**Contract:**

**ENEA – Banco Interamericano de Desarrollo (BID) or InterAmerican Development Bank (IDB)**

# Manejo de Riesgos en Valparaiso, Servicios Técnicos

Acronym: *"MAR VASTO"*

**ATN/II-9816-CH**

**Contract n.** **PRM.7.035.00-C**

# DGPS SURVEY
# IN THE CITY OF VALPARAISO

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## PREFACE

The work has been carried out during the *in situ* investigation of the Italian team of experts, done in the framework of two missions in Valparaíso (May and October-December 2007), with the help of many local Organizations **[01-03]**. In particular, we appreciated the cooperation of the personnel of the "Oficina de Gestion Patrimonial - OGP" of the Valparaiso Municipality (the director Paulina Kaplan Depolo, the architect Sotero Apablaza Minchel, the geographer Mauricio Gonzalez Loyola and the architect Cristian Palma). Moreover, a fundamental support came from the Firemen of Valparaiso (Cuerpo Voluntario de Bomberos, Sexta Compañia Bomba Italia "Cristoforo Colombo"). Furthermore, SHOA (Servicio Hidrografico y Oceanografico de la Armada de Chile) provided an indispensable help (trigonometric coordinates and monographs of vertices, software for the conversion from geographic coordinates to UTM, etc.) to our work for the MAR VASTO project.

## 1. INTRODUCTION

GPS (Global Positioning System) is a fully functional Global Navigation Satellite System (GNSS). Utilizing a constellation of about 32 satellites that transmitting precise microwave signals, the system enables a GPS receiver to determine its location, speed, direction, and time (Fig. 1).

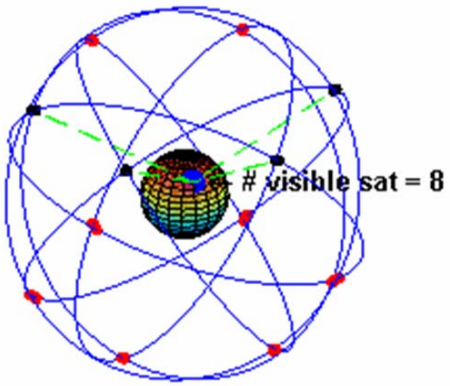



*Figure 1: a visual example of the GPS satellite constellation in motion with the Earth rotating; the number of satellites in view from a given point on the Earth surface changes with time.*

An in field survey using DGPS (Differential Global Positioning System) has been considered necessary, in order to check aerial photos and cartography provided by Chilean partners and verify the GIS database **[04]**, developed in the framework of the MAR VASTO project, from the topographic point of view. In fact, an aerial photo of the Valparaiso region **[05]** has been used as basis at the beginning, even if not well geo-referenced; moreover, the digital cartography provided by OGP (streets, buildings, quoted points, and other information) was not very accurate and didn't match the above said aerial photo. Thus, DGPS survey provided a pattern of points enabling to remove uncertainties, clarifying univocally the real geographic position of the GIS final database.

## 2. IDENTIFICATION OF THE DGPS SURVEY PATTERN OF POINTS

The choice of the DGPS pattern of points, planned in Italy before the mission (but later implemented during the in situ campaign), foresaw the following steps:
- homogeneous distribution of the points in the Valparaiso area;
- capability to recognize the points, previously identified on the aerial photo, during the in field campaign;
- easy accessibility of the sites;

- identification of a reserve stock of extra points, if some sites could be inaccessible or unnoticeable during the survey.

Furthermore, the identification of existing geodimetry landmarks was indispensable, in order to link the DGPS survey to the official Chilean cartography. In this case, SHOA was the fundamental provider of vertex trigonometric coordinates (Fig. 2), trigonometric monographs (Fig. 3), and software tools for the conversion from Geographic Coordinates (obtained by DGPS) to the UTM system (referred to the mean sea level), necessary for the final GIS database.


*Figure 2: SHOA trigonometric vertex with Geographic and UTM coordinates.*

# CERTIFICADO Y MONOGRAFÍA DE VÉRTICE

| VÉRTICE: PALM | LUGAR: SHOA |
|---|---|
| FOTOS GENERAL | |
|  |  |
| FOTO PARTICULAR | COORDENADAS SIRGAS (WGS-84) |
|  | NORTE : 6.342.493,702<br>ESTE : 253.871,355<br>M. CENTRAL : 69°<br>ZONA : 19<br>LATITUD : 33° 01' 41.73745" S<br>LONGITUD : 71° 38' 06.80713" W<br>ALT. N.M.M. : ----------<br>ALT. ELIPSOIDAL : 116,534 m.<br>TIPO ESTACIÓN : Primario |
| **DESCRIPCIÓN:** El vértice "PALM" se encuentra ubicado en el sector de las Palmeras en el patio interior del SHOA. Está monumentado por una cota de bronce empotrada en cemento en una base triangular de cemento. | |

*Figure 3: SHOA trigonometric vertex monograph.*

## 3. IN FIELD DGPS SURVEY

The in field DGPS survey has been carried out using two Trimble receivers (double frequency, model 5700), with the "Fast Static" procedure (acquisition frequency at 15 seconds, time duration of 8 minutes for each selected site), when at least six transmitting satellites were available along the entire measurement; on the contrary, in case of less signals, the measure time has been prolonged. Satellites under 13° horizon elevation have been excluded because useless (Fig. 4).

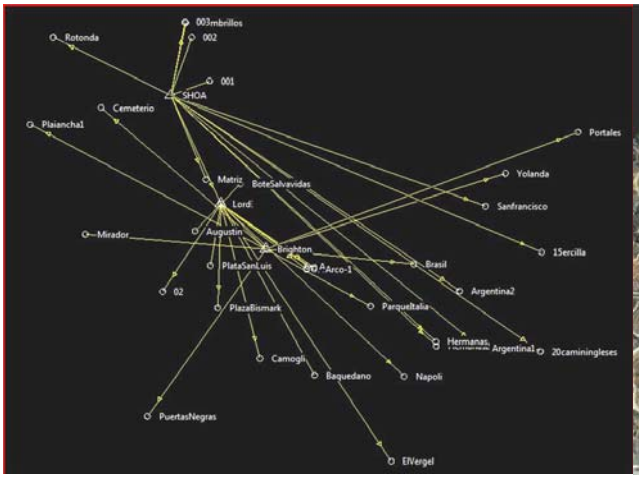
*Figure 4: the in field DGPS survey.*

In order to cover all the geo-referencing area, it has been necessary to put the Master of the DGPS equipment in three different bases (Fig. 5); this procedure permitted to keep the length of the Master-Rover vectors under 4 km. Therefore, the survey measure precision has been very satisfactory, with a maximum error in planimetry of 2.8 cm and in altimetry of 5.5 cm. The final planimetry of the DGPS survey is shown by Fig. 6.
The rough DGPS data processing, to obtain Geographic Coordinates, has been done by software "Trimble Geomatic Office version 1.7", while the conversion of those coordinates into the UTM system for the GIS database (UTM reference Time Zone 19 South with Datum WGS-84) by the software "The Geographic Calculator version 3.05".
The coordinates of the final pattern of points have been transformed in ESRI shape-files and showed by ArcGis (Fig. 7).

*DGPS Master at SHOA*

*DGPS Master at Lord Cochrane* *DGPS Master at Brighton*

*Figure 5: the DGPS Master positioning.*



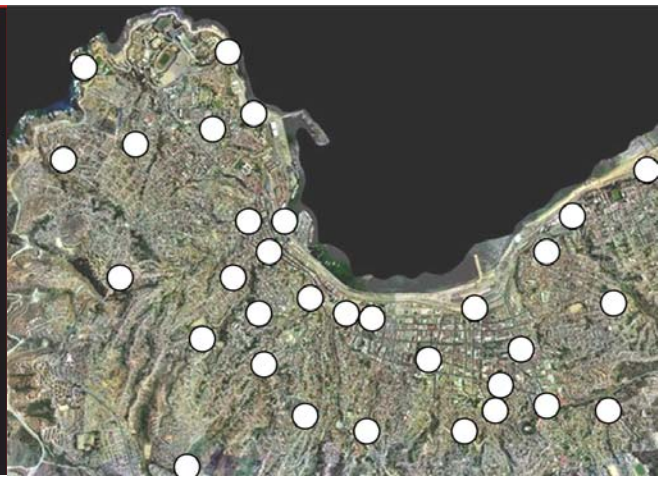



*Figure 6: final planimetry of the DGPS survey.* *Figure 7: DGPS final pattern of points showed by ArcGis.*

| POINT NAME | LAT_SOUTH | LONG_WEST | ELIPSO | NORTH | EAST | NMM |
|---|---|---|---|---|---|---|
| SHOA | 33°01'41.73745"S | 71°38'06.80713"W | 116,534 | 6342493,703 | 253871,355 | 94,62 |
| BRIGHTON | 33°02'34.16863"S | 71°37'30.72932"W | 66,921 | 6340901,854 | 254848,013 | 45,01 |
| LORDCOCHRANE | 33°02'18.54364"S | 71°37'48.05733"W | 63,067 | 6341371,976 | 254386,339 | 41,15 |
| Arco2 | 33°02'40.77177"S | 71°37'11.70597"W | 26,947 | 6340710,753 | 255346,695 | 5,03 |
| Arco3 | 33°02'40.27402"S | 71°37'14.38798"W | 26,905 | 6340724,352 | 255276,723 | 4,99 |
| Argentina1 | 33°03'09.28246"S | 71°36'06.73683"W | 31,937 | 6339874,322 | 257054,201 | 10,02 |
| Argentina2 | 33°02'49.94818"S | 71°36'14.36219"W | 28,541 | 6340465,062 | 256841,592 | 6,63 |
| Arma | 33°01'37.23172"S | 71°37'51.32961"W | 27,800 | 6342638,089 | 254269,174 | 5,89 |
| Augustin | 33°02'27.55022"S | 71°37'58.59023"W | 86,210 | 6341087,653 | 254119,981 | 64,30 |
| Baquedano | 33°03'17.00584"S | 71°37'12.64805"W | 147,202 | 6339593,849 | 255350,111 | 125,29 |
| Bote_Salvavidas | 33°02'12.06807"S | 71°37'40.20655"W | 22,168 | 6341576,574 | 254585,065 | 0,25 |
| Brasil | 33°02'40.57234"S | 71°36'32.28201"W | 26,895 | 6340742,368 | 256369,468 | 4,98 |
| La Cantera | 33°02'47.61841"S | 71°38'12.07917"W | 130,923 | 6340460,610 | 253785,494 | 109,01 |
| Camino_Ingleses | 33°03'10.87494"S | 71°35'42.91256"W | 95,750 | 6339840,562 | 257673,519 | 73,84 |
| Camogli | 33°03'10.91357"S | 71°37'34.14675"W | 146,377 | 6339767,601 | 254787,655 | 124,46 |
| Cementerio | 33°01'45.29331"S | 71°38'34.65778"W | 125,836 | 6342365,995 | 253151,336 | 103,92 |
| El_Vergel | 33°03'46.56611"S | 71°36'43.15705"W | 271,272 | 6338702,230 | 256137,884 | 249,36 |
| Ercilla | 33°02'37.52539"S | 71°35'41.43349"W | 118,009 | 6340868,930 | 257686,499 | 96,10 |
| Hermanas1 | 33°03'06.71144"S | 71°36'24.27777"W | 36,520 | 6339942,240 | 256597,146 | 14,61 |
| Hermanas2 | 33°03'08.20559"S | 71°36'24.18970"W | 46,055 | 6339896,265 | 256600,574 | 24,14 |
| Matriz | 33°02'10.29748"S | 71°37'53.75655"W | 32,758 | 6341622,318 | 254232,086 | 10,84 |
| Membrillos | 33°01'17.43485"S | 71°38'00.21443"W | 27,153 | 6343246,705 | 254023,679 | 5,24 |
| Mirador | 33°02'27.68056"S | 71°38'42.13136"W | 234,198 | 6341055,244 | 252990,273 | 212,28 |
| Napoli | 33°03'18.10144"S | 71°36'37.19294"W | 124,528 | 6339583,013 | 256270,792 | 102,61 |
| Parque Italia | 33°02'54.31444"S | 71°36'49.79717"W | 28,836 | 6340307,701 | 255925,545 | 6,92 |
| Playa Ancha | 33°01'50.38044"S | 71°39'02.89470"W | 130,775 | 6342190,805 | 252422,498 | 108,86 |
| Plata San Luis | 33°02'39.24884"S | 71°37'52.89836"W | 118,213 | 6340730,945 | 254276,705 | 96,30 |
| Plaza Bismark | 33°02'53.55708"S | 71°37'50.35720"W | 131,584 | 6340291,789 | 254353,685 | 109,67 |
| Portales | 33°01'57.52313"S | 71°35'25.86658"W | 29,049 | 6342111,274 | 258060,013 | 7,14 |
| Puertas Negras | 33°03'29.38857"S | 71°38'19.29392"W | 395,087 | 6339169,050 | 253630,644 | 373,17 |
| Redondo | 33°01'21.32036"S | 71°38'52.85001"W | 54,989 | 6343092,664 | 252660,602 | 33,08 |
| San Francisco | 33°02'21.61404"S | 71°36'03.20417"W | 67,346 | 6341345,146 | 257109,476 | 45,43 |
| Yolanda | 33°02'10.72229"S | 71°35'54.95750"W | 32,365 | 6341685,992 | 257315,160 | 10,45 |

*Figure 8: DGPS points and their geographic coordinates.*

Fig. 8 shows DGPS points and their Coordinates in:
- Geog,raphic, with South Latitude, West Longitude and Ellipsoid Height;
- UTM with Northing, Easting and Height over the mean sea level.

The DATUM is given in WGS-84 for both the systems.
Globally, a stock of 39 points have been measured and, among them, 33 have been used to geo-referencing the aerial photo, identifying its shift from the measurement. For each point, in case of difference, the photo has been "stretched" until to overlap photo and DGPS point (Fig. 9).
Figs. 10-37 show all the points of the DGPS survey.

## 4. CONCLUSIONS

The DGPS survey, carried out in Valparaiso, can be considered enough detailed to check the whole final GIS database coordinates with a very satisfactory precision. Therefore, the final GIS database can be considered a solid reference also for future developments.

*Figure 9: example of shift between aerial photo (red) and DGPS measurement (yellow).*

*Figure 10: DGPS Rover on site ARCO 2.*

*Figure 11: DGPS Rover on site ARGENTINA 1.*

*Figure 12: DGPS Rover on site ARGENTINA 2.*

*Figure 13: DGPS Rover on site ARMA.*

*Figure 14: DGPS Rover on site AUGUSTIN.*

*Figure 15: DGPS Rover on site BAQUEDANO.*


*Figure 16: DGPS Rover on site BOTE SALVAVIDAS.*

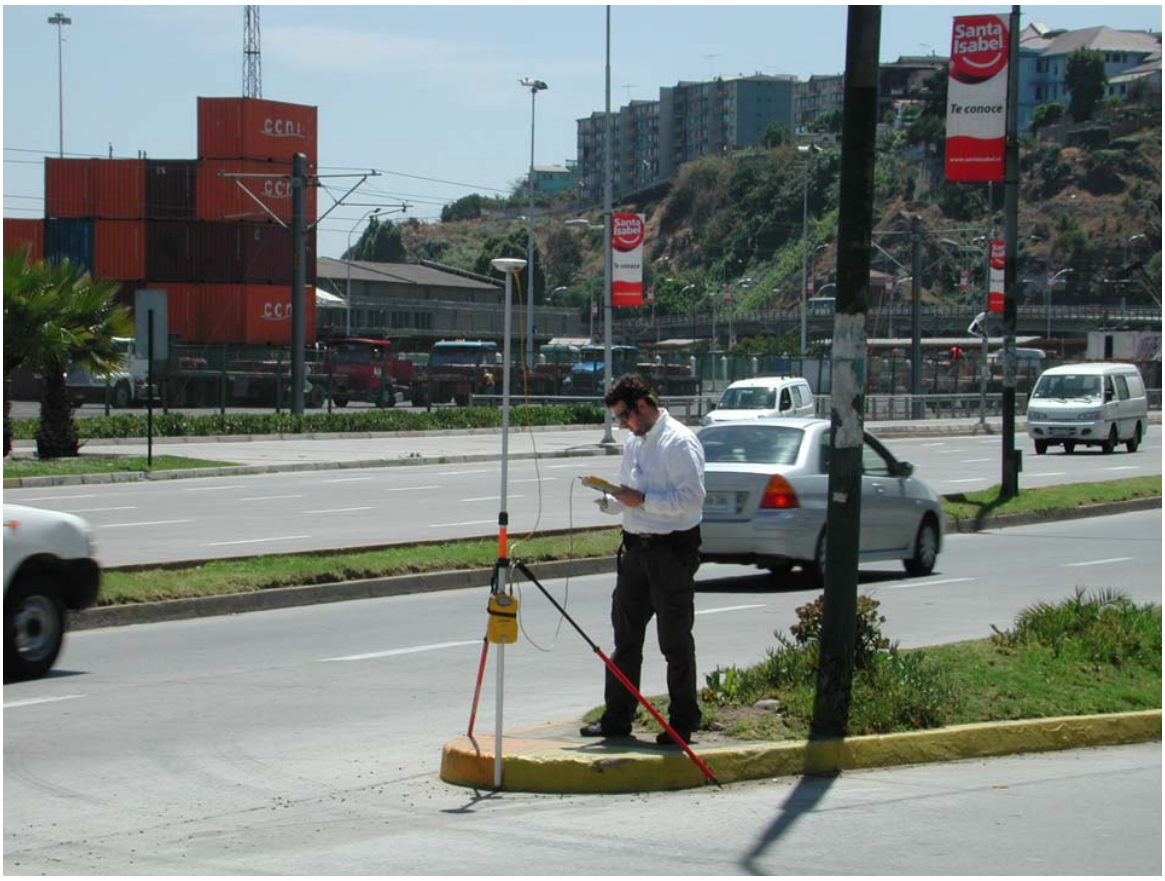



*Figure 17: DGPS Rover on site BRAZIL.*


*Figure 18: DGPS Rover on site LA CANTERA.*

*Figure 19: DGPS Rover on site CAMINO INGLESES.*

*Figure 20: DGPS Rover on site CAMOGLI.*

*Figure 21: DGPS Rover on site CEMENTERIO.*

*Figure 22: DGPS Rover on site EL VERGEL.*


*Figure 23: DGPS Rover on site ERCILIA.*


*Figure 24: DGPS Rover on site HERMANAS.*

*Figure 25: DGPS Rover on site MATRIZ.*

*Figure 26: DGPS Rover on site MEMBRILLOS.*

*Figure 27: DGPS Rover on site MIRADOR.*

*Figure 28: DGPS Rover on site NAPOLI.*

*Figure 29: DGPS Rover on site PARQUE ITALIA.*

*Figure 30: DGPS Rover on site PLAYA ANCHA.*


*Figure 31: DGPS Rover on site PLATA SAN LUIS.*

*Figure 32: DGPS Rover on site PLAZA BISMARK.*

*Figure 33: DGPS Rover on site PORTALES.*

*Figure 34: DGPS Rover on site PUERTAS NEGRAS.*

*Figure 35: DGPS Rover on site REDONDO.*

*Figure 36: DGPS Rover on site SAN FRANCISCO.*

*Figure 37: Rover on site YOLANDA.*

## REFERENCES


**[01]** MAR VASTO Project, General Progress Report n.1, 20.08.2007.
**[02]** MAR VASTO Project, General Progress Report n.2, 28.01.2008.
**[03]** MAR VASTO Project, General Progress Report n.3, 30.06.2008.
**[04]** MAR VASTO Project, A GIS database for the City of Valparaiso, 30.06.2008.
**[05]** Aerial photos provided by SHOA (Servicio Hidrografico y Oceanografico de la Armada de Chile) of the Valparaiso urban area:
scale 1:15000, black and white, 2004;
scale 1:20000, black and white, 1994.