

Geodesy and Digital Cartographic Survey in Fildes Peninsula, Rey Jorge Island, Antarctica.

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Abstract

The present paper summarizes a joint effort undertaken by the Instituto Geográfico Militar de Chile (IGM) and the Instituto Antártico Chileno (INACH) in order to obtain digital cartography of the Fildes Peninsula, Rey Jorge Island, Antarctica. This peninsula constitutes the prototype project area for the main IGM-INACH project N° 153 "Cartographic Survey and Geographic Information System of the South Shetlands Islands"

The Digital Cartography was implemented at the 1:5.000 scale, using geodetic GPS control points referenced to ITRF 92 and WGS 84 Datums. The UTM Projection was used. All products were produced in compliance with the cartographic standards of the IGM.

This cartography was designed in order to satisfy the requirements of a Geographic Information System developed by INACH. This geo-referenced database incorporates a variety of thematic information, enabling it to support scientific investigations, environmental and multi-disciplinary studies, and other applications.

As a result of this project the Instituto Geográfico Militar de Chile produced a map at 1:5.000 scale in digital format, and also a 1:10.000 topographic map, in paper format, with two editions: first edition of two charts and a second edition with one chart covering the whole project area.

Chile and other countries have a number of important permanent activities in this area. These maps are designed to support several and diverse geo-spatial studies related to these activities.

Introduction :

The increase in research in the Chilean Antarctic Territory has become manifest over the last ten years in the substantial increase in the number of scientific stations established and maintained on Rey Jorge' Island, making it necessary to regulate the use of those areas of interest for human settlement, in accordance with the provisions of the Antarctic Treaty.

The **Military Geographical Institute of Chile (IGM)** and the **Chilean Antarctic Institute (INACH)** have joined forces to carry out, in the short and medium term, a joint cartographic project in order to obtain information by means of a "Digital Database for Antarctic Cartographic Data", with the aim of its being used by researchers who use Geographic Information Systems (GIS).

The IGM and the INACH, within the terms of the agreement signed by both of them on the 30th of September 1992, have started a joint scientific and technological project identified as Project N° 153, aimed at obtaining a "Digital Cartographic Survey and Geographic Information System (GIS) for the 'Shetlands del Sur' Islands" in the Chilean Antarctic Territory, defining a trial area in the Fildes Peninsula.

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Objectives of the Project:

This project has as its main objective the development of base cartography at 1:10,000 and 1:5,000 scales in the trial area of the Fildes Peninsula, with the intention of continuing in future stages of the project to create cartography for the whole of the 'Shetlands del Sur' Islands.

In the same way, it is proposed to create a digital cartographic data base which makes it possible to develop a Geographic Information System for multidisciplinary use, thus supporting various scientific research projects being carried out in this area.

Regarding the geodesic and cartographic aspects, it is intended that enough information be set up for consolidating the geographic information for this area, which implies making the existing geodesic, photogrammetric, and cartographic information more detailed and comprehensive.

Carrying Out the Project:

Geodetic Survey

In order to have an adequate base that supports and/or provides georeferences for other work in the Chilean Antarctic Region, it is necessary to have a high-precision "**Geodetic Network**" which allows scientists to use this basic tool for local research with the various disciplines of the Geographic Sciences related to the antarctic environment or other matters.

The "Trial Area" in the Fildes Peninsula is located at the south-western end of 'Rey Jorge' island, covering an area of about 3,000 hectares, stretching along about 3 kilometers from the west coast near Nelson island to the inland ice fields of the Collins Glaciar, and is defined by the following limits :

V ₁	Latitude 62°08' S	Longitude 58°36'	W
V ₂	Latitude 62°08' S	Longitude 58°58'	W
V ₃	Latitude 62°15' S	Longitude 58°58'	W
V ₄	Latitude 62°15' S	Longitude 58°36'	W

The Fildes Peninsula, in general terms appears as a tableland made up of old coastal landforms, with an average height of 30 metres above sea level and rocky outcrops that do not reach over 100 metres. It is a territory with its own special characteristics different from those of the rest of 'Rey Jorge' Island, which is covered by the ice of the Collins Glaciar. It is possible to move across almost all this area, accepting certain limits, the climate being very cold and with random snowstorms owing to its closeness to the ocean.

The terrain, owing to its being almost free of ice because of the summer melting of the ice, has permanent snowdrifts and icesheets only in some places. All of these features make access to it very difficult, consequently it would be very hard to perform traditional geodesic measurements, so currently satellite-geodesic techniques are applied instead.

The four-year plan set up for the geodesic and cartographic research in the Fildes sector began with the "XXVII Antarctic Scientific Expedition (1992 - 1993) of the INACH". The joint geodesic work of IGM - INACH was planned and carried out in a series of separate campaigns of terrain measurement.

In the trial zone it was planned to physically mark and measure a total of 16 points or GPS Geodetic Stations, enough for supporting the work with photogrammetry, cartography, and the other geographic science disciplines mentioned previously.

For the geodetic measurements scheduled, space-geodetic measurements were implemented using the Global Positioning System (see fig. 1).



Fig. 1 GPS measurement at "Rey Jorge" station REYJ

The German scientific organization Geoforschungs Zentrum (GFZ) from Potsdam, kindly loaned several Trimble model SSE-4000 GPS receivers to IGM. Using this equipment Global Cartesian and UTM Coordinates were determined for all control points observed within the Peninsula.

In order to carry out these difficult tasks in the field, the technicians of the IGM were backed up by the logistical support of the INACH. Moreover, they had available the helicopters of the "President Frei" Air Force Base, which made possible a skilful series of movements to transport the technicians and their equipment around to make the geodetic measurements for each scheduled station.

Having obtained the Geographic and UTM coordinates and established and marked the 16 GPS stations in the area, the Chilean community now has the first *"Satellite II-Degree GPS Geodetic Network"* in the Fildes Peninsula. This quantity of Points or Stations makes possible a "framework" for engineering activities in the area and which Chilean and foreign technical researchers, scientists, or operators in the Antarctic are able to use now and in the future when they need to work in these frozen regions. Annex N° 1 presents the coordinates of the various geodesic stations measured for the project and referenced to ITRF 92.

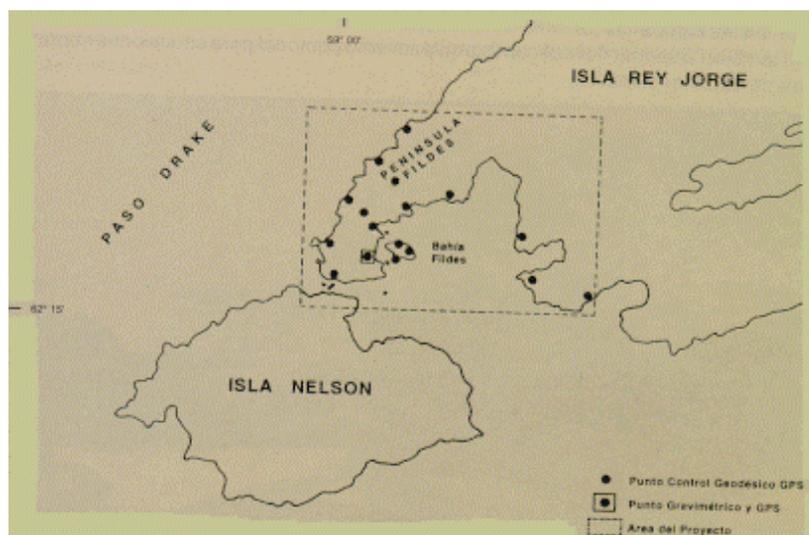


Fig. 2 Distribution of GPS points.

In order to increase the altimetric precision of the GPs stations measured, a series of observation and measurement routines were made for the "Geometric Leveling" of 5 GPS stations during the second field campaign (1994 - 1995), which were linked to a station or tidal altitude point belonging to the Hydrographic and Oceanographic Service of the Chilean Navy (S.H.O.A.), in order to close a circuit at a Gravimetric Station established on the 'Doppler' and GPS Point called "Cabezal Este" (east head) of the IGM and located in the grounds of the President Frei Air Force Base and the "Teniente Marsh" air field respectively. Having GPS stations with precise altimetric values also means that adequate support can be given to the work needed in these matters by the Antarctic personnel working in the area.

In parallel with this and as a way of getting the GPS Network of the Second Order of precision accepted into the "international scene", three new Satellite GPS stations of the First Order of precision (field campaign of 1993 - 1994) were established and measured simultaneously, located in the neighbourhood of the three Chilean Bases called "President Frei" Air Force Base, "Bernardo O'Higgins" Military Base and "Arturo Prat" Naval Base.

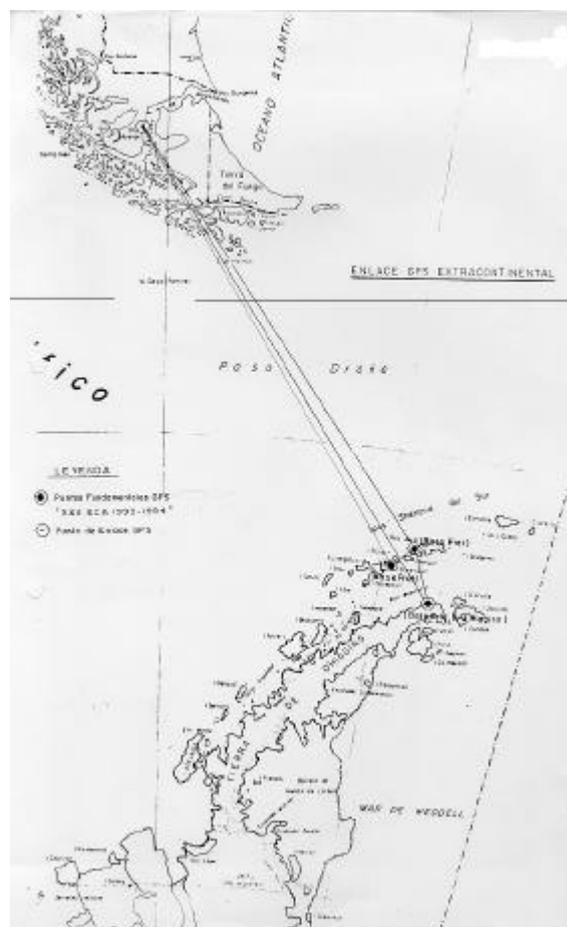


Fig. 3 Linkup with Chilean Geodetic Network

These three GPS stations make up the first "**Chilean GPS Geodetic Network of the I Order of Precision**" in the Chilean Antarctic Territory, with which it is possible to perform important applied research work in various areas of international scientific research.

The Cartographic Process

Using the photographic aerial coverage at 1:8,000 of the Fildes Peninsula provided by the AeroPhotogrammetric Service of the Chilean Air Force (S.A.F.) obtained in 1984, the planning and study of

the most appropriate technical, photogrammetric, and cartographic procedures was carried out in order to obtain the final digital cartographic product.



Fig. 4 General View of the Fildes Peninsula

With the GPS measurements finished, the digital photogrammetry work was carried out in the offices of the IGM. By means of 'Analytical Restitution' and Stereodigitizing', the first digital restitution products were obtained using the Restitution equipment supported by computer equipment ('Microstation' automated drawing software from 'Intergraph'), with a total of 11 sheets or digital charts at 1:5,000 scale covering the Fildes Peninsula.

With the digital restitution defined, the final phase of the digital cartography was performed, called the "Editing". With this the first **"Digital Cartographic Base at 1:5,000 Scale"** had been set up and defined for the Fildes Peninsula, part of "Rey Jorge" Island in the Chilean Antarctic Territory (see Fig. 5).

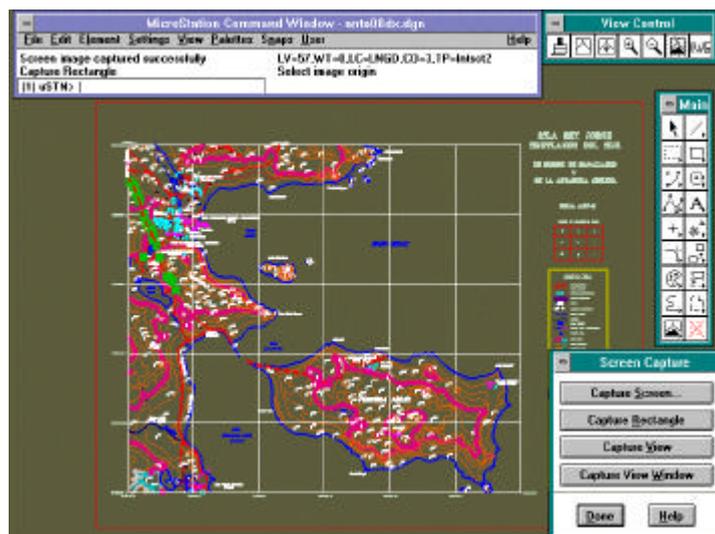


Fig. 5 View of Digital Map, 1:5,000 scale.

This cartography has been structured in accordance with the standards of digital cartographic production defined by the Military Geographic Institute of Chile, for which the graphic information is separated in 8 categories with its respective name, level, color, style, and line-width, as is indicated in Annex N°2.

Simultaneously with the above, and using modern editing and publishing computing tools from 'Intergraph', a set of **Two Charts at 1:10,000 Scale** covering the Fildes Peninsula (see Fig. 6) were printed and published as an alternative product for use by the scientific community and users in general.



Fig. 6 Chart in paper format, 1:10,000 Scale

Currently a map covering the Fildes Peninsula is in the final phase of preparation for printing on paper. This is a single cartographic sheet at 1:10,000 which will soon be released for use by the scientific community.

Future Projects :

During the short and medium term, it is intended to establish new cartography for "Rey Jorge" Island using satellite images and GPS support. For this purpose the Military Geographic Institute has signed an agreement with the company 'INCOM Chile' and with 'RADARSAT Canada' in order to achieve the creation of new digital cartographic information involving Radar-based information. Moreover, and in conjunction with the INACH, the purchase of panchromatic and multispectral images from the French 'SPOT' satellite has been negotiated. These cover "Rey Jorge" Island and will complete the the Digital Data Base for this important area.

Conclusions :

With this project, a major goal of the scientific community, that of having available a georeferenced geodesic cartographic base, has been accomplished, making it possible for the scientific and technical personnel of the Chilean Antarctic Institute to set up a Geographic Information System for the Fildes Peninsula ("Rey Jorge" Island).

The above makes it possible to perform a series of scientific assessments, especially those related to studies oriented towards the protection of the Antarctic terrain and to studies of the environmental impact of the increase in the colonization and the activities of humans in this polar region.

**CARTESIAN COORDINATES FOR THE GPS STATION: IGM - INACH PROJECT N° 153
REFERENCED TO ITRF 92**

CODE	X	Y	Z	VEL.X	VEL.Y	VEL.Z	EPOCH	dx	dy	dz
ARD8	1538453.5175	-2553476.7039	-5619776.4548	0.0179	-0.0010	0.0054	1994.078	0.0167	0.0095	0.0275
ARD9	1539185.7894	-2553313.0685	-5619576.2901	0.0179	-0.0010	0.0054	1994.078	0.0446	0.0485	0.0599
ARDL	1538471.9951	-2553923.3272	-5619504.2796	0.0179	-0.0010	0.0054	1994.078	0.0121	0.0128	0.0304
BC19	1544165.9849	-2548885.0595	-5620214.6943	0.0179	-0.0010	0.0054	1994.078	0.0050	0.0076	0.0163
BC22	1544486.4099	-2550486.1087	-5619405.2754	0.0179	-0.0010	0.0054	1994.078	0.0075	0.0186	0.0213
BCH4	1535543.3931	-2556173.0992	-5619321.6789	0.0179	-0.0010	0.0054	1994.078	0.0061	0.0097	0.0194
BTME	1537585.5375	-2556067.9627	-5618798.2001	0.0179	-0.0010	0.0054	1994.078	0.0060	0.0100	0.0185
BTMP	1536763.4921	-2557415.5638	-5618418.4368	0.0179	-0.0010	0.0054	1994.078	0.0107	0.0117	0.0207
BU13	1541018.1427	-2555354.9312	-5618181.7674	0.0179	-0.0010	0.0054	1994.078	0.0624	0.0360	0.0270
CH11	1536834.7737	-2553865.5607	-5619997.3136	0.0179	-0.0010	0.0054	1994.078	0.0066	0.0113	0.0272
CH12	1536925.3609	-2553984.2193	-5619891.0733	0.0179	-0.0010	0.0054	1994.078	0.0149	0.0273	0.0241
CH13	1536950.4791	-2553424.0405	-5620166.0022	0.0179	-0.0010	0.0054	1994.078	0.0237	0.0141	0.0205
EMBA	1537826.6976	-2555392.6023	-5619002.7158	0.0179	-0.0010	0.0054	1994.078	0.0116	0.0143	0.0192
REYJ	1536998.9522	-2555894.9820	-5619103.4594	-0.0579	-0.0272	-0.0035	1994.078	0.0060	0.0100	0.0185
TELE	1537792.9841	-2555448.0054	-5618990.5704	0.0179	-0.0010	0.0054	1994.078	0.0170	0.0278	0.0253
TORE	1537275.0554	-2556606.8121	-5618667.4066	0.0179	-0.0010	0.0054	1994.078	0.0137	0.0241	0.0250
YOLA	1538245.2163	-2557042.9825	-5618207.2535	0.0179	-0.0010	0.0054	1994.078	0.0061	0.0058	0.0216

Where:

X, Y, Z : m
Speed X, Y, Z : mm/year
Epoch 1994.078 : 29.JAN.994
dx, dy, dz : m

**GRAPHIC ATTRIBUTES ASSOCIATED TO THE CARTOGRAPHIC ELEMENTS PENINSULA
FILDES**

CATEGORY	NAME	LEVEL	COLOR	STYLE	WEIGHT
DRAINAGE	Drainage Boundary	5	7	0	0
	Ice/snow Boundary	3	7	2	1
	Coast Boundary	21	17	0	1
	Stream	23	49	7	1
	Dissipating endpoint	21	49	0	1
ELEVATION	Index Contour (earth)	19	10	0	4
	Index Contour (Ice)	42	87	0	4
	Intermediate Contour(earth)	26	6	0	1
	Intermediate Contour(Ice)	42	87	0	1
	Form Contour(earth)	28	6	2	1
	Form Contour(Ice)	42	87	2	1
	Depression Contour	28	6	0	1
	Horiz.ctl.with elevation	1	5	0	1
CULTURAL	Pipeline-Sewer	33	5	0	1
	Fuel Tank	39	0	0	1
	Scaled Buildings	39	0	0	0
	Wharf	39	0	0	1
	Satellital Antenna	39	0	0	1
	Water pump	21	49	0	1
AERONAUTICAL	Airfield	39	0	2	1
COASTAL	Submerged rock	6	0	1	1
PHYSIOGRAPHY	No Sterescopic Vision	39	0	2	1
	Rock	39	0	1	1
	Scarp	28	6	0	1
ROADS	Track, Trail	38	3	2	1
TEXT	Hydrography	22	1	0	2
	Index Contour	29	10	0	1
	Elevation Spot	39	0	0	0
	Tableland, airport, valley, peninsula, point, island, beach, hill.	39	0	0	1