ANTARCTIC GEOGRAPHIC DATA INTEGRATION (AGDI)
“BRINGING IT ALL TOGETHER”

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ABSTRACT  As digital data of Antarctica is being collected and created at an ever increasing rate, the usefulness of these data for research, GIS analysis and planning has been increasing.

Currently there is no formal standard for these datasets to meet, which causes difficulties in integrating data from different sources. Feedback from scientists and researchers is that in order to perform any kind of GIS analyses on basic and fundamental datasets they need to have access to both: standardised and integrated data (a digital data product) and the ‘raw’ data in localised areas (a data library). Up until now there has been no coordinated approach or program to acquire, or even access fundamental datasets.

The Antarctic Geographic Data Integration (AGDI) project is about bringing it all together, that is, to facilitate the availability of integrated fundamental GIS data for Antarctica through both a data product and a data library.

This paper describes what AGDI is, why have it, what its aims are, details on the different components of AGDI and the status of various projects involved in the collection of fundamental datasets. It also briefly outlines what may happen to AGDI developments and a future work program.

1 What is AGDI?

At XXIV SCAR meeting in Cambridge, in August 1996, the Working Group on Geodesy and Geographic Information (WG-GGI) agreed to a new geographic data project, termed ‘geographic data integration’. The initial task was to “develop a SCAR proposal for the collection, integration and publication of fundamental geographic datasets of

1) Bathymetry
2) Surface Elevation
3) Bedrock Elevation
4) Coastline
drawing on existing SCAR, national and international programs”

At XXV SCAR meeting in Conception, in July 1998, the Working Group agreed to the following goal for the project - Antarctic Geographic Data Integration (AGDI): to facilitate availability of integrated fundamental GIS datasets (including surface elevation, bedrock elevation, bathymetry, coastline and features) over Antarctica, through liaison with other programs and international agencies, for use by global change researchers and other scientists.

Further consultation with users in May 1999, in Hobart, Australia, resulted in a modification of the aims of the project. The most significant changes were the introduction of the “Data Library” and “1:5 000 000 scale product” concepts.

2 Why have AGDI?

The SCAR WG-GGI has identified a growing number of digital datasets from SCAR member
countries that are being or could be used in re-
search, GIS analysis and planning. Currently there
is no formal standard for these datasets to meet,
thus causing difficulties in integrating data from
different sources. There is no coordinated approach
or program to acquire, or even access fundamental
datasets. In some cases there is an unnecessary du-
plication of data. In terms of examining data, often
it is collected for a single project and could have
limited or no access available.

The seven fundamental datasets (Fig. 1) WG-GGI
has identified are considered by the scientific com-
munity to be the building blocks for further re-
search.

There is a wide range of other scientific disci-
plines for which improved fundamental datasets for
Antarctica would be a major benefit. These include:
1) glaciology - improved coastline, bathymetry
and surface elevation interpretation,
2) gravity - improved interpretation of gravity/
geoid anomalies,
3) geophysics - improved models of isostasy and
sea level.

Other users to benefit would be:
1) Logistics personnel / planners,
2) the education sector - schools, universities, etc.

3 What are the aims of AGDI?

In May 1999, in Hobart, Australia, a meeting of
Australian Antarctic scientists was held to discuss
the AGDI project.

The meeting altered the focus of the project
slightly with a distinction being made between
those researchers who wish to access the raw data
for modelling purposes (generally in a small and
contained region) and those who would like stan-
dardised, integrated data on a continental-wide scale
provided for them. Glaciologists, for example, may
alternate between modelling in small areas (like the
Amery Basin) and running the same models over a
continental-wide dataset, depending on the type of
research they are conducting.

As a result of the Hobart meeting the aims of
AGDI were revised to the following:
1) defining a standard data model for Antarctic
geographic data, to enable integration of fundamen-
tal GIS datasets,
2) promoting the data model and facilitate the
availability of data through the creation of “data li-
braries” containing all and the best available funda-
mental data. [These libraries will be accessible from
the AGDI web site and metadata records held in
the Antarctic Master Directory.]
3) creating a standardised and integrated
1:5,000,000 scale product containing all seven funda-
mental GIS datasets. The product will be made
available on the web and on CD-ROM.

4 Data library model

For the dataset to be considered for inclusion in
the AGDI Data Library (Fig. 2), it should, ideally, be compliant with the Data Type, Access, and Metadata characteristics outlined in Table 1 below.

5 1:5 000 000 product

In order for a fundamental dataset to be considered for inclusion in the AGDI 1:5 000 000 product, Fig. 3 ideally it should be compliant with all of the proposed specifications outlined in Table 1.

In order to be consistent with similar small scale projects around the globe it is proposed that the AGDI 1:5 000 000 scale datasets be based, where possible, on the Global Map specifications. BAS have already created and delivered a 1:1 000 000 scale Antarctic data for the Global Map project.

ISO TC211 standards are still being worked up, on, with a number of AGDI, nominated standards being at either the Committee Draft stage or Draft International Standard stage.

Table 2 summaries the status of the ISO projects the AGDI project is interested in.

| Theme | Geographic Data | Data | Directory | Access | Quality | Maintenance | Standards |
|-------|----------------|------|-----------|--------|---------|-------------|-----------|
| Datum | Reference Model | Profiles | Spatial Referencing by Coordinate | Quality | Metadata | Imagery & Gridded Data | ISO TC211 compliant for the following profiles: |
| AGDI | Reference Model | Profiles | Spatial Referencing by Coordinate | Quality | Metadata | Imagery & Gridded Data | ISO TC211 compliant for the following profiles: |
| AGDI | Reference Model | Profiles | Spatial Referencing by Coordinate | Quality | Metadata | Imagery & Gridded Data | ISO TC211 compliant for the following profiles: |
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Table 1 Proposed specifications for AGDI 1:5 000 000 product

Source: AGDI Web site <http://www.scar-ggi.org.au/geog/agdi/reports/table1.htm>
Current Status of Antarctic Digital Database (ADD) (in June 2000)
Revision of the 1993 published data continues. Spurious data identified by Byrd Polar Research Centre (being used for RAMP) is being corrected. Also data that was incorrectly positioned and missing features have been corrected. Inland areas have been updated with ERS-1 data plus selected areas on the coast where imagery has been available.

More Information on ADD
Home Page-British Antarctic Survey
How ADD is performing against the proposed AGDI specifications.

Data:
- WGS84

Data:
- Vector data. The source data for Version 3.0 were at 1:5 000 000; the vector datasets provided are at data capture scales and a generalized version at 1:1 000 000 scale only. Other generalized datasets, at 1:5 000 000, 1:10 000 000 and 1:30 000 000 scales, will be released as resources allow.

Directory:
- Metadata record in the BAS Metadata Management System. No entry in the Antarctic Master Directory.

Access:
- Version 2.0 of ADD is available on the WWW. Registration with BAS is required to download the data.

Fig. 2 Coastline data library from AGDI web site

Fig. 3 Example of information found on AGDI web site for 1:5 000 000 data product

Table 2 Status of ISO TC211 projects on 19 June 2000
Source: ISO TC211 web site<http://www.statkart.no/isc211/dow.htm>
6 Status of Fundamental Datasets

The current status of the fundamental datasets considered for inclusion in the 1:5,000,000 product are outlined below. The same information is available from the AGDI web site. Project leaders and their organisations responsible for each fundamental dataset are identified.

6.1 Bathymetry

General Bathymetric Chart of the Ocean (GEBCO) - Dr Meirion Jones, British Oceanographic Data Centre

There has been considerable contact, since XXV SCAR in 1998, with a number of organisations around the world responsible for gathering and storing digital bathymetric information south of latitude 60° South.

The web page <http://www.scar-ggi.org.au/geog/agdi/lib-bath.htm> shows the extent of digital bathymetry holdings the project manager has been able to identify for the Data Library component of AGDI.

Talks with the International Hydrographic Bureau (IHO) revealed that there is limited digital data held by the IHO and what they do have is large scale and concentrates on the heavily trafficked routes into bases, particularly around the peninsula region. The preferred strategy for this project is that AGDI will use the digital version of the General Bathymetric Chart of the Oceans (GEBCO) dataset for the bathymetric component of the project along with other data from IHO members and any other sources, where necessary. The GEBCO Digital Atlas (GDA) is maintained by the British Oceanographic Data Centre (BODC) on behalf of the IHO and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Formal clearance from BODC and the IHO to use the digital data for AGDI will be required.

In the past 2 years there has been a lot of work done by British Antarctic Survey turning the GDA contours into polygons for tinting. Primarily this has meant joining broken lines. The GDA has been put together as a digital cartographic product and therefore to make the contours GIS-compatible (ie. topologically structured) has meant many months of work. How this information will be fed back into the next version of GDA has not yet been determined.

There has been some concern expressed by BEDMAP about the accuracy of some GDA data for the purposes of ice-sheet modelling out to the continental shelf area. The AGDI project manager spent some time in mid-1999 contacting a number of organisations regarding their holdings of bathymetric data.

Data have been gathered from Raytheon Polar Services Company (formerly Antarctic Support Associates [ASA]) from the USA; the Japanese National Oil Company, through the Japanese Geological Survey; and to a lesser extent the Southern African Data Centre for Oceanography [SADCO] and the Royal South African Naval Hydrographer [HydroSAN]. The aim of gathering these data is to eventually integrate this into a version of the GEBCO Digital Atlas.

The AGDI project manager has successfully gathered cruise information and soundings data for the Nathaniel B. Palmer, US NSF research vessel from 1992 to 1999 (Fig. 4).

The Japanese National Oil Company (JNOC)
has delivered data from their cruises to Antarctica from 1980 to 1998 in MGD77 format (Fig. 5). This has been passed onto BEDMAP to assist in the compilation of gridded bathymetric data and to enhance the GEBCO data BEDMAP are already using.

Fig. 5  JNCC cruise tracks south of 60° S 1980 ~ 1998
Source: Takemi Ishihara, Japanese Geological Survey
E-mail: tish@gis.go.jp

The Southern African Data Centre for Oceanography (SADCO) has a web site <http://morph.csir.co.za:8080/sadco1/sadinv> where users can access bathymetric information from a data inventory.

SADCO have supplied the project manager with some of the cruise track data for those voyages south of 60° S. It will take some time to retrieve all the information from SADCO’s inventory as it has to be done voyage by voyage for more than 200 voyages into Antarctic waters.

Further information on SADCO can be found at <http://fred.csir.co.za/ematek/sadco/sadco.html>

The Hydrographic Service of the South African Navy (HydroSAN) have a lot of data, however, the sounding data is embedded in other oceanographic data and is difficult to retrieve. They are hoping to write a Fortran program that will unlock most of the sounding data. This may be some time off as resources are limited.

There was a proposal put to the SCAR Executive Meeting in Goa, India, in September 1999 for SCAR funding to assist with the compilation and integration of a number of these datasets. The aim was to assist both the BEDMAP and AGDI projects in producing a better digital bathymetric dataset in the Antarctic region. It was expected that this funding would provide a boost to both projects digital datasets. Unfortunately the funding application was unsuccessful and the work has had to be put on hold.

6.2 Surface elevation

RADARSAT Antarctic Mapping Project (RAMP) - Dr. Ken Jezek and Dr. Hongxing Liu, Byrd Polar Research Centre, Ohio State University

A continental mosaic and an orthocorrected (or georeferenced) image dataset are the primary aims of the project. The Digital Elevation Model (DEM), a secondary product being generated to aid in ortho correcting the SAR images, has now been completed and is available for use.

The RAMP DEM combines topographic data from a variety of sources to provide topographically consistent coverage of all of Antarctica and represents a substantial improvement in horizontal resolution and vertical accuracy over previous digital elevation models, particularly in mountainous and coastal regions. Fig. 6 and Fig. 7 respectively show analytical hill-shading of Antarctic DEM and 3D perspective view of Lennox King Glacier, Antarctica, using the RAMP DEM and SAR imagery.

A primary data source was ERS-1 satellite radar
altimeter data from April 1994 to March 1995. Other data include airborne radar data, detailed cartographic data from the Antarctic Digital Database, and large-scale topographic maps from the U.S. Geological Survey (USGS) and the Australian Antarctic Division. These data were collected from the 1940s to present, with most collected during the 1980s and 1990s. Data for the 1 km and 400 m DEMs are provided in Arc/Info GIS, binary, and ASCII formats. Data for the 200 m DEM are in Arc/Info format only.

Data access is unrestricted and housed on the National Snow and Ice Data Centre's FTP server. NSIDC recommend that users register with them because registered users of the RAMP DEM data automatically receive e-mail notification of product updates and changes to processing.

Detailed documentation can be found on the NSIDC web site: <http://nsidc.org/NASA/GUIDE/docs/dataset-documents/radarsat-antarctic-mapping-project-digital-elevation-model-dataset-document.html>

Other information on the RAMP DEM can be found at the NSIDC web site: <http://nsidc.org/NSIDC/CATALOG/ENTRIES/nsi-0082.html>

One of the next most important steps for RAMP is to upgrade and improve the DEM so that the ortho-corrected mosaic is of a higher quality. Paul Cooper from BAS has already identified new datasets that could be used to improve the DEM. He has also found a few parts of the DEM that contain artefacts that will require correction.

6.3 Ice bed elevation

Antarctic Ice Bed Mapping Project (BEDMAP) - David Vaughan and Matt Lythe, British Antarctic Survey

Data describing the thickness of the Antarctic ice sheet collected on surveys undertaken over the past 50 years have been brought together into a single database comprising over 2.5 million observations of ice thickness collected from more than 100 separate expeditions conducted by 12 countries since 1951. These data have allowed the compilation of a number of seamless digital topographic models for the Antarctic continent and surrounding ocean. These include grids representing:

1) ice-sheet thickness over the ice sheet and shelves,
2) water-column thickness beneath the floating ice shelves,
3) bed elevation beneath the grounded ice sheet,
4) bathymetry to 60° S including the areas beneath the ice shelves.

These grids are consistent with a recent high-resolution surface elevation model of Antarctica. While the digital models have a nominal spatial resolution of 5 km, this may not be strictly justified given the original data density over all parts of the ice sheet. Fig. 8 shows BEDMAP data coverage on 6 January, 2000, and Figs. 9 and 10 give examples of BEDMAP bed elevation and BEDMAP ice thickness, respectively.

The 2.5 million observations cover approximately 80% of the 13.98 million km² total area of the continent with a mean density of one point per 5.5 km. Although some areas, notably parts of Wilkes Land, Queen Mary Land and southern Dronning Maud Land still have only limited coverage, the number of data points in BEDMAP is two orders of magnitude greater than the only comparable compilation, the SPRI Folio 'The Bedrock Surface of Antarctica' published in 1983.

The datasets do, however, provide an unparalleled vision of the geosphere beneath the ice sheet and a more reliable basis for ice sheet modelling. The total volume of the Antarctic ice sheet is calculated to be 2.5·4 million km³ while the total sea-level equiva-
Fig. 8 BEDMAP data coverage on 6 January, 2000
Source: Matt Lythe, British Antarctic Survey
<http://www.antarctica.ac.uk/aedc/bedmap/database/bedmap-coverage.html>

The gridded data sets can be obtained from the project leaders.

A map summarizing the work of the BEDMAP Consortium has just been printed and will be displayed at XXVI SCAR; it shows the subglacial lent, derived from the amount of ice contained within the grounded ice sheet is 57 million km$^3$, comprising 52 million km$^3$ from the East Antarctic ice sheet and 5 million km$^3$ from the west Antarctic ice sheet.
bed/seabed elevation model for the entire area south of 60° S.

A summary of the data sets in BEDMAP, a list of contributors, as well as several maps describing the coverage and density of data may be viewed on the BEDMAP web site at: <http://www.antarctica.ac.uk/bedmap/>. Fig. 11 is a BEDMAP perspective example.

Fig. 11  BEDMAP perspective example
Source: Matt Lythe, British Antarctic Survey
<http://www.antarctica.ac.uk/aedc/bedmap/examples/>

There is also a prototype search facility of the BEDMAP database available at: <http://www.antarctica.ac.uk/aedc/bedmap/DataSearch.html>

6.4 Coastline

6.4.1 Antarctic Glaciology and Coastal Change Project (AGCCP) - Richie Williams, USGS, Woods Hole & Jane Ferrigno, USGS, Reston

On 19 and 20 October 1999 at USGS Woods Hole, Massachusetts, there was a meeting of the AGCCP with project leaders Jane Ferrigno and Richie Williams, the head of BAS Mapping and Geographic Information Centre, Janet Thomson and Jerry Mullins and Cheryl Hallam from USGS Reston. The purpose of the meeting was directed at compiling three 1:50,000 scale map sheets of the Antarctic Peninsula, using multiple image datasets and historical data to delineate ice fronts, ice walls, grounding line, other glaciological features, etc. They hope to collaborate with Joern Sievers from BKG in Germany, as he has compiled an excellent georeferenced Landsat TM image mosaic of most of the area of interest. Cheryl Hallam, who is responsible for the Antarctic Digital Atlas of the U.S. Geological Survey, as been appointed as a technical advisor and collaborator on the Antarctic Peninsula effort.

At the time of writing, due to a lack of communication from the project leaders and technical advisor, it is unclear as to the state of digital data production for AGCCP.

Currently AGCCP is not a SCAR WG-GGI endorsed project. The AGDI project manager has been in contact with Richie Williams to find out if AGCCP would like this endorsement with a positive answer. This issue will be a point of discussion during XXVI SCAR.

6.4.2 Antarctic Digital Database - Janet Thomson (BAS)

ADD Version 1.0 was prepared from over 200 map sources, at medium and small scales, which were up-dated using satellite imagery. The database was developed for use with PC Arc/Info and published on CD-ROM by the Scientific Committee on Antarctic Research (SCAR) in 1993.

ADD Version 2.0 is a current version of the database available as Workstation Arc/Info coverages. It can be accessed via the World Wide Web at the following address: <http://194.66.5.2/public/magic/add-main.html>

The main achievement of the work over the last 2-year period has been the significant improvement of the data in the contour layer for regions north of 80° S, using a DEM derived mainly from ERS-1 data and ADD Version 1.0. In addition, data omitted from the glacier margin, flowline and rock outcrop layers have been incorporated, as have new ice front locations. Data have been captured at a variety of scales and the whole dataset has been generalized to 1:1,000,000 scale. Further generalization datasets (at 1:5,000,000 and 1:10,000,000 scales) will be prepared after XXVI SCAR. Scale 0 and Scale 1 datasets, Version 3.0, will be released on the ADD web site in July 2000.

6.5 Features

Antarctic Digital Database - Janet Thomson (BAS)

The ADD contains some point data relating to human activity and built structures in the Antarctic environment such as aerodromes, radio masts, scientific stations, buildings, oil tanks, water tanks, automatic weather stations, Historic Monuments and Sites of Special Scientific Interest.

Any other datasets that contain built features would be considered for inclusion in a 1:5,000,000 scale product. While this kind of information is
probably most useful at large scales (particularly for logistics and planning personnel) it would also be useful for those in the education sector to learn more about the location of these types of features across the continent.

6.6 Names

Composite Gazetteer of Antarctica (CGA) - Roberto Cervellati and Chiara Ramorino (ENEA)

The CGA was published and presented to the WG-GGI members at XXV SCAR in 1998. Volume 1 of the SCAR Composite Gazetteer of Antarctica contains an alphabetical list of all the names that have been published in national gazetteers, plus basic information about those names. Volume 2 contains a list of 16,415 records (reference numbers), one for every geographic feature recognised and named in Antarctica before 30 November 1997. The CGA and further information is also available on the web at: <http://www.pnra.it/SCAR-GAZE>.

6.7 Remote sensing

This new theme was added after discussions held at the WG-GGI Project Coordinators meeting in Heppenheim, Germany in July 1999.

There are many projects in Antarctica that use remotely sensed data. Those people interested in viewing what remotely sensed data sources for Antarctica are available from the AGDI Data Library should visit: <www.scar-ggi.org.au/geog/agdi/lib-surf.htm>.

One project that is current and useful to researchers is outlined below.

RADARSAT Antarctic Mapping Project (RAMP) - Byrd Polar Research Centre, Ohio State University

Antarctica has never been fully mapped from space at high resolutions. The RAMP project is a collaborative effort between the U.S. National Aeronautics and Space Administration (NASA) and the Canadian Space Agency (CSA), to completely map the Antarctic with RADARSAT-1. Such continental-wide coverage was not possible with existing or previous space borne high resolution sensors because of their orbit inclination and/or field of view capability. The RADARSAT satellite was rotated 180 degrees in yaw to allow the radar to image to the left of the satellite track instead of to the right, and to steer the radar beam up to cover the South Pole. This manoeuvre was performed between September 9 and 11, 1997. The mapping of Antarctica with high resolution RADARSAT images began on September 26 and was completed on October 14, as shown in Fig. 12.

7 Future work program

Both the WG-GGI Chief Officer and AGDI project manager believe the project has, to date, achieved most of the goals set at XXV SCAR. Over the last 2 years there has been considerable progress made by a number of institutions and individuals in...
completing a number of fundamental datasets, particularly the RAMP DEM and BEDMAP datasets. The bathymetry dataset is poised to have an upgrade, data has been gathered, with the possibility of more on the way and the only aspect lacking is adequate funding to employ an experienced GIS operator to integrate these data.

It is now time to take stock and revise the project based on a need to provide a 1:5 000 000 scale data product to the SCAR community and others interested in Antarctic research and Antarctica in general. The options developed so far are presented below.

1) The Australian Antarctic Division (perhaps in cooperation with the Antarctic CRC) could take on production of the 1:5 000 000 product (a CD-ROM containing the 7 fundamental data layers) ready for distribution at XXVII SCAR in 2002. This could be conducted in a similar style to the BEDMAP project with a Database Manager and overall project manager.

2) The project could be downscaled with the 1:5 000 000 product being dropped. However, there would be the continuation of the Data Libraries on the AGDI web site.

These options are still being considered and form the basis for discussion at the upcoming WG-GGI meeting in Tokyo.