Positional Control in the 1:25000 Cartography, Oporto Region

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Key words: Accuracy, data acquisition, quality control, cartography

SUMMARY

The Portuguese Army Geographic Institute (IGeoE), being aware of the importance of the positional accuracy of the geographic information, as a national reference entity, evaluates periodically the accuracy of the geographic information it produces.

Now it's in production the Oporto Block consisting of 22 1:25 000 scale sheets, bounded on the north by Povoa de Varzim, on the south by Espinho, on the east by Castelo de Paiva and on the west by the Atlantic Ocean, being already concluded the restitution operations and being the information used at the moment by the Survey Section to complete and finish the data acquisition process.

The IGeoE invested human and material resources on the development of methodologies having in mind the monitoring of the positional accuracy of the Official Cartography that it produces throughout the different phases of the data acquisition process, described in this article.

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1. INTRODUCTION

According to the International Standards, ISO19113 and ISO19114, the positional accuracy is one of the elements of the geographic information quality, having an essential role since the beginning of the process of the cartography production, being impossible for a producer of geographic information to neglect this element, being necessary to ensure the quality standards required for each scale. This will condition the whole production process, requiring the implementation of processes and methodologies which guarantee the positional accuracy required to cartography.

For the production of the Military Maps of the Oporto Block (Figure 1), the digital aerial photographs at 1:44 000 scale, have been transferred to IGeoE being the photogrammetric support, the aerotriangulation and the restitution a responsibility of IGeoE.

Thus, this article aims to describe the procedures used by IGeoE in the process of data acquisition for the Military Maps, as well as the ones to monitorize the positional accuracy of those data, in what refers to the Oporto Block.

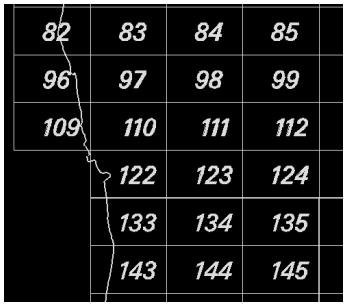

Figure 1 - Framework of Oporto Block, for the 1:25 000, M888 Series.

2. DATA ACQUISITION PROCESS

2.1 Survey of photogrammetric points

The survey of Photogrammetric Points (PP) consists in collecting three-dimensional coordinates, in the field, of well defined points on the earth surface and clearly visible in aerial photography (Figure 2), having in mind the aerotriangulation.

This task is performed by the IGeoE Survey Section. The PP are selected on the aerial photographs, according to the framework of the photogrammetric flight, with an average density of 12 PP per 1:25 000 sheet (each sheet covers an area of 160 km^2 resulting from a 16km length by 10 km width).

The Survey Section performs the field acquisition of those coordinates with the support of the SERVIR (Sistema de Estações de Referência VIRtuais) CORS (Continuous Operating Reference Stations) network. This network was implemented and is managed by that Section. Consisting nowadays of 27 GNSS (Global Navigation Satellite System) base stations distributed throughout the mainland territory, it uses the VRS (Virtual Reference Station)

technique to calculate the differential corrections that are sended to the users on the field, using GPRS (General Packet Radio Service) protocol preferentially. The distribution of the stations is the following:

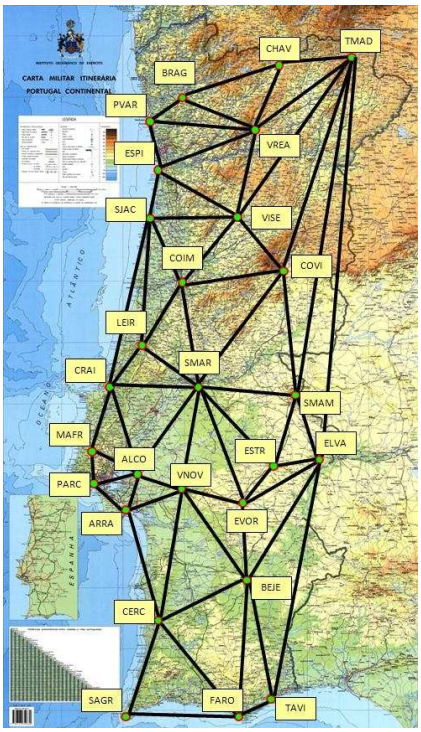

Figure 2 – Distribution of CORS network.

To the Oporto Block 292 photogrammetric points have been coordinated, having each one of them a positional accuracy better than 0.05 m (Afonso et al, 2007).

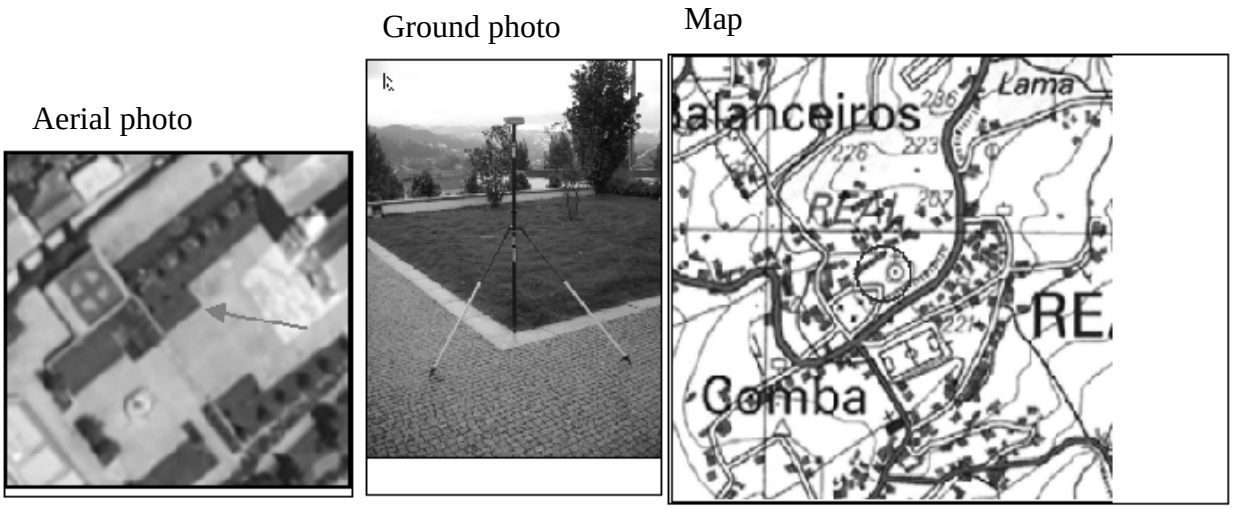

Figure 3 - Example of a photogrammetric point of Oporto block.

2.2 Aerotriangulation

The Aerotriangulation (AT) is the process of assigning ground control values to points on a block of photographs by determining the relationship between the photographs and known ground control points. This block is composed of several partial models, mathematically similar to the object, using the support available on the field.
In the AT of the Oporto Block a conventional aerotriangulation was done, having been used only photogrammetric points in the calculation and adjustment of the AT. The external orientation parameters of aerial photographs (X0, Y0, Z0, ω, φ and κ) were despised, ie the coordinates of the projection center and the rotation of optical axis at the time of the shooting weren't used, because there is no information about their precision.
The result of the AT (Figure 4) is analyzed after the final calculations are finished. The AT results are only accepted if they are within the parameters defined previously.

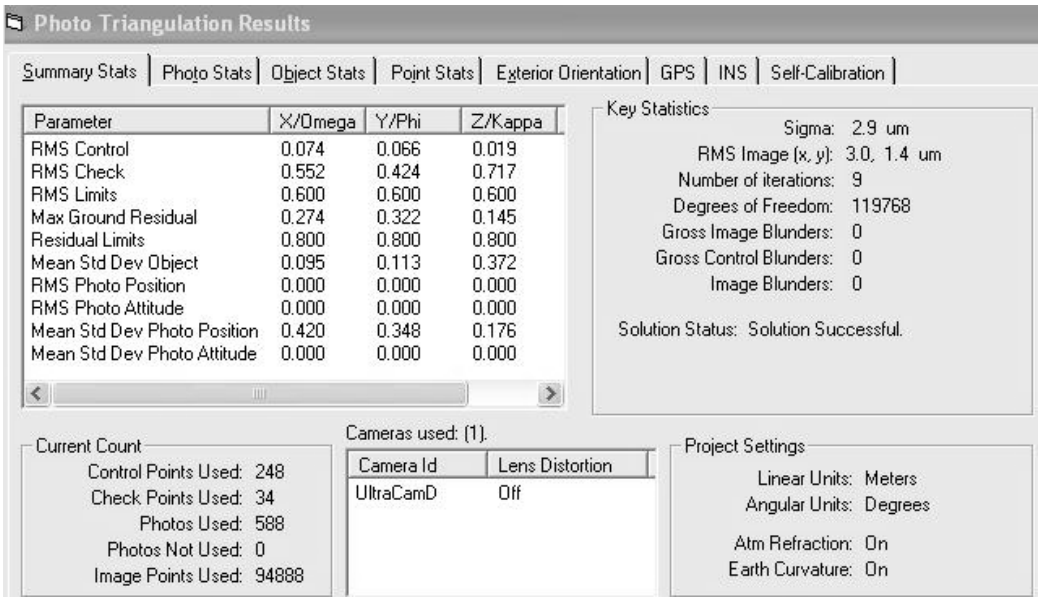

Figure 4 - Aerotriangulation results.

2.3 Positional Accuracy of the Aerotriangulation

After completing the AT, it is verified its positional accuracy, for which were used 33 independent points (geodetic benchmarks both horizontal and vertical), distributed along the Oporto Block.
Two readings were made (model coordinates) to each control point at the photogrammetric workstation, having been considered the average value of those readings for the final coordinates of each control point.
As "true" value were used the coordinates of the geodetic benchmarks, measured during the photogrametric points survey.
In order to estimate the accuracy in the calculation and adjustment of the aerotriangulatin it was used the Root Mean Square Error (RMSE) and obtained a value of 0.44 m for planimetry (1) and 0.51 m for the height (2).

$$RMSE_{MP} = \sqrt{\frac{\sum_{i=1}^{n}(E_{iT} - E_{iM})^2 + \sum_{i=1}^{n}(N_{iT} - N_{iM})^2}{n-1}} \quad (1)$$

Where:

E_{iT} , N_{iT} - "True" value of planimetric coordinates of the point i.

E_{iM} , N_{iM} - planimetric coordinates read in the photogrammetric workstation of the point i.

n is the number of control points.

$$RMSE_Z = \sqrt{\frac{\sum_{i=1}^{n}(Z_{iT} - Z_{iM})^2}{n-1}} \quad (2)$$

Where:

Z_{iT} - "True" height, of the point i

Z_{iM} - height read in the photogrammetric workstation, of the point i.

n is the number of control points.

2.4 Restitution

Restitution is the process of interpreting the existing information in the stereoscopic model (by the photogrammetrist), followed by the respective acquisition, according to the IGeoE Data Catalogue.

The restitution of information for the Military Maps is performed according to the Rules of Acquisition, to ensure homogeneity of the information in all the national territory.

Besides the content errors (omissions and / or confusions) that might appear at this acquisition phase, in what respects to the positional accuracy of the information acquired, positional errors can be added related with the photogrammetrist stereoscopic skills . So, to ensure that all photogrammetrists have the necessary requirements for the acquisition of data for the Military Maps, stereoscopic acuity tests are done, on a regular basis, having all the intervenients the classification of GOOD, with an error in the height less than 0.5 m.

3. POSITIONAL CONTROL OF THE GEOGRAPHIC INFORMATION

3.1 Control points

The choice of control points was done randomly having in mind a homogeneous distribution throughout the study area. They are only planned where it is possible to establish a unequivocally correspondence between the acquired point on the photogrametric workstation and the point measured on the field. So, the universe was substantially reduced, having the control been limited to objects in which "real" geometry and the geometry of representation in the Military Maps is the same, with well defined angles. Examples of this are buildings, walls and fences.

A total of 104 control points were planned and measured using GNSS equipments, with support of the SERVIR CORS network These were the "True" coordinates. To the same

points it was considered the coordinates measured in the workstation in the vector data file.

3.2 Results

After a first analysis, the points measured on the field that didn't match the points acquired by the photogrammetrist were removed of the sample, having resulted 101 control points to calculate the positional accuracy of the vector data. For those points was calculated the RMSE for planimetry (3) and altimetry (4).

$$\mathrm{RMSE}_{MP} = \sqrt{\frac{\sum_{i=1}^{n}(E_{iT} - E_{iC})^2 + \sum_{i=1}^{n}(N_{iT} - N_{iC})^2}{n-1}} \qquad (3)$$

Where:

E_{iT}, N_{iT} - "True" planimetric coordinates to the point i.

E_{iC}, N_{iC} - planimetric coordinates to the point i, extracted from the vector data.

n is the number of control points.

$$\mathrm{RMSE}_{Z} = \sqrt{\frac{\sum_{i=1}^{n}(Z_{iT} - Z_{iC})^2}{n-1}} \qquad (4)$$

Where:

Z_{iT} - "true" height, for the point i.

Z_{iC} - height to the point i, extracted from the vector data.

n is the number of control points.

It was obtained a RMSE of 1,02 m for the planimetry and a RMSE of 1,04 m for the height. Was also analyzed the distribution of errors along the Oporto Block. The result was an homogeneous distribution (Figure 4), not having been registered any influence neither from the type of relief nor due to the photogrametrist.

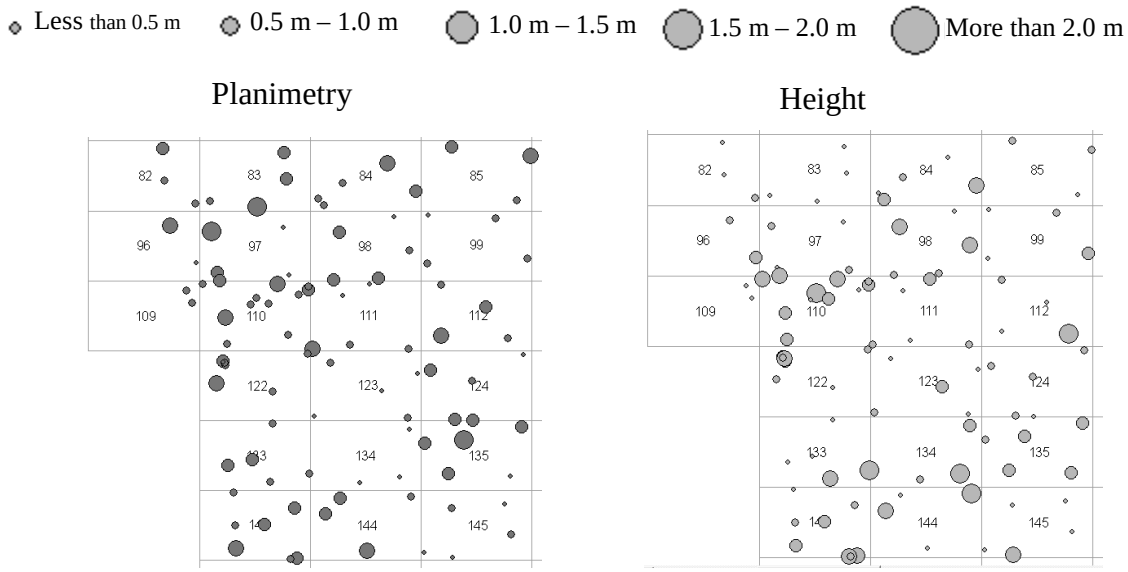

Figure 5 - Distribution of errors.

4. Conclusion

The geographic information of the Military Maps 1:25 000, Série M888, achieves and exceeds all the elements of positional accuracy required not only to the cartography of medium scales, but also to the cartography of higher scale.

This study also allowed to validate the methods and processes used by IGeoE in the production of its cartography.

IGeoE keeps asserting as a producer of cartography of high quality and accuracy.

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BIOGRAPHICAL NOTES

Rui Dias is the Head of the Photogrammetry Section of the IGeoE since July 2009. Before he was the Head of the Survey Section. He holds a Geographic Engineer degree by the Faculty of Sciences of the University of Lisbon. He published several papers related with CORS networks and quality control of the geographic information.

Rui Teodoro is the Head of the Survey Section of the IGeoE since July 2009. Before he was the Chief of the Survey Teams. He holds a Geographic Engineer degree by the Faculty of Sciences of the University of Lisbon. He is also a professor at the Military Academy and at the Internal Security and Police Sciences Institute. He published several papers related with CORS networks, vector data generalization and survey practical applications.

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