

Establishment of Algerian-Tunisian Unified GPS Network

Mr. M. Haddad

National Institute of Cartography and Remote Sensing.

123, Tripoli Street – P.O.B 430, Hussein Dey, Algiers, Algeria.

E-mail : inct99@wissal.dz Fax : +213 21 23 43 81

ملخص : تسمح أجهزة تحديد المواقع (GPS) بإعطاء قياس دقيق في أي وقت ، سهل التطبيق و منخفض الكلفة. تجعل هذه المميزات من أجهزة تحديد المواقع الأداة الملائمة للمواقع و رصد الظواهر الجيوفيزيائية بمقاييس مختلفة، (تكتونية الصفائح ، المراقبة الزلزالية ، قياسات الجيود). في هذا السياق، تكون مدة الأرصاد في أغلب الأوقات جد طويلة (بعض الأيام في عدة سنوات) . أنجزت عملية البحث بالشراكة بين المعهد الوطني للخرائط و الكشف عن بعد (الجزائر) و المركز الوطني للكشف عن بعد (تونس) حول إنشاء شبكة GPS الموحدة الجزائرية التونسية و تحسين دقة المواقع ، خصوصاً العمودية ، بإستعمال تقنية GPS . في هذا السياق ، أرصد في وقت واحد المعهد الوطني للخرائط و الكشف عن بعد (الجزائر) و المركز الوطني للكشف عن بعد (تونس) ثمانية نصب بإستعمال تقنية GPS خلال أسبوع رقم 1502 (من 19 إلى 25 أكتوبر 2008) . علجت معطيات GPS المجمعة بالبرنامج برنس 5.0 بالطريقة الآلية بإدماج معطيات IGS و النتائج. تكمن الدقة المحصل عليها لكل الإحداثيات في نظام بعض المليمترات .

الكلمات الأساسية : شبكة GPS الموحدة الجزائرية التونسية ، برنس ، PCF RNX2SNX ، إحدثيات rms المكررة .

Résumé: Le système de positionnement global (GPS) permet une mesure précise n'importe quand, facile à mettre en application et de coût faible. Ces caractéristiques font du GPS un outil favorisé pour le positionnement et l'observation des phénomènes géophysiques à diverses échelles (tectonique des plaques, surveillance sismique, mesures de géoïde). Dans ce contexte, la durée d'observations est en général très longue (quelques jours dans plusieurs années). L'action de recherche est réalisée conjointement par l'Institut National de Cartographie et de Télédétection (Algérie) et le Centre National de Télédétection (Tunisie) sur l'établissement du Réseau GPS Unifié Algero- Tunisien et l'amélioration de la précision du positionnement, en particulier vertical, en utilisant la technique GPS. Dans ce contexte, huit bornes (de limite de terrain) Algero-Tunisien ont été observées simultanées par l'Institut National de Cartographie et de Télédétection - Algérie et le Centre National de Télédétection-Tunisie en utilisant la technique GPS pendant la semaine GPS n°1502 (du 19 jusqu'au 25 octobre 2008). Les données GPS collectées ont été traitées par le logiciel scientifique Bernese 5.0 en mode automatique en intégrant les données IGS et les produits. La précision obtenue pour toutes les coordonnées est dans l'ordre de quelques millimètres.

Mots-clés: Réseau GPS Unifié Algero- Tunisien, Bernese, PCF RNX2SNX, coordonnées rms répétées.

Abstract : GPS allows a precise measure at any time, easy to implement and of weak expense. These characteristics make of GPS a favored tool for positioning and for geophysics phenomena observation with various scales (plate's tectonics, seismic surveillance, measures of geode). In this context, the duration of observations is in general very long (some days in several years).

A research action is jointly performed by the National Institute of Cartography and Remote sensing (Algeria) and the National Centre of Remote sensing (Tunisia) on the establishment of Algerian-Tunisian Unified GPS Network and improvement of the positioning precision, notably vertical, using the GPS technique. In this context, eight Algerian-Tunisian boundary markers were observed by the National Institute of Cartography and Remote Sensing - Algeria and the National Centre of Remote sensing - Tunisia in simultaneous using GPS technique during the GPS Week n°1502 (from 19th till 25th October 2008). The collected GPS data were processed using Bernese 5.0 scientific software in automatic mode while integrating the IGS data and products. The precision obtained for all coordinates is in the order of some millimeters.

Key words : unified Algerian-Tunisian GPS network, Bernese, RNX2SNX PCF, repeatability coordinates rms.

1. Introduction

In the goal of unification of GPS networks of Algeria and Tunisia, a set of eight Algerian-Tunisian boundary markers (102, 219, 315, 02, 146-01, 17-02, 275 and 005-01) were observed by the National Institute of Cartography and Remote Sensing - Algeria and the National Centre of Remote sensing - Tunisia in simultaneous using GPS technique during the GPS Week n°1502 (from 19th till 25th October 2008). Considering the precision asked for the data processing, it was necessary to use adapted scientific software. For that, the collected GPS data processing was performed using Bernese software available at level of the National Institute of Cartography and Remote Sensing.

The difficulty of Bernese software manipulation and the tiring character of the preparation of processing as well as the possibility of choosing numerous processing options, forced us to use its BPE automatic mode. This mode allows having the simplicity of use of commercial software while benefiting from advantages of scientific software.

The objective of this paper consists in the presentation of the different stages of data processing and the analysis of acquired precision.

2. Campaign of GPS measurements

The campaign of observations of unified Algerian-Tunisian GPS network took place during all GPS week n°1502 (from 19th till 25th October, 2008). Observations were organized by daily sessions of 24 hours. The cadenza of recording was 30 seconds with an angle of elevation of 5°.

The table (1) represents collected daily GPS observations (in blue by National Institute of Cartography and Remote Sensing - Algeria and in red by National Centre of Remote sensing - Tunisia) and the GPS data of IGS used as reference stations.

Table 1. Collected GPS data.

Num. Station	19 October 2008	20 October 2008	21 October 2008	22 October 2008	23 October 2008	24 October 2008	25 October 2008
102							
219							
315							
02							
146-01							
17-02							
275							
005-01							

The figure (1) represents the geographical distribution of the eight Algerian-Tunisian boundary markers (points in red):



Fig. 1 Geographical distribution of the eight Algerian-Tunisian boundary markers.

Data collected by National Institute of Cartography and Remote Sensing - Algeria and National Centre of Remote sensing - Tunisia were transformed from constructor's format to the international standard format RINEX to be useful by software Bernese. The RINEX observations files are in the form of an ASCII file and decline in two versions: an O file which contains observations and an N file which contains the ephemerides satellites.

3. Preparation data and products IGS files

For the preparation of the group of files necessary for the GPS observations processing by Bernese 5.0, an informatics program "Rin2Sindown" was developed. We note that this program is based on the subroutines of the free program "NetDownload" developed by Dr. Marco Roggero of the polytechnic school of Italy. "Rin2Sindown" allows the automatic downloading from Internet the precise ephemerides (sp3) files, clock information (clk) files and GPS observations files of IGS stations in RINEX format. The figure (2) represents the execution window of "Rin2Sindown" program:

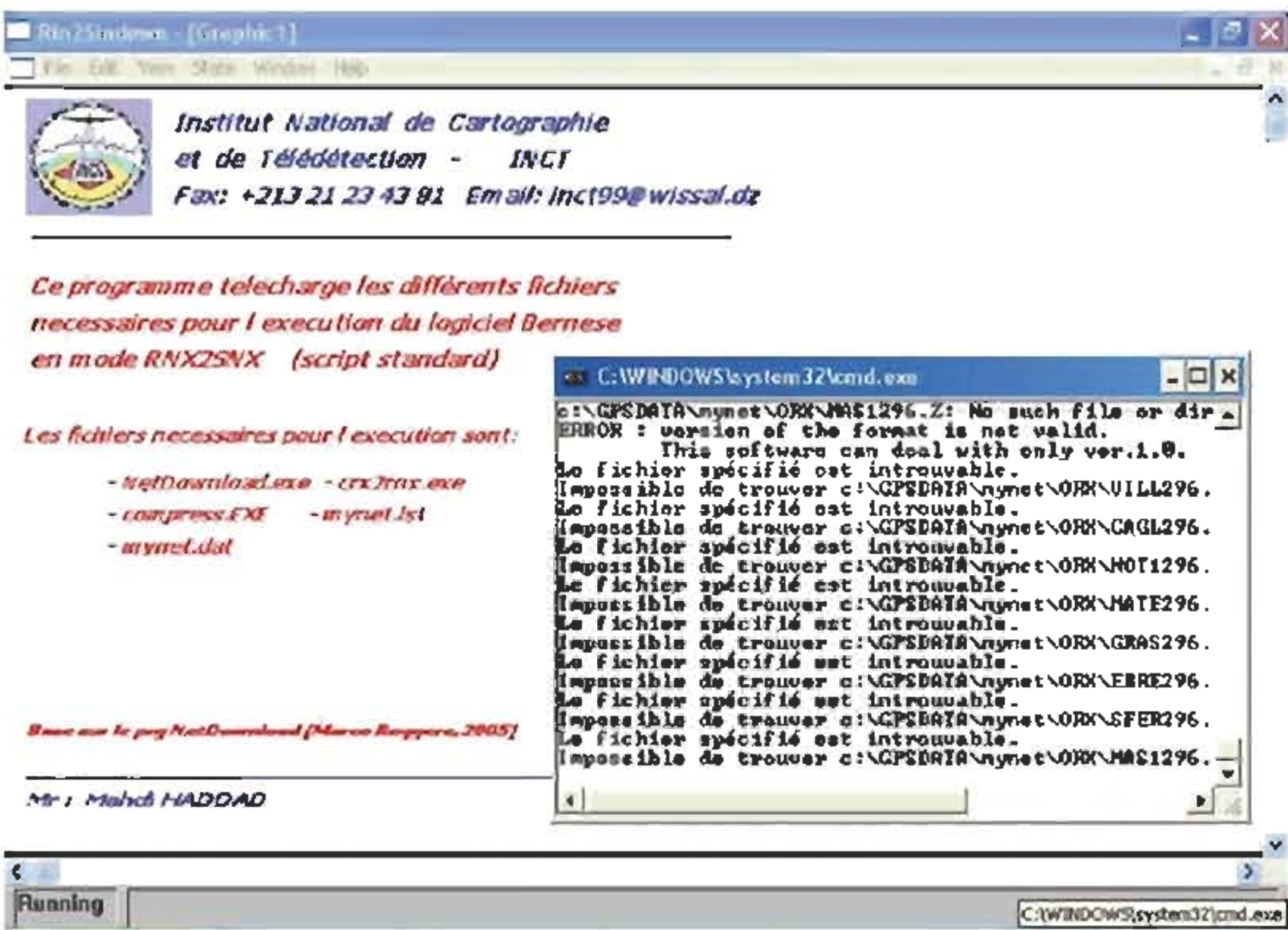


Fig. 2 Execution window of "Rin2Sindown".

4. Data processing

The Bernese GPS Software v5.0 (Dach et al., 2007 & 2004) was used to process the daily observations sessions of unified Algerian-Tunisian GPS network, session by session.

The reference sites used in process are the seven stations of International GNSS Service (IGS): GRAS (France), Cagliari (Italy), Matera (Italy), NOT1 (Italy), MAS1 (Spain), SFER (Spain) and VILL (Spain).

A first process was performed in automatic mode using the PPP PCF of Bernese 5.0. Coordinates acquired from the eight stations, from sub-decimetric precision, were used on one hand, for the preparation of the oceanic tide corrections file and on the other hand, as approached coordinates for the final process using Bernese 5.0 in RX2SNX PCF automatic mode.

The RX2SNX.PCF is intended for a double-difference based analysis of RINEX GNSS observation data from a regional network. Station coordinates and troposphere parameters are estimated and stored in Bernese and SINEX format to facilitate further processing and combination.

For the seven daily data sessions of unified Algerian-Tunisian GPS network, the basic options of the used RX2SNX processing strategy are:

The consideration of “absolute” GNSS receiver and satellite antenna phase center offset (I05).

- Observation files with significant gaps or unexpectedly big residuals will automatically be removed from the processing to ensure a robust processing and a reasonable network solution.
- Phase ambiguity fixing is attempted for baselines up to 2000 km length based on the Quasi-Ionosphere-Free (QIF) resolution strategy.
- The final network solution is a minimum constraint solution, realized by three no-net-translation conditions imposed on a set of IGS05 reference coordinates. The coordinates of all involved fiducial stations are subsequently verified by means of a 3-parameter Helmert transformation. In case of discrepancies, the network solution is recomputed based on a reduced set of fiducial stations.

For each session, the corresponding normal equation information is saved for a subsequent multi-session solution.

5. Final coordinates

The Bernese GPS Software allows estimating final site coordinates in a network analysis. The normal equation systems from different sessions are combined in a multi-session solution with ADDNEQ2. All coordinate parameters belonging to the same station are combined to one single set of coordinates.

The seven daily solutions of unified Algerian-Tunisian GPS network were therefore combined by adapting the Minimum Constraint Solution strategy. The IGS stations were considered as fixed stations. The resulting coordinates then refer to the middle epoch (October 22, 2008).

Held count, that we do not dispose enough observations repeated on more than a year, we did not consider the speed dimension in this combination.

To appreciate the quality of results, we are interested to the weekly coordinate repeatability. A bad repeatability indicates possible environmental, station, or processing problems. It also may be caused by geophysical phenomena (e.g., Earthquake).

For that, a seven-parameter Helmert transformation was applied to compare each individual solution of unified Algerian-Tunisian GPS network with the combined solution. The geodetic datum of the network is defined based on minimum constraint solution. The table (3) represents the repeatability coordinates rms values of the combined solution:

Table 3. Repeatability coordinates rms values of the combined solution.

Station	#Days	Weekday Repeatability (mm)			
		0123456	N	E	U
102	4	XXXX	1.58	0.91	3.15
146-01	3	XXX	0.91	0.32	3.43
17-02	3	XXX	0.71	2.19	2.69
219	7	XXXXXXX	1.51	1.19	5.37
275	3	XXX	6.29	6.75	3.95
315	7	XXXXXXX	1.14	1.17	9.79
005-01	3	XXX	0.72	1.63	4.58
02	7	XXXXXXX	0.41	1.34	3.90
CAGL	7	XXXXXXX	2.15	1.33	4.51
GRAS	7	XXXXXXX	0.95	0.86	1.96
MAS1	7	XXXXXXX	1.23	1.08	2.68
MATE	7	XXXXXXX	1.05	0.84	2.85
NOT1	7	XXXXXXX	0.69	0.88	1.92
SFER	7	XXXXXXX	0.86	1.08	3.06
VILL	7	XXXXXXX	0.85	0.49	3.83
Total	86		1.56	1.57	4.41

The precision of results acquired for all the coordinates' stations is in the order of 1-7 mm for planimetric components and of 2-10 mm for the vertical components.

After verification of the precision of processing, descriptive maps were prepared. Each map contain the coordinates of point expressed in the IGS05 geodetic system at the epoch October 22, 2008, the detailed description of the geodetic monument and extract of topographic map and satellite image.

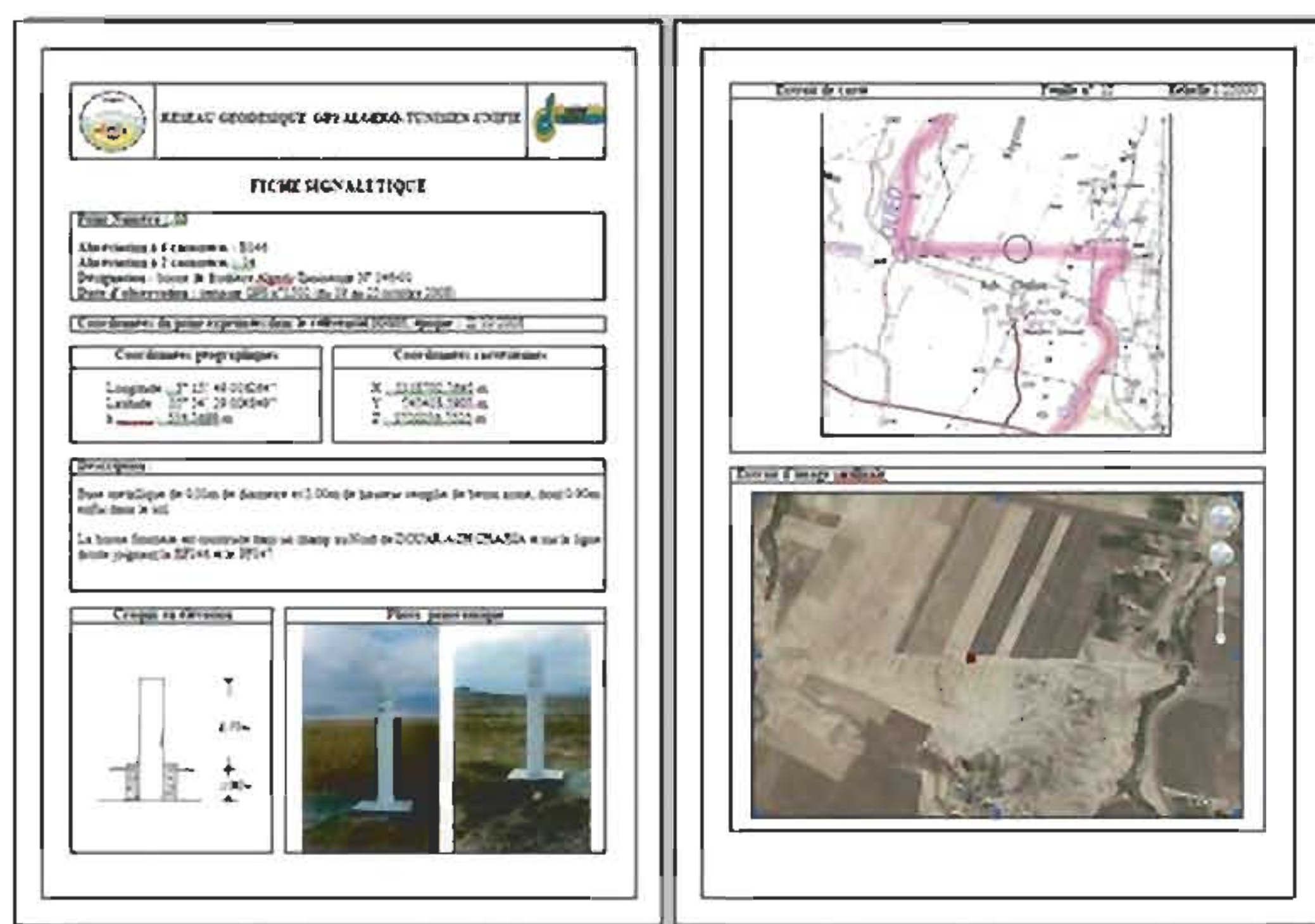


Fig. 3 Example of descriptive map.

6. Conclusion

The essential objective of this project "definition of a unified Algerian-Tunisian GPS network" concerns the mastery of a new technology: positioning by GPS satellites in general and her application at concrete needs having a direct impact on the modernization of Algerian and Tunisian geodetic facilities.

On data processing of Algerian-Tunisian unified GPS network, all our efforts are shared out on two parts:

- Make easier the preparation of IGS files essentials for the GPS data processing by Bernese 5.0 software.
- Data processing of unified Algerian Tunisian GPS network by Bernese 5.0 software.

In the first part, an informatics program was developed and exploited with intent to make easier the preparation of GPS campaigns to be treated by Bernese 5.0. In effect, this program allows recovering automatically the ephemerid files, the satellites clock information files and the GPS observations files of IGS stations in RINEX format.

Concerning the second part, a series of data processing of the eight Algerian-Tunisian boundary markers was made with software Bernese 5.0 while integrating the data of seven IGS stations: GRAS (France), Cagliari (Italy), Matera (Italy), NOT1 (Italy), MAS1 (Spain), SFER (Spain) et VILL (Spain).

The process in PCF RNX2SNX automatic mode has allowed us to get closer to the simplicity of commercial software use while benefiting from advantages of Bernese 5.0 scientific software. The precision obtained after compensation of all the baselines of the seven daily sessions of unified Algerian-Tunisian GPS network in the order of some millimetres is very promising.

In conclusion, we will keep the importance of the densification of the unified Algerian Tunisian GPS network which represents a key stake for the modernization of Algerian and Tunisian national geodetic facilities. This densification will indeed allow the improvement of quality and precision of this network.

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