Texas: WAIS Ice Divide Migration" (Divide).

- I. Whillans and B. Csatho of the Byrd Polar Research Center of The Ohio State University. Finalized survey targets for their investigation "Laser Altimetry for Ice-Sheet Volume Balance" (LIV).

- R. Bindschadler of the NASA/Goddard Space Flight Center and J. Behrendt of the Institute for Arctic and Alpine Research, University of Colorado. SOAR previously completed experiment designs for "West Antarctic Glaciology-V" (WAG).

- I. Whillans and C. van der Veen of the Byrd Polar Research Center of The Ohio State University. SOAR previously completed experiment designs for "Stress Transmission at Ice-Stream Margins" (STI).

Project Development and International Collaboration

Massimo Chiappini of the Italian Istituto Nazionale di Geofisica was a science observer during SOAR's South Pole Operations. SOAR and Italian scientists have been coordinating efforts for the upcoming TAM/Wilkes Basin survey. With Italian logistical support at Dome C, the survey corridor can be extended approximately 210 km.

Two sessions were held at the September 1998 WAIS Chapman Conference to develop the potential for international collaboration in studying the Thwaites and Pine Island Glacier drainage basins. Both SOAR directors chaired an organizational session and D. Blankenship chaired a planning session with approximately twenty-five US and UK researchers. These sessions contributed to a British proposal for a 5-year project involving both the SOAR platform and the British Antarctic Survey airborne geophysics platform.

The Lake Vostok workshop highlighted the need for an aerogeophysical site survey as an initial effort in the multidisciplinary program. This prompted one of the SOAR directors to submit a proposal to survey the area using the SOAR aircraft.

Interagency Coordination

SOAR continued discussions with NASA on the development of a coherent radar system and coordinated with NASA to install and test a coherent radar on the SOAR platform in Antarctica during the 1999/00 season. JPL has submitted a proposal to NASA to support their participation in this test. Discussions on the transfer of coherent radar technology to SOAR are continuing.

Issues to Address

Individual Investigators

SOAR received six requests for survey resource evaluation in support of new proposals with fieldwork planned after the 1999/00 season (after the expiration of the current SOAR Cooperative Agreement). Three of these arrived just prior to the June 1, 1999 NSF proposal deadline and one arrived a week before an earlier deadline, leaving SOAR insufficient time to thoroughly evaluate all requests.

Utilization of SOAR Resources

The demand for SOAR support has been increasing in the scientific community. Since SOAR resources are limited, new procedures should be developed to utilize these resources in a way that maximizes both the scientific merit of the work accomplished and the number of investigators who benefit from SOAR. Interdisciplinary proposals with large PI groups comprise an exceedingly small number of the surveys on SOAR's docket.

Interagency Coordination

SOAR should continue to foster interagency development of new technology and participate in the development of new science programs. NASA interest in Antarctic programs and instrumentation is a prime example of these opportunities.

Targets for 1999/00

Individual Investigators

SOAR will continue working with investigators to clarify SOAR's capabilities for data acquisition and management and to assess the SOAR resources needed to meet their science goals. Investigators should contact SOAR as early as possible in their proposal process so that SOAR has ample time to evaluate the resources required to meet survey goals.

Utilization of SOAR Resources

SOAR will encourage NSF to adopt a plan for developing more interdisciplinary projects which utilize SOAR resources more thoroughly and efficiently.

Interagency Coordination

SOAR will continue to pursue interagency collaborations that enhance SOAR's capabilities or bring SOAR into new science programs. During the 1999/00 field season SOAR plans to install and test on SOAR's platform a coherent radar built by NASA/JPL. Engineers from JPL will assist in the field test and subsequent data analysis. SOAR will continue discussions with NASA on the transfer of coherent radar technology to SOAR.

II. Data Acquisition

Goal

SOAR's data acquisition goal is to meet the experimental needs of science projects by providing simultaneous observations of subglacial topography, ice-surface topography, gravity, and magnetics. When the prime experimental objective is a subset of these data, SOAR aims to maintain the data quality of the secondary data sets wherever possible without compromising the primary data sets required by the science projects.

Plans for 1998/99

Field Plan

During the 1998/99 season, SOAR was to focus on completing the remainder of the TAM Pensacola-Pole Transect (PPT; Bell, Buck, and Blankenship) and Western Marie Byrd Land (WMB; Luyendyk and Siddoway) projects. Table A.1 lists planned flights and bases of operation for the 1998/99 field season, and Figure A.1 shows the locations of the survey targets. Both of these projects had dedicated time frames for completion. Given early project completion, SOAR intended to survey any remaining transects from the 1997/98 field season.

Operational Bases for 1998/99

The Twin Otter was to be configured and tested at Siple Dome (SDM). Both SDM and South Pole (NPX) were to be used as primary bases of operation with parallel base infrastructures

Table A.1
SOAR Field Plan for 1998/99

Experiment	Main Base	Secondary Base	Number of Flights
TAM (PPT)	NPX	DNB	24
WMB	SDM	FRD	59
Total Flights:			83

NPX = South Pole Stn. SDM = Siple Dome Camp
DNB = Downstream B FRD = Ford Ranges Camp

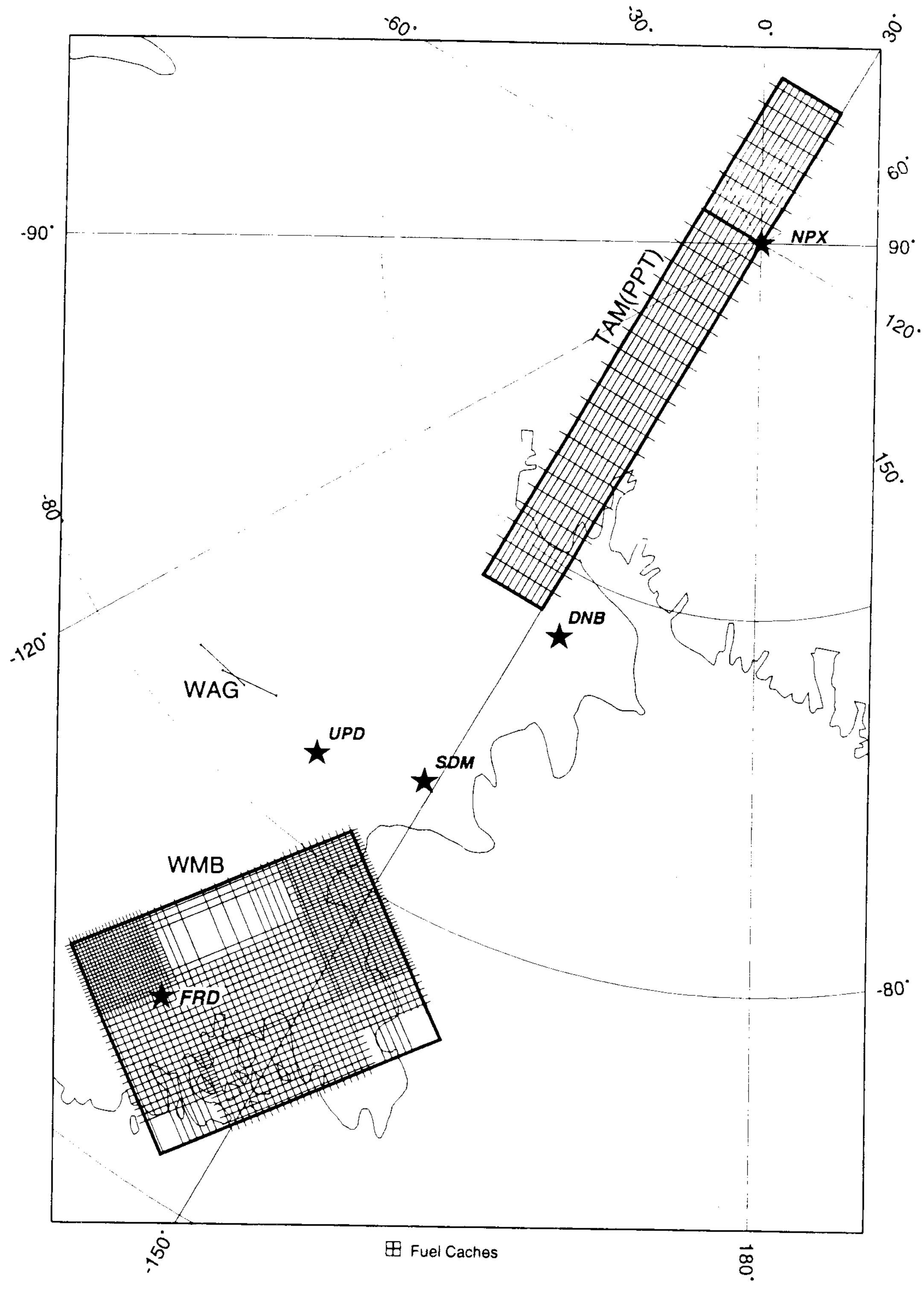

Figure A.1 - Survey targets and transects flown by SOAR during the 1998/99 field season. Boundaries of the targeted survey areas are indicated with heavy lines for TAM (PPT) (Transantarctic Mountains, Pensacola-Pole Transect), and WMB (Western Marie Byrd Land). See Figure A.2 for evolution of WMB survey target. Two WAG transects added at the end of surveying are also shown. Main and secondary bases are marked with stars: NPX (South Pole Station), DNB (Downstream B), SDM (Siple Dome Camp), and FRD (Ford Ranges Camp).

to be installed at each during aircraft configuration and testing. Flight operations were to begin from NPX on December 3, 1998 using Downstream B (DNB) as a secondary base. The survey target was the TAM/Pensacola-Pole Transect (PPT). Surveying was to continue until December 18, 1998, at which time operations were to return to SDM for the WMB survey. The Ford Ranges camp (FRD) was to serve as a secondary base for the WMB survey. This arrangement of focusing operations from a single main base and a single secondary base was intended to reduce transit time and provide additional flexibility.

Secondary bases were to support ground power needs of the aircraft and accommodate the crew for three days of operation, and five days of occupation in case of poor weather conditions. Each secondary base was to be ready for full operation when required for survey support.

Science Observers

SOAR requested that each project be limited to a single science observer, implying SOAR was to support only two science observers during the 1998/99 field season. Minimizing the

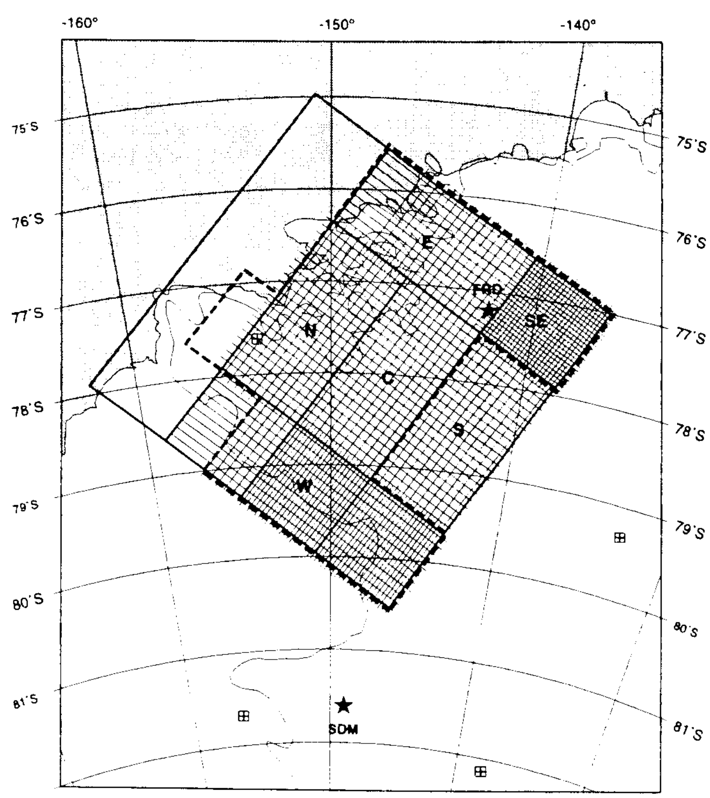

Figure A.2 - WMB survey target modifications. For safety and logistical reasons, SOAR initially modified the PI's original survey (large square block encompassing perimeter) and planned to survey the area enclosed within the heavy dashed line. The individual transect lines reflect the final survey design as determined during the field season after logistical constraints were realized. Figure A.1 shows actual transects surveyed in 1998/99.

number of science observers was critical due to the complexity of moving between different bases of operation. SOAR developed a schedule for science observers, attempting to place them in the field during survey activities for their specific projects; however, SOAR's priority was to accomplish the season's flight program even if the appropriate science observers were not present. SOAR planned to provide e-mail support for the science observers, but no additional computing or engineering support. Some mechanism was to be put in place to discourage additional "drop-in" science observers.

Project Completion

NSF, SOAR, and possibly SOAR's oversight committee, were to develop a definition of project completion. A number of models exist, ranging from the commercial aerogeophysical definition which requires every requested line to be flown with excellent data quality, to the marine science community definition which is generally determined by the number of dedicated ship days in the field. A definition of project completion for SOAR was necessary due to full schedules for the 1998/99 and 1999/00 seasons and the potential for significant weather delays during the Western Marie Byrd Land operations.

Table A.2
1998/99 Survey Summary

Project	Flights Planned†	Flights Completed	Transects Planned†	Transects Completed	Line-km Planned†	Line-km Completed*
WMB	59	64	170	196	35,859	34,450
TAM (PPT)	24	31	46	62	12,620	14,705
WAG	0	1	0	2	0	177
Season Total	**83**	**96**	**216**	**260**	**48,479**	**49,332**

†Represents plans as presented in the 1997/98 Annual Report. After experiment redesign, prior to start of surveying, targets were 14,990 line-km for PPT, 38,393 line-km for WMB. In original resource statements, PPT was estimated at 12,620 line-km, WMB at 44,218 line-km.

*Does not include lines repeated due to weather or instrumentation problems (6090 line-km).

Table A.3
Flight Operations Summary (1998/99)

Flight Number	Take Off Date (GMT)	Time (GMT)	Duration (hh:mm)	Originating Base	Project or Purpose
TF01	11/20/98	00:15	00:25	SDM	Antenna Test
TF02	11/24/98	04:27	02:39	SDM	Radar Test
TF03	11/30/98	04:10	01:18	SDM	
TF04	12/01/98	01:36	01:40	SDM	
TF05	12/02/98	05:14	01:40	SDM	SDM-DNB
TF06	12/02/98	08:02	01:30	SDM	DNB-SDM
TF07	12/03/98	03:04	02:04	SDM	
TR	12/03/98	22:00	05:00	SDM	SDM-DNB-NPX
TF08	12/08/98	03:01	02:58	NPX	Gravity Platform
F01	12/09/98	01:10	03:46	NPX	PPT/East
F02	12/09/98	12:14	04:29	NPX	PPT/East
F03	12/10/98	01:09	03:54	NPX	PPT/East
F04	12/10/98	14:12	01:51	NPX	PPT/East
F05	12/10/98	18:56	03:46	NPX	PPT/East
F06	12/11/98	01:16	03:26	NPX	PPT/East
F07	12/11/98	12:50	04:21	NPX	PPT/West
F08	12/11/98	19:00	04:13	NPX	PPT/East/West
F09	12/12/98	01:28	04:27	NPX	PPT/West
F10	12/12/98	12:41	04:44	NPX	PPT/West
F11	12/12/98	18:44	04:31	NPX	PPT/West
F12	12/13/98	01:13	04:20	DNB	PPT/West
F13	12/13/98	15:02	03:23	NPX	PPT/West
F14	12/13/98	20:39	03:13	DNB	PPT/West
F15	12/14/98	01:55	03:45	NPX	Refly PPT/East
F16	12/15/98	19:06	04:39	NPX	Refly PPT/East
F17	12/16/98	02:05	04:26	NPX	PPT/West
F18	12/16/98	13:50	04:15	NPX	PPT/West
F19	12/16/98	19:35	03:20	NPX	PPT/West
F20	12/17/98	00:53	04:13	DNB	PPT/West
F21	12/17/98	13:01	04:17	NPX	PPT/West
F22	12/17/98	19:18	03:13	DNB	PPT/West
F23	12/18/98	15:13	03:40	NPX	PPT/West
F24	12/18/98	21:37	04:22	DNB	PPT/Local DNB
F25	12/19/98	15:56	03:02	DNB	PPT/Local DNB
F26	12/19/98	21:07	03:35	DNB	PPT/Local DNB
F27	12/20/98	14:43	04:13	DNB	PPT/Local DNB
F28	12/20/98	21:22	04:15	DNB	PPT/Local DNB
F29	12/21/98	14:54	02:50	DNB	PPT/Local DNB
F30	12/21/98	21:34	04:15	DNB	PPT/Local DNB
F31	12/22/98	19:46	04:31	DNB	PPT/Local DNB
TR	12/23/98	03:17	01:18	DNB	DNB to SDM

Note: All times are GMT (continued on next page)

Table A.3 (continued)
Flight Operations Summary (1998/99)

Flight Number	Take Off Date (GMT)	Time (GMT)	Duration (hh:mm)	Originating Base	Project or Purpose
F32	12/24/98	01:34	04:42	SDM	WMB
F33	12/26/98	12:47	04:43	SDM	WMB
F34	12/26/98	18:48	05:08	SDM	WMB
F35	12/27/98	01:36	04:11	SDM	WMB
F36	12/27/98	12:24	04:26	SDM	WMB
F37	12/27/98	18:55	04:31	SDM	WMB
F38	12/28/98	01:50	04:29	SDM	WMB
F39	12/28/98	12:50	04:18	SDM	WMB
F40	12/28/98	19:18	04:39	SDM	WMB
F41	12/29/98	01:16	04:25	SDM	WMB
F42	12/29/98	12:19	03:43	SDM	WMB
F43	12/30/98	19:09	04:07	SDM	WMB
F44	12/31/98	01:24	04:17	SDM	WMB
F45	01/01/99	12:50	04:51	SDM	WMB
F46	01/01/99	19:09	03:20	SDM	WMB
F47	01/02/99	01:08	04:16	SDM	WMB
F48	01/02/99	13:02	03:30	SDM	WMB
F49	01/02/99	18:44	04:24	SDM	WMB
F50	01/03/99	01:22	04:29	SDM	WMB
F51	01/03/99	12:44	04:56	SDM	WMB
F52	01/03/99	19:11	04:08	SDM	WMB
F53	01/04/99	01:24	04:01	SDM	WMB
F54	01/04/99	13:09	03:28	FRD	WMB
F55	01/04/99	19:45	04:50	FRD	WMB
F56	01/05/99	13:05	04:48	FRD	WMB
F57	01/05/99	19:48	04:00	FRD	WMB
F58	01/06/99	01:54	03:39	SDM	WMB
F59	01/07/99	01:23	04:25	FRD	WMB
F60	01/07/99	19:39	04:29	SDM	WMB
F61	01/08/99	01:14	04:11	FRD	WMB
F62	01/08/99	18:48	04:34	FRD	WMB
F63	01/09/99	01:26	04:21	FRD	WMB
F64	01/09/99	19:02	02:44	FRD	WMB
F65	01/10/99	02:14	04:02	FRD	WMB
F66	01/10/99	20:45	03:58	FRD	WMB
F67	01/11/99	02:09	03:48	FRD	WMB
F68	01/11/99	13:06	03:53	SDM	WMB
F69	01/11/99	18:50	04:51	FRD	WMB
F70	01/12/99	13:17	04:37	FRD	WMB
F71	01/12/99	20:24	04:25	FRD	WMB
F72	01/13/99	13:15	04:11	FRD	WMB

Note: All times are GMT (continued on next page)

Table A.3 (continued)
Flight Operations Summary (1998/99)

Flight Number	Take Off Date (GMT)	Time (GMT)	Duration (hh:mm)	Originating Base	Project or Purpose
F73	01/13/99	19:00	03:51	FRD	WMB
F74	01/14/99	21:50	02:26	SDM	WMB
F75	01/15/99	01:58	04:01	FRD	WMB
F76	01/15/99	18:59	04:29	FRD	WMB
F77	01/16/99	01:35	04:11	FRD	WMB
F78	01/16/99	12:58	04:09	SDM	WMB
F79	01/16/99	18:57	04:23	FRD	WMB
F80	01/17/99	13:25	04:28	FRD	WMB
F81	01/17/99	19:13	04:01	SDM	WMB
F82	01/18/99	01:43	04:25	FRD	WMB
F83	01/18/99	18:48	04:28	FRD	WMB
F84	01/19/99	01:02	04:11	FRD	WMB
F85	01/19/99	18:50	04:15	FRD	WMB
F86	01/20/99	01:03	04:00	FRD	WMB
F87	01/20/99	12:43	03:58	SDM	WMB
F88	01/20/99	18:20	04:27	FRD	WMB
F89	01/21/99	13:11	04:13	FRD	WMB
F90	01/21/99	18:52	04:12	FRD	WMB
F91	01/22/99	12:40	04:25	FRD	WMB
F92	01/22/99	18:50	04:38	FRD	WMB
F93	01/23/99	13:51	04:46	FRD	WMB
F94	01/23/99	19:53	02:29	FRD	WMB
F95	01/23/99	23:42	04:33	SDM	WMB
F96	01/24/99	05:53	02:32	SDM	WAG

Note: All times are GMT

1998/99 Accomplishments

Field Plan

SOAR completed 96 survey flights which included 258 transects in support of the two science programs targeted for completion (Tables A.2 and A.3) and a flight dedicated to a previously incomplete project from the 1997/98 field season, "West Antarctic Glaciology - V" (WAG; Bindschadler and Behrendt). Two transects were flown in support of that project.

Surveying for TAM(PPT) was completed out of NPX and DNB within the designated time frame. An additional low-level survey was flown over Ice Stream A from DNB after the designated time frame because weather would not allow the planned main base shift from NPX to SDM. These flights were also used to train a temporary replacement pilot.

The number of flights dedicated to WMB was achieved within the allotted time frame. The average transit time per flight was greater than expected due to a delay in the establishment of the FRD camp, increasing the number of flights required to cover the survey area. Figure A.2 shows an outline of the original survey block as proposed by the investigator, the block as modified by SOAR and the investigator prior to the 1997/98 field season, and the final survey design determined during the 1998/99 field season, driven by field support as provided by ASA.

Operational Bases for 1998/99

SOAR successfully accomplished its operational plan for the 1998/99 field season with few problems. Transitions between the various operational bases went smoothly, due in large part to SOAR's successful implementation of its new portable data download and QC stations. These units allowed rapid setup of new base stations, reducing the impact of moves on surveying.

The Twin Otter was configured and tested at SDM while parallel main base infrastructures were constructed at SDM and NPX. Flight operations began out of NPX as scheduled on December 4, 1998. DNB served as a secondary base. The TAM(PPT) survey was completed using these bases. DNB was ready to support flight operations when required with only a few logistical problems on the part of ASA. Flight operations were completed on time at NPX, but the return to SDM was delayed from December 20 until December 23, 1998 due to weather. During that period, SOAR did not have a primary base of operation but was able to take advantage of its secondary base at DNB to complete a low-level survey over Ice Stream A and train a new Borek pilot temporarily assigned to SOAR.

The WMB survey was conducted using SDM as a primary base and FRD as a secondary base. The establishment of the FRD base was delayed due to poor weather. SOAR modified flight plans to operate solely out of SDM until FRD could provide support. SOAR completed 22 flights during nine days of flying without a secondary base. Lack of the secondary base during this period, however, caused a decrease in efficiency by increasing the average transit time required to reach the survey target.

Table A.4
SOAR Field Plan for 1999/00

Experiment (Project/Set)	Main Base	Secondary Base	Approx. Number of Flights	Survey line-km
TAM (Robb Glacier)	ZCM		2	430
TAM (Wilkes Basin)	MID	ZCM	19	9560
TAM (Dome C Ext.)	MID	DMC	18	7410
Divide	NBY		7	2160
LIV/OB2	NBY	SDM	3	594
STI/TKD	NBY	SDM	2	186
WAG	NBY	SDM	1	177
LIV /TKE	SDM	NBY	3	662
LIV/TKC	SDM	NBY	3	731
LIV/OB1	SDM	NBY	2	407
Totals (line-km does not include run-ins/outs):			**60**	**22,317**

Both DNB and FRD bases were able to accommodate the flight crews for multiple days of operation, although berthing was in tents rather than in a jamesway as requested. Available power was marginal for starting the aircraft. The main/secondary base arrangement was successful in maximizing the use of the Twin Otter. Only two flights (the moves between NPX and SDM) were dedicated to non-survey transits during the entire season, as opposed to 25 transit flights during the 1997/98 season.

Science Observers

SOAR scheduled two science observers to be in the field during surveying for their respective projects. Massimo Chiappini of the Istituto Nazionale di Geofisica was a science observer during the TAM(PPT) operations. He was with SOAR at NPX for the duration of PPT operations. Marcy Davis of the University of California at Santa Barbara served as science observer for WMB and was with SOAR from just prior to field activities through the end of the field season.

Project Completion

For the purpose of field operations, SOAR considered a project "complete" at the end of a designated time period. This decision was driven largely by the logistics of the 1998/99 field season. When the designated period for one project was over, the next would begin. In the event that all survey lines were not flown by the designated date, SOAR was committed to move on to the next scheduled survey.

Data Transfer to North America

SOAR successfully utilized the GOES satellite link to transmit multiple data files containing QC products from SDM to North America. The GOES link allowed a transfer of between 40 to 50 megabytes of data per day, and provided SOAR and other science groups information and communication resources which were previously unavailable.

Issues to Address

Project Completion

SOAR's current policy for project completion during field operations defines a designated time frame for each project. This does not address the possibility of early completion. A method needs to be developed for determining if a project is sufficiently complete to move on to the next survey, before the end of the designated time period. This primarily involves factors such as coverage and data quality.

Long-term Survey Priorities

SOAR and NSF need to develop a method for prioritizing continuing or incomplete projects from previous years. The need for this arises when scheduling projects for upcoming field seasons and occasionally during fieldwork. When the opportunity arises to perform additional survey work without impacting the goals of the current field season, SOAR tries to maximize its usefulness by completing portions of incomplete or continuing projects. However, to take advantage of such opportunities, planning prior to the field season is important.

Data Transfer to North America

SOAR should determine which data products are optimal for sending to North America from the field when a GOES link is available. With a daily transfer rate of 40-50 megabytes, SOAR personnel in North America can more effectively monitor activity in the field to provide more thorough and timely guidance for operations and troubleshooting.

Targets for 1999/00

1999/00 Field Plan

During the 1999/00 season, SOAR will divide its efforts between surveys in East Antarctica and West Antarctica. SOAR's objective is to complete the following surveys (SOAR acronyms for each project are given in parentheses):

East Antarctica:

- "Collaborative Research: Contrasting Architecture and Dynamics of the Transantarctic Mountains (TAM)" Wilkes Basin, Dome C extension, Robb Glacier; Bell, Buck, and Blankenship.

West Antarctica:

- "Collaborative Research: WAIS Ice Divide Migration" (Divide); Waddington, Morse, and Blankenship;
- "Laser Altimetry of Ice-Sheet Volume-Balance" (LIV); Whillans and Csatho;
- "Stress Transmission at Ice-Stream Shear Margins" (STI); Whillans and van der Veen;
- Western Antarctic Glaciology - V" (WAG); Bindschadler and Behrendt.

Figure A.3 is a regional map showing the locations of these survey targets. Figures A.4 and A.5 show details of the East and West Antarctic survey areas. Surveys in East and West Antarctica will have dedicated time frames in which to be completed. Table A.4 lists the number of flights and bases of operation planned for each project.

In addition to the data acquisition goals for these science projects, SOAR's airborne platform and SOAR personnel will be used to conduct Antarctic testing of JPL's newly developed coherent radar during the 1999/00 field season.

Operational Bases for 1999/00

The Twin Otter will be configured and tested at McMurdo Station (ZCM) early in the season. Flight operations for the TAM/Wilkes Basin corridor and Dome C extension will begin immediately from ZCM after aircraft configuration and testing are complete. The Italian midpoint (MID) will be used as a secondary base for a short period (4-5 days). The second flight crew and an additional ground crew member will then be moved to MID so that maxi-

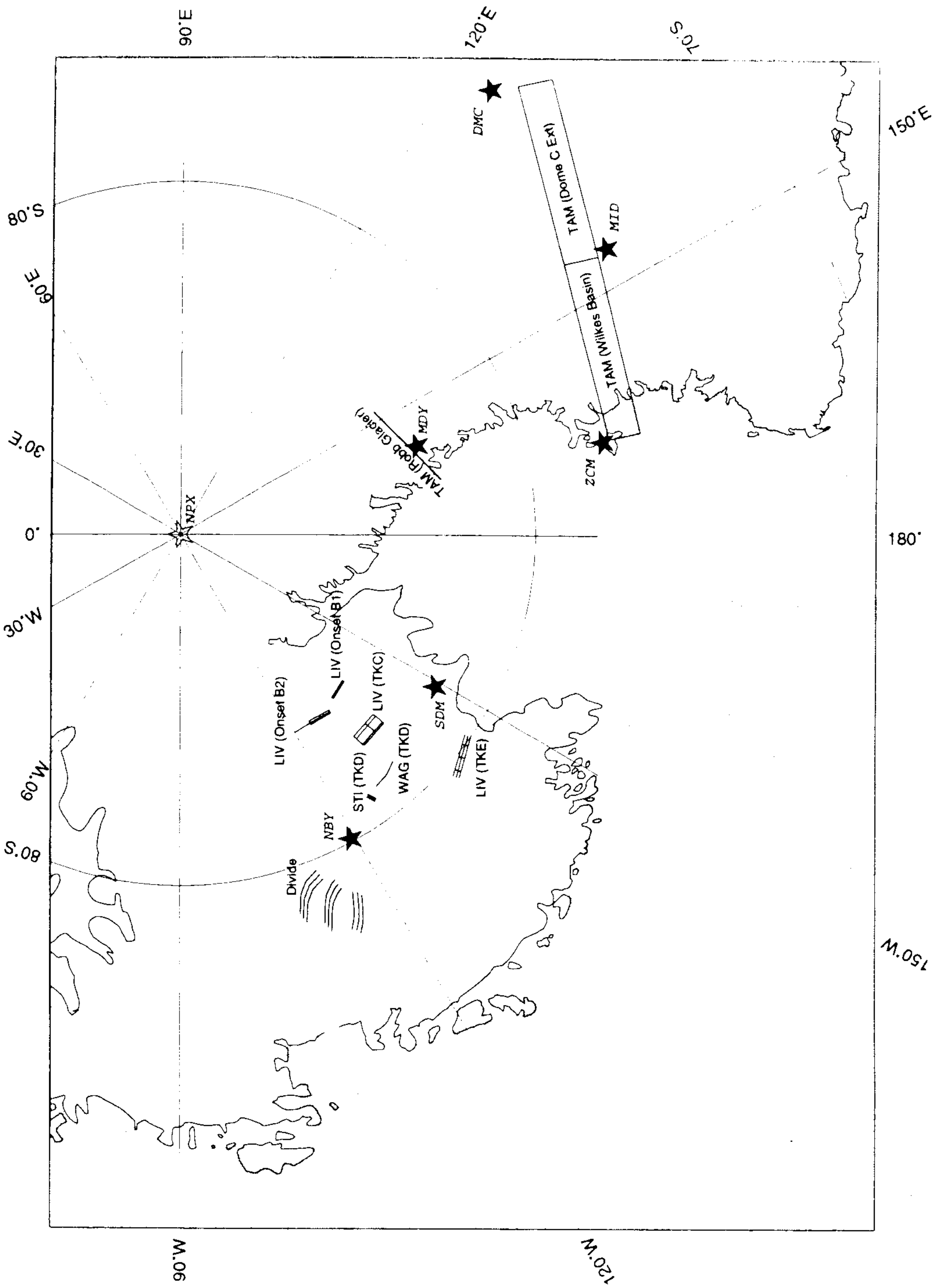

Figure A.3 - SOAR survey targets for 1999/00 are shown with corridors delineated as blocks: [1] TAM (Transantarctic Mountains): Wilkes Basin, Dome C Extension, and Robb Glacier; [2] LIV (Laser Ice Volume Experiment): onset of ice streams B1 (OB1) and B2 (OB2), as well as the trunks of ice streams C (TKC), and E (TKE); [3] STI (Shear Transmission at Ice Stream Margins): trunk of ice stream D (TKD); [4] WAG (West Antarctic Glaciology): trunk of ice stream D (TKD); [5] Divide (WAIS): Ice Divide Migration. Main and secondary bases are marked with stars: ZCM (McMurdo Station), MID (Italian Midpoint), DMC (Dome C), SDM (Siple Dome Camp), and NBY (Byrd Surface Camp).

mum efficiency can be achieved. After an additional 5-6 days, the remaining crew at ZCM will be moved to DMC so that surveys can be accomplished between MID and DMC. The TAM/Robb Glacier transect will be flown out of ZCM early on, requiring fuel stops near the mouth of Robb Glacier. On a pre-determined date, SOAR will move to West Antarctica and install a main base of operations at Byrd Surface Camp (NBY) and a secondary base at Siple Dome (SDM). From these two bases, SOAR's flight objectives will be the LIV, WAG, STI and Divide survey targets. After the designated period of time for completion of these projects SOAR will return to MCM to reconfigure the aircraft and conduct testing of JPL's coherent radar.

Secondary bases must be able to support ground power needs of the aircraft and base station equipment and accommodate the crew for up to five days at a time. Each base must be in full operation when needed to support SOAR activities.

Project Completion

SOAR plans to develop criteria for determining when surveying for an individual project may be considered complete for the purpose of field operations, so that project completion before the end of a designated time period is possible.

Long-term Survey Priorities

SOAR will develop a method of prioritizing continuing or incomplete projects from previous years in light of a long-term definition of project completion. Input from NSF may be required for this.

Data Transfer to North America

SOAR will determine which specific data products will regularly be sent to North America from the field via the GOES satellite link when possible. Once decided, a transfer procedure will be incorporated into SOAR's field plan.

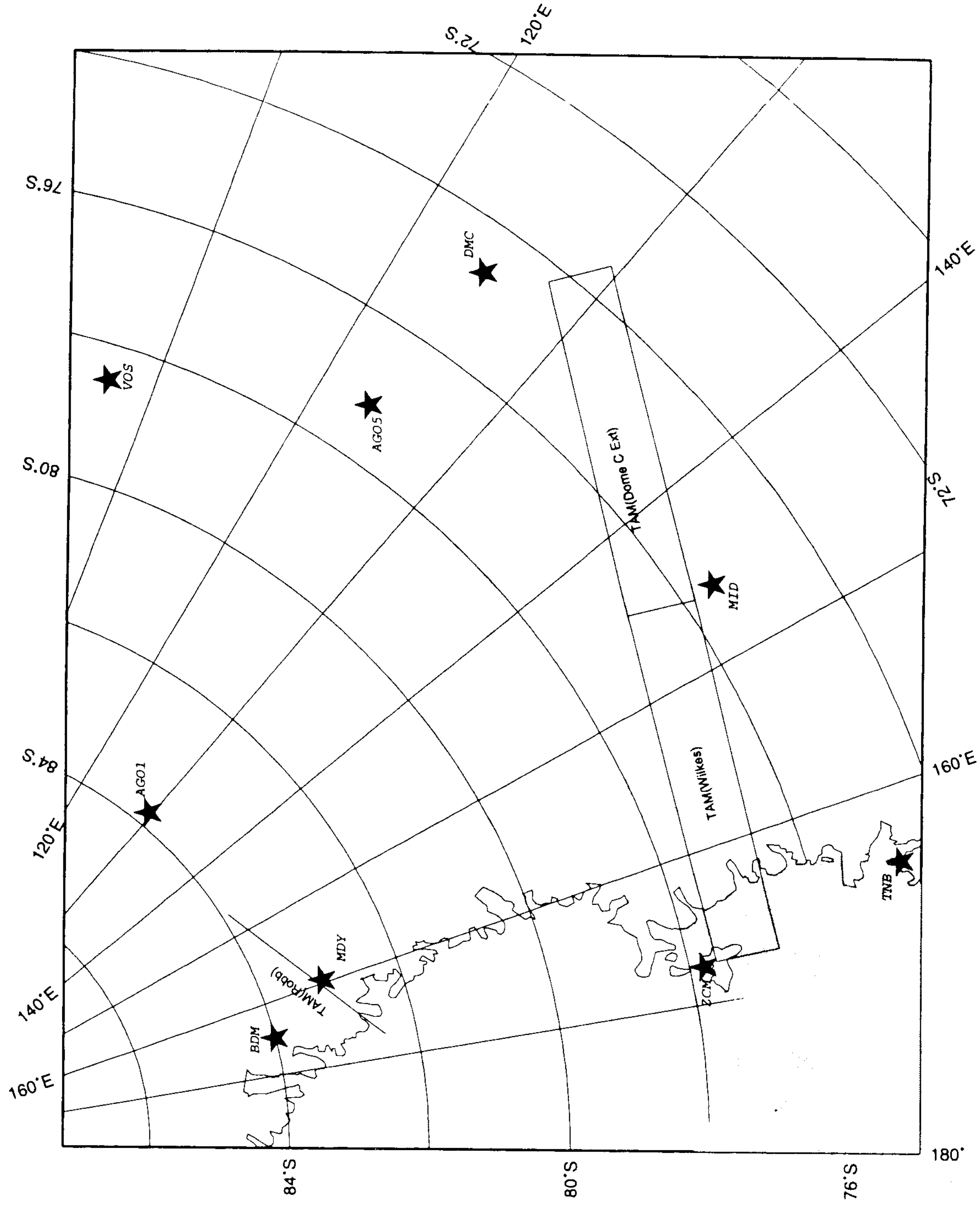

Figure A.4 - Detail of SOAR East Antarctic survey targets for 1999/00 are shown. The TAM(Wilkes) corridor will be flown from ZCM, MID, and DMC. The TAM(Robb) line will be flown from ZCM with a fuel stop and temporary base station at Moody Nunatak (MDY).

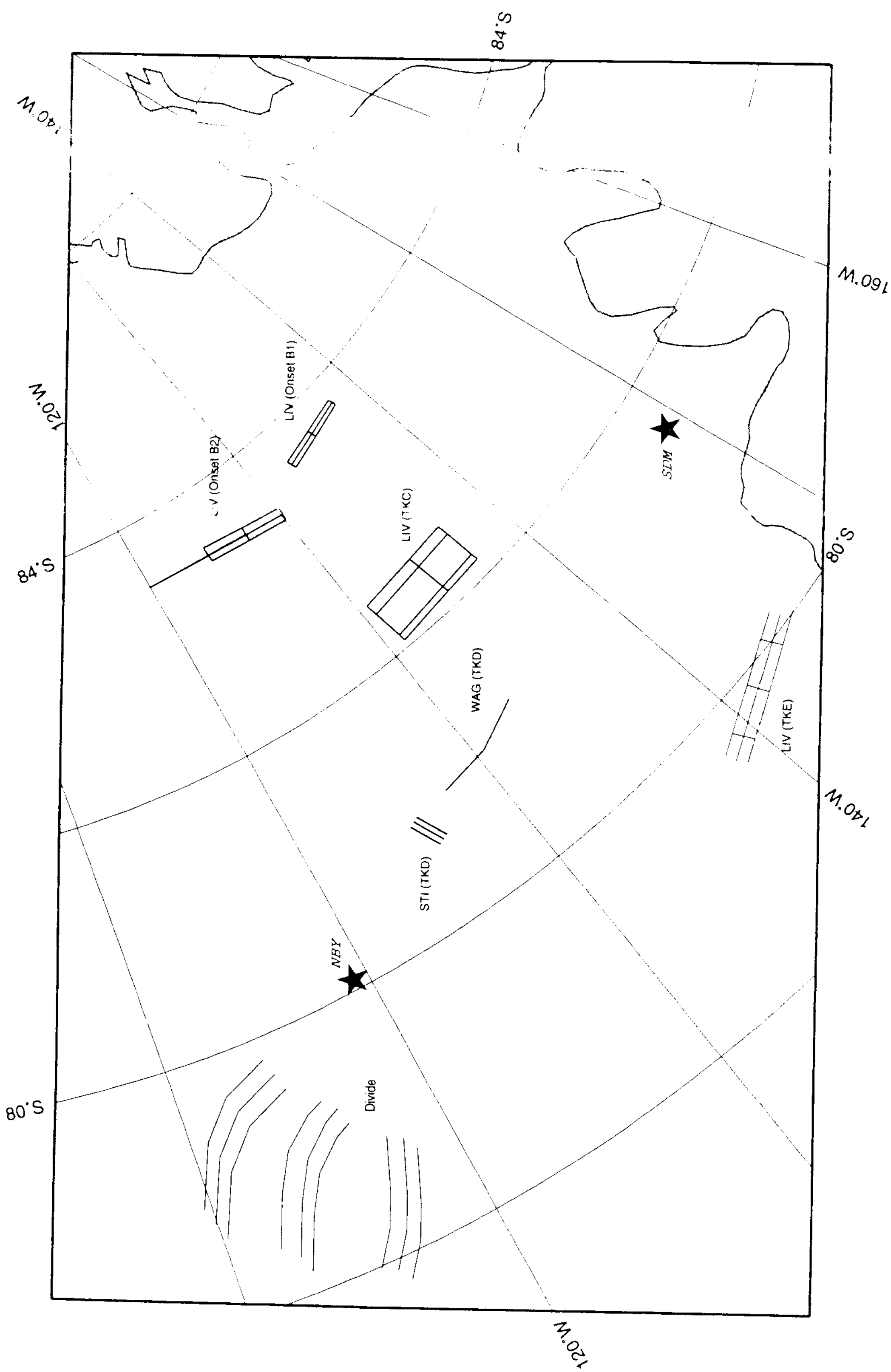

Figure A.5 - Detail of SOAR survey targets in West Antarctica for 1999/00. All survey targets in West Antarctica will be flown with NBY as a main base and SDM as a secondary. NBY is optimal for surveying Divide, LIV/OB2, STI/TKD, and WAG/TKD while SDM is optimal for LIV/TKE, LIV/TKC, and LIV/OB1. In the event of weather constraints, some targets can be reached from either base.

III. Data Management

Goal

SOAR's data management goal is to efficiently [illegible] data acquired by SOAR.

Plans for 1998/99

Data Distribution and Reduction

SOAR was to continue to provide raw data products for each geophysical and positioning data stream when needed. Quality control and raw data products from the 1997/98 field season were to be delivered to the appropriate science clients or SOAR data reduction facility by August 1, 1998. Reduced data were to be distributed to the science clients by November 1, 1998 in order to meet the oversight committee target of nine months after completion of the fieldwork. Table A.5 summarizes the 1997/98 data products SOAR planned to deliver in 1998/99.

Data Archiving

SOAR was to continue discussions with the National Snow and Ice Data Center (NSIDC) and the National Geophysical Data Center (NGDC) regarding the archiving of the SOAR ASCII data. The goal was to archive SOAR reduced products, including gravity, magnetics, ice surface elevations and bedrock topography at one of these institutions. The major out-standing issue was the archiving of the binary radar data. SOAR was to pursue the archiving of radar data through the NSIDC.

1998/99 Accomplishments

Data Distribution and Reduction

SOAR distributed raw data from the 1997/98 field season to clients on July 21, 1998. Paper QC and field notes to accompany raw data were distributed to UTIG, LDEO, and the LIV project in August, 1998. Time-stamped laser and radar profiles were delivered to WAG investigators on November 20, 1998, and have been available to other clients (WMB, STI, and LIV) via the Internet since January 22, 1999. Potential fields data reduction for 1997/98 surveys was postponed until the completion of data acquisition for those projects in 1998/99.

The SOAR data reduction facility at UTIG has developed a web page detailing reduction and distribution events (http://www.ig.utexas.edu/research/projects/ soar/soar.html).

Table A.5
Data Distribution Tasking for 1997/98 Data

Client	Data Product			
	Raw	Transect Morphology	Transect Geopotential	Map
TAM	♦	♦	♦	
WAG		♦		
LIV	♦	♦		
WMB		♦	♦	
STI		♦		

Table A.6
Data Distribution Tasking for 1998/99 Data

Client	Data Product			
	Raw	Transect Morphology	Transect Geopotential	Map
TAM	♦	♦	♦	
WMB		♦	♦	
WAG		♦		

Data Archiving

SOAR continues its plan of short-term storage of all data collected in the field until permanent archiving of the data is established. Duplicate copies of data sets are currently stored at the University of Texas Institute for Geophysics and at the Lamont-Doherty Earth Observatory.

Issues to Address

Data Distribution

The cooperative agreement states data should be available for general release two years after the acquisition of a geographically contiguous data set, contingent on the approval of NSF. SOAR has received requests for previously collected data from several individuals. NSF and SOAR need to develop a standard procedure to address this type of data distribution.

NSF and SOAR need to develop a policy regarding distribution of data collected during test and transit flights.

Data Archiving

The major outstanding issue is the archiving of binary radar data. The British continue to benefit from radar data collected in the 1970's. Future researchers in the US and elsewhere should have the same access to binary SOAR radar data.

Targets for 1999/00

Data Distribution and Reduction

SOAR will continue to provide raw data products for each geophysical and positioning data stream when needed. Quality control and raw data products from the 1999/00 field season will be delivered to the appropriate science clients or SOAR reduction facility by August 1, 2000. Reduced data will be distributed to science clients by November 1, 2000, meeting the oversight committee target of nine months after the completion of the field work. A summary of the SOAR data distribution and tasking for data collected in 1998/99 is represented in Table A.6.

NSF and SOAR should develop a procedure for distribution of older data, test data, and transit data. Development of these procedures should take into account SOAR resources required for distribution.

Data Archiving

SOAR will continue to pursue the archiving of binary radar data.

Appendix B: Technology

SOAR Annual Report
1998/1999

This appendix focuses on the facility's technical goals, plans, accomplishments, outstanding issues and future targets.

Goal

The SOAR technical goal is to prepare, configure and operate the geophysical and positioning systems aboard the survey aircraft to obtain the highest quality observations consistent with simultaneous operation of these systems. This technical goal includes providing base station facilities and a computational framework for data reduction. The geophysical observations are ice-penetrating radar, laser altimetry, gravity, and magnetics. The positioning observations are GPS (including post-processed differential carrier-phase), precision pressure altimetry, and inertial navigation.

Plans for 1998/99

Plans for major technical improvements during the fifth year of facility operations were the following:

Base Station Equipment

In order to increase portability of the QC platforms at main and satellite bases, SOAR planned to design and build two stand-alone "plug-and-play" QC platforms. These were to be rack mounted, include flat displays and have printers, digital linear tape and 4mm DAT tape archiving capabilities. In designing this system, SOAR was to review current and projected hardware needs of the platform in light of increasing speed and efficiency of running base station QC. Existing workstations for QC were to become the spares pool for the "plug-and-play" systems.

SOAR also planned to develop three rack mounted "plug-and-play" base monitoring stations including three GPS receivers (including a spare), a new base station magnetometer, and all necessary logging hardware. Laptops were to be replaced with "lunchbox" style computers which combine a flatpanel display and a small, portable chassis with full desktop functionality.

Spare critical components for the "plug-and-play" base monitoring stations were to also be part of the rack mounted systems.

Data Reduction

SOAR was to purchase discs, tape drives and printers for data reduction tasks in order to replace those on loan from science groups.

Aircraft Magnetometer

SOAR was to acquire a spare cesium magnetometer for the aircraft.

Parts for the spare magnetometer winch were to be assembled and sent to Kenn Borek Air, Ltd. for installation and full check-out prior to deployment to the field.

Ownership of the second magnetometer bird currently on loan from the USGS was to be resolved.

Coherent Radar

SOAR was to continue using its existing radar system while working with JPL on the specification and testing of coherent radar technology. JPL has been developing a prototype ice-penetrating radar as a testbed for a radar to be built for the Europa orbiter. This technology was to be compared with current systems at SOAR and the University of Kansas. Three months of SOAR engineering resources (and some travel) were to be allocated to these tasks.

SOAR was to request a dialog between NSF, SOAR, and NASA regarding field testing and transfer of JPL's coherent radar technology. Field testing of any jointly developed coherent radar system was planned for the 1999/00 field season.

Digital Avionics Interface

SOAR was to assemble and test a spare for the Western Avionics DAI 1200.

Precision Navigation

SOAR intended to resolve the 1997/98 season's differential GPS (DGPS) correction problems by utilizing a wider frequency shift modulation method to allow for easier tuning. SOAR also intended to investigate the transmittal of GLONASS/GPS corrections to the aircraft and the possibility of GPS navigation using the Y-code for the 1999/00 field season.

SOAR was to review erratic behavior of the GPS navigation system that occurred during flights near the South Pole during 1997/98 and determine the navigation system's limitations by simulating a GPS NMEA stream for near-pole conditions. SOAR was to evaluate the necessity of a coordinate shift to keep the INS on the aircraft operating near the pole, and was to work closely with navigation system manufacturers to develop a solution to these problems.

Integrated QC

In order to provide a more integrated QC process across the three platforms of aircraft, satellite base, and main base, the following were to be accomplished:

- SOAR was to evaluate and rewrite sections of the existing QC in order to achieve maximum flexibility. Four and one-half months of systems analyst time were to be allocated to the rewrite.

- SOAR was to design and build identical "plug-and-play" platforms for QC and data archiving at main and satellite bases.

- SOAR was to provide user-friendly, real-time monitoring and trend display of data at each position on the aircraft prior to the 1998/99 field season. SOAR was to allocate four and one-half months of systems analyst resources to this task.

Repair and Refurbishment

SOAR intended to replace aging NEC Versa laptop and Apple Powerbook computers before the 1998/99 field season. Rack-mount computers and flat panel monitors were to be acquired for the aircraft and additional laptops were to replace out-of-date models used for field logistics and inventory management.

SOAR was to acquire spares for the True-Time time code generator.

SOAR intended to send its laser altimeters for factory refurbishment.

GPS Receivers

Due to budgetary limitations, SOAR was to continue borrowing the necessary Ashtech Z-12 GPS receivers (6) from LDEO.

Acquisition System

SOAR was to upgrade the QNX operating system used for data acquisition to a new version which supports current hardware. A new windowing system was to be acquired.

Aircraft Intercom System

SOAR was to purchase a stand-alone intercom and noise-canceling headset system. This system was to be mounted directly on the racks with a single cable interface to the Twin Otter.

Satellite Telephones

SOAR was to acquire three low-earth-orbit satellite telephones to maintain communications between bases and the aircraft during periods of inadequate HF communications.

TUD Radar Antennas

SOAR was to engineer the modifications required for existing antennas in order to have a complete set of ready-to-install spare radar antennas. Plans were to be passed to Kenn Borek Air, Ltd. for implementation. Two months of Research Engineering resources were to be allocated to this task.

TUD Radar

During flights to South Pole Station during the 1997/98 season, it was determined that the TUD radar high power amplifiers stopped operating at altitudes above approximately 8,000 feet due to low cooling air pressure. SOAR was to investigate this situation and make modifications to enable the TUD radar to operate at high altitudes.

1998/99 Accomplishments

Base Station Equipment

Using a combination of newly purchased and existing equipment, SOAR designed, built, and implemented three stand-alone rack-mounted "plug-and-play" QC platforms. The platforms were configured identically and included all hardware and software required to archive data and generate QC at all bases. One system was used at each base of operations and the third system was used as a spare when necessary. This scheme greatly increased the speed and efficiency in which base station QC systems can be transported, set up, and used for generating and archiving QC.

Three base monitoring stations were assembled and operated in the field. Laptop computers used previously for magnetometer logging were replaced by portable "lunchbox" computers with GPS clock cards. Rack mounting of monitoring equipment proved to be impractical for our operations.

A single base-station cesium magnetometer was purchased and provided extremely reliable operation during the entire field season.

Data Reduction

Funds for the purchase of discs, tape drives and printers to replace those on loan from science groups were diverted to data acquisition tasks. No hardware purchases were made.

Aircraft Magnetometer

SOAR purchased a spare cesium magnetometer for the aircraft.

A spare magnetometer winch was built by SOAR and inspected by a Kenn Borek Air, Ltd. aircraft mechanic in the field. It was used near the end of the field season when electrical relays in the primary winch failed. The spare winch worked perfectly, and due to the availability of the spare, no survey time was lost.

The USGS does not expect SOAR to return the second magnetometer bird.

Coherent Radar

No funds were allocated for coherent radar development in 1998/99; however, JPL has finished design and construction of their Europa testbed coherent radar. SOAR reached reached an agreement with JPL to test this radar on the SOAR platform in Antarctica during the 1999/00 field season. This protoype radar is a 500 watt peak power chirped system with center frequencies of 40, 60, and 80 MHz, and a 15 MHz bandwidth. Chirp and down-conversion signals are synthesized from a digital signal generator employing a numerically controlled oscillator. Transmission is through a single antenna, although dual channel receivers and recording allow for great flexibility in data post-processing. Figure B.1 shows a block diagram of this radar. The planned technology comparison between this new radar and the existing radars of both SOAR and the University of Kansas is ongoing. The JPL radar was recently deployed in Greenland on the University of Kansas radar platform and evaluation of the data is currently taking place.

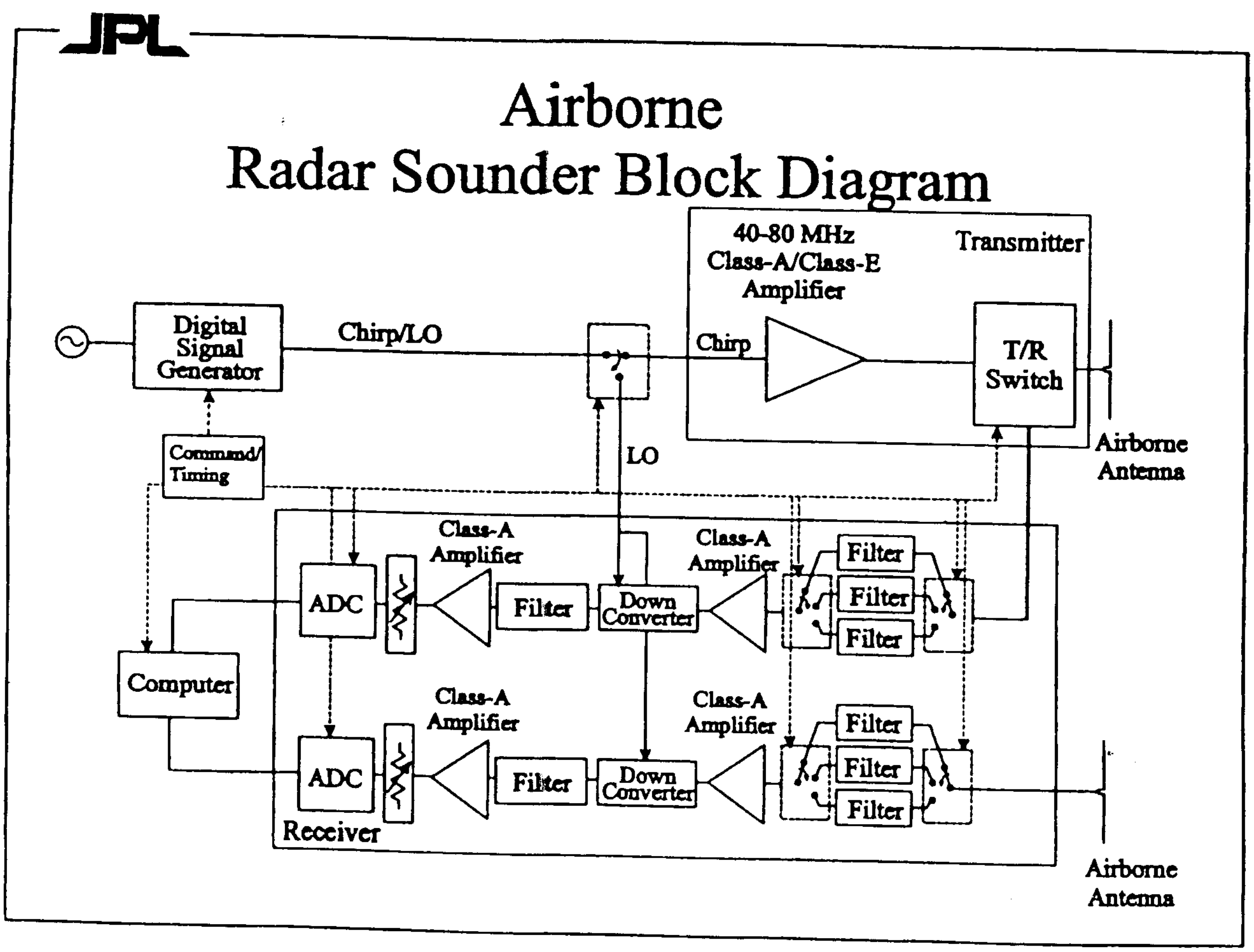

Figure B.1 Block diagram of the JPL testbed radar.

Digital Avionics Interface

SOAR has assembled a complete set of spare components for the Western Avionics DAI 1200, and has constructed a second spare DAI. However, outstanding development issues related to the substitution of currently available, more modern digital components have thus far prevented the second DAI from reaching operational status.

Precision Navigation

During the 1998/99 field season, SOAR used a combination GLONASS/GPS receiver onboard the aircraft for survey navigation. Differential GPS (DGPS) navigation using a correction signal broadcast directly to the aircraft from a base station was not used for several reasons. Only a relatively small region of one of the 1998/99 survey areas (Western Marie Byrd Land, WMB) could have been served by a DGPS transmitter operating at Siple Dome. This is due to HF transmission limitations, differential correction relevance, and the logistical constraints of setting up operations for two survey areas using four bases. GLONASS/GPS has the advantage of being able to operate anywhere. This was an important capability during the 1998/99 field season, with its extended and remote survey areas. Although GLONASS/GPS navigation is not quite as accurate as real-time differential GPS, it provided sufficiently accurate navigation for our needs, much better than GPS alone. Most of the surveying for this season was done at a grid spacing of at least 10.6 km, which in combination with the science objectives (which had no requirement of high-precision repeat surveys) eliminated the need for navigation precision beyond that of GLONASS/GPS. An additional reason for this decision was the severe impact DGPS tests would have had on survey operations. An especially active season due largely to consistently good weather gave us the opportunity to survey nearly continuously. Due to these many factors, it was decided not to employ real-time differential GPS navigation during the 1998/99 field season.

SOAR reviewed erratic GPS data collected when the Twin Otter approached South Pole during the 1997/98 field season. By simulating a NMEA stream of near-pole data into the primary real time navigation display system, SOAR determined existing navigation projection algorithms were inadequate in the vicinity of the pole. However, the existing GLONASS/GPS engine was found to be fully functional in extreme polar regions. SOAR worked with the navigation system manufacturer to develop new software which supported polar stereographic projections, alleviating the navigation problem.

A coordinate shift to keep the Twin Otter's inertial navigation system (INS) operating near the pole was unnecessary. The INS gyros were kept running when the aircraft was parked at South Pole Station, and could be updated in flight when sufficiently far from the pole.

SOAR did not have the resources available to thoroughly investigate the use of GPS Y-code for precision navigation during the 1998/99 season.

Integrated QC

SOAR designed and built three identical "plug-and-play" QC platforms for main and satellite bases (described above under "Base Equipment"). QC generation and data archiving procedures were developed to ensure consistency between multiple bases of operation. These QC platforms and the procedures developed to operate them worked extremely well.

SOAR developed and utilized software for user-friendly, real-time monitoring of data on the aircraft. SOAR developed real-time monitoring capability of base station magnetometer data allowing for real-time continuous QC of these data. Both of these capabilities were a great success during the 1998/99 field season.

SOAR began its evaluation of the existing QC code in preparation for a possible rewrite. Critical problems were fixed in the code to allow complete QC generation in the field. These fixes included the allowance for very long or very short transects, the removal of geographic constraints and the adjustment of various scaling problems in the QC graphical output.

Repair and Refurbishment

SOAR purchased 5 rackmount computers to be used in the aircraft for data acquisition system control and real-time data monitoring. SOAR also purchased three portable "lunchbox" computers for base station operations. These replaced outdated and increasingly unreliable NEC Versa laptops which were retired or served as spares. Two Apple Powerbook computers were purchased for administrative purposes, field logistics, and inventory management. SOAR also purchased two flat-panel displays (LCD's) which replaced much heavier, larger displays.

SOAR acquired a spare True-Time time code generator for the aircraft.

SOAR had its laser altimeters refurbished and recolumnated by the manufacturer.

GPS Receivers

SOAR borrowed six Ashtech Z-12 GPS receivers from LDEO. Three additional receivers were also borrowed from the University of Maryland to fill in for three of the primary six which could not arrive in time for the start of the field season.

Acquisition System

SOAR upgraded the QNX operating system employed for data acquisition to a new version which supports current hardware. New windowing system software (Photon) was acquired and used for the development of improved real-time data monitoring capabilities.

Aircraft Intercom System

SOAR purchased active noise canceling headsets that were used in conjunction with the existing intercom system on the Twin Otter. With the much improved headsets and a better understanding of pilot control of the existing intercom, the system proved quite functional, comfortable, and reliable.

Satellite Telephones

SOAR placed an order for two low-Earth-orbit satellite (Iridium) telephones, but delivery did not take place. The order was cancelled.

TUD Radar Antennas

SOAR provided drawings of modifications required for the existing spare antennas to Kenn Borek Air, Ltd. The modifications were accomplished and SOAR now has a complete set of ready-to-install spare antennas.

TUD Radar

SOAR investigated the high altitude cooling problem in the TUD high power amplifiers encountered during the 1997/98 season. The amplifiers were modified to accept new, very high performance fans, which were shown in the lab to provide almost twice the cooling system pressure. The amplifier used during survey work performed well at all times in high altitude operations during the 1998/99 season, and was operated to 18,000 feet without failure.

Issues to Address

Base Stations

Our cesium magnetometers have proven to be vastly more reliable than proton precession magnetometers, whether used on the aircraft or on the ground. Two additional cesium magnetometers, one for each of two base stations and one spare, are desired. SOAR currently has only one cesium base station magnetometer.

The logging of base station GPS data for carrier-phase, differential GPS measurements is highly critical for our work. The collection process, however, is quite complicated and prone to errors from many sources. This process needs to be streamlined for efficiency, made more robust to reduce hardware and software problems, and possibly automated to reduce operator error.

GPS Receivers

Carrier-phase GPS data for kinematic, differential GPS are required for SOAR's laser and gravity measurements. SOAR currently owns three GPS receivers, and has continued to borrow six additional GPS receivers from other institutions for use at base stations and on the aircraft. This has always proven to be logistically complicated, requiring a large effort on the part of SOAR personnel to arrange the loans, oversee transfers, and verify the proper functioning of these receivers. The potential impact to survey operations in the event that GPS receivers are unobtainable is enormous. Operations would be much smoother and more reliable if SOAR owned the required GPS receivers.

Aircraft GPS Logging

A laptop computer has been used to record dual-channel carrier phase GPS data on the aircraft, specifically from a borrowed Ashtech GPS receiver. There have been many problems associated with this hardware arrangement including intermittent power loss, disk space limitations, and accessory disk drive problems. SOAR needs to develop a more robust and permanent hardware solution for GPS data logging on the aircraft.

Data Reduction Hardware

SOAR still has a need to purchase disk drives, tape drives and printers to replace those on loan from science groups.

Coherent Radar

The JPL Europa testbed radar will be ready for testing in the SOAR aircraft during the 1999/00 field season. Plans for integration, flight testing, and data analysis should be formulated. A formal agreement for transfer of coherent radar technology from JPL to SOAR needs to be established.

Digital Avionics Interface

Outstanding development issues related to the substitution of currently available, more modern digital components should be addressed, so that the second DAI will reach operational status.

Precision Navigation

The use of differential GPS using a correction signal broadcast to the aircraft needs to be re-evaluated. As stated above, uncorrected GLONASS/GPS provided adequate navigation for the 1998/99 season. Due to the unreliable nature of HF communications, the limited area in which differential corrections are relevant, and the increasingly widespread nature of SOAR operations, the future of DGPS use is unclear. However, SOAR now has the capability to develop and test a differential GLONASS/GPS system, which may provide extremely accurate real-time navigation in a limited area. It must be decided whether such benefits would result in enough improvement in the data quality of future projects to justify the expense and resources required to implement the system given time constraints in the field.

Currently, SOAR possesses only an older version of the GLONASS/GPS receiver to use as a spare. Because the older model features a different physical format and different connectors, it is not a true drop-in spare. SOAR needs to modify this receiver so that it can be more quickly installed in the aircraft to reduced the potential for missed flight opportunities in the event that the primary GLONASS/GPS receiver failed.

GPS navigation using the Y-code as a possible alternative or addition to current survey navigation methods should be investigated.

Potential navigation problems resulting from the Y2K date rollover and GPS week 1024 rollover (August, 1999) should be evaluated. This will likely require firmware upgrades to many receivers.

Y2K

All aircraft and base station equipment and software should be thoroughly checked for the possibility of year 2000 errors before the 1999/00 field season.

Integrated QC

The existing QC software is rapidly becoming outdated as SOAR's technology and surveying strategy continue to evolve. The entire QC process needs to be evaluated, and the software should be rewritten to reflect our needs and to provide a more flexible and user-friendly interface.

SOAR needs to decide how best to utilize the additional data available with the new real-time monitoring software on the aircraft following the successful testing of this software in 1998/99.

The only component of the planned data acquisition system software on the aircraft which remains to be developed is the acquisition control and monitor software and radar monitor software.

Gravity Meter

SOAR experienced difficulties with the BGM-3 gravity sensor stabilized platform and platform controller during the 1998/99 field season. The primary platform controller functioned correctly upon arrival in the field, but failed during transit from Siple Dome to South Pole Station just prior to the start of surveying. The spare platform controller was determined to be inoperable. SOAR personnel were able to create one working controller from the parts contained in the two malfunctioning ones, although the modifications for airborne use were not fully functional. In addition, the stabilized platform itself demonstrated intermittent problems appearing to indicate a failing gyro. The Naval Oceanographic Command (NAVOCEANO) was able to send spares to Antarctica, but the possibility still existed for significant delays in surveying if the stabilized platform had failed completely. The need for sufficient and functioning spare components for the gravity meter in Antarctica is evident, and the need for an entire spare BGM-3 gravimeter should be evaluated. A complete spare system would enable a quick recovery in the case of a major platform failure or a failure of the sensor. An intermittent sensor failure threatened to interfere with the 1997/98 season, and would have been a major setback if the problem had worsened due to the lack of an on-site spare.

Repair and Refurbishment

Both laser altimeters should be returned to the manufacturer for a routine checkout. Repairs should be made to the laser altimeter which failed during the field season.

The proton precession magnetometers used for base station monitoring continue to be problematic. They should be repaired or replaced with more reliable units.

Aircraft System Documentation.

The design and layout of SOAR's current aircraft systems are not thoroughly documented. With the upcoming test of JPL's coherent radar, and possible subsequent integration of a coherent radar into SOAR's platform, it is highly desirable to document the current system for future reference.

Satellite Telephones

SOAR still does not have access to low-Earth-orbit (LEO) satellite telephone communications. SOAR plans to continue simultaneous multiple-base operations in 1999/00 in order to meet survey objectives within the time constraints. Without satellite telephones, SOAR must rely on frequently poor HF radio communications between remote base camps in order to synchronize base station data acquisition. It is also a significant safety issue for the survey aircraft to have adequate communication capabilities in the event of a forced landing.

Targets for 1999/00

Base Stations

SOAR plans to purchase a single cesium magnetometer for base stations, along with associated data logging hardware. Budgetary constraints preclude the purchase of a spare unit for base stations. The proton precession magnetometers will serve as spares.

Methods for streamlining and improving GPS logging will be evaluated and an appropriate course of action will be taken.

GPS Receivers

Due to limited resources, SOAR will continue to borrow GPS receivers to meet the requirements of carrier-phase GPS measurements in the field.

Aircraft GPS Logging

SOAR plans to construct two rack-mount computers with uninterruptible power supplies for the logging of Ashtech GPS data on the aircraft using a combination of existing and newly purchased hardware. One of these systems will serve as a spare. This design will be superior to using a laptop for GPS logging, and will eliminate one computer display since the rack-mount computer can be routed to the existing display in the rear of the airplane.

Data Reduction Hardware

SOAR plans to purchase a tape drive to replace one on loan from science groups.

Coherent Radar

SOAR resources will be allocated to support testing of the JPL Europa testbed radar in Antarctica at the end of the 1999/00 field season, after the SOAR platform has been partially deconfigured. This will require one week of effort for four SOAR personnel in Antarctica and three person-months overall for integration and data evaluation. JPL will send two engineers to Antarctica to assist in testing the radar, and one engineer to Austin to participate in data evaluation.

SOAR will continue discussions with JPL on the issue of technology transfer, with the ultimate goal of having a coherent radar on the SOAR platform.

Digital Avionics Interface

Outstanding development issues related to the substitution of currently available, more modern digital components will be addressed and the appropriate hardware will be purchased if necessary, to bring the second DAI to operational status.

Precision Navigation

The feasibility of GPS navigation using the Y-code will continue to be investigated.

Potential Y2K and GPS week 1024 rollover problems will be thoroughly evaluated prior to the 1999/00 field season.

SOAR will deploy the differential GPS system in West Antarctica during the 1999/00 field season.

Y2K

All aircraft and base station systems will be evaluated for the possibility of Y2K glitches and will be tested accordingly.

Integrated QC

A complete rewrite of the QC software will require extensive system analyst time. Completion of this goal is not feasible for the 1999/00 field season. The existing QC software will continue to be maintained and modified. SOAR will continue to ensure consistency of QC between multiple bases of operation during the 1999/00 season.

SOAR plans to utilize two months of systems analyst time to develop a Photon Windows version of the control and monitor software and radar monitor software on the aircraft. This will allow them to run concurrently with the real-time data monitoring system on all relevant operator consoles.

Gravity Meter

SOAR will evaluate the need for BGM-3 gravimeter spares and work with NAVOCEANO to obtain the additional spares required for the 1999/00 season. SOAR will also request that NAVOCEANO repair the components which were problematic during the 1998/99 season.

Repair and Refurbishment

The laser altimeters will be returned to the manufacturer for repair and refurbishment.

SOAR will have its two proton precession magnetometers refurbished. SOAR will request ASA do the same for the magnetometers which they supply to SOAR.

Aircraft System Documentation.

SOAR will evaluate the system documentation needs and the resources required to perform this work. If major resources are not required, documentation will begin during this 1999 calendar year.

Satellite Telephones

SOAR plans to purchase two satellite telephones for the 1999/00 field season in order to improve safety for our field crew members and maintain reliable communications between bases of operations. SOAR will request Kenn Borek Air, Ltd. provide a compatible satellite telephone for the survey aircraft during the 1999/00 season.

Appendix C: Logistics

SOAR Annual Report
1998/99

This appendix details the logistical support aspects of the facility's 1998/99 field season. It is divided into the following sections:

1. Aircraft Support - interactions with the aircraft contractor Kenn Borek Air, Ltd.,

2. Field Support - interactions with Antarctic Support Associates (ASA),

3. Technical Support - interactions with organizations providing equipment and services directly to SOAR, specifically, the University Navigation Consortium (UNAVCO) and the Naval Oceanographic Office (NAVOCEANO), and

4. Cargo Support - interactions with NSF and ASA cargo systems.

I. Aircraft Support

This section discusses the facility's goals, plans, accomplishments, issues to be addressed, and future targets as they pertain to the survey aircraft contractor. Kenn Borek Air, Ltd., of Calgary, Alberta, Canada provided the Twin Otter survey aircraft, flight crew, and maintenance support in the field.

Goal

SOAR's principal aircraft support goal is to receive the survey aircraft from the contractor optimized to SOAR's specifications for use as an aerogeophysical platform, and after configuration and testing by SOAR personnel, to operate it safely and reliably in the field during the survey period.

Plans for 1998/99

To meet its aircraft support goal for the 1998/99 field season, the following items were identified in pre-season planning:

Secondary Base Operations

In order to achieve three consecutive flight-days of operation, and five days of residence at a secondary camp, Borek Air was to:

- comply with aircraft certification requirements at secondary bases without impacting SOAR flight crews,
- supply necessary aircraft support equipment, and
- be willing to spend multiple nights away from the main base camp.

Aircraft Autopilot

Borek Air was to maintain the ability to repair or replace the aircraft autopilot to ensure compliance with the altitude hold requirement of ±12 meters with the capability for response tuning in the field.

On-site Spares and Aircraft Repairs

Borek Air was to maintain on-site spares of the critical contractor supplied systems and implement a plan for quick delivery of replacement aircraft parts, particularly spares for the INS and autopilot (see Table C.1, Equipment to be Supplied by Kenn Borek Air, Ltd.) Special attention was to be given to the repair of the power cabling for the magnetometer winch prior to deployment.

Spare Radar Antennas

SOAR was to engineer a spare antenna design for the existing unused antennas originally configured for an LC-130. The new design was to be implemented by Borek Air. A visit by SOAR personnel to Calgary was planned to assure the work was completed.

Table C.1
Equipment to be Supplied by Kenn Borek Air, Ltd.

Equipment	**Specifications**
GPS positioning*	CA code with latitude and longitude (+0.1 minute) available over an RS-232 port.
Inertial Navigation*	Litton LT-92R or equivalent with all raw binary output available for SOAR interfacing.
Pressure Altitude*	0.5m pitot boom and Paroscientific 1015a or equivalent with pressure (+0.1mbar) over a range of 600-1100mbar, available over an RS-232 port.
Outside Air Temperature*	Temperature (+1°C) over a range of -40 to +25°C available for SOAR interfacing.
Autopilot †	Roll, pitch and pressure altitude stabilized with all controls available to both pilot and copilot. Altitude hold performance must attain +12 meters maximum excursions with the capability of tuning responses in the field.
Antenna system refurbishment and cable raceway in wings	For user-supplied radar antennas to be mounted beneath wings; includes flight preparation and/or relamination of user supplied antennas and struts, including modification and/or fabrication of spares.
Securing mechanisms and viewing window	For the "bird" containing the magnetometer sensor that is to be towed on a 30m retractable cable, and laser range finder which is mounted in viewport.
Auxiliary Power Units †	10kW at 28V. One APU is required at the main base and each of the satellite bases.
Precision Navigation Equipment Interfaces	HF radio† with audio line output and antenna to receive DGPS correction signal.
Radar Altimeter*	Altitude above surface (+0.5m) over a range of 0 to 500m, available for SOAR interfacing.
Low Earth Orbit (LEO) Satellite Communications	A satellite telephone system compatible with SOAR supplied ground units must be acquired and installed.

*Engineering diagrams and manuals must be available in the field for these avionics systems.
†Spare parts, engineering diagrams, and manuals must be available in the field for these systems.

Predeployment Site Visit to Borek Air

A predeployment site visit to Borek Air by SOAR personnel was planned to ensure the aircraft conformed to SOAR specifications (see Table C.1, Equipment to be Supplied by Kenn Borek Air, Ltd.)

HF Receiver Interface for DGPS Data

SOAR was to work with Borek Air to ensure the HF receiver interface used to pass DGPS correction data to the SOAR precision navigation equipment was functioning adequately for the 1998/99 field season.

Two Flight Crews

Two flight crews (four pilots), including the personnel required for daily aircraft inspections at secondary bases, were to be available to complete an 83-survey-flight season lasting from early November 1998 through January 1999. The planned flight rate was three flights per day.

Delivery of the Twin Otter to Siple Dome

Borek Air was to deliver the Twin Otter to Siple Dome Camp directly from the contractor facility in Calgary.

Intercom

Borek Air was to provide assistance installing SOAR supplied intercoms. Installation and testing was to take place in Calgary prior to the start of the 1998/99 field season.

Satellite Telephone

With the completion of the Iridium low Earth orbit satellite constellation, satellite telephone coverage was to be available for all of Antarctica. An Iridium telephone was to be installed in the survey aircraft for use during periods of unreliable HF communications.

Safety Procedures

SOAR intended to join the International Airborne Geophysical Safety Association (IAGSA) and strongly recommended that Borek Air also join. SOAR was to begin development of a safety procedures manual in conjunction with Borek Air.

SOAR was to produce a risk assessment of the Marie Byrd Land survey area with assistance from Borek Air.

1998/99 Accomplishments

This section focuses on the aircraft support accomplishments during the fifth year of the facility operations.

Secondary Base Operations

SOAR was able to operate for five consecutive days at secondary bases due to adequate facilities and the professionalism of Borek Air personnel. Limited accomodations did not deter the pilots and mechanic from staying at secondary bases for multiple days. Daily aircraft certification requirements were met by substituting the Borek Air mechanic for one of the three SOAR instrument operators.

Aircraft Autopilot

Borek Air experienced difficulties with the aircraft autopilot and often was not able to maintain altitude within the specified ±12 meters. Drift from the specified altitude ranged as high as 150m. This was especially true during high altitude flights. The Borek Air mechanic spent a considerable amount of time attempting to solve the problem using existing spares.

On-site Spares and Aircraft Repairs

Borek Air maintained spares of critical contractor supplied systems as specified in Table C.1 (Equipment to be Supplied by Kenn Borek Air, Ltd.), although no satellite telephone was available. No changes to previous field repairs of the power cabling for the magnetometer winch were made, but no problems with existing cabling were encountered.

Spare Radar Antennas

SOAR developed a plan for the quick replacement of a damaged radar antenna system component in the field. Because SOAR uses a customized adaptation of struts originally developed for use on an LC-130, it is not possible to create an identical spare antenna system from existing strut material. SOAR engineered a new configuration for the spare antennas which will allow them to be quickly adapted in the field to any location and strut geometry. Struts damaged in the field can be replaced by modifying existing strut material. Borek Air completed all modifications to the spare antennas necessary to establish this capability.

Predeployment Site Visit to Borek Air

SOAR personnel visited Borek Air's facility in Calgary during mid-October, 1998 to ensure the aircraft conformed to SOAR specifications. Some hardware was missing during the visit, but was later discovered to have been left at McMurdo Station, Antarctica by Borek Air. Otherwise, the aircraft conformed to SOAR specifications with the exceptions of the satellite phone and magnetometer winch rewiring. Borek Air determined that the winch power wiring was acceptable as it was. SOAR personnel were not able to inspect the radar antennas during that visit.

HF Receiver Interface for DGPS Data

An HF receiver interface was set up to pass DGPS correction data to the SOAR precision navigation equipment. No modifications from the 1997/98 field season setup were made. SOAR relied solely on GLONASS/GPS data for precision navigation during the 1998/99 field season.

Two flight crews

Two flight crews (four pilots) and one mechanic were provided for the field season. All personnel were highly professional, enthusiastic, and proficient. Aircraft maintenance and assistance with mechanical installations were first rate. However, Borek Air did not provide sufficient personnel to perform daily aircraft inspections and maintenance at secondary bases without impacting SOAR operations. SOAR's operational plan includes three instrument operators on the aircraft. SOAR accomplished its surveying with only two instrument operators on the aircraft during multiple days of operation away from the main base in order to allow Borek Air's mechanic to accompany the aircraft. Since this was the only option under these circumstances, the mechanic's enthusiasm to cooperate in this regard was key to SOAR's success. Except for extended operations away from the main base, SOAR maintained three flights per day to complete 96 survey flights during the 1998/99 field season.

Delivery of the Twin Otter to Siple Dome

The Twin Otter was dedicated to SOAR on November 15, 1998, as originally scheduled, but was redirected by NSF to assist with the LC-130 recovery operation at Upstream D. Radar antennas had been installed on the Twin Otter, but were removed prior to the aircraft's departure to Upstream D. The Otter was returned to SOAR on November 18, 1998.

Intercom

SOAR did not acquire a new intercom system for the Twin Otter but did acquire new noise-cancelling headsets. Borek Air tested the existing intercom system, concluding no repairs were required, and the system worked reasonably well throughout the 1998/99 field season.

Satellite Telephone

Borek Air did not pursue the installation of an Iridium telephone on the survey aircraft for use during emergencies or periods of unreliable HF communications.

Safety Procedures

SOAR joined IAGSA, participated in a safety workshop at the 1998 Society for Exploration Geophysics (SEG) meeting, and developed the following list of issues to consider:

1. oxygen for all instrument operators during surveying above 10,000 feet altitude,
2. regular safety meetings and safety log updates in the field,
3. pilot fatigue,
4. survey navigation as primary navigation,
5. flight following equipment,
6. emergency procedures, and
7. first aid training and equipment.

SOAR has not yet begun development of a safety procedures manual. Borek Air has cooperated when necessary regarding safety issues, but has not joined IAGSA. ASA requested information from SOAR regarding IAGSA.

Recent discussions with Borek Air personnel revealed that the Twin Otter's single engine climb rate used in previous risk assessments was overestimated. SOAR consequently re-evaluated its risk assessment of the TAM(PPT) survey area. Because of the limited availability of topographic maps for the WMB survey area, SOAR developed and applied a different assessment scheme.

Issues to Address

Secondary Base Operations

Borek Air must comply with certification requirements for the aircraft during multiple days of operation at the secondary base without impacting survey operations. Certification requirements for the aircraft must be met without requiring SOAR to reduce its flight crew from three to two.

Aircraft Autopilot

The aircraft autopilot did not operate within SOAR's required specifications, particularly at higher altitudes. Much of SOAR's survey operations during the 1999/00 field season will be flown at high altitude.

On-site Spares and Aircraft Repairs/Mods

The following items need repair and/or modification:

- aircraft autopilot,
- a fracture in the magnetometer bird cradle,
- fractures in the main radar struts and/or attachment hardpoints, and
- the mount for the TrimFlight navigation display needs to be redesigned for improved viewing by both pilots and to maintain an escape route between the cabin and cockpit in the event of an emergency.

Predeployment Site Visit to Borek Air

SOAR personnel need to be able to inspect all repaired or modified equipment during their predeployment site visit to Borek Air.

HF Receiver Interface for DGPS Data

SOAR needs to work with Borek Air to be certain the DGPS signal can be received properly during the 1999/00 field season.

Two Flight Crews

Last season, Borek Air provided two flight crews and one mechanic for the 1998/99 survey period. Logistical constraints, such as aircraft certification requirements, prevented SOAR from surveying with three instrument operators on the aircraft when operating away from the main base for multiple days. This increases the workload on the two remaining SOAR instrument operators which increases the likelihood for mistakes, possibly resulting in lost survey time. In the event of equipment failure, this also reduces the number of SOAR personnel available to troubleshoot and make repairs. Borek Air needs the ability to comply with aircraft certification requirements without including additional personnel on the flight crew.

Without notice, a temporary pilot was substituted for one of the SOAR pilots midseason. Such a switch slows SOAR operations while the pilot becomes acquainted with SOAR procedures. The lack of planning for these substitutions is a risk factor that needs to be addressed.

Satellite Telephone

Iridium phones proved to be unavailable for the 1998/99 season, but the need for one to be installed on the survey aircraft still exists for the 1999/00 season.

Cross Track Error

SOAR specifications require the aircraft to stay within ±25 meters of a planned flight line, consistent with the radar beam pulse width. Cross track errors were often greater than 25 meters, particularly when surveying over scenic areas. Large cross-track errors affect data quality, and can make repeating a transect difficult or impossible.

Preseason Communication with Borek Air

More coordination between SOAR and Borek Air personnel prior to the field season may help to avoid problems in logistical coordination. For the 1998/99 field season, SOAR requested hourly weather observations from South Pole Station, Siple Dome, Downstream B, and the Ford Ranges Camp; however, during the season additional hourly weather observations were required from Upstream D camp. ASA eventually sent extra personnel to Upstream D to accommodate this request.

Safety Procedures

SOAR needs to continue integrating IAGSA safety procedures into its operational plan with the help of Borek Air. SOAR also needs to compile these issues and plans into a Safety Procedures Manual which can be referred to by SOAR and Borek Air personnel. SOAR encourages Borek Air to take a more active role in developing a safety procedures manual.

SOAR does not have a good general procedure for conducting risk assessments of survey targets. In some cases, topographic coverage of the survey target is poor. SOAR needs a better understanding of what pilots would find useful in a risk assessment.

Targets for 1999/00

Secondary Base Operations

Borek Air must be able to comply with aircraft certification requirements for multiple days of operation from a secondary base. Compliance must occur without requiring the mechanic to travel with the aircraft so that SOAR survey operations can continue with three instrument operators on the aircraft. SOAR suggests the following as options to Borek Air:

- Borek Air provide two mechanics during operations which require surveying from multiple bases;
- Borek Air provide one mechanic and at least one pilot who is also a certified mechanic licensed to inspect the aircraft.

Aircraft Autopilot

Borek Air should repair or replace the aircraft autopilot to ensure the altitude hold requirement of ±12 meters can be met. SOAR recommends the replacement of the existing pneumatic autopilot with an electric autopilot. Pneumatic system inadequacies at high altitudes contributed to the poor performance of the autopilot during the 1998/99 season. The capability for response tuning in the field should be maintained.

On-site Spares and Aircraft Repairs

Borek Air should maintain on-site spares of the critical contractor supplied systems and implement a plan for quick delivery of replacement aircraft parts (see Table C.1, Equipment to be Supplied by Kenn Borek Air, Ltd.) Of particular interest are:

1. the repair or replacement of the aircraft autopilot and its spare,
2. available spares for the INS,
3. repair of a fracture in the magnetometer bird cradle,
4. repair of fractures in the main radar antenna struts, and
5. redesign of the TrimFlight navigation system mount for improved viewing by both pilots and to maintain an escape route between the cabin and cockpit in the event of an emergency.

Predeployment Site Visit to Borek Air

A predeployment site visit to Borek Air by SOAR personnel is planned in order to inspect aircraft fabrications and modifications and to verify SOAR specifications (see Table C.1, Equipment to be Supplied by Kenn Borek Air, Ltd.). Equipment should be available for inspection unless previously notified.

HF Receiver Interface for DGPS Data

SOAR and Borek Air need to ensure the HF receiver interface used to pass DGPS correction data to SOAR precision navigation equipment is functioning adequately for the 1999/00 field season.

Two flight crews

Two flight crews (four pilots), plus the personnel required for daily aircraft inspections at satellite bases, should be available to complete a field season with a planned flight rate of three per day. Borek Air should make every effort to avoid pilot swaps midseason, but if one is necessary, a plan should be developed with SOAR in order to minimize risks to productivity.

Delivery of the Twin Otter to McMurdo Station

Borek Air should deliver the Twin Otter to McMurdo Station, Antarctica by November 2, 1999, directly from the contractor facility in Calgary.

Intercom

For the safety and productivity of all personnel on the aircraft, Borek Air needs to ensure the intercom jacks on the aircraft function properly with SOAR provided headsets.

Satellite Telephone

A low-Earth-orbit (Iridium) telephone should be installed in the survey aircraft for use during periods of unreliable HF communications.

Cross Track Error

Borek Air should do whatever is necessary in terms of equipment and/or personnel to stay within the specified ±25 meters of a designated flight line.

Preseason Communication with Borek Air

SOAR will communicate its field operation plans to Borek Air prior to the 1999/00 field season in order to better coordinate the logistical requirements of both organizations.

Safety Procedures

SOAR plans to renew its IAGSA membership and to incorporate IAGSA safety procedures into its operational plans. SOAR strongly recommends that Borek Air also join IAGSA.

SOAR would like to work with Borek Air personnel to produce a reasonable procedure for risk assessment. This should occur prior to the field season. SOAR plans to produce useful assessments which reflect realistic capabilities of the Twin Otter during emergency situations.

II. Field Support

Field support includes services provided by ASA to SOAR principally for operation of field camps. This section focuses on these services.

Goals

The goals of the SOAR field support efforts primarily are to ensure that the field camps are set up to optimize configuration and safe operation of the survey aircraft, and secondarily, to minimize the time and resources necessary for field setup and maintenance.

Plans for 1998/99

Main Bases

SOAR requested support for main bases of operation at Siple Dome Camp and South Pole Station for the 1998/99 field season. This included adequate radio communications, food preparation, berthing appropriate for regularly scheduled aircraft operations, fuel for operating the survey aircraft, and power to operate equipment. Tightly scheduled moves between these camps were required in order to meet the survey objectives for the season.

Secondary Bases

SOAR requested secondary base station support for up to three days of flight operations or five days of occupation. This included adequate radio communications, support for food preparation (during flight operations), berthing appropriate for regularly scheduled aircraft operations, fuel for operating the survey aircraft, and power to operate equipment.

Flight Following

SOAR requested flight following capability with hourly weather updates from four locations during flight operations: South Pole Station, Siple Dome, Downstream B, and the Ford Ranges Camp.

Establishment of Higher Bandwidth Voice and Data Communication

For the 1998/99 field season, SOAR required voice communication at the level of service provided by ATS, and a higher bandwidth of data communications suitable to support transmission of QC products to North America. SOAR generates approximately 400 megabytes of raw data and four megabytes of QC products per flight. Because of the narrow ATS bandwidth, QC transmission to North America in previous seasons had been impossible, and maintaining camp e-mail was a burden. SOAR requested an expansion of the data communications bandwidth level to 10 megabytes per day. With that data rate, QC data transmission to North America would be possible and camp e-mail would no longer be a burden on SOAR.

Voice Communications between Operational Bases

Reliable communication between SOAR bases is critical for survey operations due to the requirement to synchronize data acquisition at all bases and the aircraft. Distances between operational bases make the current level of radio support inadequate. SOAR was to purchase low-Earth-orbit (Iridium) satellite telephones for main bases and satellites. An additional phone was to be installed in the Twin Otter by Borek Air.

Access to Reliable Weather Forecasts

SOAR requested two complete Weatherfax systems: one for Siple Dome Camp, and one for the active secondary base. SOAR requested that ASA provide a trained observer for each Weatherfax. SOAR was to arrange for the University of Wisconsin to provide 12 hour forecasts of regions over which SOAR was surveying.

Alternate Landing Sites

SOAR required the maintenance of two alternate landing sites per survey area (four total), with fuel caches, positioned at least 75 km and not more than 200 km away from each active base of operations. New fuel caches were to be installed to accommodate this requirement.

Camp Medivac Policy

SOAR requested that camp medical personnel inform the camp manager and SOAR senior personnel of any developing medical situation requiring emergency use of the fully configured

Twin Otter. SOAR reiterates that the fully configured survey aircraft is entirely inappropriate for medical evacuations.

Gravity Meter Transport

The path for gravity meter transport was to be re-evaluated with the objective of identifying significant risks for damage. Field offload represented the most significant apparent risk.

1998/99 Accomplishments

Main Bases

Facilities and support at Siple Dome Camp and South Pole Station were ready when required and were completely sufficient for SOAR's operations. The facilities provided for SOAR at South Pole Station were exemplary. LC-130 support for moves between these bases was provided when required, disregarding delays caused by weather.

Secondary Bases

Secondary bases were able to regularly support three consecutive days of operation, and were able to support five days of operation when needed. The camp at Downstream B was not initially prepared for SOAR's berthing requirements, and with only two support staff, the camp could not meet SOAR's communication requirements (i.e., hourly weather updates) and could not provide regular assistance with food preparation during flight operations.

Delays in the installation of Ford Ranges Camp caused SOAR to modify its flight plans in order to survey from a single base. When Ford Ranges Camp was established, limited fuel was a factor until midway through that phase of operations. Staffing at Ford Ranges Camp was adequate to handle radio communications and to assist in food preparation during flight operations.

Flight Following

SOAR's requirement of hourly updates was not thoroughly understood by ASA personnel at Downstream B and Ford Ranges Camp. Staffing at Downstream B was inadequate to handle hourly updates as needed. After a slow start early in the occupation of each secondary base, hourly updates were obtained from South Pole Station, Siple Dome, Downstream B, and the Ford Camp. During the season, SOAR requested and received additional hourly updates from the Upstream D camp.

Establishment of Higher Bandwidth Voice and Data Communication

ATS voice communications were established at Siple Dome on November 25, 1998, twelve days after the main body of SOAR personnel arrived at Siple Dome. Technicians had to return to McMurdo for additional parts before ATS data communications were established on November 30, 1998. GOES became operational after initial problems with the main power amplifier were rectified by ASA. After the GOES equipment was repaired in McMurdo, reinstallation at Siple Dome was to occur prior to the Christmas holiday, but the equipment was not loaded on the same aircraft as the GOES technician and did not arrive at Siple Dome until after the holiday. GOES data communications were established on December 29, 1998, allowing a higher bandwidth of communication for all science groups at Siple Dome. The main power amplifier failed again in mid-January, but was repaired by SOAR personnel using SOAR equipment.

With the higher communications bandwidth, SOAR successfully transmitted data products to North America on a test basis. The GOES system allows approximately 50 megabytes of data to be transferred per day from that location.

Voice Communications Between Operational Bases

Due to the unavailability of low-Earth-orbit satellite phones, SOAR relied solely on HF communications. Direct communication between the bases of operation were unreliable approximately 75% of the time. Messages between Siple Dome and Ford Camp were often relayed through South Pole Station or McMurdo Station.

Access to Reliable Weather Forecasts

ASA provided two Weatherfax systems: one for Siple Dome Camp, and one for the active secondary base. ASA personnel at Siple Dome learned the operation of the Weatherfax system "on the job." SOAR provided Weatherfax observations from the secondary base and also provided a more powerful computer to support the system.

SOAR inquired about the feasibility of 12-hour forecasts from the University of Wisconsin Department of Meteorology for areas to be surveyed. UW was not able to provide this service.

Alternate Landing Sites

Alternate landing sites/fuel caches were available within 200 km of Downstream B, Siple Dome, and Ford Ranges Camp. The camp at Upstream D also served as an alternate landing site for Siple Dome. The nearest fuel cache to South Pole Station was more than 200 km from the station.

Camp Medivac Policy

There were no circumstances in which the configured Twin Otter was required for a medivac.

Gravity Meter Transport

The gravity meter was shipped to and from the field without incident. Shipment of the gravity meter to Antarctica is discussed in the cargo section of this appendix.

Issues to Address

Secondary Bases

SOAR secondary bases need to be supported as requested, and SOAR should be notified of any deviations from requests. Unexpected deviations may result in diminished safety and delays in flight operations. Delays in the installation of Ford Ranges Camp and delivery of fuel also resulted in changes in flight operations.

Flight Following

ASA did not provide enough personnel to accommodate hourly weather observations at all satellite bases. Two persons are insufficient to provide 24-hour radio communications and maintenance of the skiway. ASA personnel at the supporting camps were unfamiliar with SOAR requirements.

Voice and Data Communication

Better coordination of communication equipment and technicians must occur in future seasons. ASA needs to provide experienced installation engineers and critical spares and supplies for both ATS and GOES communication systems. Both voice and higher bandwidth data transfer communications need to be established earlier in the season. Should SOAR have encountered significant technical problems during setup and early survey operation at Siple Dome, no support from North America would have been available for troubleshooting or shipping needed supplies.

Voice Communications between Operational Bases

Voice communications between the main and secondary bases were difficult because:

- the secondary bases did not have adequate staffing to continuously monitor radio communications;
- radio transmissions were often very poor between the main and secondary base;
- Iridium telephones were not available.

Relaying communications through a third station caused delays and the potential for miscommunication of technical information.

Access to Reliable Weather Forecasts

The Weatherfax systems became an essential part of flight planning and proved useful to other science groups. While operating from South Pole Station, SOAR personnel relied on Weatherfax data gathered at Downstream B for planning purposes. Complete Weatherfax systems, including computers powerful enough to support them, and the trained personnel required to operate them, should be available at all active SOAR bases.

Alternate Landing Sites

SOAR requires the maintenance of alternate landing sites, with fuel caches, positioned at least 75 km and not more than 200 km away from each active base of operations.

Gravity Meter Transport

Transport of the gravity meter continues to be difficult and time consuming, requiring several weeks of SOAR personnel effort.

Targets for 1999/00

Main Bases

SOAR will require support at McMurdo Station (Williams Field), the Italian Midpoint, and Byrd Surface Camp for double-flight-crew operations. This includes adequate fuel, berthing, radio communications, food preparation, and power for aircraft and ground-based equipment.

Secondary Bases

SOAR will require support for five consecutive days of operation from Dome C, Siple Dome, Williams Field and Italian Midpoint when these camps are acting as secondary bases. This includes adequate fuel, berthing, radio communications, support in food preparation (during flight operations), and power for regularly scheduled aircraft operations. When logistical support deviates from SIP requests, ASA should notify SOAR of these differences.

Flight Following

ASA should staff bases with enough personnel required for all tasking including hourly weather observations and radio communications. ASA should familiarize its personnel with the projects they are supporting. Better understanding of project goals may result in more enthusiastic execution of duties.

Voice and Data Communication

During the 1999/00 field season, SOAR will require voice and high bandwidth data transfer communication. While working from Williams Field, SOAR requires a full Ethernet connection to the McMurdo network. ATS and GOES communications will be required at Byrd Surface Camp during the West Antarctic phase of survey operations. ASA should provide trained installation engineers and the required equipment, including critical spare parts, for the installation of the ATS and GOES systems. The systems should be operational prior to SOAR's occupation of the base.

Voice Communications between Operational Bases

Reliable communication between bases of operation is critical. Current radio support is inadequate due to the distance between operational bases. SOAR will purchase Iridium satellite phones for its main and secondary bases. An additional phone must be installed in the Twin Otter.

SOAR recommends that ASA re-evaluate staffing requirements at secondary bases to support hourly communications needs.

Access to Reliable Weather Forecasts

SOAR requests complete Weatherfax systems and operators at all active SOAR bases during the 1999/00 season: McMurdo Station, Italian Midpoint, Siple Dome and Byrd Surface Camp. SOAR specifically requests the use of a Weatherfax at Williams Field, McMurdo Station due to the need for direct, immediate observations by Borek Air personnel and SOAR flight planners.

Alternate Landing Sites

Maintenance of landing sites, with fuel caches, positioned at least 75 km and no more than 200 km away from each base of operations is required. New fuel caches will need to be installed for the 1998/99 field season.

Camp Medivac Policy

SOAR requests that camp medical personnel inform the camp manager and SOAR senior personnel of any developing medical situation which may require emergency use of the fully configured Twin Otter. We reiterate that the fully configured survey aircraft is entirely inappropriate for medical evacuations.

Gravity Meter Transport

ASA should prepay the commercial transport of gravity meters. All transport of gravity meters must be evaluated with the objective of identifying significant risk for damage.

III. Technical Support

This section covers the interactions of the SOAR facility with other organizations providing technical support. Technical support was provided for the gravity meter and the geodetic GPS receivers.

A. Gravity Meter

Goal

The goal of SOAR is to ensure access to a gravity meter designed for airborne applications and of sufficient sensitivity to meet our science requirements.

Plans for 1998/99

The plan for the 1998/99 field season was to obtain and operate a BGM-3 gravimeter, modified for airborne use, owned by the Naval Oceanographic Command (NAVOCEANO), for the period from late October through March 1, 1999.

1998/99 Accomplishments

The gravity meter sensor used by SOAR during the 1997/98 field season was unavailable for the 1998/99 field season. NAVOCEANO provided a stabilized platform used previously by SOAR and another sensor on October 6, 1998.

SOAR installed and tested the gravity meter at Siple Dome Camp with few difficulties except for increasing startup problems for the stabilized platform. Once stabilized, the gravity meter functioned properly. Similar but less frequent problems occurred during previous seasons. During transit to South Pole Station, the stabilized platform stopped working completely. Installation of spare power supplies did not solve the problem.

The spare control power supply provided by NAVOCEANO was not functioning properly. After some interchange of parts, SOAR was able to create a functioning unit. NAVOCEANO personnel, via numerous e-mail and radio-phone conversations, provided excellent support solving these problems, and SOAR was eventually able to begin survey operations. An additional spare platform control power supply and stabilized platform (not modified for airborne use) were quickly sent to South Pole Station from North America.

The gravity meter and all spares were returned to NAVOCEANO on February 25, 1999.

Issues to address and Targets for 1999/00

Transportation of the gravity meter is difficult because of its need to be powered constantly and to have an escort. The instrument is fragile and care must be taken during transport. This issue is fully addressed in the Cargo Section.

In order to support the next field season, SOAR plans to obtain the gravity meter for the period from October 15, 1999 through February 28, 2000. SOAR will require the same sensor used during the 1998/99 field season. Appropriate repairs to the stabilizing platform will be required. In addition to the typical complement of spares, SOAR will request that a spare gyro-stabilized platform and sensor be available in Antarctica for at least the duration of the TAM survey. In order to avoid significant delays during the survey season, SOAR requires that all gravity meter components, including spares, be thoroughly tested before their loan to SOAR.

B. GPS Systems for Precise Positioning

GPS technology is utilized by SOAR in two different ways: 1) as a real-time tool to allow accurate airborne navigation along a predetermined flight path, and 2) to precisely determine the aircraft's position for post-mission data reduction. This section addresses this latter use of GPS, as a precise geodetic positioning system.

Goal

The goal of SOAR for precise positioning is to gain reliable access to the GPS equipment best suited for routine sub-meter position determination of the survey aircraft.

Plans and Accomplishments for 1998/99

Again this year, SOAR used both Ashtech Z-12 and TurboRogue GPS receivers. For reliability, the two receiver types were operated in parallel in the aircraft and on the ground to prevent data loss due to individual receiver failure.

SOAR intended to borrow six Ashtech Z-12 receivers from SOAR host institutions in order to equip the aircraft, a main base, and a secondary base, including spares. SOAR was able to borrow six receivers from LDEO but three were unavailable until after surveying was to start, so three additional receivers were borrowed from the University of Maryland.

SOAR planned to request static positioning of its GPS receivers at Siple Dome Camp and South Pole Station, as well as runway thresholds and laser calibration ranges. UNAVCO was able to provide GPS antenna positions and laser calibration site locations. SOAR ultimately did not ask for runway thresholds.

Issues to Address

After reviewing our requirements for the 1999/00 field season, SOAR must obtain six Ashtech Z-12 receivers.

Targets for 1999/00

SOAR needs six Ashtech Z-12 receivers to equip the aircraft, main base, and secondary base. For the upcoming season, SOAR intends to borrow all six receivers from LDEO.

SOAR encourages the NSF Office of Polar Programs to continue fostering a relationship with UNAVCO to ensure continuing excellent technical development and support. SOAR will require static positioning of its GPS receivers at McMurdo Station, Italian Midpoint, Dome C, Siple Dome Camp, and Byrd Surface Camp, as well as runway thresholds and laser calibration ranges.

IV. Cargo Support

This section reviews the cargo support provided to the facility by ASA. A significant quantity of cargo must be moved annually from the SOAR office in Austin, Texas, to the field site in a timely manner. To date, it has been necessary for a subset of this equipment to be returned to North America quickly so that data distribution activities can begin soon after the field season.

Goal

The SOAR cargo goal is to move equipment to and from the field site in a manner which supports timetables for configuring and operating the survey aircraft, configuring and operating ground support facilities, and distributing data products after the field season.

Plans for 1998/99

Cargo Requirement

SOAR estimated the 1998/99 cargo requirements would be similar to amounts for the 1997/98 field season. SOAR also anticipated that handcarry amounts would be similar.

Shipping Containers

SOAR was to investigate the acquisition of custom cases for the two magnetometer "birds" as well as the Henry HF Radio Amplifier. The custom cases would replace aging wooden cases used in previous seasons. New storage tubs and eight general purpose shipping cases were also to be purchased.

Gravity Meter Transport

SOAR intended to arrange for commercial transport of the gravity meter and its escort from Dallas to Hawaii, and military transport from Hawaii onward. Similarly, the gravity meter and its escort were to return by military transport through to Hawaii, and commercial transport back to Dallas.

1998/99 Accomplishments

Cargo Shipping

Cargo deployment accomplishments are shown below in two tables Table C 2 describes the mount of cargo in each of the SOAR 1998/99 shipments. Table C.3 describes the timing of these cargo shipments.

In addition to the cargo denoted in the Tables C.2 and C.3, it was necessary to hand carry certain items from North America to Antarctica because of their late availability, critical importance, or immediate need upon arrival. SOAR personnel hand carried six pieces (750 lbs) this year. This includes the gravity sensor box, which weighs 325 pounds.

Shipping Containers

SOAR did not purchase new cases for the magnetometer birds, but did purchase a custom case for the Henry radio amplifier to replace the wooden case used in previous years. Eight general-purpose shipping containers (16 ft^3) were purchased to accommodate new equipment and to decrease the number of hand-carried items. Several more wooden boxes were retired again this year as SOAR continues to phase out its supply of old and unreliable cases. New storage tubs were also purchased.

Gravity Meter Transport

As it is each year, shipping the gravity meter was a high profile and resource intensive process. The escorted gravity meter sensor weighs 325 pounds including its shipping container and backup power. The complete system included three additional boxes totaling 375 pounds (shipped separately) for a total gravity meter weight of 700 pounds.

SOAR and ASA had come to an agreement regarding the commercial shipment of the gravity meter and escort from Dallas to Hawaii, and back to Dallas at the end of the season. ASA was to cover those expenses. Ultimately, due to timing constraints, SOAR arranged and paid for commercial transport of the gravity meter and escort from Dallas to Hawaii. SOAR was eventually reimbursed for that expense by ASA.

Table C.2
Cargo Summary

Shipment Number	Number of Pieces	Total Weight (lbs)	Volume (ft3)
1 (Kilo Air Shipment)	23	6348	650
2	7	712	60
3	3	882	62
4	10	1952	167
5	25	4582	445
6	14	3282	310
7	1	198	9
8	8	1182	100
9	2	189	13
10	3	96	6
11	3	52	6
Totals	**99**	**19,475**	**1,828**

Table C.3
Cargo Timetable

Shipment Number	Date Departed Austin, TX	Arrival Dates		
		Port Hueneme	Christchurch	McMurdo
1	25-Aug	28-Aug	4-Oct	4-Nov
2	15-Sep	18-Sep	13-Oct	4-Nov
3	22-Sep	25-Sep	19-Oct	4-Nov
4	6-Oct	9-Oct	21-Oct	4-Nov
5	13-Oct	16-Oct	28-Oct	4-Nov
6	20-Oct	23-Oct	4-Nov	9-Nov
7	21-Oct	23-Oct	4-Nov	9-Nov
8	27-Oct	30-Oct	24-Nov	24-Nov
9	11-Nov	13-Nov	27-Nov	2-Dec
10	19-Nov	20-Nov	30-Nov	4-Dec
11	23-Nov	24-Nov	11-Dec	12-Dec

Issues to Address

To optimize resources during the next field season, the following issues must be addressed:

Gravity Meter Shipping

Modifying transportation arrangements for the gravity meter increases the chance that the system will undergo an expensive failure or that it will become separated from its escort. Lengthy delays in gravity meter transport cause significant additional costs.

Shipping Containers

SOAR cargo was observed being rained upon in Christchurch. Upon arrival at Siple Dome, it was discovered that the contents of several Cabbage shipping containers were damp. SOAR needs to be certain that critical items do not sustain damage from water during shipment.

Targets for 1999/00

Gravity Meter Transport

SOAR recommends commercial transport of the gravity meter and its escort from Austin to Hawaii, and military transport from Hawaii onward. Similarly, the gravity meter and its escort should return by military transport through to Hawaii, and commercial transport back to Austin.

Shipping Containers

SOAR plans to purchase custom cases for the two magnetometer birds. These cases will replace aging wooden cases currently being used. SOAR will also purchase three new general-purpose shipping containers to continue replacing older, less reliable boxes. To ensure that equipment stays dry during transport, SOAR will wrap all critical components in plastic bags prior to packing.

Appendix D: Personnel

SOAR Annual Report
1998/99

This appendix covers the goals, plans, accomplishments, outstanding issues and future targets for SOAR personnel.

Goals

The SOAR personnel goals are to staff the facility with a stable core of highly qualified technical people and to maintain a flexible management structure that allows the core personnel to be easily augmented during periods of peak activity.

Plans for 1998/99

The personnel plan for 1998/99 SOAR activities focused on the following:

Overall Staffing Levels

To meet the technical objectives of the SOAR program and to improve SOAR's ability to retain personnel through numerous field seasons, an overall increase in personnel was necessary. Additional personnel resources included engineering costs for the coherent radar specification, antenna strut design, and upgrades to both in-flight and base station quality control software. We do not anticipate substantial reductions in personnel costs in future years unless there is a trend toward less complex field seasons requiring fewer core personnel.

Technical

1. SOAR was to hire a new Technical Coordinator to assume responsibility of day-to-day operation of the facility. The position was budgeted at six months in recognition of the difference between the departure date of the previous Technical Coordinator, and the date on which the position was expected to be filled.

2. SOAR intended to hire two new engineers to fill its need for additional full-time engineering

support. One of these new hires was to augment and eventually replace an engineer currently on staff who is returning to graduate studies. The other was to replace an engineer planning to reduce SOAR commitments. The new positions were budgeted at nine and seven months, respectively, to reflect realistic hiring dates.

3. SOAR intended to hire two new systems analysts to take responsibility for streamlining QC software and to maintain SOAR's data acquisition systems. The senior systems analyst was to eventually replace SOAR's current senior systems analyst. The other systems analyst was to be responsible for many of the activities previously supported by a subcontractor, Expedition Computing Services.

4. The data reduction staff (at both UTIG and LDEO) were budgeted in 1998/99 at the same level requested in the 1997/98, with nine months of support for data reduction specialists and additional support for lower level data processors. The UTIG reduction budget also included support for a senior systems analyst for upgrades and maintenance of the reduction software.

5. Support for spare radar antenna design was to be provided by a research engineer at a level of three months.

Administrative

SOAR intended to create a new Lab Manager position to replace the Administrative Associate position. The Lab Manager would be responsible for logistical and information management and for North American QC coordination.

Field Activities

1. To meet SOAR's field computing needs, two additional systems analysts and an additional senior systems analyst were to be hired. These augmented positions were budgeted at 4.5 months and 2 months, respectively.

2. To prevent the loss of personnel due to the requirement of lengthy field deployments in multiple consecutive years, SOAR was to fully implement its personnel rotation policy. The goal was an eight week field season for experienced SOAR personnel. An employee's first season is considered a training period, requiring participation in a full Antarctic field season. Each subsequent consecutive season would be limited to approximately eight weeks. Be-

cause of the number of new SOAR core personnel expected during the 1998/99 field season, two experienced core personnel would be required for the entire 1998/99 field season to maintain technical continuity.

3. The basic staff level to support survey operations during the 1998/99 field season was calculated at sixteen, including seven core SOAR personnel. SOAR planned to augment its core field staff to include a field science coordinator, an installation engineer, and an installation systems analyst, as well as two augmented systems analysts, a research engineer, and two field assistants (one to be supplied by the USGS). A SOAR director would be available at critical times in the field to assist with operational transitions, bringing the personnel total to seventeen. This field staffing level was expected to be sufficient to handle aircraft and base assembly and takedown as well as aircraft and base station operation. Each operational secondary base (Downstream B and Ford Ranges Camp) would require two SOAR personnel.

4. SOAR budgeted for a field Science Coordinator (4.5 months) due to the SOAR Science Coordinator, S. Magsino, being on maternity leave. SOAR planned to fill the position with a scientist having extensive Antarctic field experience. The expense of the field Science Coordinator was balanced by a reduction of SOAR's support for Magsino from twelve to nine months.

1998/99 Accomplishments

Technical

1. SOAR hired Dr. Jack Holt to serve as the new Technical Coordinator and assume responsibility of day-to-day operation of the facility. Holt served as Technical Coordinator for 5.5 months during the 1998/99 fiscal year.

2. SOAR did not hire new engineers but promoted one engineer, R. Biggs, to a higher level to reflect the role he played as Acting Technical Coordinator prior to the field season. The hiring of another engineer was ultimately not achieved. One of SOAR's existing engineers was tasked with the design of the spare antenna system. No funds were allocated for coherent radar development.

3. SOAR hired a new systems analyst, Steve Terry, to take over much of the responsibility previously supported by Expedition Computing Services. His responsibilities include streamlining QC software and maintenance of SOAR's data acquisition system. Terry was on staff with SOAR for seven months during the 1998/99 fiscal year. A new senior systems analyst was not required because the current senior systems analyst remained on staff.

4. SOAR invited all new and temporary employees hired for the 1998/99 field season to participate in a training session at the SOAR facility in Austin. Employees were trained in the operation of base station equipment, data download, QC generation, and data archiving.

<u>Administrative</u>

SOAR has not yet hired a Lab Manager. SOAR's Administrative Associate remained on staff.

<u>Field Activities</u>

1. SOAR augmented full-time systems analysts by hiring a senior systems analyst and two systems analysts for the field season. The senior systems analyst was supported for two months during the installation phase of operations. One systems analyst, supported for 4.5 months prior to and through the first half of the field season, was tasked with writing and implementing SOAR's plan for real-time QC on the aircraft. The remaining systems analyst was supported for the duration of the field season.

2. SOAR gave eligible employees the option of a shortened field season in an effort to meet its personnel rotation goals for the 1998/99 field season. Three full-time SOAR employees eligible to participate in a shortened season opted to participate in the full field season.

3. Survey operations during the 1998/99 field season were supported by 16 people including seven core SOAR personnel and nine augmented SOAR personnel. D. Blankenship was in the field during equipment installation, test flying, and the first half of survey operations.

4. The responsibilities of the field Science Coordinator were shared by two individuals. Marcy Davis participated in preparatory activities in Austin prior to the field season and assisted in flight planning and QC evaluation during the entire field season. Vicki Langenheim participated in the field under the USGS subcontract. Langenheim assumed partial responsibility for flight planning and QC evaluation during the WMB phase of operation at Siple Dome.

To augment the core staff for the field season the following positions were temporarily filled:

- Augmented Science Coordinator - Marcy Davis
- Augmented Field Assistant - Victoria Langenheim, employed by the USGS, participated under the USGS subcontract to SOAR.
- Augmented Senior Systems Analyst - Mark Maybee
- Augmented Systems Analyst - Laura Connor
- Augmented Systems Analyst - Effie Jarrett
- Augmented Field Assistant - Lena Krutikov
- Augmented Field Assistant - Martha Young
- Augmented Field Assistant - Jeremy Edwards
- Augmented Field Assistant - Rowena Lohman

SOAR personnel

The core SOAR personnel during 1998/99 were:

Scientific Director - Don Blankenship (Ph.D. Geophysics, 1989, University of Wisconsin-Madison) has 14 austral summers of field experience in Antarctica, nine as chief scientist including the Corridor Aerogeophysics of the Southern and Eastern Ross Transect Zone (CASERTZ) surveys and the five SOAR field seasons. His efforts there have concentrated on aerogeophysics and seismology. Blankenship was in Antarctica during the installation and test phase of operation as well as the first half of survey operations during the 1998/99 season.

Scientific Director - Robin Bell (Ph.D. Geophysics, 1989, Columbia University) has spent three austral summers in Antarctica as chief scientist for the CASERTZ surveys and two austral summers doing long-range aerogeophysics over the Weddell Sea. Her research has focused on marine and airborne geophysics with an emphasis on gravity measurements.

Technical Coordinator – John W. "Jack" Holt (Ph.D. Geology, 1997, California Institute of Technology) assumed responsibilities of Technical Coordinator at the beginning of the 1998/99 field season. His background includes paleomagnetic studies of geomagnetic field behavior, airborne and satellite-based synthetic aperture radar (SAR) remote sensing studies, and experience as an engineer in the Radar Science and Engineering section of the Jet Propulsion Laboratory. The Technical Coordinator's primary responsibilities include the day-to-day operation of the SOAR facility. Holt was in Antarctica for the entire 1998/99 field season.

Science Coordinator - Sammantha Magsino (M.S. Geology, 1994, Florida International University) joined SOAR shortly before the 1997/98 field season. Her background is in physical volcanology and geologic hazard evaluation. The Science Coordinator's primary responsibilities include interaction with SOAR science clients and data distribution. Magsino spent the 1997/98 austral summer in Antarctica but was on maternity leave during the 1998/99 field season.

Senior Research Engineer / Installation Engineer - Ken Griffiths (B.S. Electrical Engineering, 1968, Duke University) is a Research Engineer with the Institute for Geophysics who acts as installation engineer for SOAR. Griffiths has participated in more than ninety marine, land and airborne geophysical field programs including all five SOAR field seasons. Griffiths has both developmental and operational responsibilities for geophysical and navigational systems. Griffiths was in Antarctica the entire 1998/99 field season.

Senior Systems Analyst - Scott Kempf (M.S. Computer Science, 1992, University of Wisconsin-Madison) also moved to SOAR from CASERTZ where he had spent a year programming database applications for underway geophysics. His background at the University of Wisconsin includes experience in systems architecture, programming tools and assembly language applications as well as six years as a network administrator. His primary responsibilities include software development for data acquisition, data distribution and data reduction.

Systems Analyst - John Gerboc (M.S. Systems Science, 1991, State University of New York at Binghamton) joined SOAR prior to its first field season. His previous experience was in software development for vision and airborne systems. While a software engineer at IBM Federal Systems Division, he participated in a number of aircraft based field projects. While with SOAR, he has participated in all aspects of the field programs with operational responsibility for data acquisition, quality control, and distribution. Gerboc was in Antarctica the entire 1998/99 field season and escorted the gravity meter to and from Antarctica.

Systems Analyst - Steve Terry (B.S. Computer Science, University of Texas at Austin, 1996; B.S. Geological Sciences, Texas A&M University at Corpus Christi, 1987) joined SOAR just prior to the 1998/99 field season. His previous experience includes a position as a project lead and software architect with the Texas Natural Resource Conservation Commission. His primary responsibilities include design, implementation, and maintenance of analysis and system software. Terry was in Antarctica the entire 1998/99 field season.

Research Engineer - Matt Peters (Ph.D. Electrical Engineering, 1994, The Ohio State University) joined SOAR immediately upon completion of his Ph.D. His doctoral research focus was on antennas and wave propagation for airborne applications. One of the early engineers on the CASERTZ project, he assisted in field preparations and participated in two CASERTZ field seasons. Peters has participated in all five SOAR field programs and has primary operational responsibility for geophysical systems. He was in Antarctica for the installation and test phases of operation, and the first half of survey operations during the 1998/99 season.

Research Engineer - Ryan Biggs (B.A. Physics, 1997, University of Texas at Austin) joined SOAR prior to the 1997/98 field season. His experience includes work as a research assistant in plasma and nuclear physics. His primary responsibilities with SOAR include integration of aircraft instrumentation and has served as one of the radar and data acquisition system operators. Biggs served as acting Technical Coordinator prior to SOAR hiring the new Technical Coordinator, and was in Antarctica the entire 1998/99 field season.

Data Reduction Specialist - David Morse (Ph.D. Geophysics, 1997, University of Washington) joined SOAR in February, 1998 to oversee the reduction of the morphology data sets (i.e., ice-penetrating radar and laser altimetry). He has substantial experience in ground-based radar and GPS studies of ice sheet dynamics. He also has experience reducing airborne radar and laser altimetry data collected by the CASERTZ project over Taylor Dome in East Antarctica, as well as over the West Antarctic ice streams. Morse is responsible for coordinating the reduction of SOAR airborne radar and laser altimetry observations.

Data Reduction Specialist - Robert Arko (M.S. Computer Sciences, 1997, Columbia University) joined SOAR in October, 1997 to oversee the reduction of the potential field data sets. He has been involved in the design and implementation of the airborne gravity reduction process at LDEO, and has worked closely with the USGS on magnetic data reduction. He has substantial experience in GPS studies, including Antarctic field work, as well as experience in support of other Marine Geology and Geophysics database and visualization programs.

Administrative Associate - Wilbert King (B.S. Economics, 1995, University of Texas at Austin) was selected for this position because of his familiarity with computer oriented administration. He has substantial experience with the management of administrative databases as well as University of Texas budgeting. His responsibilities for SOAR include information management and logistics coordination.

The temporary personnel added to augment staffing for the field deployment this year were:

Senior Systems Analyst (augmented) - Mark Maybee (Ph.D. Computer Science, 1994, University of Colorado-Boulder). His background includes over ten years of research experience in software engineering as well as substantial systems programming experience. He has participated in all five SOAR field programs. Maybee was in Antarctica during the installation and test phase of operation, and the first half of survey operations during the 1998/99 season.

Field Science Coordinator (augmented) - Marcy Davis (B.S., Geological Sciences, 1998, University of California, Santa Barbara) has experience in field geophysics including two summer field geophysics internships and participation on a geophysical research cruise. She assisted SOAR by assuming many of the responsibilities of Science Coordinator just prior to and during the field season. She served as an instrument operator on the ground and in the aircraft and also played an important role in flight planning. Davis was in Antarctica the entire 1998/99 field season.

Field Assistant (augmented) - Vicki Langenheim (M.S. Geology, 1989, University of California at Berkeley) is a geophysicist with the USGS where she uses potential field data to solve tectonic problems. This year, she assumed some of the responsibilities for flight planning. This was her fifth field season with SOAR. Langenheim was in Antarctica for the second half of survey operations during the 1998/99 season.

Systems Analyst (augmented) - Laura Connor (B.S., Biology, University of Illinois at Urbana-Champaign) is currently a graduate student in computer science at the University of Texas, San Antonio where she is working on her thesis involving real-time visualization of kinematically-acquired geophysical data. She was hired by SOAR prior to the 1998/99 field season to develop and test real-time QC software for the aircraft. Connor was in Antarctica for the installation and test phase of operation, and for the first half of survey operations during the 1998/99 field season.

Systems Analyst (augmented) - Effie Jarrett (B.S., Computer Science, 1998, University of Texas at Austin) has worked as a research assistant on CASERTZ data reduction at UTIG and as an intern with IBM while completing her degree. Her main responsibilities included providing base station computer support during the MBL phase operations. Jarrett was in Antarctica for the second half of survey operations during the 1998/99 season.

Field Assistant (augmented) - Lena Krutikov (B.A. Geology, 1997, Colgate University) has experience as a Staff Scientist with Southwest Research Institute assisting with geophysical data collection and analysis. She assisted with the initial SOAR put-in and served as an instrument operator on the aircraft and base station during the 1998/99 field season. This was Krutikov's second full Antarctic season with SOAR.

Field Assistant (augmented) - Martha Young (B.A., Anthropology; B.A. Studies in the Environment, 1992, Yale University) is currently a graduate student in Marine Environmental Science at the State University at Stony Brook where she is studying physical phase speciation of chromium in the Hudson River Estuary. She assisted SOAR as an instrument operator on the ground and in the aircraft. Young was in Antarctica the entire 1998/99 field season.

Field Assistant (augmented) - Jeremy Edwards (B.A., Plan II Honors Program, minor in cognitive science, 1996, University of Texas at Austin) has experience as a computer programmer at the University of Texas Academic Computing Instructional Technology Service. He assisted SOAR in its base station computer operations at main and satellite base stations. Edwards was in Antarctica the entire 1998/99 field season.

Field Assistant (augmented) - Rowena Lohman (B.S., 1998, California Institute of Technology) is currently a graduate student at Caltech. She has experience in field glaciological and geophysical investigations and had prior Antarctic experience drilling ice cores. She assisted SOAR primarily as a base station operator. Lohman was in Antarctica for the second half of survey operations during the 1998/99 field season.

Issues to Address

Technical

1. SOAR anticipates a vacancy of an engineering position in the fall of 1999. A replacement for this position should be found as soon as practical prior to the field season.

2. SOAR will require approximately three months of combined engineering and systems analyst resources in anticipation of coherent radar tests. Some of these resources should be allocated to the reduction of test data. Two engineers from JPL will be assisting SOAR with coherent radar tests in the field.

3. SOAR needs to hire an additional systems analyst to perform data reduction at UTIG and to provide field support previously provided by a subcontractor.

4. SOAR will require two months of additional systems analyst resources to complete and refine the real-time QC software for the aircraft.

5. SOAR needs to train augmented field personnel in the setup and use of base stations, data downloading and archiving, and QC generation prior to deployment to the field. This is especially important given the requirement for multiple primary and secondary bases in a single field season.

Administrative

SOAR needs to hire a Lab Manager for logistical and information management as well as management of the increased level of data products coming to North America from the field during the field season.

Field Activities

1. More systems analyst resources are needed at the beginning of the field season and fewer once operations are running smoothly. SOAR needs to evaluate its systems administrative needs in the field and redistribute personnel accordingly.

2. The personnel rotation plan is necessary to maintain the established levels of safety and productivity without significant staff turnover. SOAR must maintain its field personnel rotation plan in upcoming seasons.

3. To meet the operational goals for the upcoming field season, SOAR must augment its core staff by 7 people. This includes 9.5 person-months for aircraft setup and operation, 12.5 person-months for base station functions, and an additional field assistant provided under the USGS subcontract.

Targets for 1999/00

Overall Staffing Levels

To meet the objectives of the SOAR program which include increasingly complex field seasons, and to improve SOAR's ability to retain personnel, an overall increase in staffing has been necessary.

Technical

1. SOAR intends to replace an engineer returning to graduate studies in the fall of 1999.

2. SOAR intends to augment its engineering and systems analyst staff for a combined three months in anticipation of coherent radar tests planned for the 1999/00 field season

3. SOAR intends to hire a systems analyst primarily for data reduction activities at UTIG and for additional field support. This position will further replace support previously provided by a subcontractor.

4. SOAR intends to hire a systems analyst for two months prior to the field season to complete and refine the real-time QC software to be used on the aircraft.

5. SOAR intends to invite all augmented field personnel to the Austin facility to participate in a base station training session. Personnel will be trained in the setup and use of base station equipment prior to the field season. A training session will not add to the overall salary budget, but additional resources will be required for travel and lodging expenses.

Administrative

SOAR intends to hire a Lab Manager to replace the Administrative Associate. The lab manager will be responsible for logistical and information management and for North American QC coordination.

Field Activities

1. SOAR intends to evaluate its need for field systems analysts and redistribute personnel in the field accordingly. An overall increase in resources should not be necessary to accommodate this.

2. SOAR intends to continue its personnel rotation policy to maintain established levels of safety and productivity without significant staff turnover. Some SOAR staff are taking advantage of this policy during the 1999/00 field season.

3. The basic staff level to support survey operations in the upcoming field season is calculated to be fifteen, including eight core SOAR personnel. SOAR will augment its core staff to include an installation engineer, three systems analysts, and two field assistants. An additional field assistant will be supplied under the USGS subcontract. This field staffing level is the minimum required to handle aircraft and base assembly and takedown, as well as aircraft, main and secondary base station operations. If it is possible, an additional flight crew member will be hired so that the Technical Coordinator can provide continuous oversight of survey operations. A SOAR director and an additional SOAR engineer will be present in the field for the coherent radar test.

Appendix F: Cooperative Agreement

SOAR Annual Report
1998/99

This appendix contains the five-year Cooperative Agreement between the National Science Foundation Office of Polar Programs and the University of Texas at Austin creating the Support Office for Aerogeophysical Research. This agreement needs to be extended for one year in order for SOAR to fulfill the commitments currently planned by NSF.

COOPERATIVE AGREEMENT NO. OPP-9319379

PARTIES:	**National Science Foundation** **and** **The University of Texas at Austin**
TITLE:	**Support Office for Aerogeophysical Research** (SOAR)
AMOUNT:	**$3,734,824**
EFFECTIVE DATE:	**August 1, 1994**
EXPIRATION DATE:	**July 31, 1999**
AUTHORITY:	This agreement is awarded under the authority of the National Science Foundation Act (42 U.S.C. 1861 et seq.) and the Federal Grant and Cooperative Agreement Act (31 U.S.C. 6301 et seq.)

This Cooperative Agreement is entered into between the United States of America, hereinafter called the "Government," represented by the National Science Foundation, hereinafter called the "Foundation" or "NSF," and The University of Texas at Austin, hereinafter called the "Awardee".

NSF Program Official:

Scott G. Borg
Office of Polar Programs
Telephone (703) 306-1033
Electronic mail: sborg@nsf.gov

NSF Grant and Agreement Official:

Pamela A. Hawkins
Division of Grants and Agreements
Telephone (703) 306-1213
Electronic mail: pahawkin@nsf.gov

TABLE OF CONTENTS TO

COOPERATIVE AGREEMENT OPP-9319379

I. Special Conditions

I. SPECIAL CONDITIONS

Article 1. Statement of Purpose and General Responsibilities

A. The Support Office for Aerogeophysical Research (SOAR), hereinafter called the "Facility," is a research facility for aerogeophysical work in Antarctica. The goal of the Facility is to develop, maintain and operate a suite of geophysical systems aboard a Twin Otter Aircraft in support of research in Antarctica for five years. The Facility has the capability of collecting and reducing ice penetrating radar, laser altimetry, magnetics and gravity data sets in addition to GPS navigation information. The Facility data product will be a well organized data set under a spatially based hierarchy described in Attachment I. Data is to be made available to the general research community according to NSF policies (see Article 2.D.4 and Article 11.B.(1) (b).

B. The Facility will be housed at the Institute for Geophysics at the University of Texas at Austin.

C. The Awardee will manage joint aerogeophysical projects under the terms and conditions of this Cooperative Agreement and an Annual Program Plan in accordance with the awardee's proposal dated July 12, 1993, revised budget dated July 7, 1994 and revised cover page dated August 22, 1994 An Annual Program Plan is to be developed in consultation with the NSF Program Official in accordance with Article 2.

D. The National Science Foundation through its Polar Earth Sciences Program will provide general project oversight, monitoring, coordination and evaluation to help assure appropriate project performance and administration.

Article 2. Scope of Work and Specific Responsibilities of Awardee

A. The Awardee will ensure that the Office of Polar Programs' scientific and other programmatic needs are effectively integrated with NSF needs as well as the needs of the national and, where appropriate, the international scientific community. All work shall be performed in accordance with this Agreement and an Annual Program Plan.

B. The Awardee shall be responsible for the activities and projects agreed upon in the Annual Program Plan. The Awardee shall establish the facilities, organization, and staffing, as well as perform the supervisory functions of scheduling, planning, budgeting, resource allocation, fiscal control, contracting, and administration necessary to fulfill the requirements of the program delineated in this Agreement and in the Annual Program Plan.

C. The Awardee shall establish the means whereby it will control the business functions of the Facility and its tasks such as, but not limited to: schedule and budget development; fiscal control, reporting, accountability, and strategic planning, and selection and subcontracting for the Facility.

D. The Facility will be used to support the Office of Polar Program sponsored aerogeophysical research in Antarctica. The projects to be supported involve the need for high quality, integrated, geographically based ice thickness, surface elevation, magnetics and gravity data sets from continental Antarctica. The following elements are integral components of the overall Awardee responsibilities:

(1) **Facility Capability**: The basic Facility will provide approximately 55 survey flights per year operating from a single base camp over approximately a 3.5 month field season. The Facility will collect ice penetrating radar, laser altimetry, magnetics and gravity data sets in addition to GPS navigation information. The personnel required to maintain this effort will be 5 facility personnel supported approximately 9 months per year augmented by temporary personnel. The Facility will include the flexibility to expand the number f lights and bases of operations with appropriately increased funding levels. As the number of science groups supported by the Facility expands, increased management expenses will also be budgeted. The Facility staff will operate the platform exclusively during this initial period of five years.

(2) **Facility Management**: The operating structure of the facility will be a Management Team consisting of two co-directors, a technical coordinator and a scientific coordinator. The co-directors are responsible for scientific guidance and technical direction of the facility. The technical coordinator will be responsible for day-to-day management of the facility and will serve as the point of contact for NSF/Operations, U.S. Antarctic Program contractors, facility contractors and sub-contractors. The scientific coordinator will be responsible for evaluating and maintaining data quality and will serve as the point of contact for collaborating investigators.

(3) **Community Interaction**: Optimum use of this community facility requires that survey design and other planning be accomplished prior to funding and scheduling of any work. During the pre-proposal phase, the Facility will be responsible for ascertaining its capabilities and limitations with respect to the proposed work, including, but not limited to, data accuracy and resolution, the design of field experiments and data management considerations. This interaction should begin no later than 60 days prior to proposal submission. The pre-proposal interaction will ensure that the investigator's specific goals can be met, that the proposed project is technically feasible, and that the project could be accommodated with uncommitted facility time. The Awardee will maintain an ongoing dialogue with NSF to allow adequate planning of future work. After notification by NSF of science project funding, the Awardee, NSF and investigators will develop plans for budgeting and project implementation. Scheduling of the aircraft will be the responsibility of the Facility Management Team in consultation with NSF. The collaborating investigator and other users of the facility may provide a representative on site during data acquisition but this representative will not be used to supplement the technical personnel either abroad the aircraft or in a ground support role. The facility personnel will be solely responsible for field operations.

(4) **Data Products and Data Policy**: The Facility product will be a well organized data set of contiguous transacts under a spatially based hierarchy (see Attachment I). Following the field season the data requested in each proposal will be gathered into its spatial hierarchy and sent by the Awardee to the collaborating investigator; this task will be completed within six months following the end of data acquisition. Each investigator may process this data to meet his/her specific objectives. The facility will also collaborate with users who do not wish to reduce their own data. The budgets for this reduction including staffing, computer resources and any associated software development will be negotiated directly with NSF. Approximately two years after acquisition of a geographically contiguous data set is completed for a science project, the data will be available for release to the general community contingent on the approval of the NSF Program Official.

(5) **Scientific Oversight**: The Facility will establish an external oversight committee tasked with defining broad areas of scientific interest and keeping abreast of technological developments. The external oversight committee, representing both the earth science and glaciology communities, will meet at least once annually and may visit the Facility annually. This committee will consist of four members; one representing the polar earth science community, one representing the polar glaciology community, one member with technical expertise in aerogeophysical operations, and one member from the general earth science community. The Facility Co-Directors will be present at all oversight committee meetings. NSF will be represented at oversight committee meetings by the NSF Program Officer, or a designated representative, and an NSF Operations Manager from the U.S. Antarctic Program. The Awardee will negotiate costs to support the activities of the oversight committee directly with the Office of Polar Programs.

(6) **Technical Development**: The Facility will pursue appropriate technical development to enhance its ability to accomplish its scientific goals. Development of capabilities beyond those required to accomplish these goals will be considered directly by NSF in consultation with the Facility Management Team and oversight committee.

(7) **Facility Administration**: The Awardee will identify points of contact to ensure close communication between the Awardee, the NSF Program Official and the NSF Grants and Agreements Official. These points of contact will be the Director of the Office of Sponsored Projects, the Office of Accounting and the Assistant to the Director of the Institute for Geophysics. Their particular responsibilities will include implementation and monitoring of Articles 8, 13 and 15 outlined below. The Awardee will also be responsible for providing a centralized location with proximal laboratories and office space of sufficient size and stability to allow facility personnel both to accomplish the tasks outlined in this article and to interact effectively with collaborators, subcontractors and other Facility visitors. The Awardee will maintain its commitment to the matching salary support outlined in the budget justification of the attached budget estimates.

Article 3. Period of Performance

This Agreement shall be effective for 60 months -- from August 1, 1994 through July 31, 1999.

Article 4. Contractual Arrangement

The Foundation authorizes the Awardee to enter into the proposed contractual arrangements with Lamont-Doherty Earth Observatory and the U.S. Geological Survey, and to fund such arrangements with agreement funds up to the amount indicated in the approved budget. Such contractual arrangements should contain appropriate provisions consistent with the applicable agreement general terms and conditions and any special conditions included in this Agreement.

Article 5. Antarctic Clause

Neither Article 5, Expenditures for Related Projects," of GC-1 nor Article 3, "Programs of Related Projects," of FDP-II may be applied to agreements from NSF's Office of Polar Programs relating to the U.S. Antarctic Program.

This agreement is subject to the Antarctic Conservation Act, 16 U.S.C. 2401 ("ACA"). Unless authorized by regulation or permit, violation of the ACA may result in civil or criminal fines up to $10,000, imprisonment for up to one year, and where appropriate, administrative sanctions up to and including debarment. Please refer to the USAP Personnel Manual for general guidance.

Article 6. Allotment of Funds

A. The total estimated cost of this Agreement from its effective date through expiration is $3,734,824.

B. For purposes of payment of cost, pursuant to the terms outlined in Article 6, the total amount currently allotted by the Government to this Agreement is $666,075. This allotment covers the initial 9-month period of performance through April 30, 1995.

Article 7. Funding Schedule and Review

A. Contingent on the availability of funds, and the acceptance of the Annual Progress Report and Annual Program Plan, NSF expects to provide funding at the following approximate levels:

Fiscal Year	Approximate Funding Level	Period of Performance
1995	$785,895	12 months
1996	$742,886	12 months
1997	$755,820	12 months
1998	$784,148	15 months

B. Under normal circumstances, data organization and management activities continue after data acquisition and are performed concurrently with planning and preparation for the next field season. In light of this, and because of the schedule in year one, an additional three months has been added to the period of performance of the final fiscal year. This will allow completion of the required organization, management and distribution of data from the final field season.

C. The actual level of continued NSF support for years 2 through 5 will be negotiated annually with the Awardee and will depend upon an annual review of progress, which may include a site visit, and the availability of funds. Continuation is dependent on NSF decisions to fund peer reviewed science proposals requiring the Facility. Should NSF decide to terminate the Facility, NSF and the Awardee will negotiate support to complete all projects in progress at that time. In the event that the anticipated level of NSF support cannot be awarded because of budgetary constraints, NSF and the Awardee will negotiate a change in the scope of Facility activities. The Facility will be reviewed after the third year of this agreement (after completion of the third field season) as described in this Article 7.D below. The review will determine if the Awardee is meeting the stated goals and objectives in order to determine if an aerogeophysical facility should be continued beyond the five year period under this Agreement.

D. A formal review of the Facility will be conducted prior to April 30, 1997. The purpose is to determine if the Facility is meeting the stated goals and objectives of this Agreement in order for NSF to determine if an aerogeophysical capability should be continued beyond the five year term of this Agreement. If this capability is to continue, this review will also be used by NSF to determine how continued work should be competed. The review is to be scheduled as not to jeopardize field operations to acquire data. The review process can include observations of NSF or reviewers from any time during the performance prior to the formal review. The review panel will be selected by NSF. The Awardee will negotiate costs to support the activities of the review panel directly with the Office of Polar Programs.

Article 8. Limitation of Funds

NSF shall not be obligated to reimburse the Awardee for costs incurred in excess of the amount currently allotted to the Agreement. The Awardee shall not be obligated to continue performance under this Agreement or incur costs in excess of said amounts unless and until the NSF Grants and Agreements Officer notifies the Awardee in writing that the amount allotted to the Agreement has been increased and specifies in such notice a revised allotment which constitutes the amount allotted for performance under this Agreement.

Article 9. Indirect Costs

The amount granted includes an indirect cost allowance at the following rate: 22% off campus rate. This modified total direct costs consists of all salaries and wages, fringe benefits, materials and supplies, services, travel and subagreements and subcontracts up to $25,000 of each subagreement or subcontracts. Equipment, capital expenditures, charges for patient care and tuition remission, rental costs, scholarships, and fellowships as well as the portion of each subagreement and subcontract in excess of $25,000 shall be excluded from the modified total direct costs.

Article 10. NSF Responsibilities

A. NSF involvement must be consistent with the general scope of work as set forth in this Agreement.

B. Performance under this Cooperative Agreement shall be subject to the general oversight and monitoring of the NSF Program Official cited on the Agreement's cover page. This NSF involvement may include, but is not limited to, the following:

1. provide advice, especially with regard to integration and coordination with NSF's Office of Polar Program activities, including:

(a) negotiate support for science project interaction with the Facility, including definition of annual tasking and deliverables;
(b) negotiate for twin otter support and other resources required to implement field work in Antarctica under the Annual Program Plan;
(c) enforce and support the policy for release of data to the general research community. This policy is that approximately two years after acquisition of a geographically contiguous data set is completed for a science project, the data will be available for release to the general community. The NSF Program Official will be responsible for determining the date of completion of data acquisition for specific projects and for approving the release of data.

C. The NSF Program Official does not have the authority to and may not:

(1) request additional work outside the general scope of the Agreement;

(2) issue instructions which constitute a change as defined in Article 8 of GC-1;

(3) cause an increase or decrease in the estimated cost or time required for performance under the Agreement; or

(4) change the expressed terms and conditions of the Agreement.

D. If, in the opinion of the Awardee, any instructions or requests issued by the NSF Program Official are within one of the categories as defined in 10.C (1) through (4) above, the Awardee shall not proceed, but shall notify the NSF Grants and Agreements Officer and request, if appropriate, modification of the Agreement in accordance with Article 38, "Changes -- Limitation of Funds," of the attached Cooperative Agreement General Conditions.

E. Unless stated otherwise, all NSF approvals, authorizations, notifications and instructions required pursuant to the terms of this Cooperative Agreement must be set forth in writing by the NSF Grants and Agreements Officer.

Article 11. Awardee Reporting Requirements

A. The Awardee shall provide the NSF Program Official with annual program report detailing the prior year's effort by March 1st of each year (normally five (5) copies will be sent). This will also serve as the Awardee's request for continued support. The documentation will usually include, but is not necessary limited to the following:

(1) summary of accomplishments, future plans, and discussion of major change in direction/pace.

(2) a financial report containing the following information:

(a) a budget explanation by major project and major function for the current fiscal year and the preceding fiscal year;

(b) 4-column table (use Form 1030 budget categories) containing actual expenditures, project estimates to end of the current fiscal year, and total expenditures (actual plus projected costs). This information should also be supplied for subcontracts;

(c) a statement of funds estimated to remain unobligated at the end of the current award year;

(d) a proposed program plan in accordance with this agreement and a proposed budget for the next award year in accordance with NSF Form 1030.

B. The Awardees' staff will meet, as necessary, with NSF staff to review the relevant operations of the Facility and to exchange views, ideas, and information concerning the Facility and the Polar Earth Sciences Program.

C. The reports and plans shall be sent in the specified number of copies to the following destination:

No. of Copies	Addressee
5	National Science Foundation Office of Polar Programs, Room 755 Polar Earth Sciences Program Attn.: NSF Program Official

Article 12. Acknowledgment of NSF Support and Reports from Users

In accordance with Article 20, "Publication" of the GC-1 Grant General Conditions, appropriate acknowledgment of NSF's support should be included in reports or publication based on work performed under this Agreement.

Article 13. Key Personnel

The Facility will be under the direction of a Management Team. The following individuals are considered to be essential to the work being performed. Any change in these individuals, or any significant change in the level of effort of the individuals, under this Agreement shall require the prior written approval of the NSF Grants and Agreements Officer.

Personnel	Title	Level of Effort
Donald D. Blankenship	Scientific Director	4 months/year
Robin E. Bell	Scientific Director	4 months/year
Keith A. Najmulski	Technical Coordinator	9 months/year
TBD	Scientific Coordinator	9 months/year

Article 14. Prior Approval and Notification Requirements

In addition to the prior approval requirements as set forth in Article 2 of the GC-1 General Conditions, prior written approval by the NSF Program Official is required for equipment purchases over $15,000, which were not identified in the approved budget, and the reprogramming of funds over $30,000.

Article 15. Permanent Equipment

Title to all equipment purchased and/or fabricated with Government funds under this Agreement shall passed directly to the Government from the vendor. Within 30 days from the date of delivery by the vendor, the Awardee shall furnish the Foundation Property Management Officer with a full description of the equipment, including model and serial number, acquisition cost (including transportation charges), and the date of acquisition. The Awardee shall be responsible for property control over Government equipment until such time as it is delivered to an agent of the Foundation. Upon expiration of the Agreement, disposition of the equipment will be determined by the Foundation in consultation with the Awardee.

Article 16. Order of Precedence

Any inconsistency in this Cooperative Agreement shall be resolved by giving precedence in the following order: (a) the Special Conditions; and (b) the General Conditions.

II. General Conditions

The following General Conditions attached hereto shall apply to this Cooperative Agreement and are incorporated herein:

1. **Grant General Conditions**, GC-1 (5/94)

2. **Cooperative Agreement General Conditions**, NSF CA-1 (5/94), which is amended as follows:

   Delete Article 41, "GC-1 Deletions" in its entirety and substitute the following in lieu thereof.

41. GC-1 Deletions

The following articles in GC-1, Grant General Conditions, are not applicable to this Cooperative Agreement:

4. No-Cost Extensions
5. Expenditures for Related Projects
33. Resolution of Conflicting Conditions (GC-1)
40. Resolution of Conflicting Conditions (CA-1)

IN WITNESS WHEREOF, the parties have executed Cooperative Agreement No. OPP-9319379 "Support Office for Aerogeophysical Research (SOAR)."

UNITED STATES OF AMERICA:

Aaron R. Asrael

(Signature)

Aaron R. Asrael
Grants and Agreements Officer
(Name and Title)

8/31/94
(Date)

NATIONAL SCIENCE FOUNDATION
Arlington, VA

ACCEPTANCE:

X S. Monti

(Signature)

STEPHEN A. MONTI
VICE PROVOST
(Name and Title)

SEP 27 1994
(Date)

UNIVERSITY OF TEXAS
Austin, TX

Attachment I

The data stream from each of the aircraft's independent geophysical and navigation systems is collected by a central acquisition computer. A similar system is used to collect base station observations. These acquisition computers, upon recognizing a packet from a particular system, tag it with an identifier and the time from a master clock. This packet is then written in the order of its arrival to an archival medium. At the completion of a flight, these multiplexed data structures both for the aircraft and the base station are demultiplexed and recombined into a hierarchical file structure. This file structure contains a continuous data stream for each aircraft system along each transect and a continuous data stream for each base-station system for the entire flight period. At the completion of the field season the large radar data stream is separated from the other aircraft streams and all transects are spatially gathered. The data streams requested for each proposal/investigator are then archived for distribution.