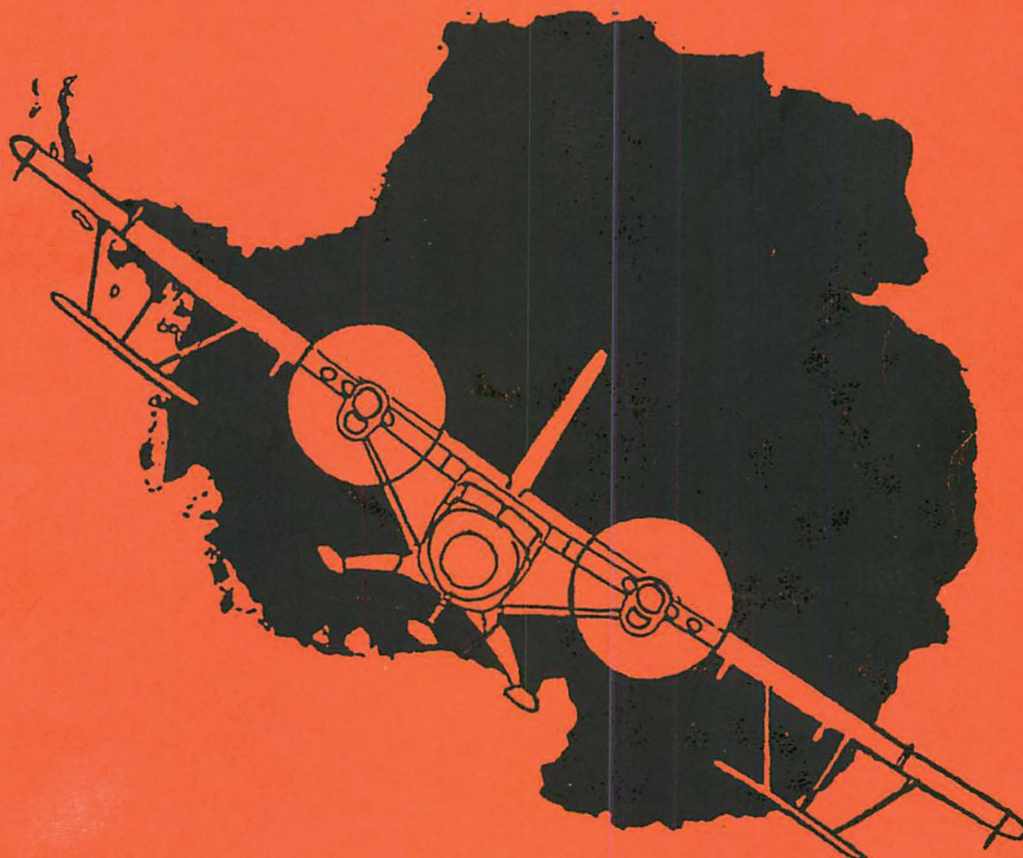
SOAR
(Support Office for Aerogeophysical Research)

Annual Report
1994/95



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Executive Summary

Overview:

Airborne research platforms are uniquely suited to study the earth's processes in remote regions. As a research vessel traverses the world's oceans, an airborne research platform is similarly well suited to study the interior regions of Antarctica. As a research vessel is difficult to instrument and staff so is a scientific research aircraft. The Support Office for Aerogeophysical Research (SOAR) is the innovative effort of the National Science Foundation's Office of Polar Programs to make an aerogeophysical research facility available to a broad multi-disciplinary research community.

This aerogeophysical facility grew out of a series of science programs funded by the National Science Foundation beginning in 1990 with the CASERTZ (Corridor Aerogeophysics of the Southeastern Ross Transect Zone) program in Antarctica. The aircraft assembled by the CASERTZ investigators and their staff was also used to assist other investigators in geophysical survey work at the McMurdo Dome ice-coring site and to collect ice thickness data across the West Antarctic ice streams. The support of these science programs and the increasing number of requests for access to the instrumented aircraft and its staff lead to the concept of an aerogeophysical facility.

SOAR today is a multi-institutional facility supported by the Office of Polar Programs under the auspices of a five year Cooperative Agreement between the National Science Foundation and the University of Texas (Appendix G). The institutions involved include the Institute for Geophysics at the University of Texas at Austin, Lamont-Doherty Earth Observatory of Columbia University and the Geophysics Branch of the U.S. Geologic Survey. The central SOAR office is located in Austin.

A successful 1994/95 Antarctic field season capped the inaugural year for SOAR. Important accomplishments in staffing and technology development in this first year have also laid the foundation for a productive and efficient facility. This foundation will ensure that state-of-the-art aerogeophysics is accessible to the broader geological and glaciological community.

This report summarizes the goals and accomplishments of the facility over the nine months since it was formed and the plans for the facility's future.

Goals and Accomplishments:

This section reviews the goals and accomplishments of the facility in six different areas. These areas are: experiments, technology, logistics, personnel, facilities, and finances. Each general area is supported by a detailed appendix.

Experiments:
The experimental goal for SOAR is to meet the needs of the client science projects by providing simultaneous airborne observations of gravity, magnetics, ice-surface topography and subglacial topography. In the facility's first year, the primary project was the West Antarctic Ice Sheet (WAIS) aerogeophysics project. The WAIS science goals require an orthogonal survey grid with 5.3 km line spacing covering an area of 200,000 square kilometers (Figure 1). This work was proposed to be completed over three 55 flight field seasons beginning in 1994/95. Ultimately, the target of 55 flights for the first field season was reduced because of delays in funding.

During the 1994/95 field season, SOAR completed 32 survey flights yielding over 18,000 km of geophysical profiling (Figure 2). The experimental goals of acquiring a grid of data sufficient for locating a deep ice-coring site and for extending the interdisciplinary analysis begun in the completed CASERTZ survey area were met. The quality of the data collected this season was outstanding with over 90% of the profiles rated good to excellent by the on-site quality control process.

Technology:
The technical goal of the facility 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. The geophysical systems include a gravimeter, magnetometer, a laser altimeter and an ice-penetrating radar. The positioning systems include differential GPS (both real-time pseudo range and post-processed carrier phase), pressure altimeter and an inertial navigation unit. Between the facility's inauguration in August 1994 and the beginning of survey flights in January 1995 SOAR had four major technical objectives. These objectives included:

- Designing and implementing a robust and reliable data acquisition system for the survey aircraft;
- Implementing a field computing facility for efficient data downloading, quality control and archiving as well as logistics management and systems integration;
- Refurbishing the ice-penetrating radar, its digitizer unit and the aircraft racking systems; and
- Implementing a real-time differential GPS (DGPS) navigation system for the survey aircraft.

The real-time data acquisition system was a major undertaking. The goal was to implement a reliable system with a simple recording path and a rapid data transfer following a flight. A reliable real-time acquisition system would

(a)

(b)

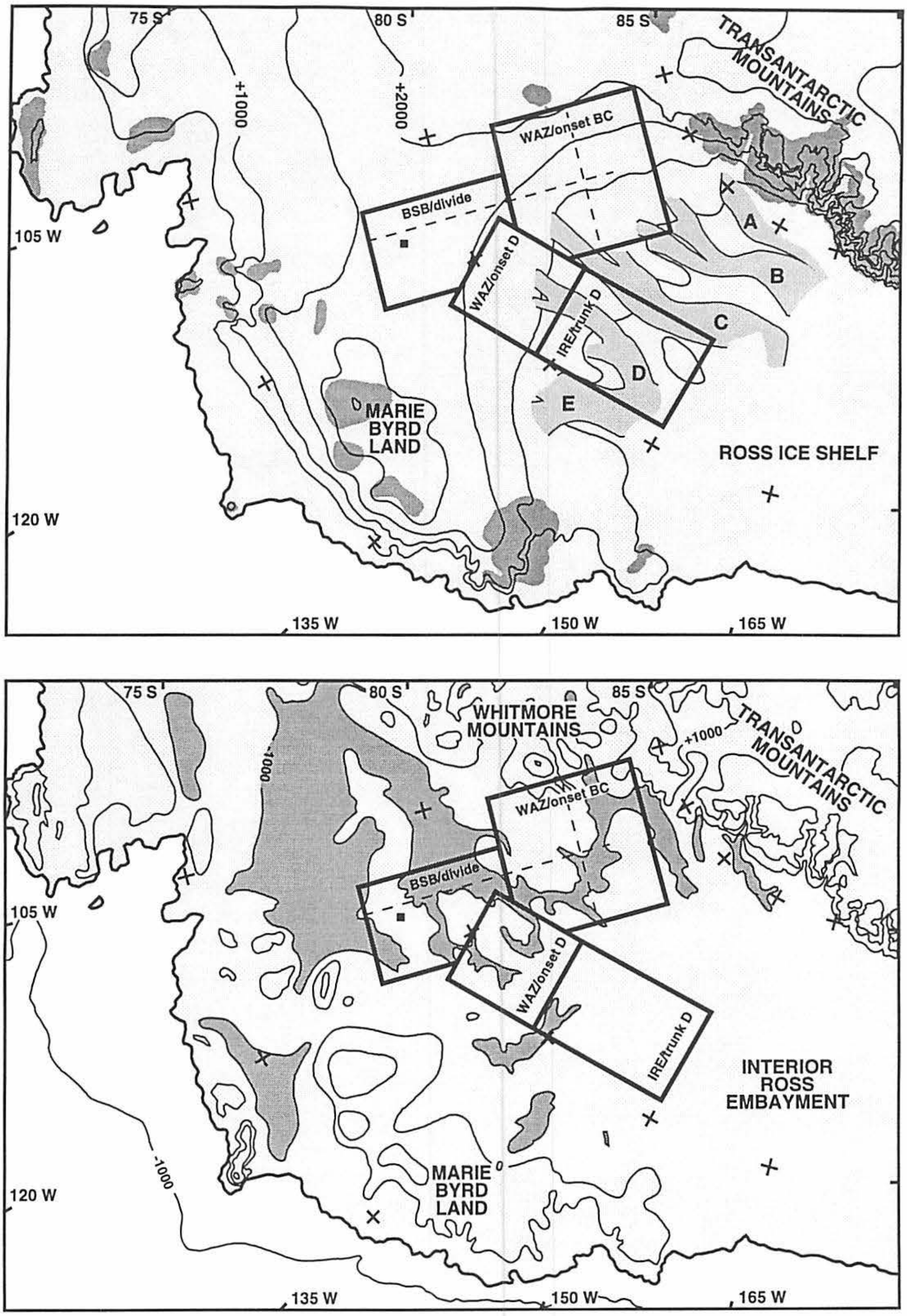

Figure 1 - SOAR survey targets shown on the surface and bedrock topography of West Antarctica. The three targets are outlined with blocks: [1] **BSB/divide** [2] **WAZ/onset D** [3] **IRE/trunk D**. The previously completed CASERTZ work is marked **WAZ/onset BC**. A small square marks the proposed WAISCORES deep-drilling site. Siple Dome, on the ridge between ice streams C and D, is the proposed site for the WAISCORES drilling effort to reconstruct the collapse history of the West Antarctic ice sheet. Possible candidates for ANTALITH seismic traverse routes are shown with dashed lines. A surface glaciology corridor will bisect the **WAZ/onset D** block. (a) Survey targets on the ice surface. (b) Survey targets on the bedrock topography map.

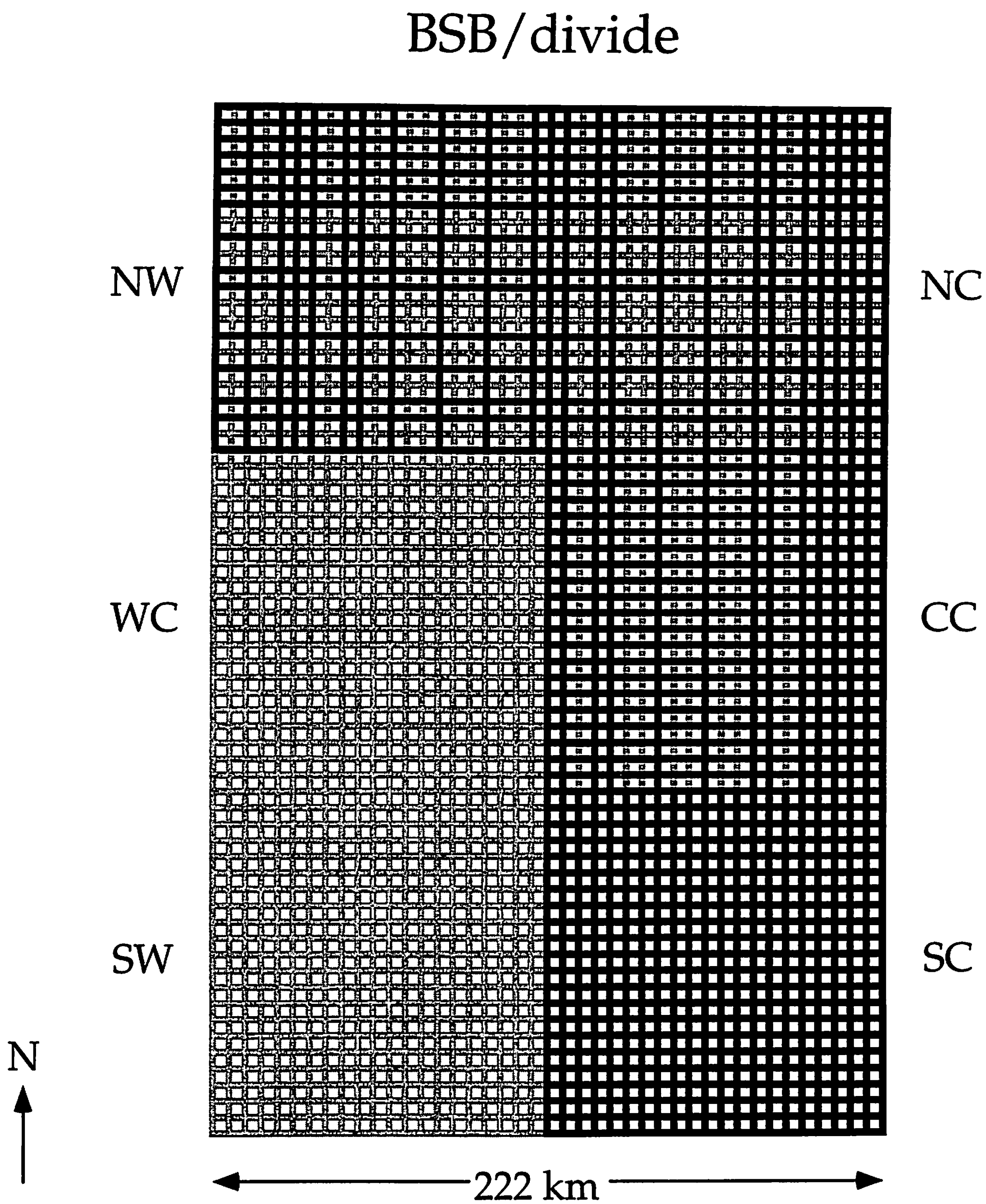

Figure 2 - SOAR survey coverage of the **BSB/divide** target area during 1994/95 field season. Completed profiles are black. Each completed profile is augmented by 15.9 km of run-in and run-out that is not shown. The ice divide runs approximately east-west, bisecting blocks NW and NC. The completed previously CASERTZ survey lies along the south edge of the SC block.

reduce the need for reflights and maximize the time available for surveying. The new acquisition system functions independently of the in-flight monitoring system and records the data to multiple removable disk drives which are compatible with the field computing facility. The success of this system is highlighted by the absence of data acquisition failures during the 1994/95 surveying and the routine downloading of data from the aircraft within minutes of a flight's arrival.

Field computing facilities are critical not only for data downloading, quality control, and archiving, but also for systems integration and logistics management. This season the facility designed, implemented and administered three computer networks to support these activities. A significant effort went into streamlining the organizational hierarchy for data, software and field notes and to optimizing the existing applications software to use this hierarchy. An example of the effectiveness of the field computing facilities was our ability to complete quality control and archiving of all geophysical data within four hours of a flight's return.

The refurbishment efforts for the ice-penetrating radar, its digitizing system and the aircraft racking system were uniformly successful with no critical failures in any of these systems. These efforts increased reliability, improved data quality and contributed to safer operations.

A variety of airborne DGPS navigation systems were reviewed and ultimately one was specified and purchased for the survey aircraft. When fully implemented this system will permit high quality navigation with increased reliability and fewer remote installations than for existing radio navigation systems. During the 1994/95 field season the aircraft guidance component of the DGPS system was successfully installed and utilized for all survey flights.

Logistics:
The diverse logistical needs of the facility were provided by a number of outside organizations. These needs and organizations include:

- Aircraft Support, encompassing Twin Otter operation and other equipment and services provided by Kenn Borek Air Ltd.;
- Field Support, including SOAR interactions with Antarctic Support Associates (ASA) and the Naval Support Force Antarctica (NSFA) in preparation and operation of the aircraft at the field site;
- Technical Support, encompassing the organizations which provide the facility with GPS receivers and gravity meters; and
- Cargo Support, covering a variety of groups involved in transport of SOAR equipment between North America and the field site.

For aircraft support, SOAR aims to ensure that the contractor supplied aircraft meets SOAR specifications and that use of the aircraft is optimized for our experimental objectives. In general, Kenn Borek Air provided excellent support to the facility both in configuration of the aircraft and during the geophysical surveying. This season, three weeks were required to configure and test the aircraft. After that a very high level of productivity was achieved with 32 survey flights completed in 1.5 weeks of flight operations.

Field support includes services provided to the facility by Antarctic Support Associates (ASA) principally for operation of the field camp. The SOAR goal is to ensure that the field camp is set-up to optimize configuration and operation of the survey aircraft while minimizing the resources necessary for field site support. During the facility's first year the field site at Byrd Surface Camp (80°S 120°W) was occupied from mid-December 1994 through the first week of February 1995. Because communications with North America are critical to our success, satellite voice communications and an intermittent data link with the North America were established by ASA. ASA also provided a camp manager, a cook, a general field assistant and a mechanic while NSFA provided a medic and a weather observer to support a maximum of thirteen science staff and five Kenn Borek Air Ltd. crew. The camp ran smoothly throughout this period.

Outside technical support for both GPS receivers and gravity meters is required because of the expense of the equipment and the demand for its use by other research groups. The University Navigation Consortium (UNAVCO) provided GPS receivers and superior support ranging from software and hardware debugging to in-field advice on optimizing operations. The gravity meter was provided by the Naval Oceanographic Office (NAVOCEANO) of the U.S. Navy. This meter was in excellent condition and produced outstanding results from the SOAR airborne platform. We are in the process of arranging long-term access to NAVOCEANO gravity meters.

Because of the need to transport a complete systems integration laboratory, a computing facility and the equipment necessary to operate the survey aircraft, SOAR requires a large amount of cargo. To maximize the preparation time in North America, the goal for the 1994/95 field season was to obtain the appropriate cargo at the field site just before it was needed. A total of 13,500 pounds of cargo was shipped to Antarctica in four phases complemented by 1,800 pounds of handcarry including the gravity meter which required an escort. Each phase of the cargo shipment arrived at the field site precisely when it was needed. Both NSF and ASA personnel including L. DeGalen, B. Stone, L. Taogaga and M. Lanyon were instrumental to the safe and efficient transport of the SOAR equipment.

Personnel:
When SOAR was initiated in August 1994, the personnel available were the two directors, a technical coordinator, a senior systems analyst and an installation engineer. One of the major accomplishments of the first year was the hiring of a technical staff qualified to prepare and complete a major Antarctic aerogeophysical field program in seven months. Since the inception of the facility, four additional core personnel were hired including a science coordinator, a systems analyst, a research engineer and an administrative assistant. In addition, four temporary personnel were hired to support field preparation activities in North America and seven people were hired or "borrowed" from other organizations to augment core personnel in the field. A flexible management structure using task-driven groups overseen by a management team made up of the directors and coordinators was successfully implemented both in the laboratory and in the field. This structure proved critical to efficiently organizing the activities of so many new employees.

Facilities:
The main SOAR offices are located at the Institute for Geophysics of the University of Texas at Austin. This 7500 square foot central facility houses the offices, computer laboratories, electronics laboratories and staging areas necessary for SOAR activities. The Austin facility was renovated and equipped during the first two months of SOAR operations.

Finances:
The facility was budgeted at $666,075 for the first year with an expected $44,000 over expenditure to be covered by second year funds. The actual expenditures were $711,181.

Future Plans:

This section reviews the issues and plans for SOAR in the upcoming years. The focus is primarily on the next two field seasons in West Antarctica. Each general topic is fully described in the detailed appendix.

Experiments:
The experimental objective of the facility in the next two field seasons will be to complete the scientific surveying for the WAIS project and an overlapping University of Wisconsin (UW) program which will utilize a portion of the data collected for WAIS. The 1995/96 field season is planned as an augmented field season of 78 flights based from Byrd Surface Camp. This augmented field season will require ten-twelve SOAR personnel at Byrd Surface Camp for 2.5 weeks of field set-up and aircraft configuration beginning in mid-November and 8.5 weeks of flight operations beginning in early December and extending through January. The work will begin with surveys in the region of the deep ice coring site near the

divide of the West Antarctic ice sheet (the **BSB/divide** target of Figure 1) and move downslope towards the ice streams (the **WAZ/onset D** target of Figure 1). A significant effort to improve weather forecasting capability will be crucial to safely completing this surveying.

The collaborative work with UW will begin about mid-way through flight operations during the 1995/96 field season (i.e. late-December/early January). This collaboration will continue through the 1996/97 field season. The portion of the WAIS data set requested for the UW project will be extracted and made available to UW within four months of the end of each field season.

To complete the WAIS (and the UW) surveying, the facility is planning a 55 flight field season in 1996/97 from a new field camp centrally located on or adjacent to ice stream D (the **IRE/trunk D** target of Figure 1). A camp located on Siple Dome is also an attractive option but this option will require an additional five to ten flights.

Technology:
The technical objective of the facility for the next two years will be to complete the two major development projects begun during the first year, to complete computing and laboratory equipment acquisition and to refurbish the radar digitizing system.

The two major developments from the facility's first year are: the implementation of in-flight quality control software and the implementation and testing of the transmission portion of the real-time DGPS navigation system for the survey aircraft. The software development effort is critical to reduce the time lag in identifying failures in the geophysical and positioning systems and completion of the DGPS system will ensure that the aircraft is capable of the high-quality real-time navigation required for work over West Antarctic ice streams.

During its first year, the facility was unable to acquire a full complement of workstations, portable computers and test equipment. Much of this equipment was borrowed or leased for the field season. The facility proposes to purchase most of the missing equipment over the next two years while relying on lease agreements for the remainder. These purchases will insure the efficiency of equipment preparation in the laboratory, field aircraft configuration and flight operations.

The principal refurbishment project for the next two years will be to improve the sampling capability of the radar digitizing system. Presently in areas of thick ice, resolution must be sacrificed to recover returns from bedrock. This technical development will permit the SOAR radar system to recover the maximum resolution available from the current ice-penetrating radar even in areas of thick ice.

Logistics:
In the future the logistical needs of the facility will be met by the same organizations as for the first year.

For aircraft support the issues are: streamlining the aircraft configuration process, enhancing efficiency during the survey period and replacing damaged flight structures. To streamline the aircraft configuration process, permanent radar cables should be installed in the Twin Otter wings by Kenn Borek Air and the aircraft should be delivered directly from its North American checkout to the SOAR operation in Antarctica. To enhance the operational efficiency, refined plans for spares of contractor supplied instrumentation must be implemented. The 78 flight field season planned for 1995/96 will require a cockpit crew of three at Byrd Surface Camp from mid-November through the end of January. Finally the wing-mounted radar-antenna strut system, damaged during the 1994/95 field season, needs to be replaced prior to the 1995/96 field season.

Field support by ASA should focus on optimizing the use of field time and enhancing the safety of flight operations. To optimize field time, satellite communications links must be in place prior to the arrival of the SOAR field personnel and the DGPS transmission tower needs to be installed shortly after the arrival of an advance team of SOAR personnel. To enhance flight safety, a more rigorous plan for flight following is required, a minimum of two new alternate landing sights must be established and weather satellite images should be available at Byrd Surface Camp.

The facility plans few changes in its relationship with the technical support organizations. Continued linkage between UNAVCO and Polar Programs will ensure superior support for GPS receivers and a gravity meter from NAVOCEANO will be requested again in 1995/96.

Because the cargo system is working so well, the only considerations for future changes will be identifying a more stable path for transporting the SOAR gravity meter to and from Antarctica, reducing the amount of SOAR handcarry and increasing the amount of cargo stored in Antarctica for future field seasons.

Personnel, Facilities and Finances:
The personnel, facilities and financial objectives for SOAR are intertwined. The enhanced field season will require the core personnel to be augmented by four engineers and analysts. This represents the largest change from the early budget estimates contained in the Cooperative Agreement. The other noteworthy change

is the moderate increase to cover the test equipment and computer acquisition described above.

Vision for the Future:

Three prime issues arise in developing a vision for the future of SOAR. These issues are: the appointment of a steering committee, the development of a robust strategy for interaction with the scientific community and refining the plan for technical development.

SOAR in conjunction with NSF has developed the concept of an oversight committee of four scientists who will meet annually during a facility visit. The scientists will include an Antarctic glaciologist, an Antarctic earth scientist, a non-polar earth scientist and an industry aerogeophysical specialist. The suggested nominees are:

- R. A. Bindschadler - Glaciologist, Goddard Space Flight Center, NASA;
- T. J. Wilson - Associate Professor, Department of Geology, The Ohio State University;
- L. Cordell - Geophysicist (retired), U.S. Geological Survey; and
- T. J. McConnell - President, World Geoscience Inc., Houston, Texas.

The facility recommends that the first meeting of the oversight committee take place during the summer of 1995. As SOAR will be actively preparing for the 1995/96 field season, this will be an ideal time for the committee to visit.

SOAR interactions with the scientific community will be via an annual newsletter informing the community of present activities and pending proposals. The newsletter will be supplemented by an annual meeting of current and potential users of the facility. This meeting will be a forum for discussing ongoing science with the aircraft and potential new projects. The goal is to have wide-ranging discussions with the community prior to the development of proposals and to help inform new users of the facility's capabilities and limitations. Proposals will be developed along the timeline presented in the Cooperative Agreement. This first year, the newsletter will be replaced by a brief article in EOS describing the facility's capabilities and announcing the first annual meeting. The first meeting will be held this May during the Spring meeting of the American Geophysical Union in Baltimore.

Technical developments will proceed with an emphasis on enhancing present techniques. This approach for technical developments is outlined in the Cooperative Agreement. The facility will also investigate possible liaisons with the aerogeophysical industry.

Appendix A: Experiments

SOAR Annual Report
1994/95

This appendix reviews the experimental goals, plans, accomplishments, outstanding issues and future plans of the facility.

Goals:

The overall experimental goal of SOAR is to meet the scientific needs of the client projects it is serving by providing simultaneous observations of gravity, magnetics, ice-surface topography and subglacial topography. The goals of the current projects are summarized below.

• Presently the scientific client for the facility is the CASERTZ/WAIS project with investigators D.D. Blankenship, R.E. Bell, J.C. Behrendt and C.A. Finn, and an overlapping project for C.R. Bentley of the University of Wisconsin (UW). The UW work, a subset of the CASERTZ/WAIS program, will be presented in the larger CASERTZ/WAIS context. The CASERTZ/WAIS program requires aerogeophysical data in three adjacent regions of central West Antarctica. These regions are (Figure 1):

- the ice divide where it overlies the Byrd Subglacial Basin (**BSB/divide**);
- the onset of ice stream D which overlies the lithospheric "accommodation" zone between the Byrd Basin and the Ross Embayment (**WAZ/onset D**); and
- the trunk of ice stream D in the Interior Ross Embayment (**IRE/trunk D**).

A portion of the data collected in **WAZ/onset D** and **IRE/trunk D** will be used jointly by CASERTZ/WAIS and UW researchers.

• Completion of these scientific objectives requires an orthogonal survey grid with 5.3 km line spacing covering a 200,000 square kilometer region. This work was proposed to require 165 survey flights over three 55-flight field seasons beginning in 1994/95.

Plans:

The experimental plans for the 1994/95 field season were for an abbreviated field season because of delays in establishing the facility. These objectives, which assumed 15-20 survey flights from Byrd Surface Camp, are given below.

• The first objective was to complete the surveying necessary to select a deep ice coring site on the ice divide over the subglacial sinuous ridge that bisects the Byrd Subglacial Basin. This survey required grid spacing of about 10 km or approximately one-half of the profiles within survey blocks NW and NC of the **BSB/divide** target (Figure 2).

• The second objective was to complete a coarse survey with an approximate 20 km line spacing in the region between the sinuous ridge/divide survey and the previously completed CASERTZ survey. The minimum plan was to cover about one quarter of blocks CC and SC of the **BSB/divide** target (Figure 2).

Accomplishments:

The surveying during the 1994/95 field season substantially exceeded the above objectives. The season's experimental accomplishments include the following.

• 18,137 km of simultaneous aerogeophysical observations were obtained in 32 survey flights over the **BSB/divide** target. The track lines are presented in Figure 2 and the flight parameters are given in Table A.1. In summary about 60% of blocks NW and NC over the ice coring site were completed and about 90% of blocks CC and SC linking the new survey to the earlier CASERTZ survey were completed.

• The data quality for the individual measurements of gravity, magnetics, subglacial topography and ice-surface topography was excellent. On site quality control evaluation of the data rated more than 90% of the profiles "good" to "excellent". A summary of these evaluations is presented in Table A.2 for geophysical systems and Table A.3 for positioning systems.

Issues To Address:

To meet the needs of the client projects the facility must address the following issues.

• The abbreviated 32 flight 1994/95 field season was 23 flights short of the 55 flights proposed for the first season of WAIS. These flights need to be integrated into the schedule.

• During the 1994/95 field season the distribution of flights between the two areas was weighted towards the region linking the new survey with the completed CASERTZ survey. This distribution was driven by unreliable weather forecasts for the ice-divide region. The efficient and safe completion of the work in central West Antarctica requires improved weather forecasting ability.

• Work over the **IRE/trunk D** target will require a base of operations on or adjacent to Ice Stream D. The timing of this move needs to be resolved.

• Arrangements for the transfer to UW of a portion of the data that will be collected within **WAZ/onset D** and **IRE/trunk D** need to be finalized.

Future Targets:

Preliminary facility plans to address these issues are summarized here.

• To meet the CASERTZ/WAIS schedule, SOAR plans to add 23 flights to the 1995/96 field work. The entire field season will be conducted from Byrd Surface Camp. This 78 flight field season will allow for the completion of the **BSB/divide**

Table A.1
Flight Operations Summary

Flight Number	Date (GMT)	Start Time (GMT)	Duration (h:mm)	*Flight Lines	Comments
T01	29 Dec. 94	04:10	0:45	N/A	Radar Antenna Mounting Test
T02	16 Jan. 95	04:05	0:45	N/A	Rack System Mounting Test
T03	16 Jan. 95	19:45	1:40	N/A	Equipment Power-On Test
T04	19 Jan. 95	20:45	1:45	N/A	Data Recording Test
F01	20 Jan. 95	01:45	3:45	4/4	First Survey Flight
F02	20 Jan. 95	12:50	3:35	4/4	
F03	20 Jan. 95	18:55	4:30	6/4	
F04	21 Jan. 95	01:20	4:40	6/5	
F05	21 Jan. 95	12:40	2:30	5/1	Poor Weather
F06	22 Jan. 95	01:45	3:30	4/4	
F07	22 Jan. 95	12:05	3:50	4/4	
F08	22 Jan. 95	18:40	4:25	6/6	
F09	23 Jan. 95	01:00	3:25	4/4	
F10	23 Jan. 95	12:05	4:20	5/5	
F11	23 Jan. 95	18:30	3:40	4/4	
F12	24 Jan. 95	00:55	4:15	6/6	
F13	24 Jan. 95	12:00	4:20	5/5	Weather Diversion **
F14	25 Jan. 95	12:00	3:50	4/4	Weather Diversion
F15	25 Jan. 95	17:25	3:20	4/4	
F16	25 Jan. 95	21:45	3:55	5/3	Weather Diversion **
F17	26 Jan. 95	03:35	4:20	5/5	
F18	26 Jan. 95	11:10	4:10	5/5	
F19	26 Jan. 95	16:40	3:15	4/4	
F20	26 Jan. 95	21:10	2:50	4/2	Poor Weather
F21	27 Jan. 95	02:30	1:30	4/0	Poor Weather
F22	27 Jan. 95	11:20	4:00	5/4	
F23	27 Jan. 95	16:45	3:30	4/4	
F24	27 Jan. 95	21:35	4:15	5/5	
F25	28 Jan. 95	02:45	4:05	5/5	
F26	28 Jan. 95	11:05	3:35	4/4	
F27	28 Jan. 95	16:20	4:00	5/4	
F28	28 Jan. 95	21:15	4:20	5/5	
F29	29 Jan. 95	02:40	4:45	5/5	
F30	29 Jan. 95	10:55	3:35	4/4	
F31	29 Jan. 95	16:00	3:30	4/3	Auto Pilot Failure
F32	29 Jan. 95	20:50	4:20	5/5	No Auto Pilot

*Note: Flight lines are denoted by number of lines planned/number of lines completed.
**Note: Strut system damage.

Table A.2 – Data Quality Summary - Geophysical Systems

(1994/95 SOAR field season; BSB/divide target)

Line #	Gravity								Magnetics							
	NW		NC		CC		SC		NW		NC		CC		SC	
	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
1	G	X	G	G	X	G	G	E	E	G	E	E	E	E	E	E
2				G	X	G	E	G				G	E	G	E	E
3	E	G	E		E		G	E	G	E	G		E		E	E
4	G		G	E	E	E	G	G	E		E	E	G	E	E	E
5		G		G	G	G	G	G		E		G	E	G	E	E
6	G	G	G		G		G	E	E	E	E		G		E	E
7		E			E		G	G		E			G		E	E
8				G	G	G	E	G				E	E	E	E	E
9	E	G	E		G		E	E	E	E	E		E		E	E
10		G			E		G	G		E			G		E	E
11				E	E	E	E	G				E	X	E	E	E
12	G	G	G		E		E	E	G	E	G		E		E	E
13	X		X		E		G	E	E		E		G		E	G
14				G	E	G	E	G				E	E	E	E	E
15	G	G	G	E	E	E	E	G	G	E	G	E	E	E	E	E
16					G		G	E					X		E	G
17	X		X	X	E	X	G	E	E		E	E	E	E	E	E
18	G	E	G	E	E	E	G	G	G	E	G	E	G	E	G	G
19	X		G	G	G	G	G	E	G		G	E	X	E	E	E
20	G			X	G	X	G	G	E			E	E	E	G	G
21	G	E		G	G	G	E	E	G	E		E	E	E	E	G
22	G		X	G	G	G	G	G	G		G	E	X	E	G	E

Line #	Ice-Penetrating Radar								Laser Altimetry							
	NW		NC		CC		SC		NW		NC		CC		SC	
	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
1	G	E	G	E	E	E	G	E	G	G	G	E	E	E	E	E
2				E	E	E	G	G				G	E	G	E	E
3	G	E	G		G		G	G	E	G	E		E		E	E
4	E		E	E	G	E	G	G	E		E	E	E	E	E	E
5		G		E	G	E	G	G		X		G	G	G	E	E
6	E	G	E		G		G	G	G	G	G		E		E	E
7		E			G		G	G		E			E		E	E
8				G	G	G	G	G				G	E	G	G	E
9	E	G	E		G		E	G	E	G	E		G		G	E
10		G			G		E	G		G			E		E	E
11				G	G	G	G	G				E	E	E	E	E
12	G	E	G		G		E	G	G	X	G		G		E	E
13	G		G		G		G	G	G		G		E		E	E
14				G	G	G	G	G				E	E	E	E	E
15	E	G	E	G	X	G	G	G	G	G	G	E	G	E	E	E
16					G		G	G					E		E	E
17	G		G	G	G	G	G	G	G		G	E	E	E	E	E
18	E	E	E	G	X	G	G	G	G	G	G	E	E	E	E	E
19	G		G	G	G	G	G	G	G		G	E	E	E	E	E
20	G			G	G	G	G	G	G			E	E	E	E	E
21	E	E		G	X	G	G	G	G	X		E	G	E	E	E
22	E		E	G	G	G	G	G	G		G	E	E	E	E	G

E - excellent, G - good, X- bad

Table A.3 --Data Quality Summary - Positioning Systems

(1994/95 SOAR field season; BSB/divide target)

Line #	Geodetic GPS							
	NW		NC		CC		SC	
	x	y	x	y	x	y	x	y
1	G	E	G	G	G	G	E	G
2				G	G	G	E	E
3	E	G	E		G		E	E
4	E		E	G	G	G	E	E
5		G		G	G	G	E	E
6	E	E	E		G		E	E
7		G			G		E	E
8				G	E	G	E	G
9	E	E	E		E		E	E
10		G			G		E	E
11				G	E	G	E	E
12	G	G	G		E		E	E
13	G		G		G		E	E
14				G	G	G	E	E
15	G	G	G	G	E	G	E	G
16					E		E	E
17	G		G	G	G	G	E	E
18	E	G	E	G	E	G	E	E
19	G		G	G	E	G	E	E
20	G		G	G	G	G	E	E
21	E	G	E	G	E	G	G	E
22	G		G	G	E	G	E	G

Line #	Inertial Navigation							
	NW		NC		CC		SC	
	x	y	x	y	x	y	x	y
1	E	E	E	E	E	E	E	E
2				E	G	E	E	E
3	E	E	E		E		E	E
4	E		E	E	G	E	E	E
5		E		E	E	E	E	E
6	E	E	E		E		E	E
7		E			E		E	E
8				E	E	E	E	E
9	E	E	E		E		E	E
10		E			E		E	E
11				E	E	E	E	E
12	E	E	E		E		E	E
13	E		E		E		E	E
14				E	E	E	E	E
15	E	E	E	E	E	E	E	E
16					E		E	E
17	G		G	E	E	E	E	E
18	G	E	G	E	E	E	E	E
19	E		E	E	E	E	E	E
20	E		E	E	E	E	E	E
21	E	E	E	E	E	E	E	E
22	G		G	E	E	E	E	E

Line #	Pressure Altimetry							
	NW		NC		CC		SC	
	x	y	x	y	x	y	x	y
1	E	E	E	E	E	E	E	E
2				E	E	E	E	E
3	E	E	E		E		E	E
4	E		E	E	G	E	E	E
5		E		E	E	E	E	E
6	E	E	E		E		E	E
7		E			E		E	E
8				E	E	E	E	E
9	E	E	E		E		E	E
10		E			E		E	E
11				E	E	E	E	E
12	E	E	E		E		E	E
13	E				E		E	E
14				E	E	E	E	E
15	E	E	E	E	E	E	E	E
16					E		E	E
17	E		E	E	E	E	E	E
18	G	E	G	E	E	E	E	E
19	E		E	E	E	E	E	E
20	E		E	E	E	E	E	E
21	E	E	E	E	G	E	E	E
22	E		E	E	E	E	E	E

Line #	Weather							
	NW		NC		CC		SC	
	x	y	x	y	x	y	x	y
1	G	X	G	G	E	G	E	E
2				G	E	G	G	E
3	G	G	G		E		E	E
4	E		E	E	E	E	E	E
5		X		E	G	E	E	E
6	E	G	E		E		E	E
7		G			E		E	E
8				G	E	G	E	G
9	E	G	E		G		G	E
10		G			E		E	E
11				G	E	G	G	E
12	G	X	G		G		E	E
13	G		G		E		E	E
14				E	E	E	E	E
15	G	G	G	G	G	G	E	E
16					E		E	E
17	G		G	E	E	E	E	E
18	G	G	G	G	G	G	E	E
19	G		G	E	G	E	E	E
20	G		G	E	E	E	G	E
21	G	X	G	E	G	E	E	E
22	G		G	E	E	E	E	G

E - excellent, G - good, X- bad

and **WAZ/onset D** sections. These production levels will require twelve SOAR personnel for 2.5 weeks of field set-up beginning at Byrd Surface Camp in mid-November and ten SOAR personnel for 8.5 weeks of operation beginning in early December and extending through January. This schedule is based on the assumption of one-third bad-weather days and two flights per day of good weather over the 60 day period of flight operations. The flow of the work will begin with the **BSB/divide** target and move to **WAZ/onset D**. The collaborative work with UW will begin about mid-way through flight operations (i.e. late December/early January).

• The problems of balancing flight operations in response to changing weather conditions over the **BSB/divide** target will arise again in the proposed 1995/96 field program. Addressing the weather and safety issues laid out in the Logistics Appendix will allow this work to be prioritized by experimental objectives and not by the quality of the weather forecasts.

• The planned 1995/96 flight schedule moves flight operations in the **IRE/trunk D** target to a new field camp on or adjacent to ice stream D at the start of the 1996/97 field season. If this camp is near the center of the **IRE/trunk D** target then the WAIS experimental objectives and the UW collaboration can be finished with the 55 flights proposed for 1996/97. If it is located in a corner of the **IRE/trunk D** target (e.g. Siple Dome) then an additional five to ten flights will be required to cover the area due to the extended transits.

• The portion of the **WAZ/onset D** data set requested by UW will be extracted and transferred as soon after the 1995/96 field season as is practical. Assuming that SOAR equipment returns to North America by early April this data transfer will be accomplished by June of 1996. A similar schedule will be applied to the portion of the data from **IRE/trunk D** data set to be collected in the 1996/97 field season. A budget for accomplishing this data transfer will be submitted separately.

Appendix B: Technology

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

Goals:

The SOAR technical goal is to prepare, configure and operate the geophysical and positioning systems aboard the survey aircraft in order to obtain the highest quality observations consistent with simultaneous operation of these systems. The geophysical observations include gravity, magnetics, laser altimetry and ice-penetrating radar sounding. The positioning observations include differential GPS (both real-time pseudo range and post-processed carrier phase), pressure altimetry and inertial navigation.

Plans:

The technical plan for the first year of facility operations had several key components. These components included the following efforts.

- Design and implementation of real-time data acquisition hardware and software for the survey aircraft that emphasizes a simple recording path, reliable data collection and efficient data downloading.

- Implementation of a field computing facility and associated software systems capable of:

  - Downloading data from a survey flight within 1.5 hours;
  - Performing quality control for each geophysical and positioning system for a particular flight in less than four hours ; and
  - Archiving digital field notes, quality control products and data at all processing levels in a well defined hierarchy on a variety of media.

- Repair and refurbishment of the ice-penetrating radar, its digitizer unit, and aircraft racking systems.

- Implementation of an accurate and reliable real-time differential GPS (DGPS) navigation system for the survey aircraft.

Accomplishments:

This section highlights the principal technical accomplishments of the facility in the first year.

- *Data Acquisition System: Summary.* The new SOAR data acquisition system was designed and implemented over a four-month period. It was completed just before the beginning of flight operations. The objectives of simplifying the recording path, increasing reliability and speeding data download were achieved. The new system functioned flawlessly throughout the flight operations period.

- *Data Acquisition System: Recording Path.* Data within the survey aircraft is generated simultaneously by about a dozen different devices at rates ranging from twenty to twenty thousand bytes per second. To simplify the recording path a single machine was used to gather, time stamp and channel the data to a recording device. All other data acquisition tasks were performed by separate machines. This design used the QNX operating system which allows a program to perform multiple synchronized tasks on multiple computers simultaneously. The non-critical control and monitor functions of the data acquisition program were off-loaded to a network of laptop computers. Any or all of the laptops could fail without inhibiting data recording.

• *Data Acquisition System: Reliability.* The SOAR primary acquisition computer deals with two forms of data transfer from the devices within the survey aircraft. Most of the devices use a standard serial interface but the digital radar system requires a higher speed parallel interface. The acquisition computer processing has a serial input module, a parallel input module, a timing module, a spooler module, and a router module. The input modules read the data packets from the appropriate interface and add a header describing that observation's position in the hierarchy describing the experiment: Both input modules get time from the timing module. The packets are passed to the spooler module which writes the data to files on a pair of mirrored disc drives. Packets are also passed via the router module to the laptops for non-critical processing.

In operation the new data acquisition system proved extremely reliable. It experienced no failures during critical flight operations. The mirrored recording also proved valuable as on two flights the back-up data were used following a primary disc-drive failure.

• *Data Acquisition System: Data Downloading.* Moving data from the aircraft to the computing facility following a flight can cause operational delays. Both 8mm magnetic tape and ethernet systems have been used in earlier CASERTZ field seasons but magnetic tape is unreliable in the aircraft environment and ethernet systems are slow. For the SOAR 1994/95 endeavor, a removable hard-drive system was implemented. This system had the advantage of a standard interface used by multiple computer operating systems. Downloading of all aircraft data except the geodetic GPS observations was accomplished by simply "unplugging" the disc drive in the aircraft following a flight and "mounting" it on the computing facility download computer. In operation, the removable disc drives proved rugged both physically and electrically and the systems performance was excellent throughout the field season. The download process required about five minutes. No operational delays were caused by downloading data from the aircraft.

• *Computing Facilities: Summary.* Our efforts in networking, data organization and applications software were fruitful. By the end of the flight operations all data were being downloaded and broken out into the new hierarchy within one hour of a flight completion; this data was then quality checked and archived on both 4mm and 8mm magnetic tape well within the four hour target.

• *Computing Facilities: Networking.* The SOAR group designed, implemented and administered field and laboratory versions of three computer networks. These three networks were divided by tasks which were completed on that network. The reduction, archival, and visualization network (RAV) is a group of workstations which for the 1994/95 field season focused on the breakout, quality control and archival of the geophysical data sets. The systems integration network (SIN) consisting of a group of Macintosh and IBM compatible PC's handled aircraft integration and testing, base station operations and data download. The information and office network (ION) also made up of Macintosh and IBM compatible PC's handled flight planning, logistics databases and electronic mail.

• *Computing Facilities: Data Organization.* A new on-line organizational hierarchy designed explicitly for underway geophysics was implemented for the RAV and SIN networks. The objective was to give SOAR personnel a common framework for organizing data. This streamlined organizational scheme worked well and allowed the four-person ground team operating six computers to keep pace with around-the-clock flight operations.

• *Computing Facilities: Applications Software.* Much of the software developed for the original CASERTZ program was upgraded to take advantage of the new on-line organizational hierarchy. This included software to download auxiliary devices (i.e. both base and aircraft GPS receivers and base magnetometers), breakout of both linked and auxiliary data into a readable file structure, and quality control for all data streams. A number of new applications programs were developed including code to download the linked data from the aircraft using the removable disk drives and code to automate a good portion of the radar quality control. New programs developed by NOAA were implemented to speed GPS breakout and quality control.

• *Repair and Refurbishment.* During the laboratory testing period for the ice penetrating radar it was determined that two significant repairs were required. The final output amplifier stage and the power supply in the initial pulse modulating stage needed to be replaced. These repairs resulted in increased output power and more stable circuitry. No failures of this system were experienced during flight operations.

The radar-signal digitizing systems (DSU) used by SOAR were also tested. To accomplish this, SOAR personnel and Jerry Bradley of the USGS (Geophysics Branch) worked together to establish a software test environment. From this testing three necessary repairs were identified. The transient recorder which digitizes the input signal, the parallel interface link and a memory board were ultimately replaced. Aside from a few cable failures the DSU functioned well during flight operations.

The racking system for the survey aircraft had to be refurbished to accommodate several new systems including the data acquisition system, the real-time DGPS system and the gravity and geodetic GPS units. The new racking system reduces both the instrument weight and power consumption, shortens both signal and power cable paths and improves both device access and ventilation. The new racking systems contributed substantially to safe and efficient flight operations.

• *Real-Time Differential GPS.* Real-time differential GPS (DGPS) was chosen to be the best real-time navigation system for the survey aircraft. There are two major components to a real-time DGPS system. A main guidance component and a transceiver system for differential corrections. The main guidance component consists of a pilot display, a navigation computer and a GPS receiver. This component can provide reduced-accuracy GPS positioning in the absence differential corrections.

The accuracy of real-time DGPS is potentially better than that of the CASERTZ radio-transponder system and the improvement in logistical efficiency is substantial. The DGPS requires fewer transmitter sites than a radio navigation system. Fewer transmitters also means fewer potential technical problems and an increase in flexibility. The following considerations were made in choosing the best DGPS unit:

- The range of radio frequencies available for transmission of the differential corrections;
- Capability of receiving input from external GPS units;
- Ability to use coordinate systems that are acceptable in polar regions;
- Ability to be controlled by an external computer over standard interfaces;
- Ability to calculate and display a position in the absence of a differential correction signal; and
- Quality of the cockpit display and pilot interface.

Three site visits to manufacturers and discussions at two technical conferences led SOAR to select the Trimble Navigation Trimflight system.

The SOAR objective for the 1994/95 field season was to specify and purchase the main guidance portion of the Trimflight DGPS system. This objective was accomplished. With the assistance of Kenn Borek Air Ltd. personnel, the system was installed and tested before the beginning of flight operations. The Trimflight main guidance system was successfully used for all survey flights.

Issues To Address:

A number of technical issues must be addressed to achieve the SOAR 1995/96 experimental objectives. These include the following:

• *Data Acquisition System.* All of the critical design objectives for the data acquisition system were accomplished within the abbreviated preparation period for the 1994/95 field season. This included design of real-time monitoring software and hardware for in-flight quality control of both geophysical and positioning systems. The in-flight quality control software has not been implemented. This software needs to be implemented for the laptop network both in the aircraft and at the base station. This in-flight data monitor will significantly decrease the time required to identify and debug major failures of the on-board geophysical and positioning systems.

• *Computer Facilities.* The majority of the workstations in the RAV network implemented for the SOAR 1994/95 field season were either commercially leased or borrowed from various science projects. SOAR needs to purchase workstations to complete the field RAV network.

The SOAR 1994/95 ION network was designed to support six computers; one server in the laboratory, one server in the field and four portables that travel with the SOAR technical staff. Two of the portable computers were borrowed and need to be acquired. Also, the inability to transfer visual information to vendors and support personnel in CONUS and other non field-site locations has impaired our progress in configuring the aircraft and flight operations. For this reason a digital camera needs to be added to the field server of the ION network.

• *Repair/Refurbishment.* The SOAR ice-penetrating radar system consists of the NSF/TUD (Technical University of Denmark) transmitter and receiver and the USGS digital stacking unit (DSU). Overall resolution is currently limited by the DSU portion of this system. The DSU is capable of digitizing and stacking 6,000 of the 12,000 sweeps generated by the radar system each second. In order to extract the most information from the thick-ice regions of West Antarctica, SOAR needs to upgrade the DSU to be able to digitize and stack at full vertical resolution the 12,000 sweeps generated by the NSF/TUD radar system each second.

This year SOAR was unable to complete critical time and frequency domain diagnostics on geophysical and positioning equipment in a timely fashion. The lack of suitable equipment causes inefficiencies both in the laboratory and in the field, particularly during aircraft configuration. The facility needs to either purchase or lease time and frequency domain analyzers appropriate for the suite of instruments it operates and maintains.

• *Real-Time Differential GPS.* As was stated above, SOAR successfully implemented the main guidance component of the Trimflight DGPS system during the 1994/95 field season. The second component of a real-time DGPS system, the transceiver, consists of a radio receiver and demodulator (in the aircraft) and a modulator, radio transmitter and GPS receiver (at a base-station). For the 1994/95 field season SOAR specified and purchased the radio receiver, modulator and demodulator for the transceiver component. SOAR needs to complete the design, testing and implementation of the transmission portion of the DGPS system including purchase of the ground-based transmitter.

Future Targets:

The facility has a number of specific technical targets to meet during the next year. These include:

• *Acquisition System.* Implement in-flight data monitoring software and add two computers to the airborne laptop network prior to the 1995/96 field season.

• *Computer Facilities.* Purchase one workstation and lease two others to complete the RAV network at Byrd Surface Camp for the 1995/96 field season.

• *Computer Facilities.* Obtain two portable computers and a digital camera to complete the ION network for the 1995/96 field season.

• *Repair/Refurbishment.* Begin upgrading a DSU (with spares) so that it is capable of digitizing and stacking all 12,000 sweeps generated each second by the NSF/TUD radar system. This system should be ready to undergo field trials during the 1995/96 SOAR field season.

• *Repair/Refurbishment.* Obtain time and frequency domain test equipment including a function generator, time-domain reflectometer and a spectrum analyzer in time for the 1995/96 field-season preparation.

• *Real-Time Differential GPS.* Acquire the ground-based radio transmitter and implement the transceiver portion of the Trimflight DGPS navigation system for use during the 1995/96 field season.

Appendix C: Logistics

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This appendix covers the logistical support aspects of the facility. It is divided into the following sections:

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

II. Field Support - facility interactions with Antarctic Support Associates (ASA) and the Naval Support Force Antarctica (NSFA).

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

IV. Cargo Support - facility interactions with ASA and NSF cargo systems.

I. Aircraft Support

This appendix addresses the goals, accomplishments, outstanding issues and future directions for aircraft support provided to the facility by Kenn Borek Air, Ltd.

Goals:

The aircraft support goals are to insure that the contractor supported aircraft meets SOAR specifications and to optimize the use of the aircraft for geophysical operations after it has been configured and tested.

Plans:

The plans for the abbreviated 1994/95 field season are listed below.

- Pre-deployment visit to Calgary by the Technical Coordinator and the Installation Engineer to verify SOAR specifications (see Table C.1) and inspect fabrications and aircraft modifications.

- Arrange for the survey aircraft to arrive at the field site by the end of December 1994 with 2.5 weeks for set-up and 2 weeks of flight operations targeting 15 flights (assume 1/3 weather days and 1.5 flights/day of good weather).

- Attempt to assemble a second flight crew (i.e. a total of four cockpit crew and six instrument operators) and position sufficient fuel for doubling flight operations to 30 flights.

Accomplishments:

This section focuses on the aircraft support accomplishments during the first year of the facility operations. These accomplishments are listed below.

- Prior to deployment, two SOAR personnel made a two-day Calgary visit beginning on October 11, 1994. This visit focused on the Differential GPS mounting and integration. On-site confirmation and testing of contractor supplied devices and cabling was also completed.

- Wing cables for the ice-penetrating radar were installed in McMurdo in mid-December and the aircraft arrived at the field camp the last week of December. The aircraft configuration and testing (including three test flights) was completed in three weeks.

- Flight operations began immediately after testing and continued for 1.5 weeks with double flight crews and generally good weather allowing 32 survey flights to be completed in 122 hours of flight operations (Table A.1).

Table C.1

Equipment Supplied by Kenn Borek Air Ltd.

- 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 over an RS-232 port.)

- Pressure Altitude * (0.5 m pitot boom and Paroscientific 1015a or equivalent with pressure [+/-0.1 mbar] over a range of 600-1100 mbar available over an RS-232 port.)

- Radar Altimeter * (altitude above surface [+/-0.5m] over a range of 0-500 m available over an RS-232 port.)

- Outside Air Temperature * (temperature [+/-1° C] over a range of -40° to +25°C available over an RS-232 port.)

- Autopilot ** (roll, pitch and pressure altitude stabilized with all controls available to both pilot and copilot.)

- Strut system and cable raceway in wings (for user-supplied radar antennas to be mounted beneath wings; includes flight preparation/relamination of user supplied antennas and struts.)

- Securing Mechanisms and viewing window (for "bird" containing magnetics sensor that is to be towed on 30 m retractable cable and laser range finder which is mounted in viewport.)

- Auxiliary Power Unit * (28v at 10 kW.)

- Intercom ** (four operator headsets with push-to-talk and cockpit isolation features.)

* 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

• The Kenn Borek Air Ltd. personnel provided exemplary support to the facility through both the aircraft set-up period and flight operations. Aircraft mechanic Doug Gaunt was superb in his support of SOAR operations. Without Doug Gaunt and the support of the pilots Mike Claringbull, Matt Gacek, Bob Urban and Steve King, the expediency and quality of aircraft set-up and operations would not have been possible.

Issues To Address:

The aircraft time available to SOAR can be further optimized. Areas of potential optimization which span both aircraft configuration and flight operations include the following.

• The strut system for the radar antennas was damaged during flight operations and needs to be replaced.

• Presently new cables to the wing mounted radar antennae must be installed and calibrated each season. This time consuming task delays the configuration of the aircraft and risks damaging the cables in which case the installation must be repeated. The implementation of a permanent cable installation would eliminate this time sink.

• During the survey flights, contractor supplied instrumentation critical to successful data collection experienced intermittent failures. These systems included the DAI [Data Acquisition Interface] and the auto pilot. Also no plan for a replacement inertial navigation system is in place. On-site spares of these critical systems are necessary and arrangements for quick delivery of a replacement inertial navigation unit must be developed.

• The rate at which flights were accomplished during the 1994/95 field season is sustainable only for short periods. A more reasonable approach is to utilize a flight crew staffing of three cockpit crew and four to five in-flight instrument operators. With this staffing an 80 flight season could be completed with the aircraft on site from mid-November through the end of January. This schedule includes 2.5 weeks for aircraft configuration and testing prior to surveying.

• This season the survey aircraft was used for open-field applications prior to use as a survey aircraft. This reduces the amount of configuration that can be performed in North America and increases both the configuration and testing required in the field, ultimately delaying flight operations. Dedication of the aircraft to aerogeophysics would alleviate this delay.

Future Targets:

To address these outstanding issues, a number of aircraft-support targets exist for the next field season. These include:

- Replacing the strut system for the NSF/TUD radar antennas;

- Implementing a permanent radar cable installation for the survey aircraft;

- Obtaining on-site spares of the critical contractor supplied systems and implementing a plan for a quick delivery of a replacement inertial navigation unit;

- Utilizing a flight crew of three in the cockpit and four to five instrument operators to complete an 80 flight season with the survey aircraft on site from mid-November through the end of January; and

- Scheduling the aircraft to be delivered to the SOAR field site directly from Calgary.

II. Field Support

Field support includes services provided by ASA and NSFA to the facility principally for operations of the field camp. This appendix focuses on these services.

Goals:

The goals of the SOAR field support efforts are to first ensure that the field camp is set-up to optimize configuration and operation of the survey aircraft and secondly to minimize the time and resources necessary for field site set-up and maintenance.

Plans:

The SOAR field support plan for the abbreviated 1994/95 field season focused on ensuring that adequate services and communications were available for efficient aircraft configuration and flight operations. The plan included:

- Occupying a field site at Byrd Surface Camp, Antarctica by mid-December 1994 and departing this field site by the first week of February 1995;

- Establishing high-quality voice and data communication links at the field site; and

- Supporting configuration and flight operations of the survey aircraft from a "science" jamesway at Byrd Surface Camp.

Accomplishments:

The major field support accomplishments are given below.

- Byrd Surface Camp was occupied by SOAR personnel from December 14, 1995 through February 6, 1995. When the advance team of facility personnel arrived at the field site on December 14, 1995, the "science" jamesway specified in the ASA support information packet was nearly complete. Approximately three additional days were required by SOAR personnel to complete the field site set-up. After the completion of flight operations on January 30, 1995 one week was required for decommissioning the aircraft and packing equipment.

- An ATS satellite communications system was chosen by ASA to provide voice and data communications with CONUS for the Byrd Surface Camp field site. The timetable of events is reviewed here:

December 11,1994	Equipment at field site for voice communications.
December 16, 1994	SOAR personnel establish voice contact with CONUS using ATS.

December 26, 1994	Equipment for data communications arrives at field site along with two ASA personnel to install data equipment.
January 3, 1995	ASA personnel depart field camp without establishing reliable data links with CONUS.
January 7, 1995	SOAR personnel successfully establish intermittent data links with CONUS.

• ASA provided a camp manager, a cook, a general field assistant and a mechanic while NSFA provided a medic and a weather observer to support a maximum of thirteen science staff and five Kenn Borek Air Ltd. crew from December 14, 1994 until February 6,1995. The camp ran smoothly throughout this period.

Issues to Address:

To improve the efficiency of aircraft configuration and flight operations, as well as to ensure that flight operations are conducted safely, a number of issues need to be addressed. These are listed below.

• Voice and data communications links to CONUS continue to be critical to the operations of the survey aircraft due to the highly technical nature of the facility's suite of geophysical, positioning and computing systems. Reliable voice and data communications links must be established at SOAR field sites. These links should be installed prior to the arrival of SOAR field personnel.

• Flight following capability is critical for safe operation of the survey aircraft. This consists of a weather observer at a radio tuned to the survey aircraft frequency from one hour prior to take off of a flight until the flight lands. To meet minimum safety standards, flight following must be implemented at the base of aircraft operations (presently Byrd Surface Camp), McMurdo Station and at the closest established field site. The weather observers need to provide observations to the survey aircraft on an hourly basis. This capability should be available for approximately thirteen hours of each day of flight operations.

• Because of the frequently changing weather patterns and the unreliable weather forecasts for central West Antarctica (see Experiments Appendix) a minimum of two alternate landing sites with fuel caches and direct access to weather satellite imagery are necessary to ensure safe aircraft operations. For 1995/96 season these caches should be located at least 75 km and no more than 200 km away from Byrd Surface Camp. Similar landing sites will need to be established for the 1996/97 field season.

• The SOAR differential GPS navigation system will require a transmission tower for differential corrections at Byrd Surface Camp (see Technical Appendix).

• Science support activities at an established site like Byrd Surface Camp can easily take a back seat to general camp maintenance. Care should be taken to clearly establish camp priorities before the field season.

Future Targets:

To address these outstanding issues, SOAR intends to request the following:

• Voice and data communication links to be established at the field site prior to the arrival of SOAR field personnel;

• Flight following capability with hourly updates at three locations during flight operations;

• Two alternate landing sites with fuel caches positioned at least 75 km and no more than 200 km away from the Byrd Surface Camp field site;

• The ability to generate weather satellite images for central West Antarctica at the Byrd Surface Camp field site; and

• A DGPS radio tower capable of broadcasting a 3-4 MHz signal to a range of 300 km to be located at Byrd Surface Camp.

III. Technical Support

This appendix covers the interactions of the facility with other organizations which provided technical support. The technical support was provided for the gravity meter and the geodetic GPS receivers.

A. Gravity Meters

Goals:

The goal of SOAR is to secure reliable access to a state-of-the-art gravity meter designed for airborne applications.

Plans and Accomplishments:

Although a number of avenues were pursued for obtaining a gravity meter, the facility efforts this year focused on establishing a long term relationship with the Naval Oceanographic Office (NAVOCEANO) of the U.S. Navy (USN). The accomplishments include:

• Borrowing a NAVOCEANO BGM-3 for use by the facility during the field season; and

• Working with the NSF/ONR Gravimeter Coordination Committee to establish a formal relationship between the USN and NSF to facilitate the use of Navy equipment for academic research projects. A draft Memorandum of Understanding between the NSF and USN has been submitted for final approval.

Issues to Address and Future Targets:

The data acquired by the NAVOCEANO BGM-3 appears to be very good. The resolution of the data could be improved by using a system with a digital platform. The SOAR target for the next field season is:

• Borrowing a BGM-5, an advanced gravity meter with a digital platform, from NAVOCEANO. The integration of this meter into the SOAR acquisition system will require access to the meter prior to field deployment.

B. GPS Systems for Precise Positioning

Goals:

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

Plans and Accomplishments:

A review of available technology prior to deployment by the facility identified two GPS systems which could be used to meet the facility needs. These systems were the Ashtech Z-12 and the Turborogue GPS receivers. The sense of the aerogeophysical community is that the Ashtech has the superior algorithm for tracking satellites during Anti-Spoofing. The decision was made to attempt to obtain both types of systems to ensure that optimal data was acquired. Two organizations, UNAVCO and NASA, were very helpful in these efforts. The accomplishments this year include:

• UNAVCO provided four Turborogues for facility use. Two complete systems were delivered to SOAR in September providing ample time for integration. In addition, they provided critical information on data download and reduction systems and a well thought out package of receiver support equipment. In general, the UNAVCO support was professional and of high quality; their receivers functioned well throughout the season.

• UNAVCO also provided excellent field support for the GPS system via the two engineers stationed at McMurdo. These engineers, provided SOAR with high quality software support, an abundance of practical advice and assistance with cargo. The dedication of UNAVCO to the Antarctic program filled a large hole in USAP technical support.

• Bill Krabill of NASA provided three Ashtech Z-12's to the facility for use during the field season. The equipment was delivered to the facility early enough to ensure proper integration into the aircraft and functioned well during flight operations.

Issues to Address:

• The facility will continue to require access to dual-frequency GPS receivers capable of tracking at one Hz or better in future field seasons. UNAVCO is the ideal organization for supplying this equipment as well as field support. SOAR recommends that Polar Programs continue to support UNAVCO to ensure access to state-of-the-art GPS positioning capability. The ability of Bill Krabill at NASA to lend receivers cannot be predicted for future field seasons.

Future Targets:

• SOAR encourages Polar Programs to develop a formal relationship with UNAVCO to ensure access to well-maintained equipment and excellent field support. A minimum of four dual-frequency GPS receivers capable of tracking at one Hz or better are required for each SOAR deployment.

IV. Cargo Support

This appendix reviews the cargo support provided to the facility.

Goals:

The SOAR cargo goal is to have equipment to the field site in a manner that is consistent with the timetable for configuring and operating the survey aircraft and associated ground support facilities.

Plans:

The facility's plan for the 1994/95 field season was to:

• Have the equipment necessary to set-up the survey aircraft on-site at Byrd Surface Camp before mid-December 1994 and to have all other equipment at the field site before the arrival of the survey aircraft at the end of December; and to

• Transport the gravimeter from CONUS to Byrd Surface Camp with a SOAR escort. The escort is required to ensure that continuous power is supplied to the meter and to repair any failures during transport.

Accomplishments:

The facility cargo movements during the 1994/95 field season are outlined here.

• Cargo deployment accomplishments are shown below in Tables C.2 and C.3. Table C.2 describes the amount of cargo in each of the four SOAR 1994/95 shipments. Table C.3 describes the timing of each of these cargo shipments.

Table C.2: Cargo Summary

Ship#	Number of Pieces:	Total Weight: (lbs)	Total Cube: (ft)
1	20	4036	364
2	14	3761	452
3	14	4102	372
4	08	1520	134

Table C.3: Cargo Timetable

Ship#	Date Shipped: SOAR	Date At: Port Hueneme	Date At: Christchurch	Date At: McMurdo	Date At: Byrd Surface
1	11/22/94	11/25/94	11/30/94	12/05/94	12/14/94
2	11/29/94	12/01/94	12/06/94	12/12/94	12/14/94
3	12/07/94	12/09/94	12/14/94	12/20/94	12/24/94
4	12/14/94	12/17/94	12/22/94	12/28/94	01/04/95

• In addition, SOAR handcarry needs from CONUS to McMurdo Station were 17 pieces at a total of 1,295 pounds and 16 pieces at 1,128 pounds for the return trip.

• The gravimeter used for the SOAR 1994/95 field season was a BGM-3 gravimeter at 322 pounds with two additional travel spares boxes totaling 165 pounds for a total gravimeter weight of 487 pounds. Lee Degalen of NSF with the assistance of ASA arranged to fly the gravimeter on an Air Force C-141 from CONUS to McMurdo. Margaret Lanyon of ASA and Lee Degalen arranged for return transport on an Air Force C-141 from Christchurch, NZ to CONUS.

• Lee Degalen, Brian Stone, and Lawrence Taogaga of NSF/ASA science cargo were extremely helpful in all phases of the SOAR cargo evolution. Our aircraft configuration and operation timetable could not have been met without their assistance.

Issues to Address:

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

• The gravity meter transportation scheme was not reliable for the 1994/95 field season. The meter was bumped from flights. Changing transport arrangements for the gravity meter increases the chances that the system will undergo an expensive failure or that it will become separated from its escort.

• The amount of SOAR handcarry to and from field-sites in Antarctica is too large. This is an inconvenience for the cargo system and the risk of equipment loss and damage is high.

Future Targets:

To optimize resources during the next field season the facility aims to:

• Identify and implement a stable path for the transportation of gravimeters; and

• Reduce of the amount of SOAR handcarry to and from field-sites in Antarctica.

Appendix D: Personnel

SOAR Annual Report
1994/95

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:

The personnel plan for the first year of SOAR activities focused on the following:

• Hiring the core personnel including a technical coordinator, science coordinator, research engineer, senior systems analyst, systems analyst, installation engineer and administrative assistant;

• Augmenting the core personnel with sufficient personnel to accommodate the accelerated field preparation schedule and to allow for around-the-clock flight operations once in the field; and

• Implementing a "flat" management structure composed of groups with specifically defined scopes under the direction of a management team made up of the directors and coordinators. Laboratory groups were to include:

- Geophysical and Navigation Systems (GAN);
- Network Operation and Data Management (NOD);
- Data Acquisition and Quality Control (DAQ); and
- Logistics and Information Management (LIM).

In addition to LIM and NOD, field groups were to include:

- Experimental Design and Flight Support (EDS);
- Flight Operations (FOP); and
- Instrument Maintenance, Installation and Integration (MII).

Accomplishments:

All of the personnel objectives for the first year of SOAR operations were met. This section outlines these accomplishments.

• Upon conclusion of the Cooperative Agreement, Don Blankenship (Ph.D., 1989, Geophysics, University of Wisconsin-Madison) and Robin Bell (Ph.D., 1989, Geophysics, Columbia University) assumed their responsibilities as directors of SOAR and Keith Najmulski (B.S., 1988, Electrical Engineering and Engineering Physics, Ohio State University) was appointed Technical Coordinator. Blankenship and Bell each have about ten years of Antarctic aerogeophysical experience: Their cumulative field experience includes fifteen Antarctic field seasons. Najmulski's experience ranges from ballistic missile manufacturing to polar ice coring but focuses on aerogeophysics. His polar field experience includes six seasons in Antarctica and two in Greenland. He coordinated technical activities for all three CASERTZ field seasons.

• Outstanding candidates were recruited to fill the positions for the remaining core technical staff. These are summarized below.

Science Coordinator - Jeff Williams (M.S., 1994, Geophysics, University of Texas at El Paso) was selected from over forty candidates who responded to a nationwide search. His current focus is applied geophysics but his experience includes a spectrum of activities from physics teaching to a stint as a test director for airborne life-support systems while a captain in the U.S. Air Force.

Research Engineer - Matt Peters (Ph.D., 1994, Electrical Engineering, Ohio State University) joined SOAR immediately upon completion of his Ph.D. at Ohio State University. Peter's research focus was on antennas and wave propagation for airborne applications. He was also one of the early engineers on the CASERTZ project assisting in field preparations and participating in the 1990/91 and 1992/93 field seasons.

Senior Systems Analyst - Scott Kempf (M.S., 1992, Computer Science, University of Wisconsin-Madison) also moved to SOAR from CASERTZ where he had spent one year programming database applications for underway geophysics. His background at the University of Wisconsin includes previous experience as both a lecturer and researcher in systems architecture, programming tools and assembly language applications as well as six years as a network administrator for the Department of Geology and Geophysics.

Systems Analyst - John Gerboc (M.S., 1991, Systems Science, State University of New York at Binghamton) was selected for this position from a pool of several dozen candidates. Gerboc's recent experience is in software development for vision systems. Previous to that he gained substantial experience in avionics and airborne systems while a software engineer at IBM Federal Systems Division. While at IBM he participated in a number of aircraft based field projects.

Installation Engineer - Ken Griffiths (B.S., 1968, Electrical Engineering, Duke University) is a Research Engineer with the Institute for Geophysics who was asked to fill the role of installation engineer for SOAR. His depth of experience in geophysical and navigation systems is matched by very few people in North America. Since his early days working with Maurice Ewing to his work with CASERTZ in the 1991/92 and 1992/93 field seasons, Griffiths has participated in more than ninety marine, land and airborne geophysical field programs.

Administrative Assistant - Wilbert King (B.S., expected 1995, Economics, University of Texas at Austin) was selected from a wide variety of candidates for this position because of his familiarity with computer oriented administration. He has had substantial experience with the development and management of administrative databases as well as University of Texas budgeting. His other experience ranges from election inspector for the Secretary of State to shop foreman in an industrial warehouse.

Laboratory and Field Assistants - Bob Kucks, a system administrator for the Geophysics Branch of the USGS was contracted for the 1994/95 field work and Jerry Bradley, the chief technician for the Geophysics Branch was contracted to assist in field preparation. Bob Kucks participated in the 1991/92 CASERTZ field program and Jerry Bradley, the designer of the DSU, participated in the preparation for all three CASERTZ field seasons as well as the 1990/91 field work.

• The core personnel for SOAR were augmented by a variety of highly qualified people. These are summarized below.

Science Coordinator (augmented) - Carol Finn (Ph.D., 1988, Geophysics, University of Colorado-Boulder) who is a geophysicist at the Geophysics Branch of the USGS was asked to assist Jeff Williams as science coordinator for the 1994/95 field season because of his short training period. Finn has extensive aerogeophysics experience in both North America and Japan and serves as a principal investigator on the WAIS aerogeophysics proposal. She was a participant in the 1990/91 GITARA and 1992/93 CASERTZ aerogeophysics programs.

Senior Systems Analyst (augmented) - Mark Maybee (Ph.D., 1994, Computer Science, University of Colorado-Boulder) was recruited to assist in field networking, data management and systems integration. His background includes over ten years of research experience in software engineering as well as substantial systems programming experience.

Systems Analyst (augmented) - Bob Arko (B.S., 1992, Computer Science, Ohio State University) was also asked to join SOAR for the 1994/95 field preparation and field program. Arko, currently a systems analyst at Lamont-Doherty Earth Observatory (LDEO), has significant field computer experience gained from his long term association with the CASERTZ project both while at OSU and LDEO. He was responsible for network administration during the 1991/92 and 1992/93 CASERTZ field seasons and has contributed substantially to the development of the CASERTZ database for under-way geophysics.

Systems Analyst (augmented) - Maureen Noonan (B.S., 1988, Geology, Rensselaer Polytechnic Institute) of ORCA Technologies was contracted to support the field computer activities for the 1994/95 field season. During six years on the staff at LDEO, she participated in numerous marine, airborne and land-based geological and geophysical field programs including the 1991/92 and 1992/93 CASERTZ field seasons. Noonan's previous CASERTZ experience included the development and operation of the primary quality control environment for the CASERTZ geophysical and positioning systems.

Laboratory and Field Assistants (augmented) - A collaboration with the GITARA aerogeophysics program resulted in the participation of a geophysical technician, Vera Marcinkowski, from the German Geological Survey (BGR) for the duration of this year's field work and the assistance during flight operations of Detlef Damaske a geophysicist at BGR. In addition, Don McNair, a retired geophysical technician at the Geophysics Branch of the USGS with over twenty years of aerogeophysical field experience, was contracted for the 1994/95 field season and three University of Texas undergraduates were employed as laboratory assistants to assist in field preparation.

• The group based management structure was fully implemented beginning with the formation of the management team made up of the Directors, Don Blankenship and Robin Bell and the Technical Coordinator, Keith Najmulski. The management team formed the four laboratory based technical groups (GAN, DAQ, LIM and NOD) as soon as personnel were available. In addition, a group was formed to integrate the activities of the geophysical/navigation systems group and those of the data-acquisition/quality-control group. In an effort to reduce redundancy and prevent mistakes during the compressed field preparation period, all group activities were summarized and disseminated electronically each week and all intra- and inter-group communications were made available on the laboratory network. The resulting efficiencies in communications proved critical to meeting our field preparation timetable.

The activities of the logistics/information management group and the network operation/data-management group were transferred to the field without difficulty and the three planned field groups (EDS, FOP and MII) were successfully formed. There they operated under the direction of a management team made up of a Director, Don Blankenship, Science Coordinators, Carol Finn and Jeff Williams, and Technical Coordinator, Keith Najmulski. The new group structure functioned very efficiently under the stress of around-the-clock flight operations.

Issues to Address and Future Targets:

The core personnel objectives for SOAR were largely met in the first year. The issue and target that remains is given below.

• The enhanced 1995/96 field operations described in the Experiments Appendix (A) will require recruiting four augmented personnel. These include a research engineer, a senior systems analyst, a systems analyst and an installation engineer. It is estimated that the augmented personnel will require two months of training and preparation for the 3.5 month field season.

Appendix E: Facilities

SOAR Annual Report
1994/95

This appendix covers the goals, plans and accomplishments for the SOAR central facility.

Goals:

The goal for SOAR is to optimize efficiency by maintaining one central laboratory site with offices for the core staff, a systems integration laboratory, a staging area, a computing laboratory and data archives. In addition, this central facility needs to accommodate coordinated activities among the SOAR institutions (UTIG, LDEO and USGS) and client science projects.

Plans and Accomplishments:

The plan was to establish this central facility at UTIG within one month of the conclusion of the SOAR Cooperative Agreement. This plan was largely accomplished beginning in August 1994 resulting in a fully functioning central facility (Figures E.1 and E.2) by September. A three-year lease agreement was negotiated for this 7,500 square feet of commercial space in the building that also hosts UTIG. Structural renovations (Figure E.1), power, lighting and wiring for voice and data networks were completed in August. Laboratory and office equipment (Figure E.2) filtered in throughout September. The SOAR central facility was utilized for all 1994/95 field preparations.

Issues to Address and Future Targets:

The central facility as presently configured should be adequate for all SOAR activities over the next three years.

Figure E.1

SOAR Central Facility - Space Allocation

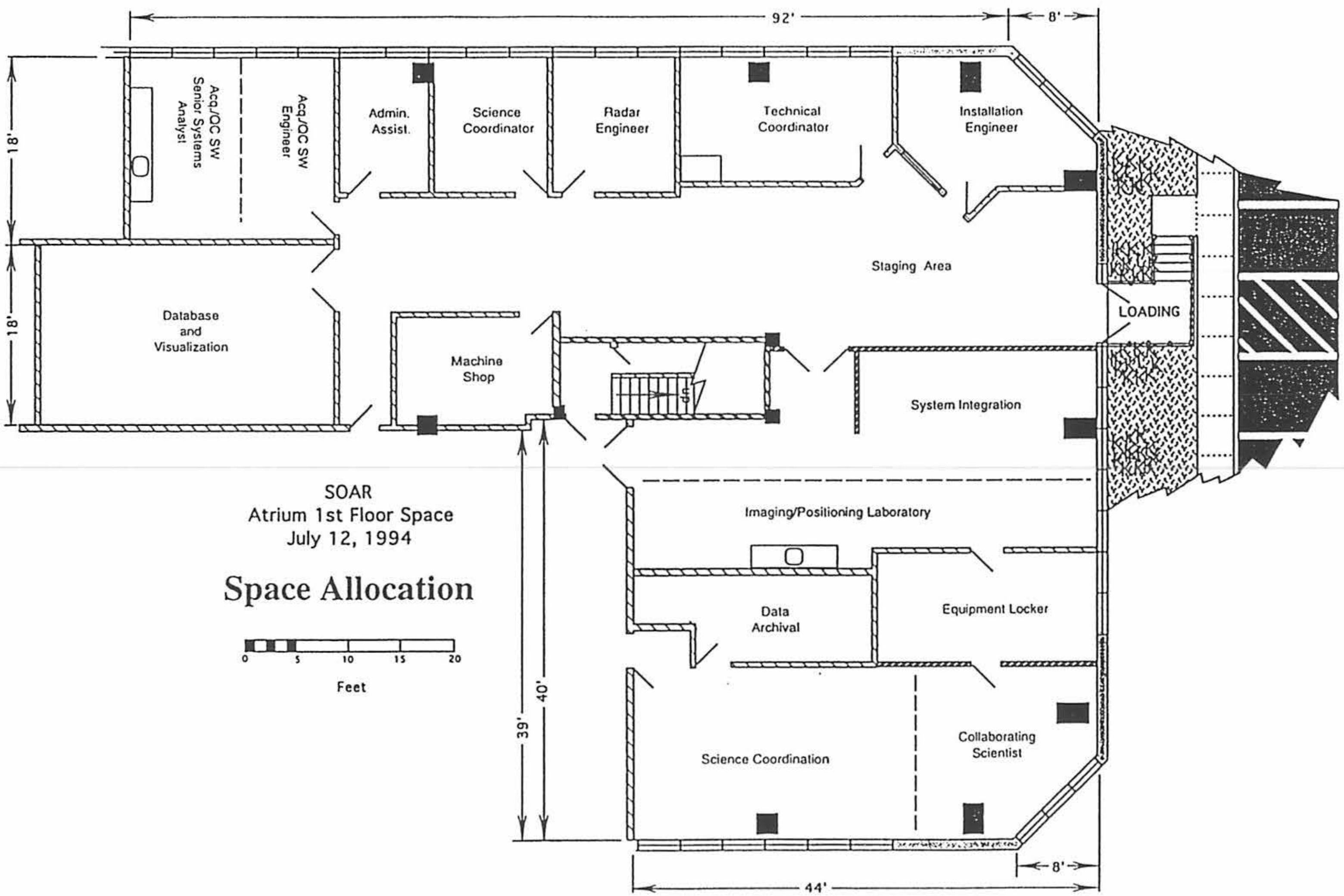
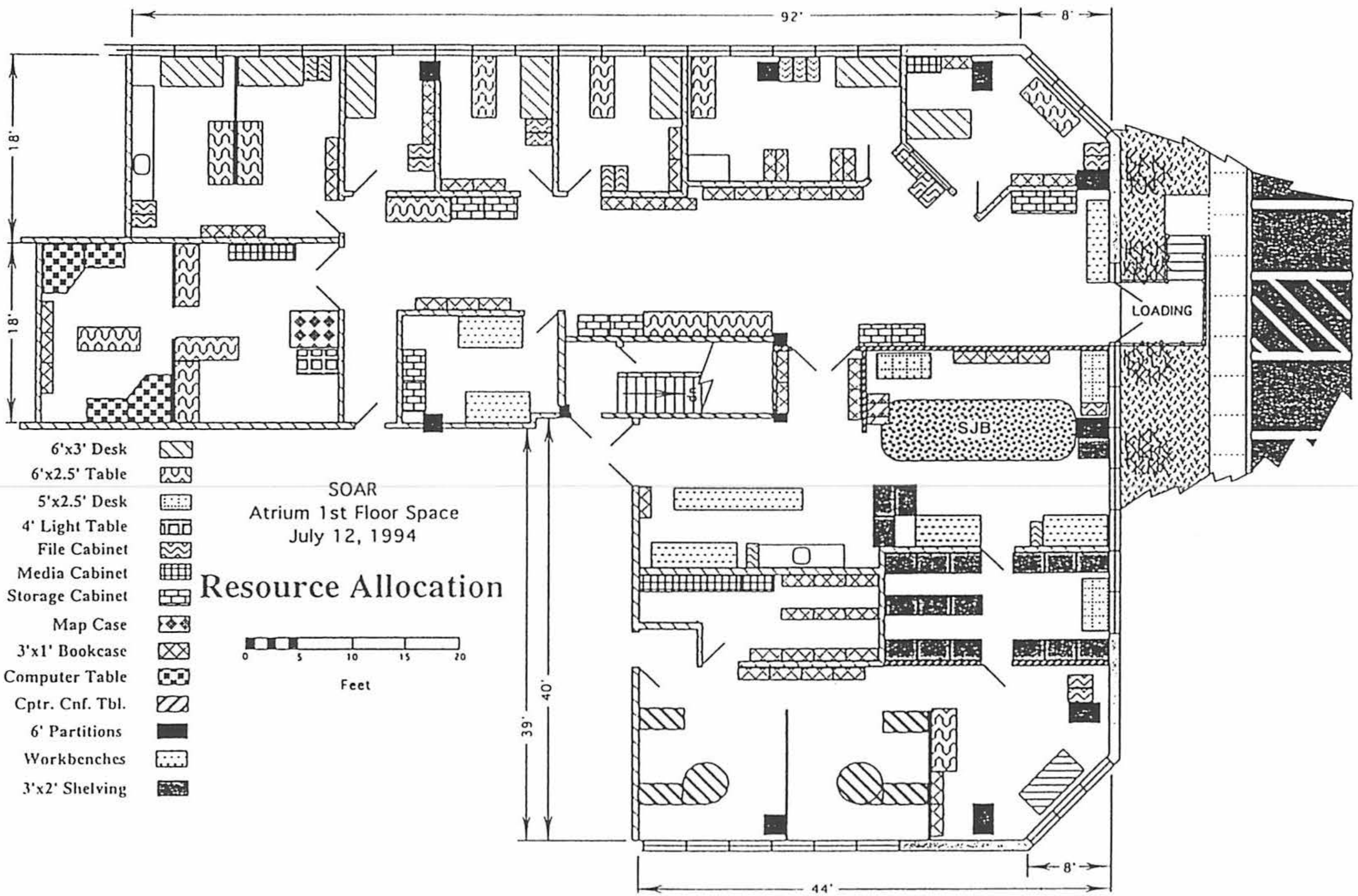


Figure E.2

SOAR Central Facility - Resource Allocation



Appendix F: Finances

SOAR Annual Report
1994/95

This appendix covers the plans, accomplishments and future targets for SOAR finances.

Goals:

The financial goal of SOAR is to support the core staff and physical plant necessary to prepare, configure and operate a geophysical aircraft in Antarctica for a five year period. These activities are to be undertaken for the lowest cost consistent with the data volume and data quality specified in the facility's experimental tasking.

Plans and Accomplishments:

The plan and accomplishments for the first year of SOAR operations are outlined in Attachment F.1 which presents the initial budget estimates and their reconciliation as of the end of April, 1995. The expenditures are in line with the estimates. The biggest shifts were funds moving from Other Personnel (section B) to subcontracts under Other Direct Costs (section G). This is a result of the requirement for augmented personnel described in the Personnel Appendix. The $41,500 over-expenditure in Year I represents two months of each of three core personnel salaries that were moved to the Year II budget as part of the COA negotiations.

Issues to Address and Future Targets:

The financial issues resulting in the Year II budget targets given in Attachment F.2 are:

- the need for augmented personnel described in the Experiment and Personnel Appendix and
- the permanent equipment requirements described in the Technology Appendix.

All other budget targets are similar to those for Year I and the plan to cover the remaining first year core personnel costs from Year II funds remains the same.

Attachment F.1
Year 1 Budget Reconciliation - Institute for Geophysics
08/01/94 - 04/30/95

		Months	Budgeted	Projected Expenditures
A.	Senior Personnel			
	1. D. D. Blankenship	4.0		
B.	Other Personnel			
	2. Technical Coordinator	6.0		
	Science Coordinator	7.0		
	Radar Engineer	7.0		
	ACQ/QC SW Systems Analyst	6.0		
	ACQ SW Engineer	7.0		
	Gravity Engineer	1.0		
	Installation Engineer	2.0		
	Installation Engineer	2.0		
	5. Administrative Assistant	2.0		
	Total Salaries		148,094	153,120
C.	Fringe Benefits		41,720	43,136
	Total Salaries & Fringe Benefits		189,814	196,256
D.	Permanent Equipment			
	1. 3 Power Supplies		15,000	
	2. 3 Acquisition Computers		18,000	
	3. GPS Modem		40,000	
	4. Fiber Optic Network		2,000	
	5. QC Computer		4,000	
	6. Oscilloscope		4,000	
	7. Shipping Containers		6,000	
	8. Printer		4,800	
	9. Workstation		14,000	
	Total Permanent Equipment		107,800	108,621
E.	Travel			
	1. Domestic			
	4 R/T Austin-Golden, CO (Denver)		5,120	
	8 Days Per Diem		1,008	
	2 R/T Austin-Calgary		2,412	
	6 Days Per Diem		756	
	2. Foreign			
	54 Days Per Diem, Christchurch		6,804	
	Total Travel		16,100	13,811
G.	Other Direct Costs			
	1. Materials and Supplies:			
	Field Supplies		4,000	
	Electronics		10,000	
	4. Computer Services		16,500	
	5. Sub-Contracts			
	USGS		30,850	
	LDEO		80,698	
	6. Other:			
	Shipping		18,000	
	Insurance		16,000	
	9 Physicals		5,400	
	Repair/Refurbishment		22,100	
	Copying		800	
	Communications		3,200	
	Lease Payments		67,392	
	Total Other Direct Costs		274,940	308,268
H.	Total Direct Costs		588,654	626,956
I.	**Indirect Costs**			
	22% Excluding Equipment and $61,548 of Sub-Contracts and lease Payments		77,421	84,225
J.	**Total Costs**		666,075	711,181

Attachment F.1
Year 1 Budget Reconciliation - Lamont-Doherty Earth Observatory
08/01/94 - 04/30/95

	Months	Budgeted	Projected Expenditures
A. Senior Personnel			
1. R.E. Bell, Associate Research Scientist	4.0		
B. Other Personnel			
2. Systems Analyst, Bob Arko	3.5		
5. Administrative Assistant, B. Hautau	3.0		
Total Salaries		34,497	34,497
C. Fringe Benefits @33.5%		11,555	11,556
Total Salaries & Fringe Benefits		46,052	46,053
D. Permanent Equipment			
1. Powerbook		2,200	
2. Fax machine		600	
3. Printer		1,200	
Total Permanent Equipment		4,000	4,011
E. Travel			
1. Domestic			
4 R/T New York-Golden, CO (Denver)		2,560	
10 Days Per Diem		1,080	
4 R/T New York - Austin, TX		4,304	
21 Days Per Diem		1,890	
Misc. Ground Transportation		166	
Total Travel		10,000	3,361
G. Other Direct Costs			
1. Materials and Supplies		300	
2. Computer Services *		2,500	
6. Other:			
Shipping		500	
Copying		200	
Communications		3,000	
Physical Exam		275	
Total Other Direct Costs		6,775	8,775
H. Total Direct Costs		66,827	62,200
I. **Indirect Costs** **1st year MTDC = 60,327x53%**		31,972	31,641
J. **Total Costs**		98,799	93,842

*** Not subject to indirect costs.**

Attachment F.1
Year 1 Budget Reconciliation - USGS/Geophysics Branch
08/01/94 - 04/30/95

	Months	Budgeted	Projected Expenditures
A. Senior Personnel			
1. C. A. Finn		N/C	N/C
B. Other Personnel			
2. Electronics Technician,			
J. Bradley	1.5		
Field Assistant	4.0		
Total Salaries			
C. Fringe Benefits		N/C	N/C
Total Salaries & Fringe Benefits		15,500	15,500
D. Permanent Equipment			
1. Computer Storage Disks		2,500	
Total Permanent Equipment		2,500	2,500
E. Travel			
1. Domestic			
2 R/T CO - Austin, TX		1,500	
2. Foreign			
13 Days Per Diem, Christchurch		1,050	
Total Travel		2,550	2,550
G. Other Direct Costs			
1. Materials and Supplies			
Field Supplies		800	
Electronics		1,200	
6. Other:			
Shipping		1,500	
Physical Exam		1,200	
Repair/Refurbishment		5,600	
Total Other Direct Costs		10,300	10,300
H. Total Direct Costs		30,850	30,850
I. **Indirect Costs**		N/C	N/C
J. **Total Costs**		30,850	30,850

Attachment F.2
Year 2 Budget Estimate - Institute for Geophysics
05/01/95 - 04/30/96

			Months	
A.	Senior Personnel			
	1.	D. D. Blankenship	4.0	
B.	Other Personnel			
	2.	Technical Coordinator	9.0	
		Science Coordinator	11.0	
		Research Engineer	11.0	
		Senior Systems Analyst	9.0	
		Systems Analyst	11.0	
		Installation Engineer	3.0	
		Augmented Installation Engineer	2.0	
		Augmented Research Engineer	5.5	
		Augmented Senior Systems Analyst	5.5	
		Augmented Systems Analyst	5.5	
	5.	Administrative Assistant	6.0	
		Total Salaries		280,721
C.	Fringe Benefits			80,005
		Total Salaries & Fringe Benefits		360,726
D.	Permanent Equipment			
	1.	GPS Transceiver		25,000
	2.	Shipping Containers		6,000
	3.	Time and Frequency Domain Analyzers		15,000
	4.	2 In-flight Monitor Computers		12,000
	5.	2 Portable Computers (ION Network)		9,000
	6.	Workstation (RAV Network)		14,000
		Total Permanent Equipment		81,000
E.	Travel			
	1.	Domestic		
		4 R/T Austin-Golden, CO (Denver)		5,274
		8 Days Per Diem		1,040
		2 R/T Austin-Calgary		2,484
		6 Days Per Diem		756
	2.	Foreign		
		66 Days Per Diem, Christchurch		8,624
		Total Travel		18,178
G.	Other Direct Costs			
	1.	Materials and Supplies:		
		Field Supplies		4,120
		Electronics		10,300
	4.	Computer Services		16,995
	5.	Sub-Contracts		
		USGS		31,971
		LDEO		88,269
	6.	Other:		
		Shipping		18,540
		Insurance		16,480
		11 Physicals		6,996
		Repair/Refurbishment		46,100
		Copying		824
		Communications		3,296
		Lease Payments		92,100
		Total Other Direct Costs		335,991
H.	Total Direct Costs			795,895
I.	**Indirect Costs**			
	22% Excluding Equipment, Sub-Contracts and Lease Payments			110,562
J.	**Total Costs**			906,457

Attachment F.2
Year 2 Budget Estimate - Lamont-Doherty Earth Observatory
05/01/95- 04/30/96

		Months	
A.	Senior Personnel		
	1. R.E. Bell, Associate Research Scientist	4.0	
B.	Other Personnel		
	5. Administrative Assistant, B. Hautau	3.0	
	Total Salaries		27,896
C.	Fringe Benefits @33.5%		9,345
	Total Salaries & Fringe Benefits		37,241
D.	Permanent Equipment		
	1. Macintosh Quadra 950		2,782
	Total Permanent Equipment		2,782
E.	Travel		
	1. Domestic		
	2 R/T New York-Golden, CO (Denver)		2,560
	10 Days Per Diem		1,080
	4 R/T New York - Austin, TX		4,304
	21 Days Per Diem		1,890
	Misc. Ground Transportation		166
	Total Travel		10,000
G.	Other Direct Costs		
	1. Materials and Supplies		300
	2. Computer Services *		2,500
	6. Other:		
	Shipping		500
	Copying		200
	Communications		6,000
	Total Other Direct Costs		9,500
H.	Total Direct Costs		59,523
I.	**Indirect Costs**		
	1st year MTDC = 60,327x53%		28,747
J.	**Total Costs**		88,269

*** Not subject to indirect costs.**

Attachment F.2
Year 2 Budget Estimate - USGS/Geophysics Branch
05/01/95 - 04/30/96

	Months	
A. Senior Personnel		
1. C. A. Finn		N/C
B. Other Personnel		
2. Electronics Technician, J. Bradley	1.5	
Field Assistant	4.0	
Total Salaries		
C. Fringe Benefits		N/C
Total Salaries & Fringe Benefits		17,121
D. Permanent Equipment		
1. Computer Tape Drive		3,000
Total Permanent Equipment		3,000
E. Travel		
1. Domestic		
2 R/T CO - Austin, TX		1,500
2. Foreign		
13 Days Per Diem, Christchurch		1,050
Total Travel		2,550
G. Other Direct Costs		
1. Materials and Supplies		
Field Supplies		800
Electronics		1,200
6. Other:		
Shipping		1,500
Physical Exam		1,200
Repair/Refurbishment		4,600
Total Other Direct Costs		9,300
H. Total Direct Costs		31,971
I. **Indirect Costs**		N/C
J. **Total Costs**		31,971

Appendix G: Cooperative Agreement

SOAR Annual Report
1994/95

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.

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
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COOPERATIVE AGREEMENT OPP-9319379

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:

(Signature)

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

8/31/94
(Date)

NATIONAL SCIENCE FOUNDATION
Arlington, VA

ACCEPTANCE:

X
(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.