THE SCAR GEODETIC INFRASTRUCTURE OF ANTARCTICA

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BACKGROUND

The scientific exploration of Antarctica has been the composite result of many nations research, not just the activities of a single individual nation. Contemporary scientific research in Antarctica began in earnest during the second International Geophysical Year in 1957/58. At that time the Scientific Committee for Antarctic Research (SCAR) was formed to coordinate and promote cooperation in scientific research through discipline based scientific working groups. In 1958 SCAR established a working group on Geodesy and Cartography to promote a joint approach to the positioning and mapping needs of Antarctic field scientists.

GEODETIC SURVEY

Traditionally the positioning of geographic features on the Antarctic continent and measurement of baseline distances to neighbouring southern continental land masses was only achievable from astronomical observations or local trigonometric surveys on exposed rock. But with the advent of artificial geodetic satellites it was possible to begin to apply space geodesy techniques to the problem of linking the isolated geodetic surveys together and the measurement of intercontinental baselines.

In 1969 the American Pageos global campaign of using ballistic cameras to photograph balloon satellites against a stellar background was extended to Antarctica with several rock sites occupied during that winter (Reece and Brownd 1977). This passive Pageos satellite project was soon followed in the early 1970s by the introduction of the active microwave Tranet Navstar navigation systems employing Doppler techniques for post processed positions (Anderle 1977). This technology was subsequently utilised in Antarctica for Geodesy, Glaciology, and mapping for more than a decade, when it began to be replaced by the application of the developing Global Positioning System in 1988

SCAR WORKING GROUP ON GEODESY AND GEOGRAPHIC INFORMATION

The Scientific Committee for Antarctic Research (SCAR) was formed at the Hague in March 1958 to coordinate the scientific research of nations active in Antarctic during the third International Geophysical Year (IGY) 1957-58. The SCAR objective was to coordinate cooperative Antarctic scientific research and a series of specialist working Groups were established to meet this objective. It was soon realised that scientific researchers needed maps and positions to assist them in their field activity and to document their work in a largely unknown continent. Six months later the SCAR Working Group on Geodesy and Cartography was created to facilitate this work. In 1988, the name was changed to the Working Group on Geodesy and Geographic Information (WG -GGI) to better reflect its total scope of activities.

The early Geodesy objectives of the WG-GGI were to provide a control base for exploration and mapping using celestial techniques or limited area survey triangulations. It was not possible to measure accurate baseline between continents or to connect widely separated local triangulations with the technology available at the time.

With advent of artificial geodetic satellites these connections became possible using space Geodesy techniques. The first Antarctic space geodesy programs were the initiatives of individual countries as part of more extensive global programs, and no coordinated international geodetic program yet existed on the Antarctic continent. In 1976 the SCAR WG-GGI began to look at the possibility of linking the individual national geodetic networks by Doppler techniques and work commenced on gathering the extent of each nations geodetic networks with view to a joint approach, but due to logistic limitations no overall plan was implemented.

The positional accuracies achievable from the developing geodetic techniques are summarised in Table 1 below.

Period	Technique	Baseline accuracy
1950s	Positional Astronomy	1 kilometre
1969-70s	Satellite/Stellar photography (PAGEOS)	10 metres
mid 1970s	TRANET Doppler	2-3 metres
late 1980s	GPS	1 metre
1990	VLBI	1 decimetre
1995	GPS	1 decimetre

Table 1 : Approximate accuracies on Antarctic baselines

THE SCAR GPS CAMPAIGNS

Despite the early GPS work by Counselman (1981) producing promising potential for accurate geodetic survey, it was not until the late 1980's that GPS emerged as a geodetic tool with a potential for Antarctic. The XX meeting of SCAR in Hobart 1988 endorsed a proposal by Australia to test the developing GPS technique for mapping control and Geodesy applications in monitoring crustal motion.

SCAR 1990 GPS Campaign

Australia arranged the initial GPS geodetic quality field observations in Antarctica, drawing on non-geodetic applications for ice surface motion the previous year (Allison 1989). The data gathered in the January 1990 campaign consisted of data from five different receiver types. It included data from the Cooperative International GPS network (CIGNET) program which was observing in the Southern Hemisphere at the same time. This resulted in a network of stations in Antarctica, Australia, and New Zealand.

Station	Observing Authority	Receiver Type	Location
McMurdo	USGS	WM102	S77 51 E166 41
Davis	AUSLIG	Trimble 4000SLD	S68 34 E77 58
Law	AUSLIG	Trimble 4000SLD	S69 23 E76 23
Mawson	AUSLIG	WM102	S67 36 E62 53
Dovers	AUSLIG	WM102	S70 14 E65 51
Hobart	U. TAS	MiniMac	S47 48 E147 26
Orroral	AUSLIG	TI4100 Gesar	S35 38 E148 56
Yaragadee	AUSLIG	TI4100 Gesar	S29 02 E115 21
O'Higgins	IFAG	TI4100 Navigator	S63 19 E57 54
Punta Arenas	IFAG	TI4100 Navigator	S53 09 E71 00
Wellington	DOLIS	Trimble 4000SLD	S41 16 E174 47

Table 2: GPS observational sites 1989/90

Initial computation was carried out using the Berne precision software to produce the first intercontinental GPS baseline measurements from Antarctica. (Govind at al 1990). The results showed acquisitions problems with the design of the equipment and difficulty was encountered with ionospheric instability from the high level of solar sunspot activity. However the trial clearly showed that baseline accuracies in the order of one metre over intercontinental distances were possible even with the low number of GPS satellite available at the time.

SCAR 1991 GPS Campaign

The second phase of the pilot study was undertaken the following summer in January 1991, and was synchronised with the first seven days of the first GPS IERS and Geodynamics Experiment 1991 (GIG 91) global campaign. Data from the sites shown below were processed using the GAMIT software and the results indicated that precisions of the order of 1 part in one hundred million were achievable (Morgan and Tiesler 1991).

- Mawson
- Dovers
- Georg Von Nuemayer (ice station)
- O'Higgins
- Terra Nova Bay
- McMurdo

SCAR 1992 GPS Campaign

A major observational SCAR GPS campaign was implemented in January 1992. Its objective was to produce definitive baselines between rock sites in Antarctica and intercontinental ties between Gondwanaland continental fragments. . The project involved twelve nations in the observation of twenty-eight stations in three phases for sites located in Antarctica and on the surrounding southern continents and islands as in Table 3 below. The campaign was successful and processed in GAMIT at the University of Canberra.

Site Location	Country	Lat	Long	Receiver Type	Start	End
Amundsen Scott	USA	90 00 S		Ashtech LD XII	01-Jan	21-Jan
Buenos Aires	Argentina	34 36 S	58 27 W	T141OO (7 chnl)	01-Jan	21-Jan
Byrd	USA	80 01 S	119 32 W	Ashtech LD XII	01-Jan	21-Jan
Casey	Australia	66 17 S	110 32 E	Trimble 4000 SST	01-Jan	21-Jan
Davis	Australia	68 35 S	77 58 E	Trimble 4000 SST	01-Jan	21-Jan
Deception Island	Argentina	62 59 S	60 42 W	Trimble 4000 SLD	01-Jan	21-Jan
Dumont D'Urville	France	66 40 S	140 01 E	Ashtech LD XII	21-Feb	26-Feb
Gnangara	Australia	31 47 S	115 52 E	Ashtech LD XII		
Grunenhogna	South Africa	72 02 S	02 48 W	Trimble 4000 SST	01-Jan	21-Jan
Hartebeesthoek	South Africa	25 53 S	24 42 E	Rogue	02-Jan	21-Jan
Heard Is	Australia	53 01 S	73 24 E	Trimble 4000 SST	23-Feb	26-Feb
Kerguelen Island	France	49 21 S	70 12 E	Ashtech LD XII	06-Jan	22-Jan
Mawson	Australia	67 36 S	62 52 E	Trimble 4000 SST	01-Jan	21-Jan
Mc Murdo	USA	77 51 S	166 41 E	Ashtech LD XII	01-Jan	21-Jan
Nordenskioldsbasen	Sweden	73 03 S	13 24 W	WM102	01-Jan	21-Jan
O'Higgins	Germany/Chile	63 19 S	57 54 W	Trimble 4000 SST	01-Jan	21-Jan
Orroral	Australia	35 38 S	148 56 E	TrimbIe 4000 SST	21-Feb	26-Feb
Port Kembla	Australia	34 29 S	150 55 E	Trimble 4000 SST	16-Jan	20-Jan
Rio Grande	Argentina	53 43 S	67 45 W	Trimble 4000 SLD	01-Jan	12-Jan
Smithfield	Australia	34 40 S	138 39 E	Tl 4100/7chnl	01-Jan	21-Jan
Sydney	Australia	33 50 S	151 16 E	Ashtech LD XII	16-Jan	21-Jan
Syowa	Japan	69 00 S	39 35 E	Trimble 4000 SST	01-Jan	21-Jan
Tahiti	France	17 27 S	149 34 W	Rogue	01-Jan	21-Jan
Terra Nova Bay	Italy	74 42 S	164 06 E	Trimble 4000 SST	01-Jan	16-Jan
Thevenard	Australia	32 09 S	133 39 E	Trimble 4000 SST	16-Jan	20-Jan
Tidbinbilla	Australia	35 24 S	148 59 E	Rogue	01-Jan	21-Jan
Townsville	Australia	19 18 S	146 52 E	Trimble 4000 SST	01-Jan	26-Feb
Ushuaia	Argentina	54 49 S	68 19 W	Trimble 4000 SLD	17-Jan	21-Jan
Wellington	New Zealand	41 16 S	174 47 E	Trimble 4000 SST	01-Jan	21-Jan
Yaragadee	Australia	29 03 S	115 21 E	Rogue	01-Jan	21-Jan

Table 3: GPS observational sites 1992 field campaign

SCAR 1993 and 1994 GPS Campaigns

Despite their success, the GPS campaigns were logistically costly and it was difficult to arrange occupation of all sites at the same time with differing nations being subject to different logistic arrangements. Consequently in 1993 permanent GPS sites were installed to provide fundamental fiducial stations to link epoch surveys together. The permanent stations were :

- McMurdo
- Mawson and
- Amundsen-Scott (ice station)
- Casey
- Davis
- Macquarie Island

This was a significant technological advance as it provided a potential continuous time series of observations and a network of key sites to used as a control framework for temporary occupations at different times. In 1994 permanent GPS trackers were also installed at :

- O'Higgins
- Syowa
- Kerguelen

SCAR 1995 GPS CAMPAIGNS

In 1995 Germany took over coordination responsibility from Australia for the summer epoch campaigns beginning with the GAP95 survey, principally focused on the geodynamics of the Antarctic Peninsula

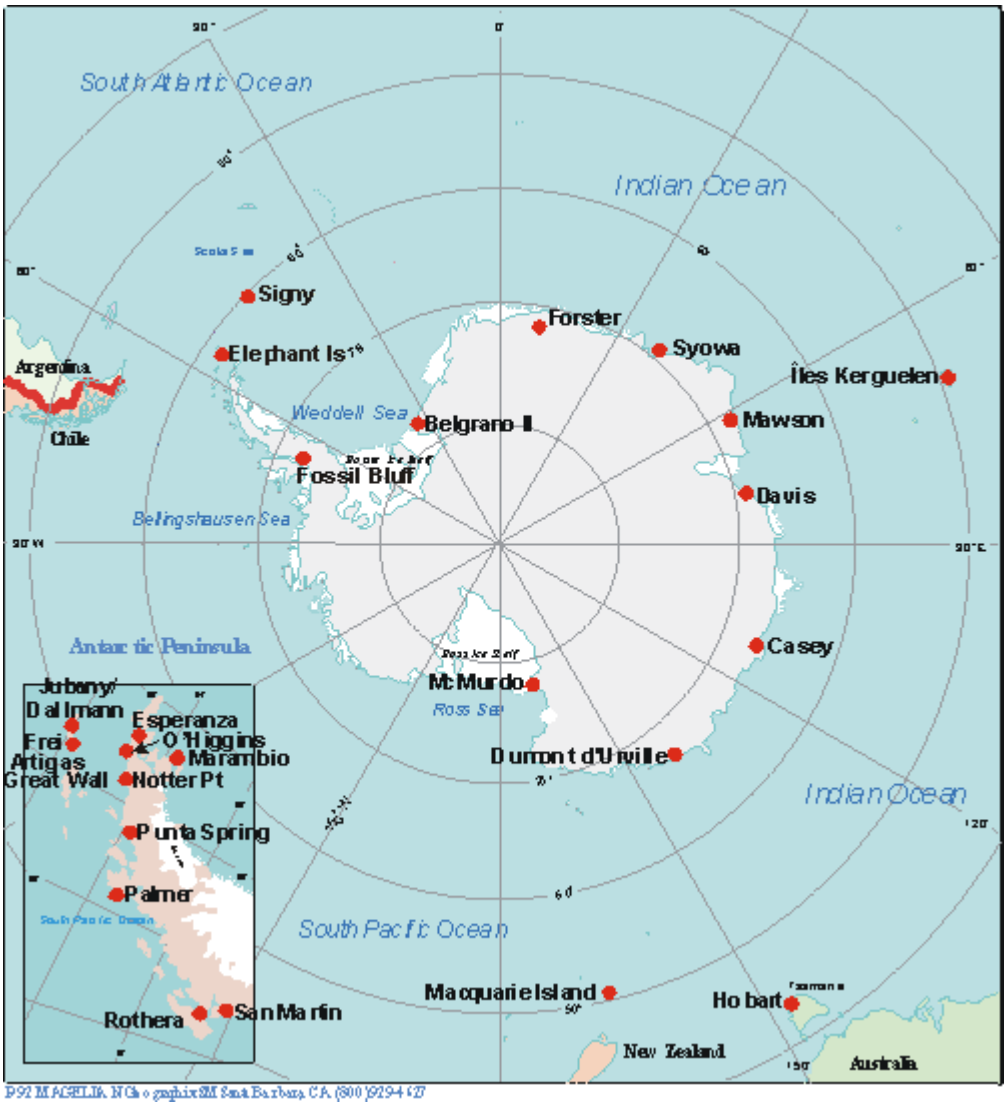

Figure 1. GAP95 Observational Sites

Results of the GAP95 campaign are published in Dietrich (1996). Germany has continued to coordinate the ongoing summer epoch campaigns. The sites occupied in each phase are

summarised below

4-ID	Station name	Station owner	95	96	97	98	99
ARCT	Arctowski	Poland					x
ART1	Base Artigas	Uruguay	x	x	x	x	
BEL1	Belgrano	Argentina	x				
BELG	Belgrano	Argentina				x	
CUR1	Curitiba	Brazil	x	x			
DAL1	Jubany/ Dallmann	Argentina/ Germany	x	x	x	x	
DALL	Jubany/ Dallmann	Argentina/Germany				x	x
DUM1	Dumont d'Urville	France	x	x			
ELE1	Elephant/Gibbs Islands	U.K.	x			x	
ESP1	Esperanza	Argentina	x	x		x	
FAL1	Falkland	U.K.	x			x	
FOR1	Forster	Germany	x			x	
FOR2	Forster	Germany		x			
FOS1	Fossil Bluff	U.K.	x	x		x	
GOUG	Gough Island	South Africa				x	x
GRW1	Great Wall	China	x		x	x	x
GRY1	Grytviken	U.K.				x	
HAAG	Haag Nunatak	U.K.		x			
HAR1	Hartebeesthoek	South Africa	x	x		x	
KOH1	Kliment Ohridski	Bulgaria				x	
KOTA	Kottas Berge	Germany				x	
MAR1	Marambio	Argentina	x	x		x	
MON1	Montevideo	Uruguay	x	x	x	x	x
NOT1	Notter Point		x			x	
OHG1	O'Higgins	Chile/Germany	x	x	x	x	
PAL1	Palmer	U.S.A.	x	x		x	
PALM	Palmer	U.S.A.				x	x
PET1	Peter I					x	
PRA1	Arturo Prat	Chile	x	x		x	
PUN1	Punta Arenas	Chile	x	x		x	
RIG1	Rio Grande	Argentina	x				
ROT1	Rothera	U.K.	x	x		x	
SAN1	Santiago	Chile	x				
SAN2	Santiago	Chile				x	
SIG1	Signy	U.K.	x			x	
SMR1	San Martin	Argentina	x			x	
SPR1	Punta Spring	Chile	x			x	
SYO1	Syowa	Japan	x				
SYOG	Syowa	Japan		x			x
TNB1	Terra Nova Bay	Italy		x		x	
TROL	Troll	Norway			x		
VER1	Vernadsky	Ukraine				x	
VESL	Sanae	South Africa				x	x
WASA	Wasa	Sweden			x		
ZSS4	Zhong Shang	China			x	x	x

Table 4. GPS sites occupied in SCAR Epoch campaigns 1995-1999

THE GEODETIC INFRASTRUCTURE OF ANTARCTICA (GIANT) PROGRAM

At the XXII SCAR meeting in 1992 , a proposal for a Geodetic infrastructure of Antarctica (GIANT) program was endorsed. The objective was to establish a precise network of points on rock sites across Antarctica, connected by space geodesy techniques which would enable existing all data on local geodetic datums to be directly related to produce a common geographical spatial data infrastructure. This was collectively identified as the Geodetic Infrastructure for Antarctica (GIANT) program.

GIANT program objectives:
The GIANT program objectives are to :

- Provide a common geographic reference system for all Antarctic scientists and operators.
- Contribute to global geodesy for the study of the physical processes of the earth and the maintenance of the precise terrestrial reference frame
- Provide information for monitoring the horizontal and vertical motion of the Antarctic.

This geodetic infrastructure will enable earth science investigators involved in individual disciplines (such as geodynamics, oceanography, geophysics, glaciology and geodesy.) to monitor temporal changes in horizontal and vertical positions, including sea level, relative to a fixed geocentric reference system traceable over a period of decades. The geodetic network will provide the spatial framework for use by scientists based on rock sites and as a reference platform for moving ice cap studies.

Implementation and development of the GIANT program has continued since 1992 and there are now seven key elements in the GIANT Program. These elements are summarised below for the current period 1998 to 2000.

1. **Permanent Geodetic Observatories** (Project Leaders: John Manning, Australia, Hans Werner Schenke, Germany)

Goal: To develop an infrastructure of permanent geodetic stations to bring all individual geodetic networks to a common datum, and to provide geodetic information for the global monitoring of natural earth processes.
Key activities:

- Collaborate with other SCAR scientists to identify requirements for space geodetic sites In conjunction with SCAR working groups design an extended network of continuous geodetic observatories;
- for manned stations
- for remote locations
- Support continuation of O'Higgins VLBI for scientific purposes and as an important contribution to the global reference frame
- Establish priorities for on-line satellite data retrieval from ground stations
- Deliver regular space geodesy solutions to IGS and IERS
- Post details of all permanent sites on web site
- Develop and publish GPS base station specifications
- Evaluate accurate local ties between collocated techniques
- Facilitate tide gauge data to Southern Ocean Sea Level Centre

2. **GPS Epoch Campaigns** (Reinhard Dietrich, Germany, Andres Zakrajsek, Argentina, Kevin Dixon, UK, Michel Le Pape, France, E Dongchen, China, Hector Rovera, Uruguay, Alessandro Capra)

Goal: To densify the geodetic infrastructure established from the permanent observatories. This will includes links to individual geodetic networks, tide gauges and the computation of surface movement vectors within a common Antarctic reference frame.
Key activities:

- Establish guidelines for ground mark monuments

- Co-ordinate annual epoch campaigns
- Arrange orderly data archive and data access from these campaigns
- Undertake GPS connections to Tide gauge benchmarks
- Deliver results to ITRF in conjunction with results from permanent observatories
- Notify results of each campaigns occupations

3. Physical Geodesy (Alessandro Capra, Italy, Lars Sjoberg, Sweden, Andres Zakrajsek Argentina, Hans Werner Schenke, Germany, John Manning, Australia)

Goal: Collection and analysis of physical geodesy data, for the development of a new high resolution Geoid for the Antarctic.
Key activities:

- The collation of extensive data holdings related to topography, bathymetry and gravity as essential inputs to Geoid computation, includes:
- Data collection and analysis of gravity related data ground/airborne/satellite data.
- Collect relevant data from satellite altimetry
- Collaboration with International Geoid Service (IGES) and International association of Geodesy (IAG)
- Collaboration with SCAR WGs Solid Earth Geophysics, Geology, Glaciology
- Collaboration with BEDMAP, ADGRAV, RAMP as data for Geoid computation
- Participate in the ADMAP meeting and Earth Science in Antarctic, NZ, in 1999
- Preparing data base of information from collated information prior to computation
- Evaluation of EGM96 improvement over OSU91 in Antarctica
- Facilitate computation of improved tidal models
- Prepare for computation of high resolution Geoid model
-

4. GLONASS Evaluation (John Manning, Australia, Larry Hothem, USA)

Goal: Evaluate the benefit of GLONASS for global geodesy, Antarctic geodesy and navigation applications in Antarctica.
Key activities:

- Participate in the International GLONASS Experiment (IGES) pilot project with dual frequency GLONASS instruments at IGS collocated sites
- Retrieve data by satellite for analysis
- Analyse GLONASS orbits, reference frame differences and ground positions for geodesy and navigation applications in Antarctica
- Participate in presentation of IGEX results 1999
- Report on use of GLONASS for Antarctic Geodesy and navigation.

4. Differential GPS Base Stations (Larry Hothem, USA, Hans Werner Schenke, Germany, IHO, Kevin Dixon, UK, Jan Cisak, Poland, Alessandro Capra, Italy)

Goal: To increase the utility of Geodetic GPS base stations by making DGPS corrections available for radio transmission for scientific field and operational use.
Key activities:

- Identify global standards for use in marine DGPS transmission using Geodetic base stations
- Develop options for base station sites for shipping navigation coverage of Antarctic Peninsula.
- Examine DGPS for real time kinematics and aviation applications in Antarctica and combination with geodetic accuracy base stations
- Liaison with COMNAP regarding transmission of GPS corrections at base stations.

5. **Remote Geodetic Observatories** (Larry Hothem, USA, Alessandro Capra, Italy, John Manning,
   Australia)

Goal: To deploy GPS equipment at unattended remote Antarctic localities for regional densification of geodetic infrastructure, and for scientific studies of surface geodynamics. This requires remote power input and data retrieval. This technology is not quite available at present and needs further development.
Key activities:

- Monitor and report on use of solar, wind and other methods of power generation for data logging information at remote GPS sites
- Monitor developments for remote retrieval of GPS data from remote sites by satellite communication techniques
- Collaboration with non-SCAR researchers

6. **Information Access** (John Manning, Australia, All members of GIANT program)

Goal: To publicise and distribute results of GIANT activities to the general Antarctic community.

Key activities:

- Prepare general papers on GIANT activities for publication.
- Ensure ready access to data from permanent observatories from host databases
- Establish cross links from WG-GGI web site to individual geodetic sites
- Develop DIFs for geodetic data in conjunction with JCADM
- Establish newsletter/newsgroup communication for information distribution on Web
- Monitor web posting of photo identifications on web sites
- Continue interaction with representatives on SCAR working Groups
- Develop IAG Commission X sub Commission on Antarctic Geodetic networks
- Publish WGS84-ITRF information paper and circulate within SCAR (SCAR Bulletin)
- Arrange an Antarctic Geodesy Symposium (AGS99) in Europe at the time of IUGG

CURRENT ACTIVITIES OF THE GIANT PROGRAM

The activities of the GIANT Program are reviewed every two years by the Working Group during the SCAR meetings. An interperiod symposium or business meting is also usually held. Work has coninued in alldefined elements since the SCAR meeting in Concepion in July1998.

The WG-GGI website (www.scar-ggi.org.au/geodesy/giant.htm) has been populated with details of the current status of Antarctic Geodetic observatories illustrating:

- Permanent GPS installations
- Permanent Tide Gauge installations
- Absolute gravity fundamental sites
- DORIS sites
- VLBI sites

These are shown below as extracts from the WG-GGI web site

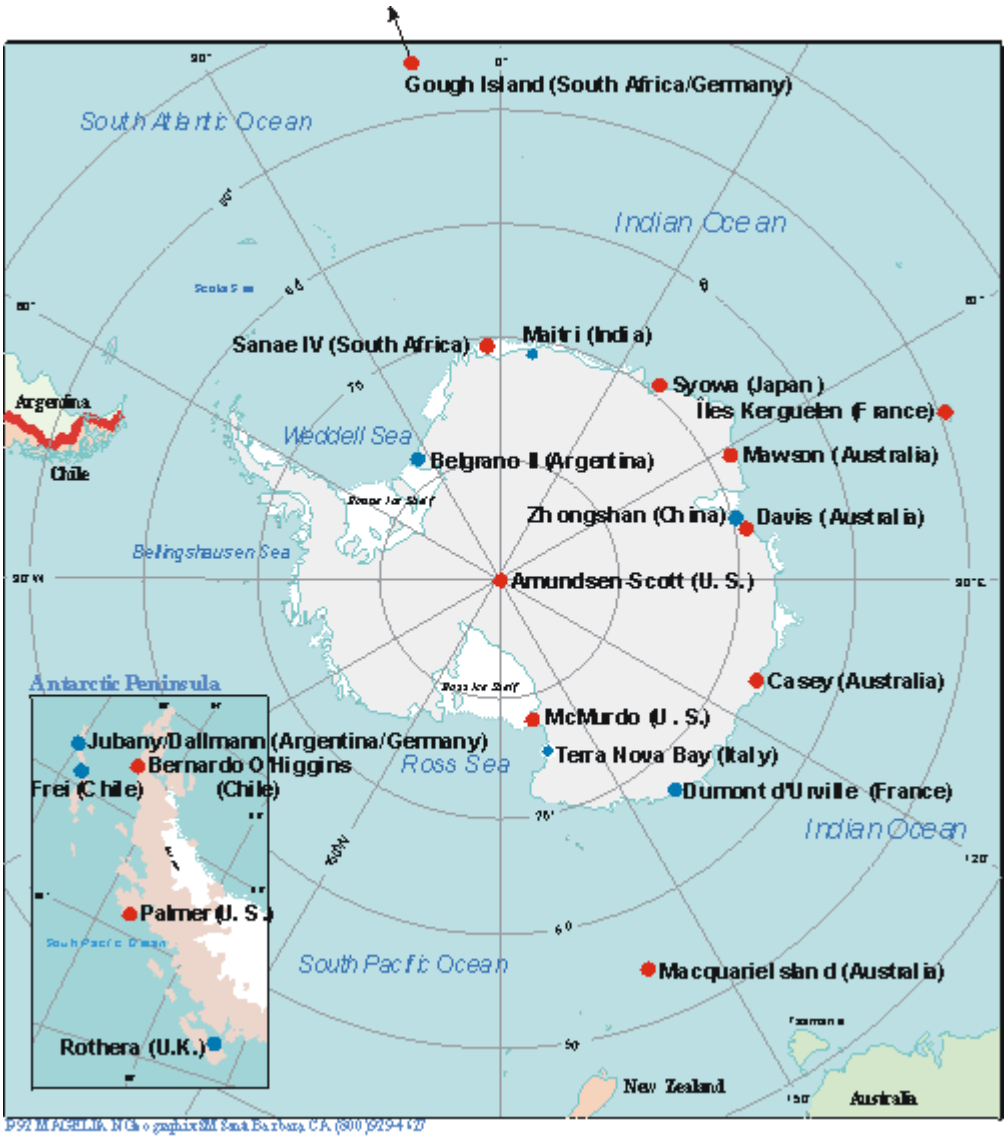

Figure 2 Continuous GPS installations

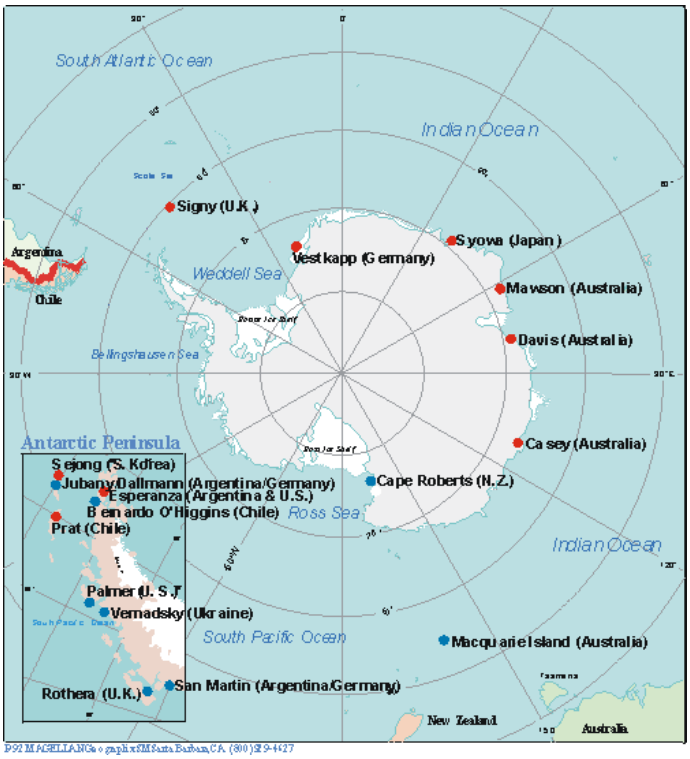

Figure 3: Tide Gauges

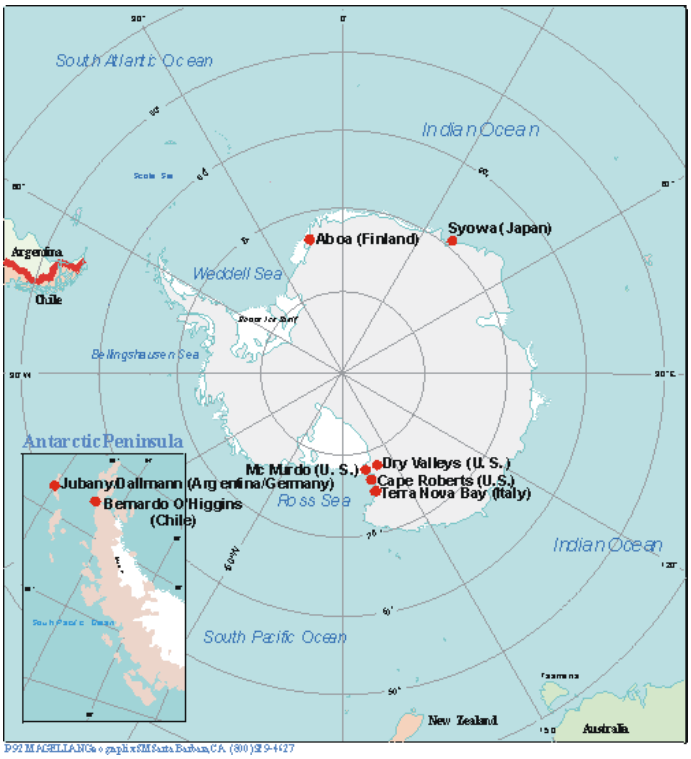

Figure 4: Absolute gravity sites

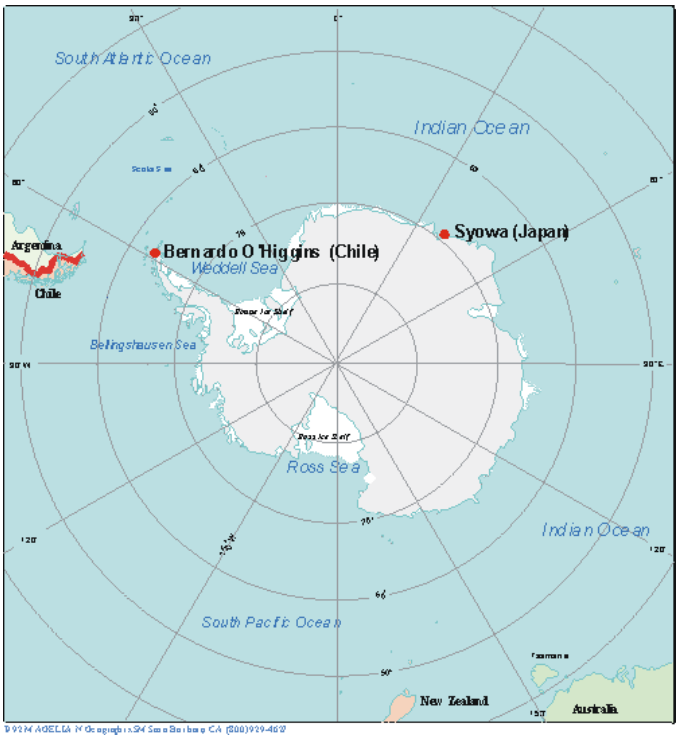

Figure 5: DORIS sites

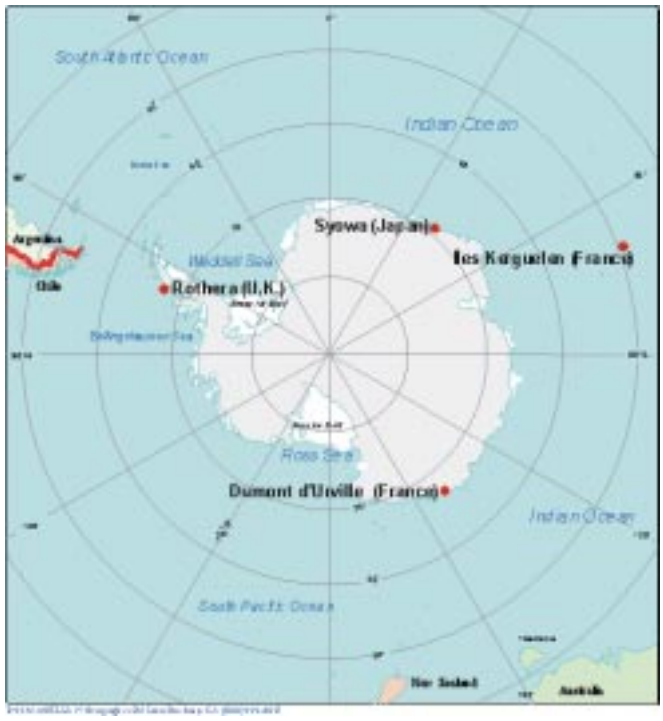

Figure 6: VLBI sites

The current activities of GIANT can be summarised as :

Permanent sites
Antarctica is important in a global geodesy sense. Global Geodesy models have heavily relied on observations from Northern Hemisphere sites and the results do not always fit in the Southern Hemisphere or represent the best global picture. Antarctic geodetic observatories provide data to rectify this imbalance with some continuous GPS sites using satellite data retrieval systems to make their data available to the IGS database. Data is available from other sites only by annual manual downloads. The status of the permanent observatories is shown in figure 2 as extracted from the WG-GGI web site

Epoch campaigns
Germany coordinated the GPS Epoch campaigns for the past five years of summer epoch camapigns 1995 to 1999. The objective has been to densify the ITRF reference frame points beyond the fiducial network of permanent GPS stations. Details of the 1995 campaign are given in Dietrich et al (1997) and the sites occupied that time are shown in Figure2 above**.** The complete list to sites occupied during the five year period is summarised in Table 4 . Dat is available through Dr Dietrich at University of Dresden (Dietrich@ipg.geo.tu-dresden.de)

Geoids
An accurate definition of the geoid is severely constrained in Antarctica by the lack of gravity information, especially across the inland of the continent. . Australia produced early versions of the Antarctic Geoid based on GEM and OSU gravity data sets, which are available on the AUSLIG web site http://www.auslig.gov.au/geodesy/antarc/antgeoid.htm. The current situation with the geoid in Antarctica remains hampered by the continuing lack of ground gravity data.. A grid of geoidal separation values initially from the OSU91A geopotential model and subsequently from the recent EGM96 that can be used to interpolate a separation value for any location south of 60 degrees latitude are available on the AUSLIG webs site for individual interpolation
These enable GPS users to refer their observed elevations (ellipsoidal values) to a nominal sea level surface, although the values are limited by the amount of data used in the Antarctic region
The gathering of geophysical data to improve the Antarctic Geoid is a major undertaking. Data collection is being undertaken cooperatively with other groups through the newly formed SCAR Neo Antarctic Group of Specialists (ANTEC) and the BEDMAP, ADGRAV and RAMP projects.

GLONASS
GLONASS observations undertaken in collocation with GPS at McMurdo in January /February 1999. Results seminar will be held as part of ION 99 conference in Nashville in September.
Report on Antarctic applications will be prepared following this seminar.

DGPS applications
The current DGPS standard for base stations used by the United States Coastguard base stations is the specification recommended for use in the GIANT Program. Details are available on the web site (www.navcen.uscg.mil/dgps/dgeninfo/dgpsant.htm). The WG-GGI has investigated the

establishment of DGPS transmission base stations along the Antarctic Peninsula . With three sites distributed as below then DGPS accuracies of better than two metre would be made available to all shipping along the Eastern side of the Peninsula a significant safety measure. The recommended sites are :

- King George Island
- Palmer
- San Martin or Rothera

This would also produce a significant benefit for aviation in the region and could be used by scientists for field work with hand held receivers. Eventually this DGPS transmission network would be extended through liaison with COMNAP to other manned stations around the continent during shipping or aviation activities.

The current DGPS standard for base stations used by the United States Coastguard base stations is the specification recommended for use in the GIANT Program. Details are available on the web site (www.navcen.uscg.mil/dgps/dgeninfo/dgpsant.htm).

Remotely operating GPS sites

At present there is a technological limitation on operating and maintaining remote placed continuous GPS equipment to be self powered and able to transmit data back to manned bases or directly by satellite to global data centres. Technological developments are continuing and ANTEC has arranged a special seminar at Pasadena USA in August to discuss the state of the technology for remote power and data transmissions for remote sites.

Antarctic research symposia

There have been a number of recent Antarctic Geodesy events held including:

- AGU San Francisco December 1998
- EUG10 Strasbourg March 1999
- EGS 99 The Hague April 1999

There will be an Antarctic Symposium arranged in conjunction with ANTEC during the European Geophysical Symposium in Italy in April2000 and a splinter GIANT meeting may be held at that time to incorporate Scandinavian and Russian geodesists.

Group of Specialists on Antarctic Neotectonics (ANTEC)

At the SCAR XXV meeting in Concepcion, Chile, Prof. Dalziel, IUGS Delegate, presented to Delegates a joint recommendation from the Working Groups on Geology, on Solid-Earth Geophysics, and on Geodesy and Geographic Information, that SCAR should establish a new Group of Specialists on Antarctic Neotectonics (ANTEC). The presentation highlighted some unique aspects of the Antarctic continent such as:

- It lies at the centre of a lithospheric plate that, unlike any other, is almost entirely surrounded by spreading ridges and, furthermore, has been essentially in a polar position for the last 100 million years;
- It appears to lack the intra-plate seismicity that characterises all other continents;
- It includes at least one intra-plate rift system, stretching from the Ross Sea to the Weddell Sea, that has unique characteristics including possible implications for the stability of the West Antarctic Ice Sheet.; and

- It is covered by the only extant continent-scale ice sheet, which applies unusual stresses to the crust.

The presentation emphasised the current development of new technologies that are making possible new studies in geodynamics and neotectonics. These provide an opportunity for earth scientists and allow Antarctica to be placed more precisely in the global framework. (SCAR Bulletin 133, April 1999). The WG-GGI has strong representation on the ANTEC as shown in table 4 below.

Member	Country	Field of Expertise	Email Address
Dr Terry J Wilson (Convenor)	USA	Tectonics	wilson.43@osu.edu
Dr Robin E Bell	USA	Gravity, Geology	robinb@ldeo.columbia.edu
Dr Alessandro Capra	Italy	Geodesy, Gravity	alessandro.capra@mail.ing.unibo.it
Dr Reinhard Dietrich	Germany	Geodesy	dietrich@ipg.geo.tu-dresden.de
Dr Jesus M Ibañez	Spain	Seismology	ibanez@iag.ugr.es
Dr Tom S James	Canada	Glacial rebound	james@pgc.nrcan.gc.ca
Mr John Manning	Australia	Geodesy, Remote sensing	johnmanning@auslig.gov.au
Dr Andrea Morelli	Italy	Seismology	morelli@ingrm.it

Table 5 ANTEC Membership

Collocation with other geodetic techniques
GPS is a major technique in use in Antarctica but for global observations collocation with other techniques is important such as DORIS, Absolute Gravity, Tide Gauges, and VLBI

The first Antarctic VLBI experiment was observed at Syowa in 1991 (Kurihara et al 1991) using a temporary configuration. A permanent installation was established by Germany at the Chilean base of O'Higgins in 1993 and has participated in a number of southern hemisphere campaigns. (Bosworth 1993), (Seeger 19994). Japan refurbished the antenna at Syowa as a permanent installation in 1998 and experiments between other sites in Australia and South Africa are continuing, whilst O'Higgins continues to be operated during the summer months.

Absolute gravity sites have been established in Antarctica by Finland, Italy, Japan, and by the USA in the McMurdo region. A super conducting Gravimeter has been in operation for four years at Syowa.

Permanent recording tide gauges have been deployed at a number of sites including Mawson, Syowa, Cape Roberts, Davis and Casey and O'Higgins.

DORIS beacons are operational at Syowa, Kerguelen, Rothera and Dumont Durville. To date Satellite Laser Ranging has not been undertaken in Antarctica, but there are plans to incorporate it in the future.

CONCLUSION

The GIANT program can make a significant contribution to the work of earth scientists in Antarctica such as in the ANTEC program. GPS and other precise geodetic observations have been made over a number of years and already provide a reference framework for geodynamics. These current movement velocities are available at a number of for comparison with long term geophysical records. An extended network of GPS sites is being developed in conjunction with ANTEC for occupation when the technology permits to contribute contemporary velocities to give a better understanding of the crustal motion both within Antarctica and in relation to the southern hemisphere land masses.

The geodetic infrastructure also provides the base linkages to consolidate individual geodetic networks into a single geodetic datum so that all spatial data dependent on geodetic positions can readily be integrated into an Antarctic Spatial Data base

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