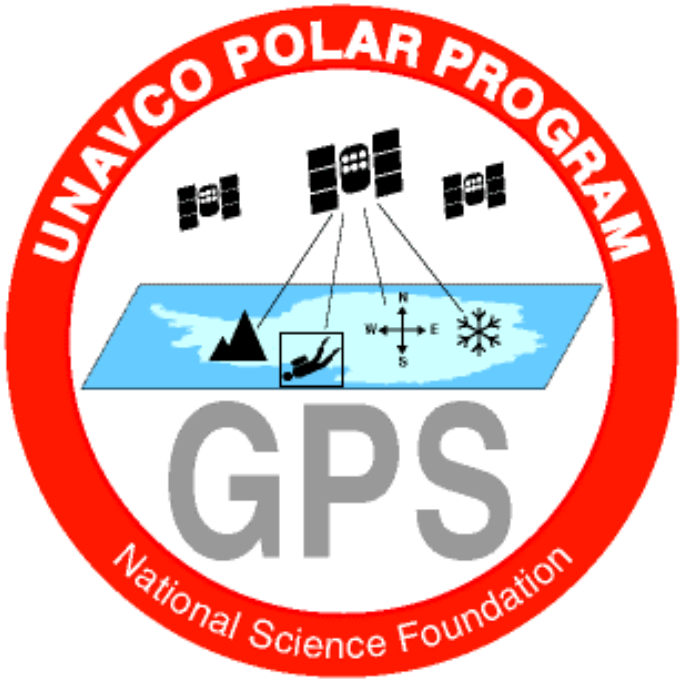
UNAVCO
University NAVSTAR Consortium

GPS Support to the National Science Foundation Office of Polar Programs



1998-99 Season Report

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Table of Contents:

Summary

UNAVCO provides year round support for scientific applications of the Global Positioning System (GPS) to the National Science Foundation's Office of Polar Programs (NSF/OPP) Antarctic Program. This support includes pre-season planning, field support, and post-season follow-up, as well as development work for supporting new applications. UNAVCO maintains a "satellite" facility at McMurdo Station during the austral summer research season, providing a full range of support services including GPS equipment, training, project planning, field support, technical consultation, data processing, and data archiving. A total of 24 projects, encompassing a range of applications, were supported throughout the 1998-99 field season.

14 projects received UNAVCO support as requested prior to the field season. A field engineer was based at McMurdo Station during the entire field season, and an additional seven projects were supported on a resource available basis. Table 1 summarizes projects using UNAVCO support, while Appendix A provides a more detailed discussion of individual project support.

UNAVCO also assisted with the ice runway survey at WINFLY, as the differential GPS station was used for this application for the first time. The DGPS station was upgraded with a dedicated GPS receiver and spare components for year-round operation without the requirement of on-site UNAVCO personnel at McMurdo.

Beginning this season, estimates of support levels to individual projects is based on "total support effort" rather than "receiver days used". The total support effort is expressed as a percent of UNAVCO's total field support effort for the season, and is based on geodetic receiver days used, DGPS receiver days used, technical support required, and equipment damage. This new method provides more representative data for project cost accounting purposes, as requested by NSF.

A substantial re-organization at UNAVCO also occurred in 1998, to enhance scientific coordination among the growing GPS science community. Most significantly, UNAVCO added the position of Scientific Director, whose primary function is to stimulate, strengthen, and coordinate the science emerging from the UNAVCO community. This position was filled by Dr. Seth Stein of Northwestern University based on a competitive international search. Increased emphasis has been placed on improving community communication and outreach. Science information on UNAVCO, including up-to-date activities, technical developments, and an on-line version of the new UNAVCO brochure are accessible through the UNAVCO Web site (Figure 1).

Table 1 - 1998-99 Projects Using UNAVCO Support

Event	Point of Contact	Support Effort (%)	Preseason Request
G-180	Sridhar Anandakrishnan	9	Yes
I-157	Hermann Engelhardt	9	Yes
I-277	Nelia Dunbar	9	Yes
I-169	Ian Whillans	8	Yes
G-063	Mike Prentice	7	Yes
I-163	Charlie Raymond	7	Yes
B-044	Ed Adams	6	No
G-053	Bernard Hallet	5	No
G-121	Bruce Luyendyk	5	Yes
I-156	George Denton	5	Yes
Ice Runway Survey	Jeff Scanniello	5	Yes
UPD Recovery	Steve Dunbar	5	No
G-052	Larry Hothem	4	No
G-058	Ralph Harvey	4	Yes
K-282	Paul Chaplin	3	Yes
B-009	Tom Gelatt	1	Yes
B-017	Randy Davis	1	No
B-042-B	Peter Doran	1	Yes
B-042-F	Andrew Fountain	1	Yes
B-042-M	Diane McKnight	1	No
G-063	Jody Strasser	1	No
G-098	Don Blankenship	1	Yes
E-302	Hunter Lenihan	1	Yes
O-283	George Weidner	1	Yes

Figure 1 - UNAVCO Boulder Facility Web Page

Science Support

Training

UNAVCO offers flexible options in providing field team training, including training before deployment to the field, training in the field, and direct field engineering support during the project. The level of training is tailored to the experience of each group. For the 1998-99 season, all science team training was provided at McMurdo Station or in the field. Training was provided to B-009, B-044**,** G-058, G-063, G-121, I-157, I-277, and O-283.

Simultaneous GPR and GPS Surveys in Taylor Valley (G-063)

Field Support

A field engineer[1] was present at McMurdo Station throughout the mainbody season. The primary responsibilities of the field engineer is managing the large equipment pool and providing technical support to field projects. Direct field support was provided to B-009, B-044, G-053, G-063, I-156, I-157, and K-282. In addition, several projects in the McMurdo area took advantage of the differential GPS system to obtain meter-level accuracy in real-time (B-009, B-017, B-042-F, B-044, G-063, O-283, and E-302).

Data Processing

Post-processing of differential GPS data is necessary to achieve the centimeter level precision required for most projects. UNAVCO supports data processing in the field using the Trimble GPSurvey software, with five packages available for project use this field season. As in previous seasons, an effort was made to ensure that most data processing was completed before field teams (that do not have their own data processing resources) left McMurdo. UNAVCO also continues to provide post-season data processing support, including advanced post-processing techniques for problem data sets. Data processing support was provided in the field to B-044, G-053, G-063, G-098, I-156, I-157, and K-282. Post-season support was also provided to B-042-B, B-042-M, G-053, G-058, I-156, I-157, I-277, and G-180.

[1] Bjorn Johns and Oivind Ruud

Data Archiving

All GPS data handled by UNAVCO are archived, both locally at McMurdo Station and at the UNAVCO Facility archive. The **Geodetic Data** section of the UNAVCO Polar Program web page is the central access point for data from UNAVCO supported Antarctica GPS projects.

Project data are sorted by project event number and Antarctic field season in the UNAVCO archive, ensuring data safeguarding and future accessibility.

Data collected to geodetic standards are archived by site name, and precise site coordinates and site descriptions are readily available. As this database of precise GPS coordinates continues to grow, future projects benefit by having pre-established geodetic control in their field study areas. This season GPS control points were added at sites in Beacon Valley, Coombs Hills, Lake Vanda, and Taylor Valley.

In the near future, graphical access to geodetic data and project meta-data will be added to provide information compatible with broader GIS initiatives, both within USAP and SCAR. Discussions have been initiated with the National Snow and Ice Data Center (NSIDC) to utilize their NSF/OPP supported Antarctic Data Coordination Center. Links between the UNAVCO archive and other appropriate Antarctic GIS databases are encouraged.

Trimble 4800 Receiver on Benchmark at Lake Bonney (B-044)

Equipment

Science Pool

Seventeen geodetic quality dual frequency receivers from the UNAVCO pool (fifteen Trimble 4000 SSE/SSi receivers and two Trimble 4800 receivers) were provided for support throughout the field season. The new 4800 receivers, which feature integral antennas, were borrowed from the UNAVCO pool for field evaluation for Antarctic applications. All necessary ancillary equipment (such as field computers, data processing software, solar panels, batteries, chargers, tripods, and cables) was also provided. Prior to the field season, all Trimble receivers were updated with the most recent firmware.

An assessment of current demand versus resources available indicated a need to provide more USAP owned receivers to the UNAVCO pool. To ensure the ability to meet predicted demand, UNAVCO purchased five new Trimble 4000 SSi GPS receivers for the UNAVCO/USAP equipment pool. This new receiver purchase (part of a UNAVCO community bulk purchase that received a substantial volume discount) brought the number of USAP owned receivers in the UNAVCO pool up to nine. Recommendations for similar equipment purchases will continue in future seasons if necessary after re-assessing equipment pool resources and demand.

Differential GPS Base

New real-time differential GPS (DGPS) equipment was purchased prior to the season, including the dedicated Trimble 4000 SSi base station receiver installed at WINFLY, two extra radio modems, and one Garmin 12XL handheld receiver capable of providing meter level accuracy in real-time. UNAVCO had three DGPS systems available for use around McMurdo Station and in Taylor Valley. Based on the popularity and low cost of the Garmin 12XL, two more Garmin DGPS receivers have been purchased for use next field season.

This season, the DGPS system was used by G-063 at McMurdo and Black Island, B-044 at Lake Bonney, B-042 at Lake Hoare, B-009, B-017, O-283, and E-302 in McMurdo Sound, and for the annual ice runway layout during WINFLY. While the system functioned properly for most of the field season, intermittent problems were detected near the end of the field season. Trouble shooting identified a faulty short-haul modem at the Crater Hill site which caused temporary outages. The modem was swapped with a spare unit. Improving system robustness will be a priority next field season.

The DGPS system is now configured for year-round operation at McMurdo. Technical support and maintenance can be provided by the science technician, who has access to spare components and system documentation. The current science technician, Joe Petit, has two DGPS receivers which can now be used during the winter and spring. The SAR team was also left with a DGPS radio modem for use in the rescue Hagglunds vehicle during the winter.

NASA International GPS Service (IGS) Base

UNAVCO provided a substantial upgrade to the MCM4 GPS station, located at the NASA McMurdo Ground Station facility, as part of UNAVCO's contractual support to the NASA GPS Global Network. Two GPS receivers and a computer were added to the existing GPS equipment in preparation for upcoming low earth orbit (LEO) satellite missions requiring low-latency GPS data from robust ground stations. MCM4 at McMurdo is an important site in the globally distributed IGS network, and data from this site will be used for both LEO satellite orbit determination and weather prediction based on satellite lim soundings of the atmosphere.

Operational Support

ASA Surveying

After the 1997-98 field season, UNAVCO worked with Antarctic Support Associates (ASA) and the U. S. Navy's Space and Naval Systems Warfare Center, Charleston (SPAWAR) to identify GPS equipment necessary for the ASA surveyors to efficiently meet runway survey requirements without having to borrow equipment from UNAVCO. The requirements necessary to ensure compatibility with the UNAVCO DGPS base station were also specified. This equipment, consisting of two Trimble 4800 dual frequency GPS receivers, Trimble GPSurvey data processing software, and radio equipment for real-time operation, was purchased by SPAWAR prior to the field season, and is fully compatible with the GPS equipment used by UNAVCO. Both ASA and UNAVCO benefit from the equipment compatibility as resources are occasionally shared. Support from UNAVCO, including training, consultation, and on-site technical support continues to be available on a "non-interference" basis.

Ice Runway DGPS Survey - WINFLY

Prior to the field season, ASA and UNAVCO equipment compatibility was checked at UNAVCO in Boulder, and Bjorn Johns accompanied ASA surveyor Jeff Scanniello to McMurdo at WINFLY to install the DGPS base station and assist with the initial ice runway GPS surveys. The DGPS system went in smoothly, but a temporary transmitter site (lower on Crater Hill) had to be used as power had been removed from the desired location on top of Crater Hill. Since good line-of-sight is important for the DGPS UHF frequency, some coverage problems were encountered at WINFLY and the transmitter was moved back to the top of Crater Hill at the beginning of the Mainbody season. The initial ice runway stakeout surveys were done entirely with GPS by Johns and Scanniello, and the final high precision surveys were done both with GPS and conventional methods by the ASA surveyors.

UPD Recovery

After an LC-130 Hercules was stuck in a crevasse at UPD, a crevasse-free skiway and camp area were needed to allow additional Hercules landings to bring in salvage personnel and parts. ASA Field Safety Supervisor Steve Dunbar requested differential GPS support from UNAVCO for mapping the area. The U. S. Army Cold Regions Research and Engineering Laboratory (CRREL) provided a ground penetrating radar unit to detect hidden crevasses, and UNAVCO provided differential GPS control for position-tagging radar data and site mapping.

Ice Stream D Crevasse

This operational support was possible due to unanticipated gaps in the UNAVCO science support schedule, including indefinite postponement of support to I-157 at UPD. While at the UPD site, UNAVCO was able to set out and survey a strain grid in support of the I-157 drilling project.

Geographical Information Systems (GIS) Applications

The common element of all GIS activity is the association of geographical coordinates with the input data. The McMurdo DGPS broadcasts combined with handheld DGPS/GIS receivers provides a powerful tool for GIS position data collection. DGPS/GIS receivers, such as the Trimble GeoExplorers available from UNAVCO, are capable of recording attribute information along with position data. This allows for accurate digitization of features such as roads, cracks, buildings, ice holes, instrument locations, area boundaries, etc. The data can be output as standard GIS files, both for use with the Trimble Pathfinder Office GIS software available from UNAVCO, or for use with common GIS software including ArcView and ArcInfo.

During the summer, UNAVCO attended an initial GIS meeting at ASA to discuss the fixed wing landing site GIS pilot project. While the immediate goals of the project do not involve field collection of GPS data, ASA staff were interested in learning more about how GPS is used for GIS data collection. As a result, UNAVCO provided a two day GPS/GIS course in Boulder to several ASA employees to demonstrate the capabilities of UNAVCO's DGPS equipment at McMurdo and Taylor Valley.

UNAVCO maintains an internal database of GPS project data and benchmark coordinates for the Antarctic, and plans to make this information accessible on the web through a new graphical interface following NSF/OPP and SCAR meta-data standards. Discussions have been initiated with NSIDC to include these data with the Antarctic Data Coordination Center. As ASA's GIS efforts evolve, some of this information is appropriate for inclusion, particularly field project meta-data and geodetic benchmark descriptions and coordinates. This has been discussed with ASA, and UNAVCO plans to continue GIS discussions with ASA and other involved parties such as All Points GIS. UNAVCO is available for technical consultation and encourages cooperation to support McMurdo GIS efforts.

Appendix A - Detailed Summary of Support Provided

B-009 (Donald Siniff)

Field project leader Tom Gelatt requested GPS support to better locate radio transmitter equipped seal positions relative to each other and to Big Razorback Island. The shoreline of the island was digitized using the GeoExplorer DGPS system, creating a geo-referenced outline suitable for GIS applications. Seal positions could then be plotted on this map, either by hand or as DGPS positions. Big Razorback Island has been the operational base for the B-009 Weddell seal census study for many years, and this year's GPS efforts were to aid the study of how male seals maintain their spatial relationships through the season.

B-017 (Randy Davis)

A Garmin DGPS receiver was provided to Lee Fuiman for a meter-level survey of the relative positions of field camp structures on McMurdo Sound. This support is an example of the benefits of using the Garmin handheld GPS receivers with the DGPS station; meter-level surveys in McMurdo Sound are now performed directly by investigators using familiar handheld GPS receivers, with no post-processing required.

B-042-B (Peter Doran)

Dr. Doran requested GPS support for several applications near the Lake Hoare field camp. Due to last minute field plan changes, B-042-B chose not to do any geodetic level GPS field work during the season, and UNAVCO did not support this project with geodetic equipment. Prior to the field season, data processing support was provided to Dr. Doran for outstanding data sets collected during the 1997-98 field season.

B-042-W (Bob Wharton)

DGPS equipment was provided to research assistant Andy Parsons to measure soil sample locations in Taylor Valley. This was during the period of intermittent DGPS broadcasting at the end of January, and DGPS corrected positions were not collected.

B-042-F (Andrew Fountain)

Dr. Fountain requested GPS support to obtain precise coordinates to measure positions and topography on the Canada Glacier. Due to other field season priorities, the field team was initially uncertain whether or not they would have time for the desired GPS surveys. Near the end of the field season, other commitments both by UNAVCO and B-042-F prevented coordination to perform the desired work. Some GPS surveying support was provided by the ASA surveyors, using their new GPS equipment.

Two handheld DGPS receivers were provided to field assistant Paul Langevin for glacier elevation surveys and other use in Taylor Valley. These receivers worked well for the initial surveys, but later in January the intermittent DGPS broadcasting trouble prevented some collection of differentially corrected positions.

B-042-M (Diane McKnight)

Data processing assistance was provided at UNAVCO to graduate student Peter Conovitz to process data collected during the 1997-98 field season. The data, collected as continuous kinematic files, digitized three Taylor Valley streambeds including the “relict channel” where water flow was routed back to an old streambed to observe the effect on algae bloom.

B-044 (Chris Fritsen)

UNAVCO supplied two Trimble 4800 GPS systems, data processing software, in-field training, and data processing support to co-PI Ed Adams. The equipment was used in kinematic mode, and the sled mounted rover unit was towed across several profiles of Lake Bonney to digitize the wind-blown surface roughness of the lake ice and provide a surface measurement method of ice thickness. Repeat surveys are planned for future seasons to attempt to measure the effect of surface topography on annual lake ice melting which directly affects the lake biosystem. One existing benchmark at the Lake Bonney camp was surveyed and added to the UNAVCO benchmark. The project data are archived at UNAVCO.

A DGPS radio modem was also provided to the project to use with their field Garmin GPS receiver to achieve meter level coordinates of soil sample locations, using DGPS corrections from the Peak 1882 repeater.

G-052 (Jerry Mullins)

One Trimble SSE geodetic receiver was provided to Larry Hothem to augment equipment used for the Transantarctic Mountains Deformation (TAMDEF) GPS project.

G-053 (Bernard Hallet)

GPS support was provided to measure surface displacements in Beacon Valley, which may occur due to sub-surface ice in the valley floor. UNAVCO provided two geodetic receivers, field assistance, and data processing support for this effort. A local TAMDEF survey mark was used for the reference receiver location. Survey marks were placed in valley floor boulders which were surveyed using the static survey method. UNAVCO also provided all post season data processing to produce the final geodetic results for this first epoch survey.

G-058 (Ralph Harvey)

GPS support was provided to obtain precise coordinates for the survey reference marks at both the Graves Nunatak and Allen Hills research areas. Field researcher John Schutt received a brief training at McMurdo and was provided one Trimble 4800 receiver. Upon his return to McMurdo, UNAVCO archived the data. After the field season, UNAVCO also post-processed data from the current and past seasons, using the JPL Auto-GIPSY point-positioning automated data processing service.

G-063 (Michael Prentice)

Geodetic GPS receivers and a data processing computer were provided to position tag ground penetrating radar (GPR) data recorded at several dry valley locations during a pilot project by the University of New Hampshire and CRREL. By simultaneously using GPR and GPS, the GPR profiles of underlying stratigraphy can be accurately referenced to surface features and locations. The GPS equipment was also used to obtain geo-referenced control for GIS applications. UNAVCO also provided training to field assistant Anders Klarhall, field assistance, post-processing support, and data archiving.

G-063 (Jodie Strasser)

A DGPS GeoExplorer receiver was provided to meet a last minute request for geodetic survey support to mark GPR survey grids at Winter Quarters Bay and near Black Island. At the time of the request, UNAVCO technical assistance was not available, but the meter-level real time positions from the GeoExplorer receivers were adequate for the project. UNAVCO provided brief training, GPS/GIS data handling software and documentation, and technical support.

G-098 (Donald Blankenship)

G-098/SOAR requested UNAVCO technical support to process data from GPS base station locations at Siple Dome and the South Pole. UNAVCO post-processed the data at McMurdo to provide accurate reference coordinates to use with the airborne surveys.

G-121 (Bruce Luyendyk)

Prior to the field season, Dr. Luyendyk requested UNAVCO assistance with field site reconnaissance, site installation, and data retrieval associated with continuous GPS site installations in Marie Byrd Land. Due to the remoteness of the project and anticipated time required in the field, support to this project required the scheduling of overlap between UNAVCO staff at McMurdo. After reviewing project plans, available resources, and field logistics at McMurdo in late November, co-PI Andrea Donnellan informed UNAVCO that field assistance was no longer required. As a result, no field support was provided. One Trimble 4800 receiver was provided to the field team to collect geodetic data from existing benchmarks.

I-156 (George Denton)

UNAVCO supplied GPS equipment and in-field support for static and kinematic surveying in Wright Valley and Coombs Hills. Topographical profiles were digitized with kinematic GPS surveys, and control points to geo-reference satellite imagery were surveyed in static mode. UNAVCO also provided data post processing and archiving. One new benchmark was installed at Coombs Hills. This project was conducted in cooperation with the ASA surveyors who also provided GPS equipment.

I-157 (Hermann Engelhardt)

GPS support was requested to measure ice stream velocities at the UPD hot water drill site. A strain grid was laid out and surveyed by UNAVCO during the LC-130 recovery effort in early December. This grid included both lateral and longitudinal components to measure both shear and elongational strain in the vicinity of the drill site. The survey was repeated in late January, providing the desired velocity information. In addition, the field team was provided with a geodetic receiver to measure several daily positions at the camp in an attempt to detect daily ice stream velocity variations that may be caused by tides or seasonal fluctuations. This receiver was not set up until late December when the science team was in the field, and data from this survey required advance post-processing using both Bernese and GIPSY software. Data archiving and all data processing were completed by UNAVCO.

I-163 (Charlie Raymond)

I-163 was provided two Trimble SSE receivers for geodetic control while conducting radio echo sounding to measure internal layering and thawed zones outside the shear zones of ice stream B and E and across the flow band that feeds ice stream D.

I-169 (Ian Whillans)

Dr. Whillans was provided two Trimble SSi GPS receivers and GPSurvey data processing software to measure shear margin strain of several West Antarctic ice streams. The field team was also provided GPSurvey data processing software which was shipped to The Ohio State University prior to the field season. The data were archived by UNAVCO upon project completion.

G-180 (Sridhar Anandakrishnan)

Prior to the field season, Dr. Anandakrishnan was provided with a GPS receiver at Pennsylvania State University for development work to integrate the GPS data stream with Reftek seismometer data. UNAVCO provided GPS consultation during this development, verifying that quality GPS data were being logged. The field team shipped the receiver to McMurdo and installed it with the Antarctic Network of Unattended Broadband Seismometers (ANUBIS) site at Siple Dome. The receiver was removed from the station at the end of the field season.

I-277 (Nelia Dunbar)

Dr. Dunbar was provided three Trimble SSE GPS receivers and GPSurvey data processing software for precise survey applications at Mt. Takahe in Marie Byrd Land, including kinematic surveys of sub-glacial/sub-aerial lava flow boundaries. Due to the remoteness (and no possibility of mid-season re-supply), a spare GPS receiver and antenna were supplied. Refresher training was provided at McMurdo prior to field party deployment, and the data were archived upon the field party's return. A data processing computer and software, as well as processing consultation, were provided after the field season for data processing by the PI at the New Mexico Institute of Technology.

K-282 (Paul Chaplin)

Two Trimble 4800 receivers and field assistance were provided to Antarctic Heritage Trust representative Chris Jacomb to survey the locations of historical artifacts at Cape Evans. These positions were used for a detailed site map. UNAVCO also provided data processing and archiving after the field work.

O-283 (Charles Stearns)

A DGPS Trimble GeoExplorer receiver was provided to Robert Holmes to survey accurate locations of Automated Weather Station sites around McMurdo sound. Precise elevations of these sites was desired to better use the meteorological data. The positions were collected by the field team using the DGPS broadcasts for corrections. Most of the sites were surveyed successfully, but a few surveys were unsuccessful due intermittent DGPS operation at the end of the season.

E-302 (Hunter Lenihan)

DGPS was used at WINFLY to relocate dive hole locations above benthic research sites which were surveyed during the previous field season. The field team was also provided a Garmin DGPS receiver to survey dive sites during the season.

Ice Runway Survey (Jeff Scanniello)

After last field season, UNAVCO worked with ASA surveyor Jeff Scanniello and SPAWAR to specify new GPS survey equipment (Trimble 4800) for the ASA survey department. This equipment, needed by ASA to meet more stringent runway survey requirements, was selected based on suitability for the surveyors, compatibility with UNAVCO pool equipment (to facilitate sharing of resources), and compatibility with the UNAVCO DGPS system. UNAVCO also purchased the necessary equipment to leave the DGPS base station operational year round. Bjorn Johns accompanied Scanniello to McMurdo at WINFLY to set up the DGPS base and support the initial ice runway surveys, using GPS for the first time. With the DGPS base station now in place, it can be utilized for future surveys without UNAVCO personnel at McMurdo. UNAVCO also provided equipment and assistance for surveying the edge of the McMurdo Ice Shelf using GPS from a helicopter.

UPD Recovery (Steve Dunbar)

After the LC-130 Hercules was stuck in a crevasse at UPD, a crevasse-free skiway and camp area was needed to allow additional Hercules landings to bring in salvage personnel and parts. ASA Field Safety supervisor Steve Dunbar requested differential GPS support from UNAVCO for mapping the area. CRREL provided a ground penetrating radar unit to detect hidden crevasses, and UNAVCO provided differential GPS control for position-tagging radar data and site mapping.