Topographic letter's control with GPS

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ABSTRACT

This study is included in the research project "GPS, Cartograpy applications and Geoid's modelling", that is being developed in the Universidad del Sur, whith the cooperation of investigators coming from La Plata University, and a group of surveyors from the municipality of Bahía Blanca.
The main objectives were to control the topographical maps, specifically those in the zone of Bahía Blanca that are being used as support of the territorial information system used by the local municipality (S.I.Te.- B.B.) and to analize the transformation parameters between Campo Inchauspe frame (which is the frame of the existing cartography) and the WGS 84 system (materialized in Argentina by POSGAR network).
Topographical GPS receivers were used to position several points that were perfectly identifiable in the maps. Relative positioning was carried out, using as base station a point placed in the Univesidad Nacional del Sur, which WGS84 coordinates had been obtained in a previous survey by linking this point to the POSGAR network (cooperation in Argentina by POSGAR network).
Naturally, the GPS coordinates were transformed to the Campo Inchauspe frame, and then projected to obtain Gauss-Kruger plane coordinates. These coordinates are directly comparable with the values obtained from the maps. An excellent correspondance was found, especially considering the type of receivers used (which are the most commonly used by the surveyors in this region), and the scale of the maps which do not justify the use of more precise receivers.

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All the information included in the territorial information system is geographically connected through a joint of
or spatial coordinates given in some reference system. This is used by the local municipality (S.I.T.e-B.B.).
Normally, it is said that the information is georeferenced.

Evidently, the system of reference must be singular (the only one) and must have the necessary internal precision suitable for the needs of the SIT.

One can define this system theoretically but when it is implemented, it must be materialized from the assignmnet of coordinates to identified points. So we can define it as the frame of reference associated to the system.

Therefore, one of the first steps towards the implementation of a SIT, will be to establish the geometric base, that is the support of all the complex. Its capacity to show precisely the relative position of the different elements, will directly affect the whole information.

The (S.I.T.e-B.B.) territorial information system used by the local municipality, has considered a group of 21 maps as a geometric support, on a scale of 1: 2.500, that cover all the urban zones that were built in 1968. These maps (from a photographic flight) allow the calculation of the Ga uss-Kruger coordinates of any identifiable point with a simple process of interpolation.

Although this cartographic document was opportunely approved by the Cartographic Departament of the Geodesy's Direction of the province of Buenos Aires, the thruth is that its real precision was never particularly and independantly verified especially with the most modern techniques.

Precisely, the main objetive of this work is to determine the intern consistency of these maps which will define a singular frame of reference on which all the S.I.T.e-B.B.
will be supported.

The differences between the coordinates obtained were compared to determine the precision. One of the methods used was the calculation of the specific points of the maps using the techniques of direct reading. The same points were calculated from the measurement of identifiable points using topographical GPS receivers as used in Posgar 94.

The analysis of the maps not only allow us to affirm their intern precision but to connect the frame of reference more tightly that they define in POSGAR 94.

The reference system.

The GPS coordinates belong to the reference system in which we express the ephemerides or the satellites positions. (This is known as the WGtS84 system: world geodetic system)

In our country, the WGS84 system is materialized by the POSGAR net (Argentine Geodetics Positions). The survey of this net was carried out by the Instituto Geográfico Militar between the years 1993 and 1994 and the calculation was made by the Facultad de Ciencias Astronómicas y Geofisicas de la Universidad de La Plata. The IGM officially established the POSGAR net as a National Frame of Reference in May, 1997.

There is one point which belongs to this net in Bahía Blanca. The 5-I-200 also belongs to the old trigonometrical net of this country situated in the nearness of the local graveyard. There are two points related to this net work: one on the roof of one of the university's buildings in Alem Avenue and another in the gardens of the Centro de I. Básicas y Aplic. De B.Bca., in "La Carrindanga" road . This network was made by the professionals and experts of IGM. Until the appearance of GPS, the Geodetic System used by our country was Inchauspe 69. The planimetrics Datum was defined in the Campo Inchauspe point, (in the province of Buenos Aires) while the altimetrical datum is established in the "Altimetrical Point of Normal Reference" in the city of Tandil city which is related to the middle level of the sea in front of the coast of Mar del Plata.

The Hayford's international ellipsoid and the Gauss-Kruger's cartographic projections were adopted. As we have previously said, the coordinates that we obtain from the maps (Inchauspe 69) can't be directly compared with those that we obtain from the GPS's measurement (WGS84), because each of them is related to a different geodesic system. It is essential to make the necessary transformation to make them compatible.

The parameters used for the transformation between the two systems: Inchauspe 69 and WGS84 (Ref. DMA Tech. Rep. 8350.2, 1987) can be traced to the works made by the Defense Mapping Agency of the Unites States in the 70s. when the relation between Inchauspe 69 and the WGS72's system was determined. The translation parameters are:

Xi69		Xwgs		+148m
Yi69	=	Ywgs	+	-136m
Zi69	=	Zwgs	+	-090m

The coordinates obtained from this transformation are converted in ellipsoid coordinates (latitude, longitude, height) and projected to Gauss-Kruger's system through the conventional formulas.

Development of the field work

The chosen method to control the maps required some points placed within them so that they could be situated in the land with GPS receivers. This assignment was not easy because we had to identify points with easy access in the urban zone, and without obstacles or obstructions (trees, buildings, light posts etc) that could interfere in the reception of the satellite signals. In most cases, we used points placed in roofs that could be clearly identified in the maps.

The points were selected in such a way so that they could include the ones taken in the different maps of the whole city. To avoid any inconvenience we selected 2 points in each map .

We finally measured 22 points. In the attached graphic the sector that is included in each map and the position of each one of the GPS measured points is indicated.

Concerning the GPS methodology, we worked in a differential way using 2 Geo-Explorer (Trimble) Topographical receivers, capable to register observations in Phase L1.

One of the receivers remained fixed in VBCA point (related to the POSGAR net). The other receiver was operated during 15 minutes in each point registering observations every 5 seconds for those satellites whose heights over the horizon are greater than 10 degrees.

Resuits

The GPS data was tried with the commercial software PHASE PROCCESOR, obtaining satisfying estimates of the solutions in all the cases. The coordinates adopted for the VBCA point in the POSGAR 94 system (WGS84) are:
Latitude: 38° 42' 2",79 south
Longitude: 62° 16' 9",22 west
Height: 58,8meters

The resultant coordinates of WGS84 for each point were transformed to Inchauspe 69 with the official translation parameters already quoted. (Ref. Del Cogliano D., and Perdomo R. 1994. The final plane coordinates were obtained using the Gauss-Krüger proyection.

On the other hand, the plane coordinates (Inchauspe 69) of the same points were read from the maps. In Table I, the direct differences between both sets of plane coordinates in the GPS- Map way can be observed.

The precision of the determined coordinates with GPS was better estimated for the 50cm horizontal components (normally between 20 and 50 cm

In the case of coordinates obtained from the maps, the limit of appreciation is in an order of 0,5mm, that for a scale of 1:2500 resulting in an indefinition of 1,25m.
Therefore, the GPS technique adopted, is adequatelly precise to make the control of these maps.

Analysis of the results.

Due to the dimensions of the measured area (8km x 10km) and the precisions involucrated, it seems adecuated to make a simple statistic analysis of the differences found in each of the coordinates.

Therefore, the simple average of the differences that figure in Table I, and the standard desviation of the distribution of the respective remainder was calculated. These behaviours are represented in figure 1.

From Table 1:

Average (dx) = 1,50m
Standard desviation (x) = 1,13m
Average (dy) = -3,80m
Standard desviation (y) = 1,27m

The resulting desviation shows the excellent internal consistency of the studied maps. It can be observed that they are of the same order of the appreciation's mistake in the reading (around 1,25m). The averages are indicative of a remaining translation between the systems defined by the two frames of involucrated reference. If at first, it is conferred to problems in the three translation parameters included in the transformation between systems, the nearly four meters found are perfectly inside within the precision estimated for them.This result is important because applying this new translation (fundamentally in Y component) to the map coordinates, the POSGAR 94 coordinates with the estimated precisions (σ: 1,3m) can be obtained.

Conclusions

-The analized maps are very suitable to be used as a geometric base of system of geographic information.

-The parameters used in the transformation are valid for our zone within estimated precisions for them even when in later works they could be improved or adjusted, taking into consideraation the great discrepancy found in the coordinate.

Meanwhile, and considering the security of the future densifications of the SIT which could be made with GPS, it seems convenient to apply the translations calculated here (especially in Y) to the maps coordinates. Thus, the coordinates between systems can be linked through the official transformation parameters without losing precision.

Finally, it will remain to the judgment of the owner of the SIT, to define the system which will be used.

-Considering the existence of specific works tending to improve the transformation parameters (Ref.: Claudio Brunini, Javier Olondriz and Rubén C. Rodriguez, Chile, 1995), in future works it is expected that they will be used and its performance in the zone will be studied.

-The landsurveyors will be able to obtain points of known coordinates for the measurings and finally use the differencial process with GPS.

-The GPS technics used with topographical instruments are suitable for the control of cartographics documents in the mentioned scales.

-Even in densily urban zones it is possible to use GPS, which convert this instrument in an ideal complement for the densification of coordinate points of the geometric base of any sig or sit, and fundamentally extend the zone farther of the zone covered by the maps, with a minimum economic cost.

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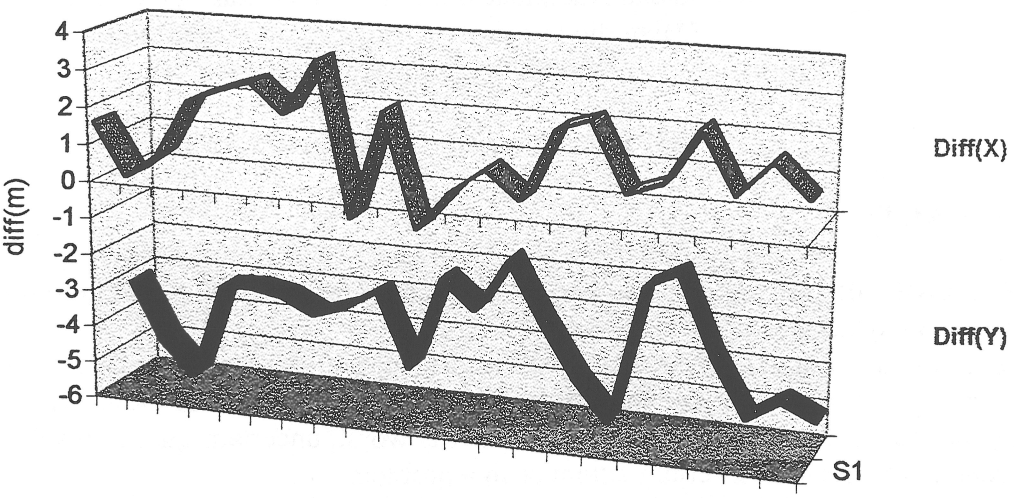
	UBICATION	ROVER FILE	BASE FILE	SOUTH LATITUDE	WEST LONGITUDE	GEOCALCS TRANSF. X(m)	GEOCALCS TRANSF. Y(m)	MEASURED IN MAP X'(m)	MEASURED IN MAP Y'(m)	DIFFERENCES X-X'(m)	DIFFERENCES Y-Y'(m)
1	Velodromo Esq. O	r080819a		38º41'18",10	62º16'29",28	5718017,0	4563166,8	5718016	4563172	1,0	-5,2
2	Aguado y Mitre	r080820a	b080819a	38º42'12",38	62º16'45",47	5716335,3	4562762,3	5716333	4562767	2,3	-4,7
3	Colombia 1070	r083012a		38º41'34",45	62º16'11",43	5717509,6	4563594,2	5717507	4563598	2,6	-3,8
4	Zelarrayan 2000	r083013a	b083012b	38º41'50",19	62º17'24",71	5717038,1	4561819,4	5717037	4561821	1,1	-1,6
5	Hospital Municipal	r083014a		38º42'35",43	62º16'39",30	5715634,4	4562905,7	5715634	4562909	0,4	-3,3
6	G.Torres y Brown	r091116a		38º47'08",03	62º15'58",56	5707220,6	4563822,7	5707219	4563826	1,6	-3,3
7	Plunket - Mz. 394 p	r091117a		38º46'34",01	62º15'46",84	5708267,1	4564114,0	5708267	4564119	0,1	-5,0
8	T. del Fuego y 1810	r091117b	b091116a	38º45'08",08	62º15'32",13	5710914,3	4564490,8	5710912	4564494	2,3	-3,2
9	Tarija 1431	r091118a		38º45'30",07	62º14'50",79	5710227,8	4565483,1	5710227	4565489	0,8	-5,9
10	Misiones y Paunero	r091119a		38º44'27",81	62º16'12",79	5712163,9	4563518,7	5712161	4563522	2,9	-3,3
11	M. Pedraza y Colon	r091119b	b091118a	38º44'20",85	62º17'30",89	5712393,2	4561634,2	5712391	4561638	2,2	-3,8
12	Chancay y Sta. Cruz	r091120a		38º43'41",45	62º17'58",69	5713613,6	4560972,1	5713614	4560975	-0,5	-2,9
13	Escuela Nº18	r091816a		38º43'07",62	62º15'20",86	5714626,5	4561792,9	5714626	4561796	0,5	-3,2
14	Cabo Farina 61	r091817b	b081816a	38º44'28",20	62º14'19",24	5712129,6	4566260,8	5712127	4566264	2,6	-3,2
15	Rem.Escal. y Newton	r091818a		38º43'36",53	62º14'22",74	5713723,4	4566189,6	5713724	4566192	-0,6	-2,4
16	Haiti	r091819a		38º42'43",36	62º14'35",38	5715304,2	4565897,3	5715303	4565899	1,1	-1,7
17	14 de Julio	r091820a	b091818a	38º41'59",82	62º12'45",47	5716685,8	4568564,9	5716685	4568567	0,8	-2,1
18	Pueyrredón 402	r092516a		38º43'43",15	62º15'49",90	5713536,6	4564082,5	5713533	4564086	3,6	-3,5
19	La Piedad - Gorriti	r092517a	b092516a	38º43'39",47	62º17'04",60	5713664,4	4562279,0	5713662	4562284	2,4	-5,0
20	OSBA Sarmiento	r092517b		38º42'04",43	62º14'52",83	5716569,6	4565486,2	5716567	4565492	2,6	-5,8
21	Sarmiento 3500-Casa	r092518a		38º41'31",13	62º14'20",51	5717590,0	4566275,7	5717589	4566281	1,0	-5,3
22	Sarmiento 3700-Alam	r092518b	b092518a	38º41'25",46	62º14'06",27	5717761,9	4566621,3	5717760	4566626	1,9	-4,8

N-S Differences



Distribution of the differences in both components,in the North-South direction.