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Maussane GPS field campaign: Methodology and Results

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1. Introduction

1.1. Project background

The European Union uses remotely sensed data in a large operational program to monitor subsidies given to farmers and to identify irregularities in claims. The trend over the last few years has been in sharp increase in the use of very high resolution sensors, with a number of different sensors being used in a complementary manner.
One of the tasks of the European Commission Joint Research Centre (JRC) is to benchmark new techniques, sensors or methods which could be used for improving the orthoimage production process, and provide guidance for quality assurance of deliverables to EU Member States.
A study site located near to Mausanne les Alpilles (south of France) was used since 1997 with a time series of reference data. The reference data include different sets of ground control points (GCPs) collected for defined purposes, digital elevation models and image data from various sources.
GCPs are needed for referencing or validating satellite imagery of different resolution and size (VHR and HR). Since the expected target accuracy for the VHR images was 50 to 75 cm RMSE and the JRC quality control guidelines stipulate that check points should be at least three times better than the target specification, check point acquisition quality needed to be better than 20-25 cm RMSE. This quality can be reached only using carrier-phase GPS receivers.

1.2. Objectives

The **main objective** of the mission is the GPS measurements of the Ground Control Points (GCPs) designed in the 10km by 10km area. Fifty objects are preliminary chosen as GCPs. Their identifiability conditions were checked on several existing images over this area (e.g. WV1, GE-1, EROSB, Cartosat2, RE, Cartosat1, ortoADS40 b-w). The 10x10km area was divided into 9 parts (sub-areas) and at least 4 points are chosen in each of the sub-area. At least one point that can serve as GCP for HR satellite imagery can be found in each sub-area while the resting points are mostly visible on VHR imagery only.
These points will be used for satellite images geo-correction and orthorectification, and the external quality control.
The **second objective** is to assess the impact of GCP position accuracy on orthorectification quality since most of these points are identifiable on the Leica Geosystems ADS40 Digital Airborne Camera Orthoimagery.
The **third objective** it is to test the GeoXH accuracy. The GeoXH announced accuracy using “H-Star Trimble method” (= “Fast Static Method” with 2 minutes of recorded data for each measured point) is better than:

- 10 cm for short baselines (<30 km)
- 20 cm for long baselines (30-80 km)

2. Method

The GPS measurements were done during a five days mission: 12-16 October 2007 included three days of field measurements and two days of travelling (Italy – France by JRC car).

2.1. Test site

The Mausanne site is located near to Mausanne-les-Alpilles in France. It has been used as test site by the European Commission Joint Research Centre since 1997. It comprises a time series of reference data (i.e. DEMs, imagery, and ground control) and presents a variety of agricultural conditions typical for the EU. The site contains a low mountain massif (elevation up to around 650m above sea level), mostly covered by forest, surrounded by low lying agricultural plains and a lot of olive groves. A number of low density small urban settlements and a few limited water bodies are present over the site. A 10/10 km area was considered for this field campaign (Figure 1).

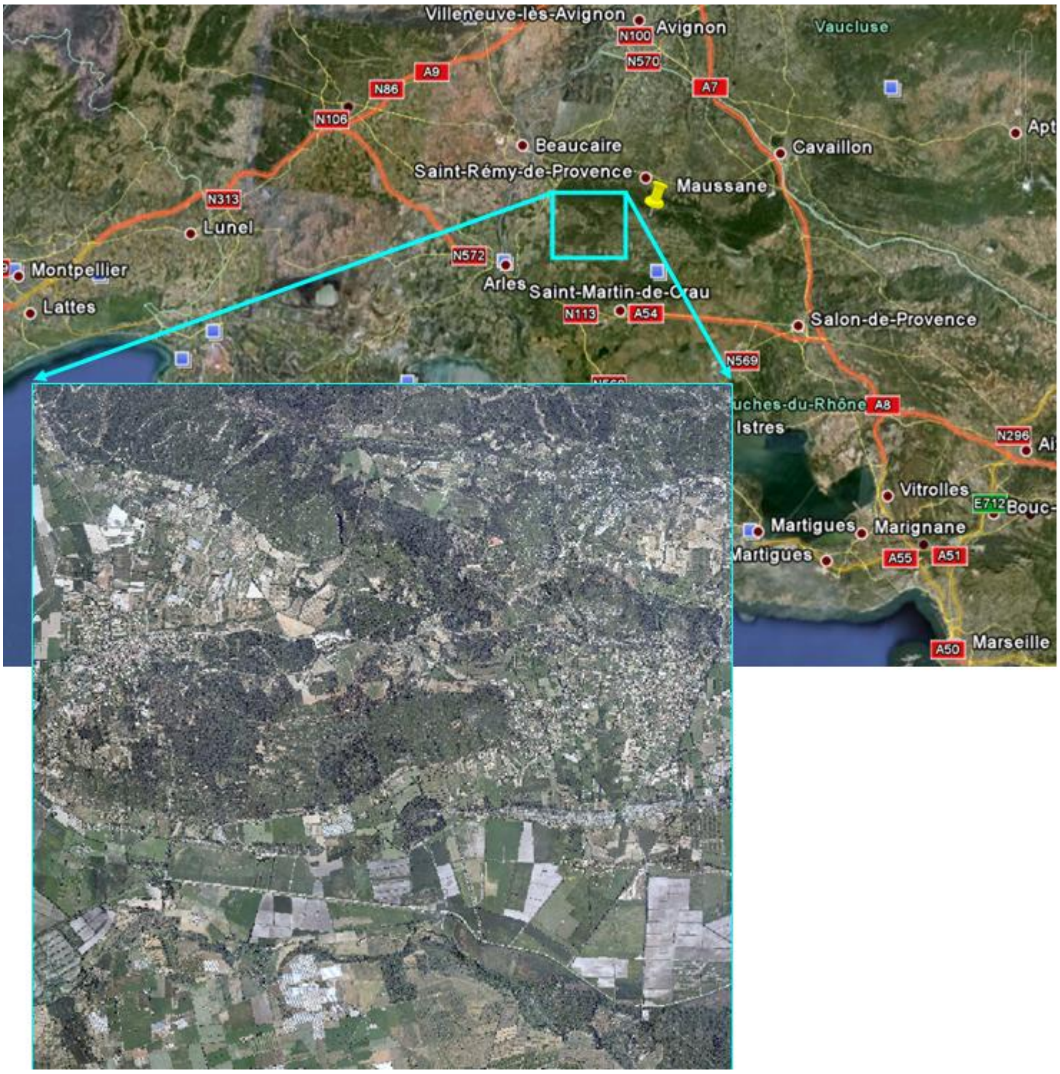


Figure 1. Maussane test site

2.2. GPS campaign

In order to reach the required accuracy (20-25 cm RMSE) the carrier-phase measurements were carried out. The data was post-processed using different base stations available on test site area. To be sure of the availability of the data for differential correction one of our T-5700 receivers was settled as Base Station (BS).

2.2.1. GPS receivers

For the missions purpose two different kind of GPS receivers were used:

- one **Trimble GeoXH** L1(/L2 carrier phase) receiver with L1/L2 Zephyr antenna and Pathfinder Office software for post-processing of data.
- two **Trimble 5700** series dual frequency carrier phase GPS receivers (with Ashtech L1/L2 antenna for our Base Station - BS) and Trimble Geomatics Office software for post-processing of the data (Fast Static method);

2.2.2. Available Base Stations

Three different BS networks are available on our test site area (Figure 2):

- *Réseau GNSS Permanent* (RGP) from *Institut Géographique National* (IGN) http://rgp.ign.fr/index.php
- EUREF Permanent Network (EPN): http ://www.epncb.oma.be/ ; only Marseille (MARS) BS is near of our test site.

- RENAG : http ://webrenag.unice.fr/index.php; unfortunately the data from Chateaurenard BS - CHRN (nearest of our test site) were not available for the period of field measurements

All these base stations provide daily/hourly free RINEX data available on the internet sites. A detailed map for each BS network is presented in Annex 2.

Figure 2. Available base stations near from our test site area: in red RGP (SGIL, NIME, AXPV, PRIE), in green RENAG (CHRN), in blue our BS settled in Chateau d''Estoublon domain. The Marseille BS is included in EUREF network.

Four different Base Stations (BS) from french IGN RGP network were used to asses the field measurements:

- Saint Giles (SGIL)
- Nimes (NIME)
- Aix-en-Provence (AXPV)
- Marseille (PRIE)

The distances between the base station and our test area are between 25 km (SGIL) and 80 km (PRIE). A detailed description of each BS is presented in Annex 3.

The CHRN BS data were unavailable on the web during the measurements period and the data does not used for these analyses. This BS included in RENAG network is managed by the *Commissariat a l'Energie Atomique* (http://www.cea.fr/) After several contacts (before and after the field campaign, 22/09 – 12/11) with Vincent Boutin and Mireille Flouzat from CEA only the CHRN data for 13 and 15 were founded.

2.2.3. Our Base Station in Chateau d'Estoublon

One Trimble 5700 receiver with L1/L2 Ashtech antenna served as our base station (Figure 3) settled within the private fenced propriety of *Le Château d'Estoublon* (http://www.estoublon.com). The antenna position was calculated in static mode with the both receivers: T-5700 (2 hours) and GeoXH (4 hours) using RGP BS data for post-processing.

Figure 3. Our BS (ESTO).

The position was unchanged during the three days of the measurement.

2.2.4. Field measurements

To have an estimation of GPS measurement accuracy, 3 geodetic points from French IGN (*Institut Géographique National*) geodetic network (http://geodesie.ign.fr/) situated in our test area were measured. The detailed description of these geodetic points is presented in Annex 4. These measurements allow to estimate the accuracy of GeoXH and T-5700 receivers and the impact of used base station data (Base Line length) on post-processing results.

A second check of GeoXH accuracy was carried out by measurement of some GCP's (the same antenna position) with both receivers: GeoXH and T-5700. Fast Static mode (8 minutes per point) was used for T-5700 receiver. GeoXH recorded data only for 2 minutes.

A set of 50 GCP to be measured was prepared in advance. The GCP approximate positions were known. Using a map (1/10000) and the GeoXH in navigation mode the GCP's were identified on the field. The measurements were carried out using the GeoXH with Zephyr antenna for 2 minutes for each point (Figure 4).

Figure 4. Example of field measurement.

2.3. GCP

2.3.1. GCPs distribution

Fifty objects were preliminary chosen as GCPs within the 10km by 10km area sub-divided into 9 parts (sub-areas). All sub-areas were covered by at least four GCPs to fulfil the requirement with regards to fair GCPs distribution over AOI.

2.3.2. GCPs identifiability conditions

The GCPs identifiability conditions were checked a priori using several existing images over this area (e.g. WV1, GE-1, EROSB, Cartosat2, RE, Cartosat1, ortoADS40 b-w). At least one point that can serve as GCP for HR satellite imagery can be found in each sub-area while the resting points are mostly visible on VHR imagery only.

2.3.3. Objects choice

The proper selection of the ground control points (GCPs), their measurement and identification on the images influence the overall accuracy of the points themselves and the output product based on them. Therefore we focused on points represented by:

- well-defined, univocal features,
- objects clearly visible on both the input and target image,
- permanent, relatively stable in time objects.

Points that are represented by stable objects without vertical displacement (i.e. lying on the ground), mostly the centres or corners of the small, well contrasting road intersections (crossroads), the centres of the small countryside bridges (Fig.5), and electric poles were chosen as the GCPs.

Figure 5. Example of a small countryside bridge.

2.3.4. Availability issues

Not all 10km by 10km Maussane Terrestrial Test area is available for GPS measurements. There are lots of private proprieties that cannot be entered. Additionally, there are some areas temporarily unavailable e.g. due to hunting. Such information cannot be deduced from the aerial or satellite imagery neither topographic maps

In case when the pre-defined ground control points (GCPs) were not accessible, the substitute object was searched in the neighbourhood and its visibility on the existing imagery was evaluated. In case of successful result, the new point was given its own ID number and was measured, otherwise we moved to the next point.

3. <u>Results</u>

3.1. GPS measurement results

3.1.1. Quality control and impact of the used Base Station data for post-processing

To have an estimation of measurements accuracy three geodetic points were measured with both receivers (GeoXH and T-5700). The recorded data were post-processed using RINEX files from four different RGP BS: SGIL, NIME, AXPV and PRIE. The results of these positions calculations are presented in Figure 5.

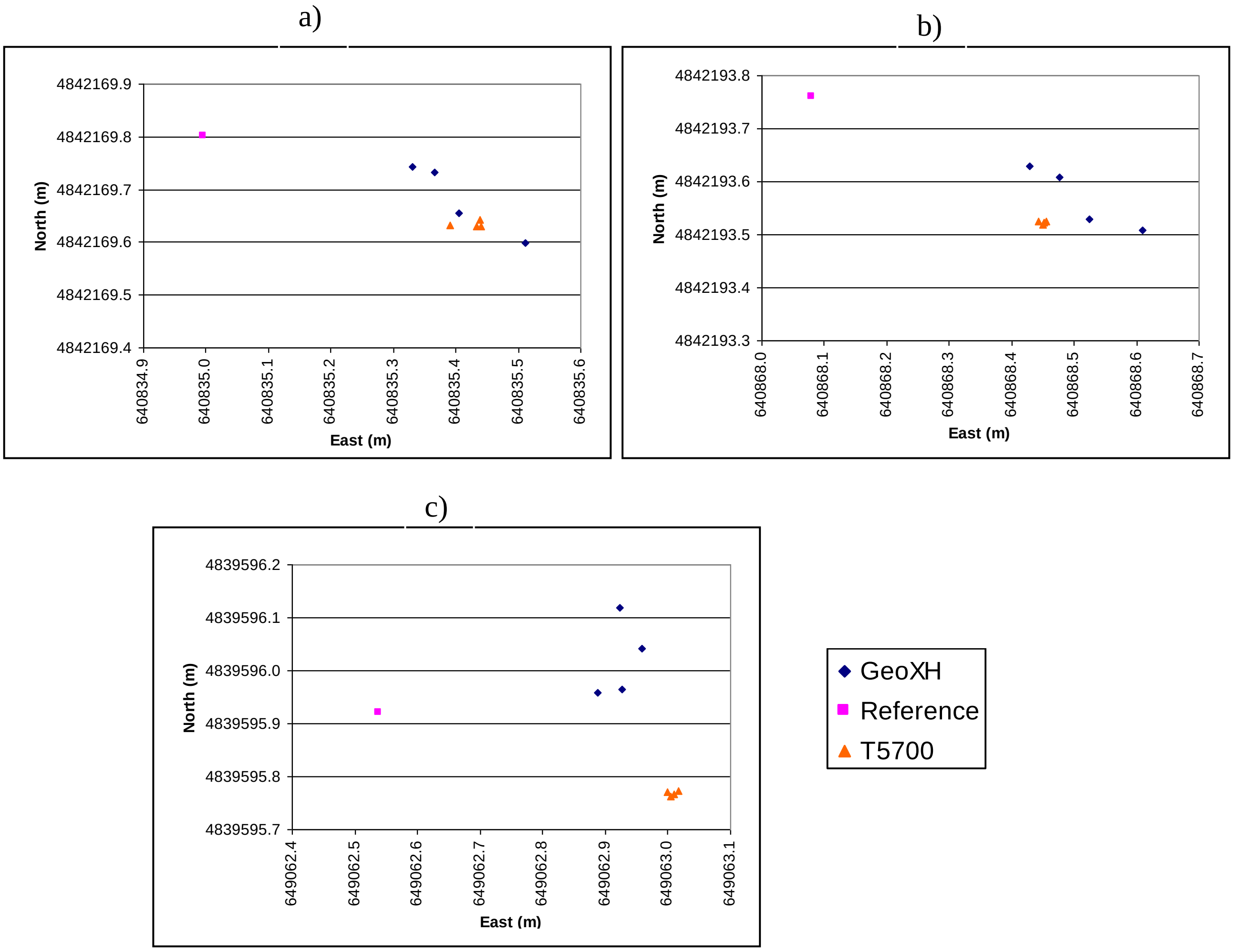
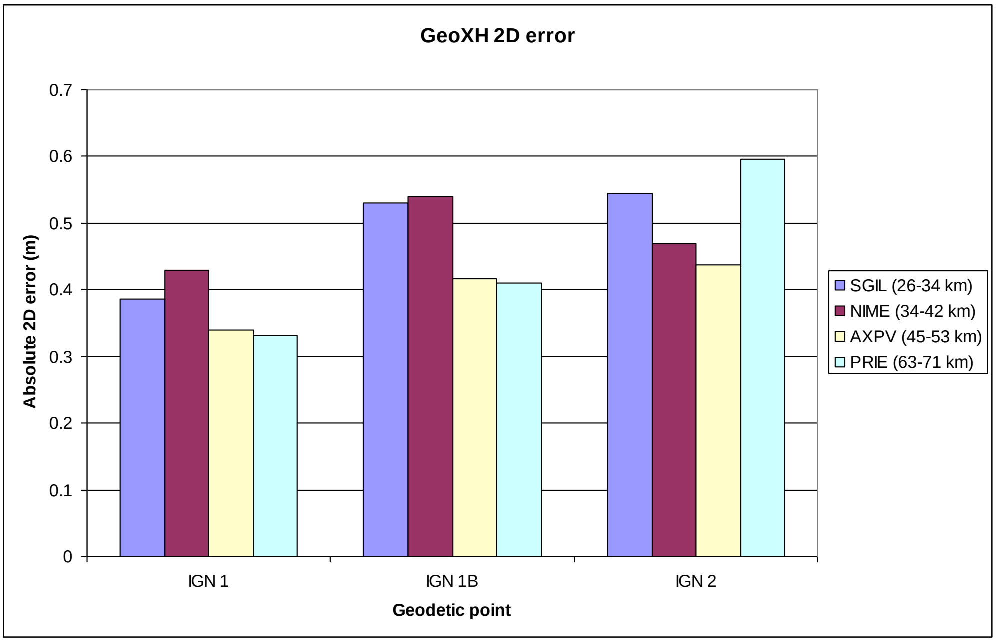


Figure 5. Reference and measured position of three geodetic points: a) 1303806 A (IGN 1), b) 1303806 B (IGN 1B), c) 1306503 A (IGN 2). The coordinates are in UTM, zone 31N.

The measurements were carried out with GeoXH (in blue) and T-5700 (in red) receivers. Geo XH receiver results are enough accurate but more much sensitive to the BS data.

The impact of Base Station used for post-processing of data on measurement accuracy result is presented in Figure 6.

a)



b)

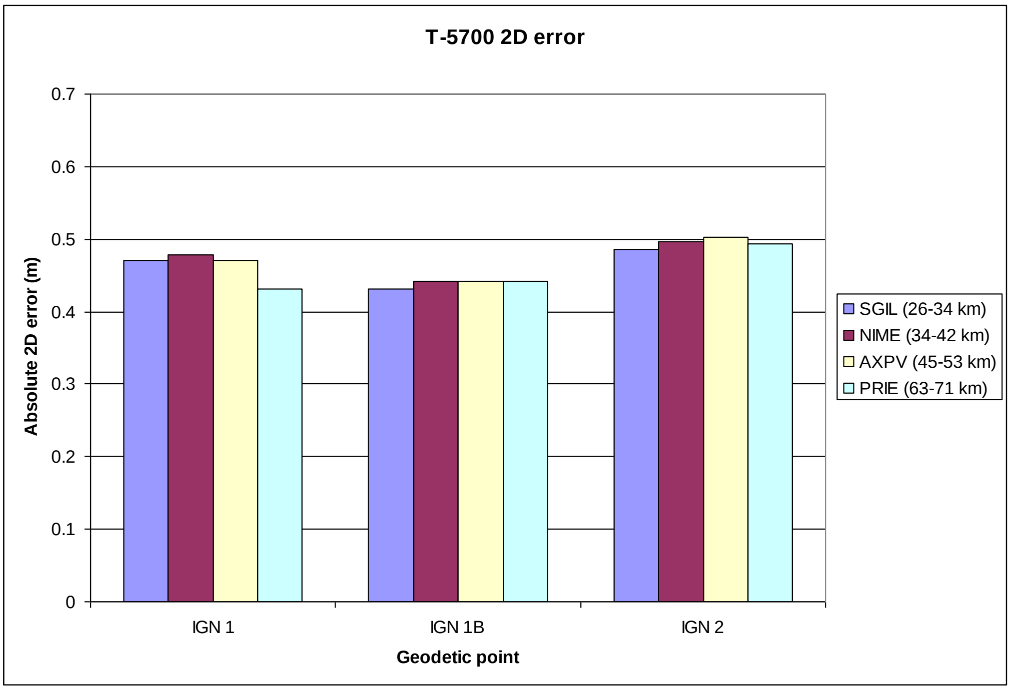


Figure 6. The plane error (2D) between reference and measured positions of three geodetic points with both receivers and using four BS data for post-processing: a) GeoXH results, b) T-5700 results

The BS impact is higher for GeoXH measurement than for T-5700 but the both receivers gives the same order of error.

The plane error global results for the three geodetic points are presented in Table 1.

Table 1. Mean plane error and standard deviation measurements results on the geodetic points calculated for each BS

		SGIL (26-34 km) n=3	NIME (34-42 km) n=3	**AXPV** (45-53 km) n=3	PRIE (63-71 km) n=3	Overall average n=12
GeoXH	Mean	0.49	0.48	**0.40**	0.45	0.46
	Stdev	0.088	0.056	**0.052**	0.136	0.079
T-5700	Mean	0.46	0.47	0.47	0.46	0.47
	Stdev	0.028	0.028	0.030	0.034	0.027

The mean plane error for GeoXH is between 0.40 and 0.49 m and for T-5700 between 0.46 and 0.47 m. The results are much more stables for T-5700 device but GeoXH results are comparable.
The Aix-en-Provence (AXPV) base station gives the best results for post processing of the GeoXH recorded data: 0.40 m plane mean error and 0.052 standard deviation. This result is also visible on the calculation of ESTO BS antenna position (figure 6). Taking in account these results, the AXPV base station was used for post processing of all data measured on the field.

3.1.2. Estoublon base station position calculation

The antenna position of our base station installed in Estoublon (ESTO) was calculated using the both devices: GeoXH during 4 hours and T-5700 during 2 hours. The differential correction was carried out using the four base stations from French IGN RGP network (Figure 7).

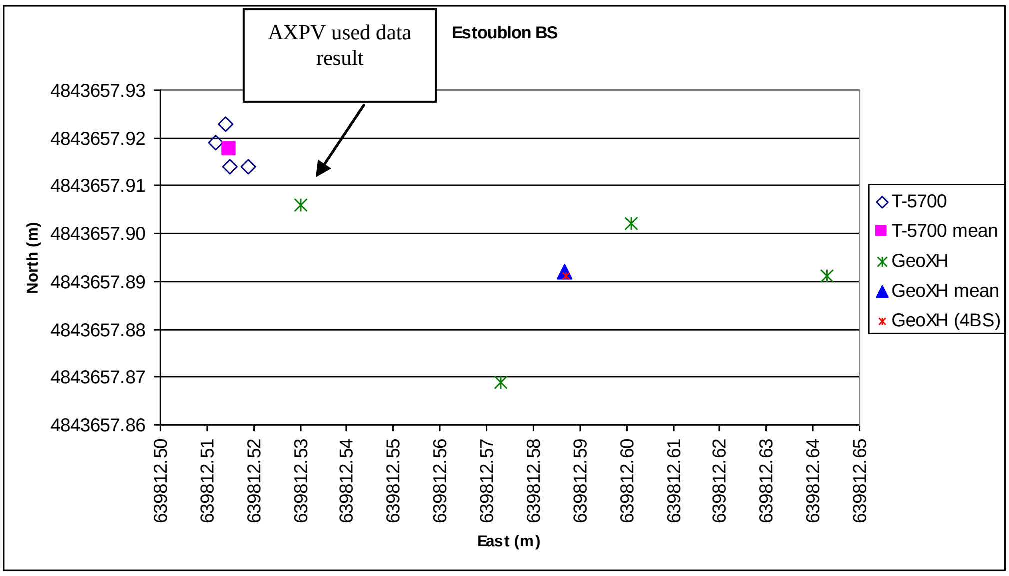


Figure 7. The Estoublon base station antenna position (UTM) calculated using the GeoXH and T-5700 receivers and four different IGN BS data for post-processing.

The T-5700 results are closer one of other and the results seem to be better estimates independently of the base station used for differential correction. The mean of 4 values was used for BS antenna position.
The GeoXH point calculated using AXPV base station data is nearest from T-5700 values and confirm the use of this data set for differential correction.
In spite of a so higher dispersion due to the use of different BS data, the GeoXH results are completely under required accuracy: < 30 cm.
A new option is available on Trimble Pathfinder Office which allows to use simultaneously more than one BS for differential correction. This option was tested for data acquired with GeoXH and post-processed using the four available BS data: SGIL, NIME, AXPV, PRIE. The results seem to be very near of the average of four differential correction results made separately (4BS in Figure 7 and Figure 8).

A new comparison between impacts of used BS data on the results of geodetic points measurements including our BS (ESTO) is presented in the
Table 2.

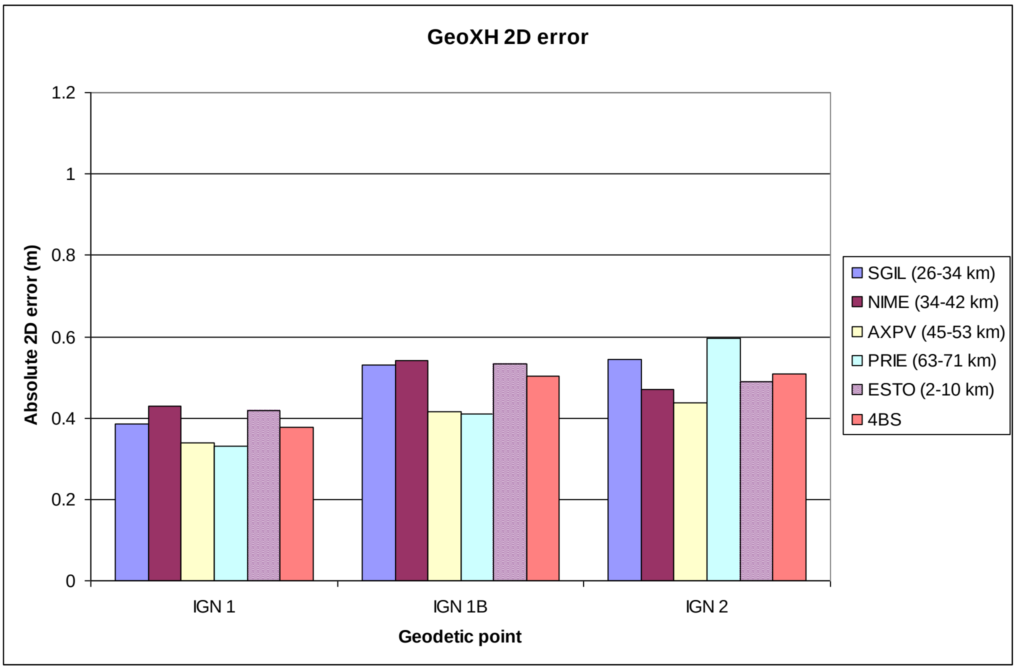
Table 2. Mean plane error and standard deviation of GeoXH measurements results on the geodetic points calculated for each BS

		SGIL (26-34 km) n=3	NIME (34-42 km) n=3	**AXPV** (45-53 km) n=3	PRIE (63-71 km) n=3	4 BS (26-71 km) n=3	ESTO (2-10 km) n=3
GeoXH	Mean	0.49	0.48	**0.40**	0.45	0.46	0.48
	Stdev	0.09	0.06	**0.05**	0.14	0.07	0.06

The use of our ESTO base station data does not improve the measurement accuracy on geodetic points position calculation.

The plane and slope error for GeoXH measurements results using all available BS data is presented in Figure 8.

a)



b)

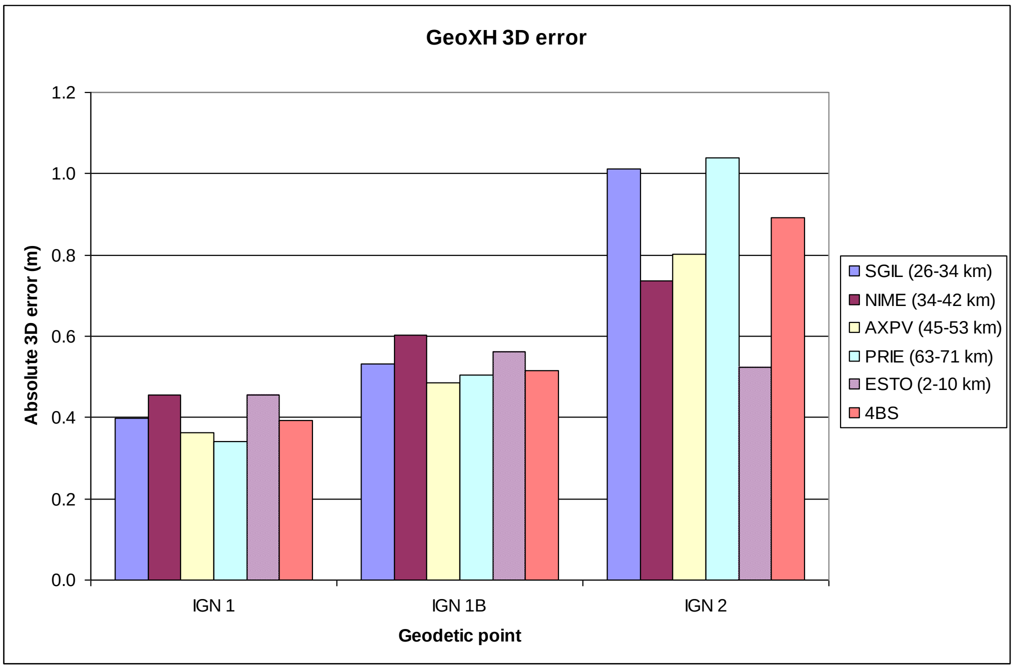


Figure 8. The error between reference and measured positions of three geodetic points with GeoXH receiver and using fives BS data for post-processing: a) plane distance (2D), b) slope distance (3D). The 4BS are the results using the multi-BS option in Pathfinder Office for differential correction.

Even the Estoublon base station is nearest one from our measurement area the results using the GeoXH are not significantly better than using another base station from French IGN network.

The detailed results for each geodetic point are presented in Table 3.

Table 3. The plane and slope distance results for each geodetic point using GeoXH receiver and the fives BS for post processing of the data.

	SGIL		NIME		AXPV		PRIE		4 BS*		ESTO	
	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D	2D	3D
IGN 1	0.39	0.40	0.43	0.46	0.34	0.36	0.42	0.45	0.38	0.39	0.42	0.45
IGN 1B	0.53	0.53	0.54	0.60	0.42	0.48	0.53	0.56	0.50	0.52	0.53	0.56
IGN 2	0.54	1.01	0.47	0.74	0.44	0.80	0.49	0.52	0.51	0.89	0.49	0.52
MEAN	0.49	0.65	0.48	0.60	0.40	0.55	0.48	0.51	0.46	0.60	0.48	0.51

* 4 BS: results using the Pathfinder Office option for simultaneously use of four BS data for differential correction

These measurement results for the three IGN geodetic points showed:

- the error between the reference position for each point and the new GPS measured position remains so high : 0.3 – 0.6 m (plane distance). The same level of error (0.6 – 0.7 m plane distance) was observed for the same geodetic points measured with T-5700 receiver in 2005 (file://S:\FMPArchive\P\4954.doc). A possible explanation could be the accuracy of reference coordinates for these points due to the movement of tectonic plates (http://geodesie.ign.fr/pdf/Util_info.pdf);
- the impact of the used BS data is higher for Geo XH post-processed data;
- the use of multi-station data for differential correction does not improves significantly the GeoXH results compared with only AXPV BS data;
- the GeoXH measurements results are enough accurate for required measurements: 0.20-0.25 m RMSE (a complementary test which arguments one more time this conclusion is presented in 3.3).

3.1.3. GeoXH – T-5700 results comparison

Few points were measured on the field using both receivers:

- T-5700: 8 minutes per point
- GeoXH: 2 minutes per point

The both data sets were differential corrected using AXPV BS data.
The difference between GeoXH and T-5700 for n=44 measurements is presented in Table 4.

Table 4. The plane and slope mean distance and standard deviation between GeoXH and T-5700 results.

	2D dif (m)	3D dif (m)
Mean	0.18	0.30
Stdev	0.22	0.26

The measurements with both receivers were carried out during 10-11 minutes (2 min for Geoxh + 8 min for T-5700 + 15-20 sec to change the connexion cable) and we can suppose to have the same GPS conditions: n. of satellites, PDOP, etc.
The mean of plane distance between GeoXH measurements and T-5700 is 0.18 m. Taking in account the accuracy of T-5700 device (< 5 cm) this value corresponding to the announced GeoXH accuracy: < 20 cm using a BS at maximum 80 km distance.
The accuracy of 3D measurements (slope distance) is less accurate, but is well known that Z estimation of GPS is around two times less accurate than plane coordinates estimation.

3.2. GCP results

Maussane GPS measurement for so-called ‘multi-use’ project was performed in October 2009 by C. Lucau and J.K. Nowak Da Costa.
The newly measured GCPs were measured on the the Leica Geosystems ADS40 Digital Airborne Camera Orthoimagery by two different observators. Then the RMS errors were calculated to evaluate the quality of the GCPs. Consequently few points were left out from the final set of ‘multi-use’ GCPs. The total number of GCPs is 41. Most of them are suitable for satellite or aerial imagery of ground sampling distance (GSD) between 0.3 to 5m, however not every measured object can serve for all

these resolutions. In general, the vast majority of measured objects can be easily identifiable on imagery characterised by less than 1 meter of GSD.

The data is stored at:
S:\Data\CID\MAUSSANE\Auxiliary_data_for_Mausanne\GCP_dataset_Maussane_prepared_for_multi-use_in_Oct-2009

The 'multi-use' GCPs naming convention is 660XX, where XX is a two-digit number that varies from 1 to 65. The full set of data consists of the text file with coordinates (ID, North[m], East[m], Ellips. Height [m]), the shape file, the imagettes and the terrestrial photos as identification aid. The ellipsoid and datum details are UTM 31N WGS84 (both horizontal and vertical).

4. <u>Conclusions</u>

GPS

- in Maussane area are enough available BS for post-processing of the data : fives situated between 20 and 80 km from our test site;
- a BS can be settled but no improvement (due of lower distance) of results observed;
- the GeoXH obtained accuracy of 0.20-0.30 m is enough for the GCP's coordinates measurement (77% of recorded data have a estimated accuracy better than 15 cm, Annex 1);
- the new "multi-station" option for differential correction can be used to improve the accuracy when no possibility to test the impact of different BS data;
- the GeoXH results are less stables than T-5700 results even for very long occupation periods (ESTO BS position estimation).

GCP

- The smaller and the more regular (symmetric) is the object to serve as ground control point, the easier point identification (both on-the-spot and satellite imagery) and the better accuracy of the GCP;
- The experience with the electric poles (to serve as GCPs) was against the above mentioned rule, probably due to not very consistent method of GPS measurement at these particular objects (long, not directly accessible); however they are easy to be identified on the very high resolution (VHR) satellite imagery (less than 1m of ground sampling distance);
- The measured set of the GCPs was designed for so-called multi-use, i.e. for satellite or aerial imagery of ground sampling distance between 0.3 to 5m, however not every measured object can serve for all these resolutions. The lesson learned: it is advisable to design ground control points separately for imagery of different geometric resolution.

A. Annexes

Annex 1: Measured coordinates of Ground Control Points

Annex 2: Available base station networks in our test site area

- EUREF
- RGP
- RENAG

Annex 3: Detailed description of RGP used BS:

- Saint Giles (SGIL)
- Nimes (NIME)
- Aix-en-Provence (AXPV)
- Marseille (PRIE)

Annex 4: Geodetic points

- 1303806
- 1306503

A.1. Annex 1: Measured coordinates of Ground Control Points

ID	Measured position (UTM - zone 31 N, WGS 84)		
	North (m)	East (m)	MSL (m)
66001	4845397.167	636937.247	57.308
66003	4846448.280	636305.211	55.838
66004	4846077.515	636363.620	54.584
66005	4845775.194	641149.126	152.591
66007	4845298.880	641804.022	145.865
66008	4845308.495	641821.834	148.530
66009	4845276.823	641850.726	147.466
66010	4845690.292	643598.100	216.984
66011	4844945.474	644844.933	198.086
66014	4845487.947	645687.638	213.998
66015	4845477.353	645830.461	210.951
66016	4837279.934	636347.009	78.847
66020	4837987.958	637261.089	80.620
66021	4837886.149	637266.470	80.065
66022	4837300.701	637947.945	75.812
66023	4838320.517	640624.493	90.505
66024	4838276.563	641320.704	93.593
66025	4841215.071	641380.518	83.021
66026	4840996.065	640049.047	106.177
66027	4840987.338	640180.763	104.916
66028	4840992.691	640296.274	107.898
66029	4837361.117	641151.790	83.925
66030	4837211.098	641183.519	82.113
66031	4839947.667	644655.956	52.608
66032	4839678.948	644563.376	51.102
66035	4837489.030	644717.258	63.612
66036	4837864.280	644548.600	56.111
66038	4841910.055	644535.092	62.494
66039	4842393.698	636607.206	55.013
66043	4843024.157	641680.340	114.404
66044	4843119.664	641321.746	117.017
66045	4842251.705	642336.270	118.855
66046	4837348.789	641148.671	84.009
66049	4843017.779	644906.913	108.938
66050	4842091.979	637124.676	81.913
66060	4843067.668	641536.619	120.421
60061	4841196.354	641347.480	82.164
66062	4842242.194	636570.501	59.044
66063	4842180.715	636896.931	66.587
66064	4839952.339	644632.994	52.561
66065	4837301.772	636400.713	79.769
440008	4843087.464	641527.389	121.360

The estimate accuracy of 77% of measurement is better than 15 cm (21.6 % between 15 and 30 cm). This estimation from Pathfinder Office is presented here:

Differential Correction Summary:
8 files processed. In these files:
16319 (97.2%) of 16786 selected positions were carrier corrected by post-processing

Estimated accuracies for 16174 corrected positions are as follows:

Range	Percentage
0-15cm	77.1%
15-30cm	21.6%
30-50cm	1.1%
0.5-1m	0.1%
1-2m	0.0%
2-5m	-
>5m	-

Differential correction complete.

A.2. Annex 2: Available base station networks in our test site area: EUREF, RGP and RENAG

A.2.1. EUREF network

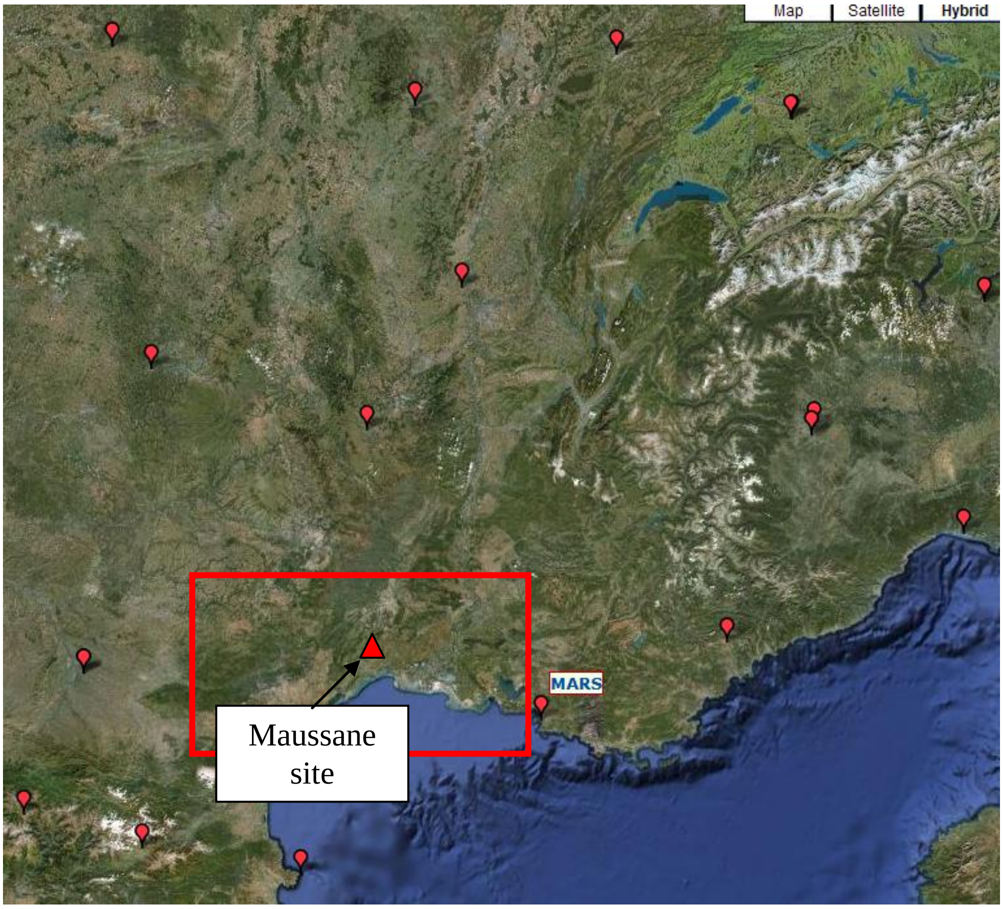


Figure 9. EUREF base stations network (http://www.epncb.oma.be/_trackingnetwork/siteinfo.php)

A.2.2. RGP network

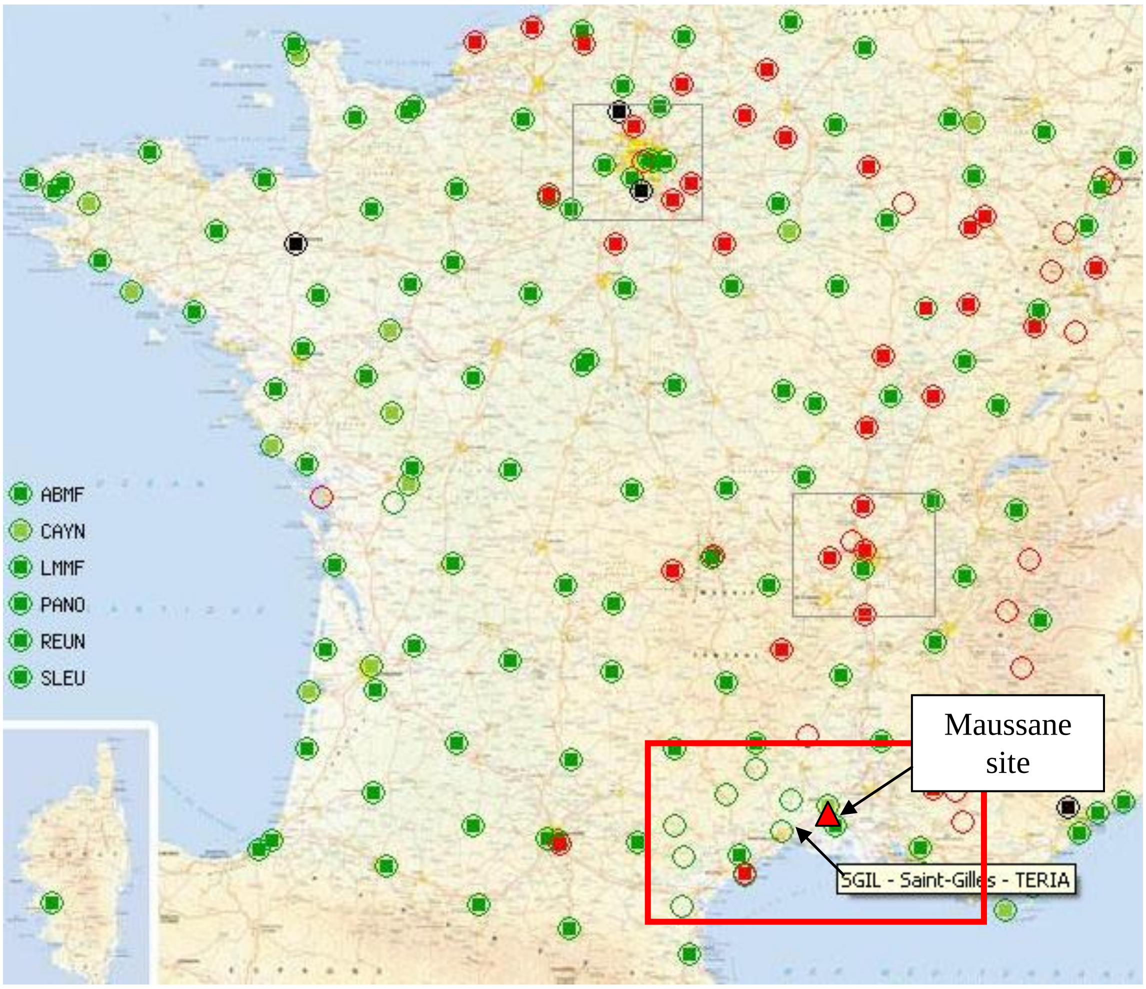


Figure 10. RGP (Réseau GNSS Permanent) base stations network

(http://rgp.ign.fr/index.php)

A.2.3. RENAG network

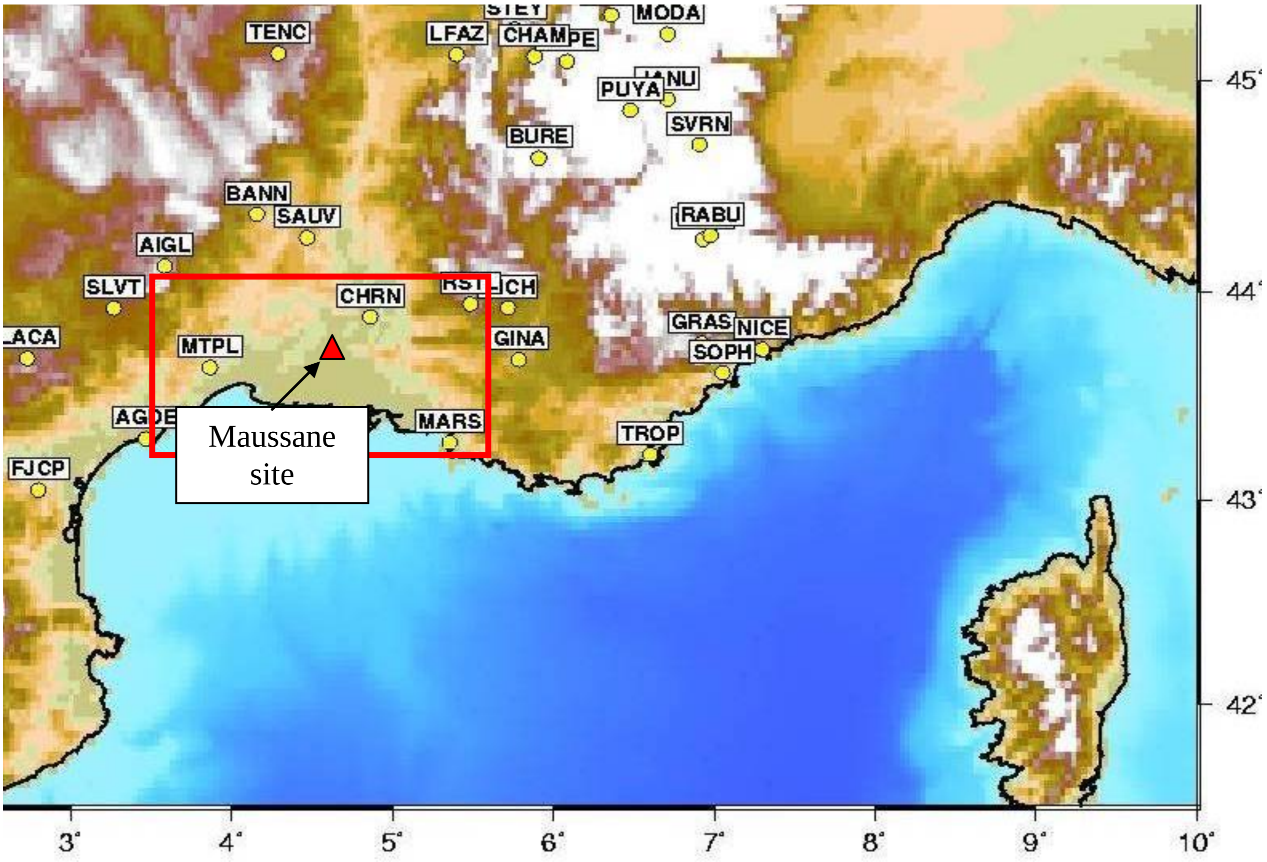


Figure 11. RENAG base stations network

(http://webrenag.unice.fr/maps.php?ID=8)

A.3. Annex 3: Description of RGP used BS: SGIL, NIME, AXPV, PRIE

A.3.1. **SGIL :** Saint-Gilles - TERIA

Propriétaire : EXAGONE
Usufruitier : EXAGONE
Mise en service : 06/12/2006
Classe : CPRG
Numéro Domes : 19824M001

Coordonnées (RGF93 - Lambert-93) valides à c\ du **06/12/2006**

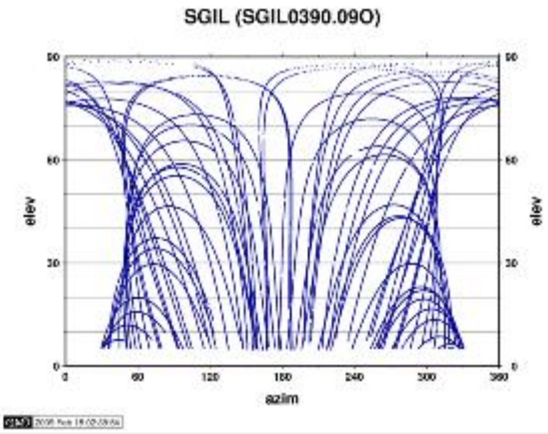
X	**Y**	**Z**	**Antenne**
4606571.410 m	357184.386 m	4382269.150 m	**Hauteur** : 0 m Fiche Antenne
Latitude	**Longitude**	**Hauteur**	
43° 40' 37,23778" N	04° 26' 01,42654" E	90.739 m	
E	**N**	**Altitude**	
815639.326 m	6287491.417 m	41.34 m	

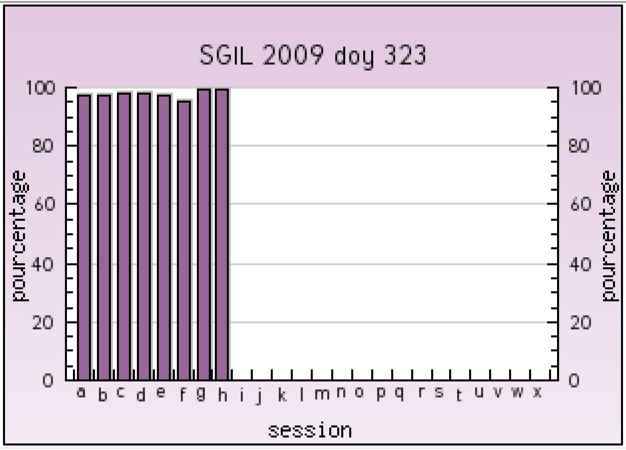
Type de données disponibles

Session/Echantillonage	1h/1s	1h/30s	24h/30s
Temps Différé	☑	☑	☑
Temps Réel	DGPS	RTK	Interpolé
	☐	☐	☑

Informations complémentaires

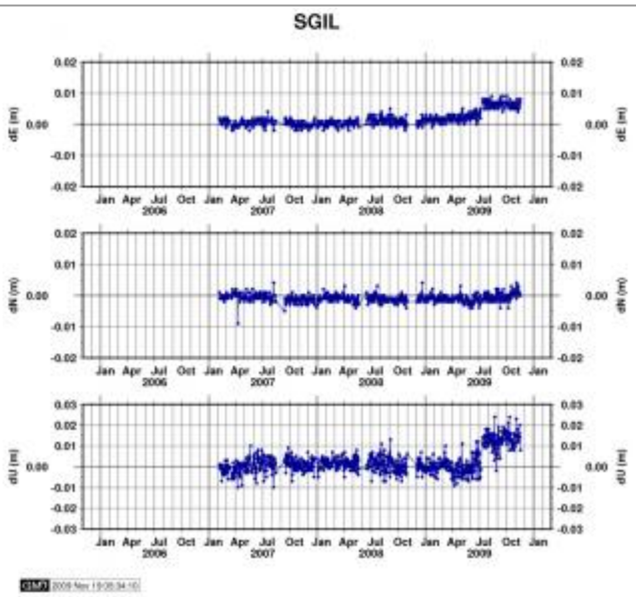
Situation	**Plan d'accès**
	
Photo du site	**Photo de l'antenne**
	
Qualité du site	**Disponibilité des données horaires**

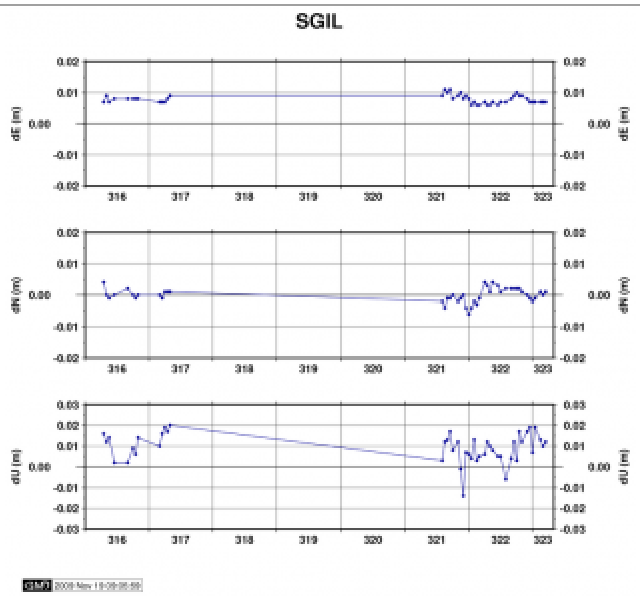




Séries temporelles

Calculs journaliers	Calculs horaires





Ecarts en mètres sur les composantes Est(dE), Nord(dN) et hauteur ellipsoïdale(dU) rapportés aux coordonnées RGF93 publiées.

- Calcul réalisé à partir des données sur 24H
- Utilisation des orbites rapides de l'IGS (igr)
- Estimation de paramètres troposphériques
- Utilisation des modèles d'antennes absolues

- Calcul réalisé à partir des données sur 6H
- Utilisation des orbites ultra-rapides (igu)
- Estimation de paramètres tropo et iono
- Utilisation des modèles d'antennes absolues
- Graphique sur 7 jours glissants

A.3.2. **NIME** - Nîmes

Propriétaire : Lycée Dhuoda
Usufruitier : Lycée Dhuoda
Mise en service : 07/03/2006
Classe : KP
Numéro Domes : 19993M001

Coordonnées (RGF93 - Lambert-93) valides à c\ du **07/03/2006**

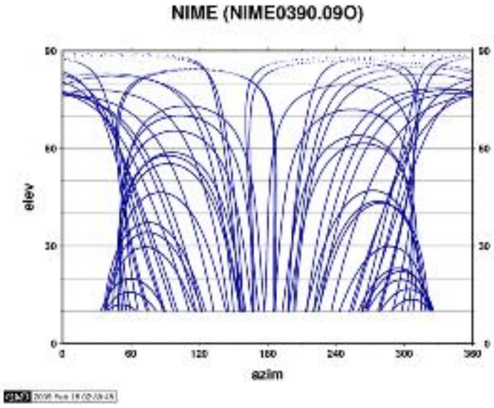
X	**Y**	**Z**	**Antenne**
4595444.127 m	350119.171 m	4394445.435 m	**Hauteur** : 0 m Fiche Antenne
Latitude	**Longitude**	**Hauteur**	
43° 49' 42,93386" N	04° 21' 24,66799" E	106.183 m	
E	**N**	**Altitude**	
809149.864 m	6304224.544 m	56.55 m	

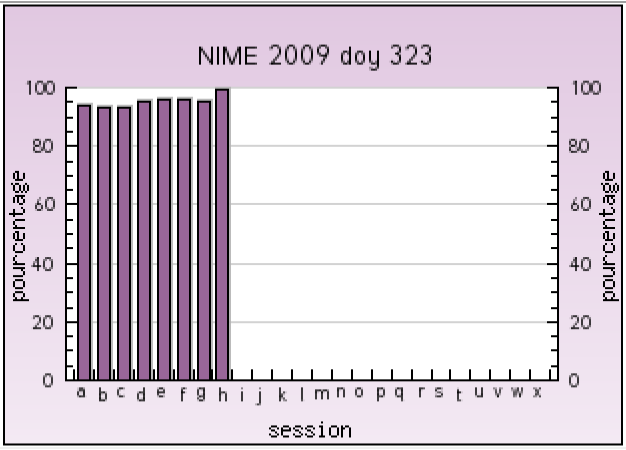
Type de données disponibles

Session/Echantillonage	1h/1s	1h/30s	24h/30s
Temps Différé	☑	☑	☑
Temps Réel	DGPS	RTK	Interpolé
	☐	☑	☐

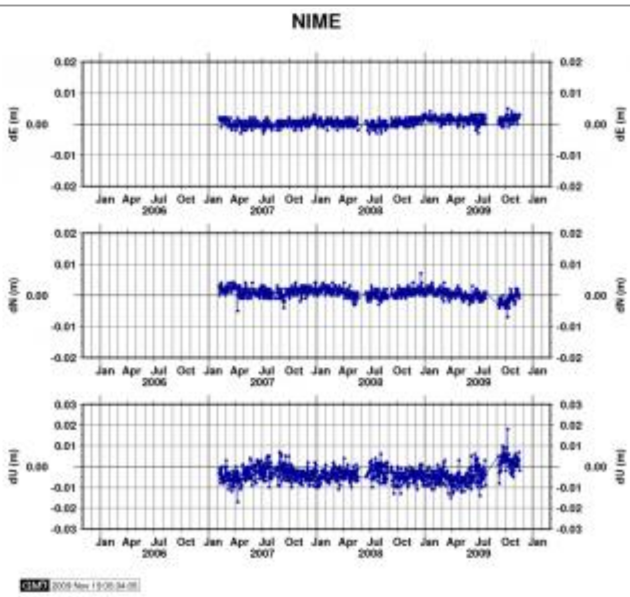
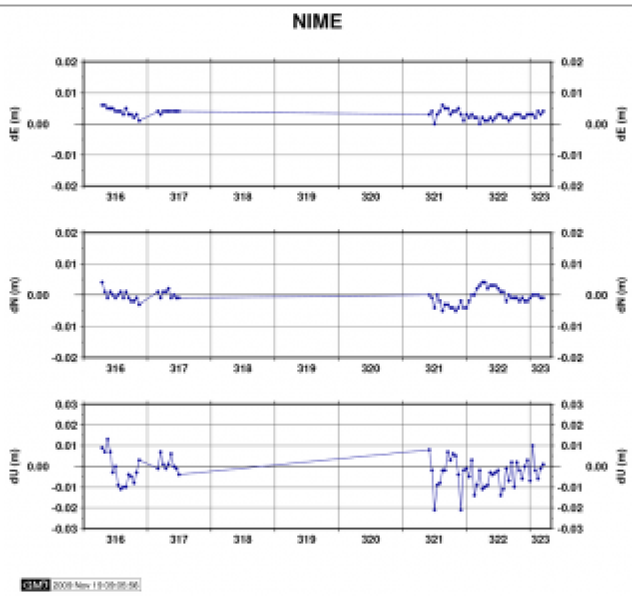
Informations complémentaires

Situation	**Plan d'accès**
	
Photo du site	**Photo de l'antenne**
	
Qualité du site	**Disponibilité des données horaires**





Séries temporelles

Calculs journaliers	Calculs horaires
	

Ecarts en mètres sur les composantes Est(dE), Nord(dN) et hauteur ellipsoïdale(dU) rapportés aux coordonnées RGF93 publiées.

Calculs journaliers :

- Calcul réalisé à partir des données sur 24H
- Utilisation des orbites rapides de l'IGS (igr)
- Estimation de paramètres troposphériques
- Utilisation des modèles d'antennes absolues

Calculs horaires :

- Calcul réalisé à partir des données sur 6H
- Utilisation des orbites ultra-rapides (igu)
- Estimation de paramètres tropo et iono
- Utilisation des modèles d'antennes absolues
- Graphique sur 7 jours glissants

A.3.3. **AXPV** Aix-en-Provence - CEREGE

Propriétaire : Institut Géographique National
Usufruitier : CEREGE
Mise en service : 17/09/2002
Classe : ITPG
Numéro Domes : 10057M001

Coordonnées (RGF93 - Lambert-93) valides à c\ du **17/09/2002**

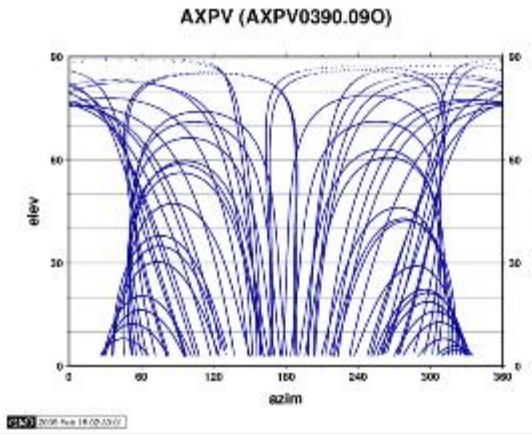
X	**Y**	**Z**	**Antenne**
4614667.160 m	430786.226 m	4367411.323 m	**Hauteur** : 0 m Fiche Antenne
Latitude	**Longitude**	**Hauteur**	
43° 29' 28,36158" N	05° 19' 59,49226" E	229.393 m	
E	**N**	**Altitude**	
888779.695 m	6268580.815 m	180.18 m	

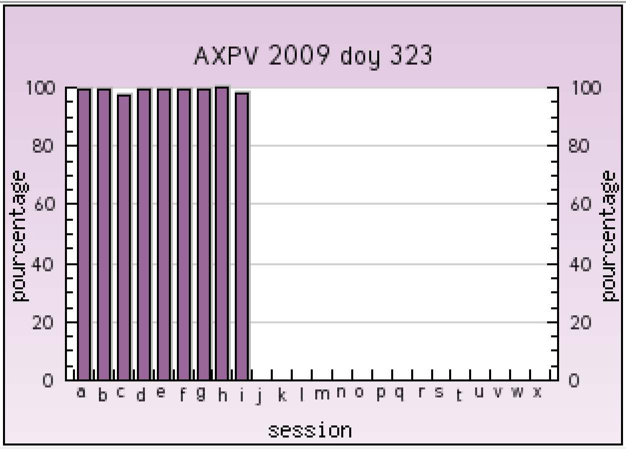
Type de données disponibles

Session/Echantillonage	1h/1s	1h/30s	24h/30s
Temps Différé	☑	☑	☑
Temps Réel	DGPS	RTK	Interpolé
	☐	☐	☐

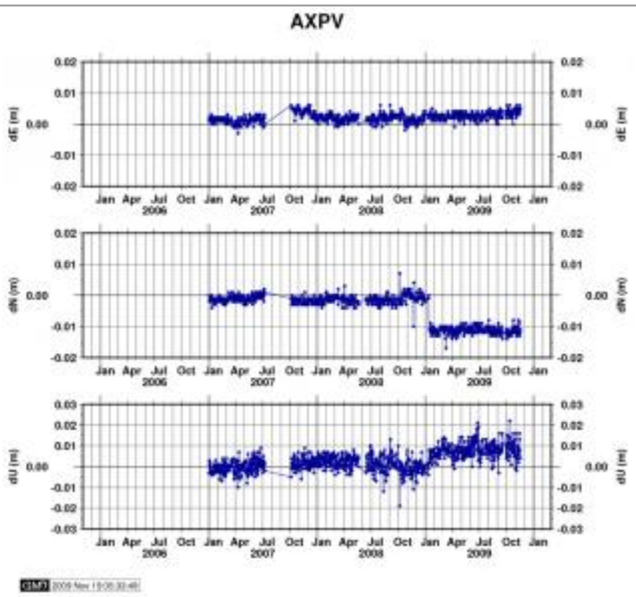
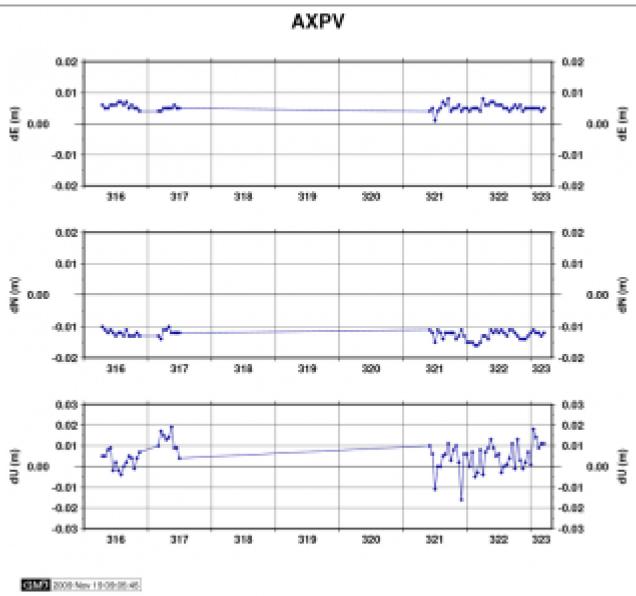
Informations complémentaires

Situation	**Plan d'accès**
	
Photo du site	**Photo de l'antenne**
	
Qualité du site	**Disponibilité des données horaires**





Séries temporelles

Calculs journaliers	Calculs horaires
	

Ecarts en mètres sur les composantes Est(dE), Nord(dN) et hauteur ellipsoïdale(dU) rapportés aux coordonnées RGF93 publiées.

- Calcul réalisé à partir des données sur 24H
- Utilisation des orbites rapides de l'IGS (igr)
- Estimation de paramètres troposphériques
- Utilisation des modèles d'antennes absolues

- Calcul réalisé à partir des données sur 6H
- Utilisation des orbites ultra-rapides (igu)
- Estimation de paramètres tropo et iono
- Utilisation des modèles d'antennes absolues
- Graphique sur 7 jours glissants

A.3.4. **PRIE** Marseille - TERIA

Propriétaire : EXAGONE
Usufruitier : EXAGONE
Mise en service : 18/09/2007
Classe : CPRG
Numéro Domes : 19867M001

Coordonnées (RGF93 - Lambert-93) valides à c\ du **18/09/2007**

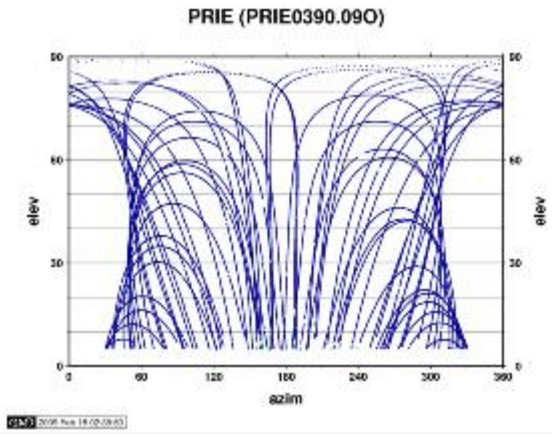
X	**Y**	**Z**	**Antenne**
4630632.088 m	435498.096 m	4350065.344 m	**Hauteur** : 0 m Fiche Antenne
Latitude	**Longitude**	**Hauteur**	
43° 16' 36,32712" N	05° 22' 21,74131" E	186.356 m	
E	**N**	**Altitude**	
892692.002 m	6244848.644 m	137.41 m	

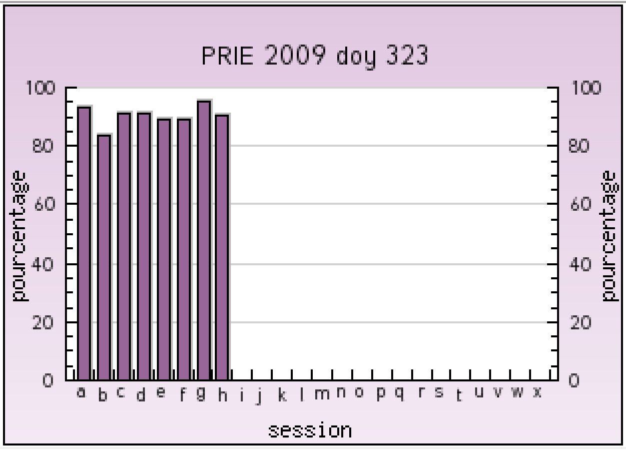
Type de données disponibles

Session/Echantillonage	1h/1s	1h/30s	24h/30s
Temps Différé	☑	☑	☑
Temps Réel	DGPS	RTK	Interpolé
	☐	☐	☑

Informations complémentaires

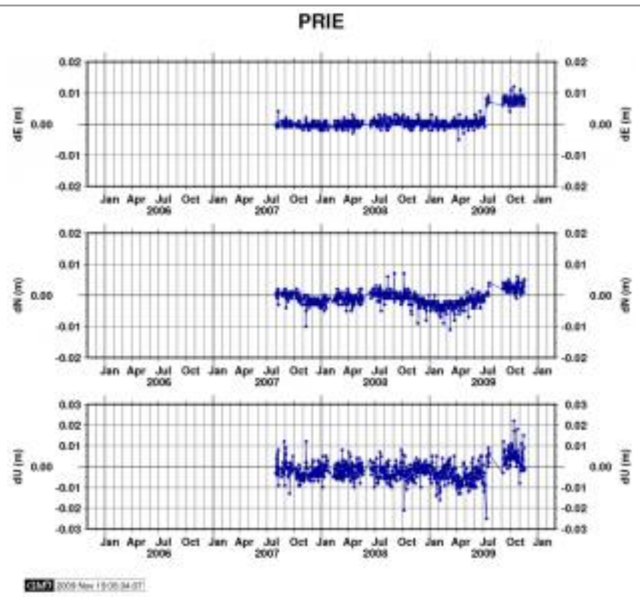
Situation	**Plan d'accès**
	
Photo du site	**Photo de l'antenne**
	
Qualité du site	**Disponibilité des données horaires**



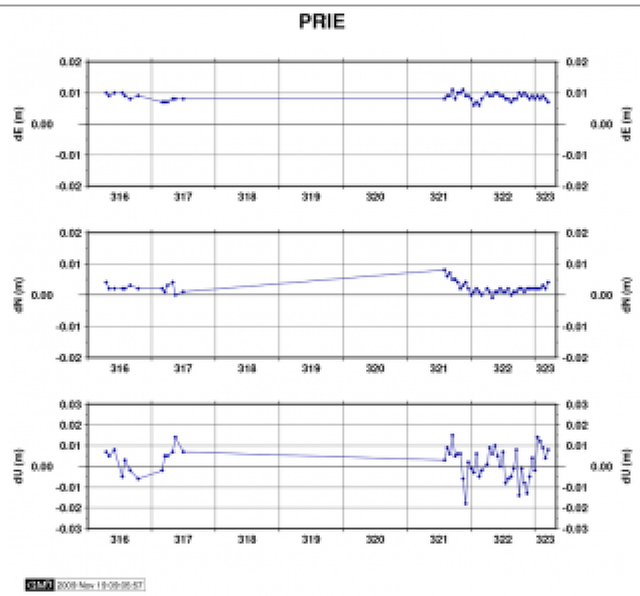


Séries temporelles

Calculs journaliers



Calculs horaires



Ecarts en mètres sur les composantes Est(dE), Nord(dN) et hauteur ellipsoïdale(dU) rapportés aux coordonnées RGF93 publiées.

- Calcul réalisé à partir des données sur 24H
- Utilisation des orbites rapides de l'IGS (igr)
- Estimation de paramètres troposphériques
- Utilisation des modèles d'antennes absolues

- Calcul réalisé à partir des données sur 6H
- Utilisation des orbites ultra-rapides (igu)
- Estimation de paramètres tropo et iono
- Utilisation des modèles d'antennes absolues
- Graphique sur 7 jours glissants

A.4. Annex 4: Description of IGN used Geodetic points

A.4.1. Geodetic point no. 1303806

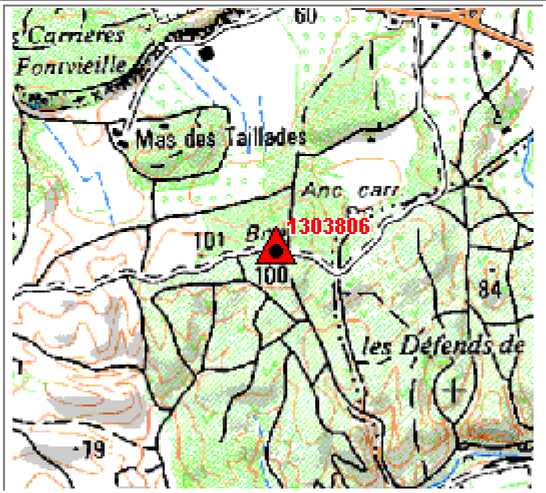
Réseau **G**éodésique **F**rançais

Service Géodésie Nivellement
Site géodésique

FONTVIEILLE VI

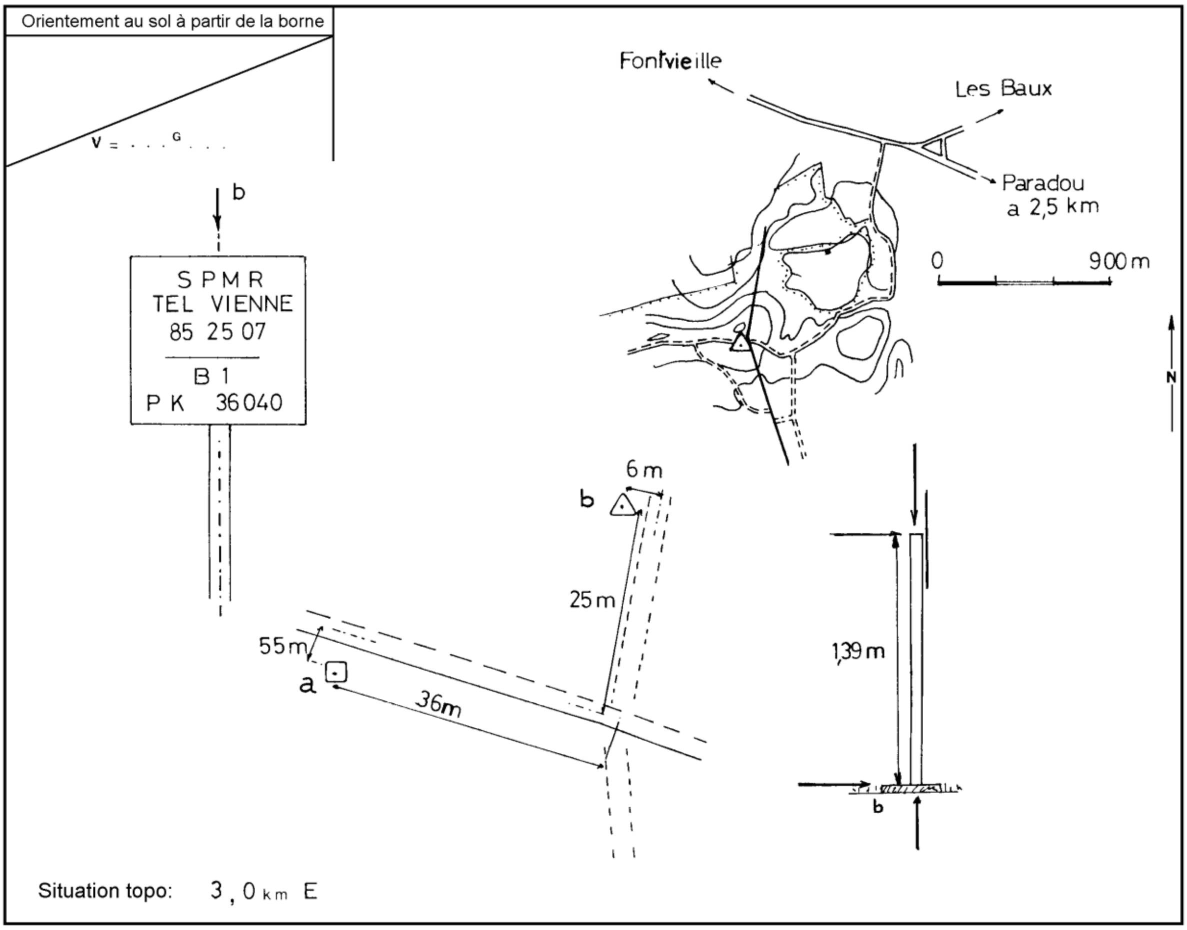
Département :	**BOUCHES-DU-RHONE (13)**	*N° Site:* **1303806**
Commune :	**FONTVIEILLE**	
Lieu-dit :		**site NTF d'ordre 4**

Azimut de la prise de vue : 375 gr



Extrait de la carte n° 3043
EYGUIERES

Points du site :	*(Cliquez sur la désignation des points ci-dessous pour obtenir les coordonnées)*
(1)	**Poteau indicateur, support de pancarte : Base**
(A)	**Borne en granit gravee IGN**
(B)	**Poteau indicateur, support de pancarte : Sommet**



Avertissement

Compte-tenu des risques de destruction ou de déplacement des bornes ou repères, il est indispensable de procéder avant usage à un contrôle de stabilité avec les repères voisins. La responsabilité de l'IGN ne saurait être engagée en l'absence d'un tel contrôle.
Toute remarque concernant la disparition ou le mauvais état des repères doit être signalée au Service de la géodésie : sgn@ign.fr

04

Site	Point	Désignation
1303806	**1**	**Poteau indicateur, support de pancarte : Base**

Remarque(s) : **- Point vu en place en 2002**

Système RGF93 - Ellipsoïde : IAG GRS80 - Méridien origine : Greenwich				
T	*Longitude*	*Latitude*	*Hauteur sur l'ellipsoïde (m)*	
	4° 44' 55,6776'' E	**43° 43' 09,8260'' N**	**149,72**	
Système RGF93 - Projection LAMBERT - 93			**NGF - IGN1969 Altitude normale (m)**	
T	*E (m)*	*N(m)*		
	840 943,58	**6 292 712,80**	**100,3**	**D**
Système NTF - Projection LAMBERT 3				
	E(m)	***N(m)***		
	794 338,72	**160 562,27**		

Azimut de la prise de vue : 399 gr

T: Coordonnées obtenues par transformation / **M** : Précision métrique / **D** : Précision décimétrique / **C** : Précision centimétrique

01

Site	Point	Désignation
1303806	**A**	**Borne en granit gravee IGN**

Remarque(s) : **- Point vu en place en 2002**

Système RGF93 - Ellipsoïde : IAG GRS80 - Méridien origine : Greenwich				
T	*Longitude*	*Latitude*	*Hauteur sur l'ellipsoïde (m)*	
	4° 44' 54,1770'' E	**43° 43' 09,0724'' N**	**149,12**	
Système RGF93 - Projection LAMBERT - 93			**NGF - IGN1969 Altitude normale (m)**	
T	*E (m)*	*N(m)*		
	840 910,51	**6 292 688,80**	**99,7**	**D**
Système NTF - Projection LAMBERT 3				
	E(m)	***N(m)***		
	794 305,83	**160 538,04**		

Azimut de la prise de vue : 210 gr

T: Coordonnées obtenues par transformation / **M** : Précision métrique / **D** : Précision décimétrique / **C** : Précision centimétrique

http://geodesie.ign.fr/fiche_geodesie.asp?num_site=1303806&X=840900&Y=6292700

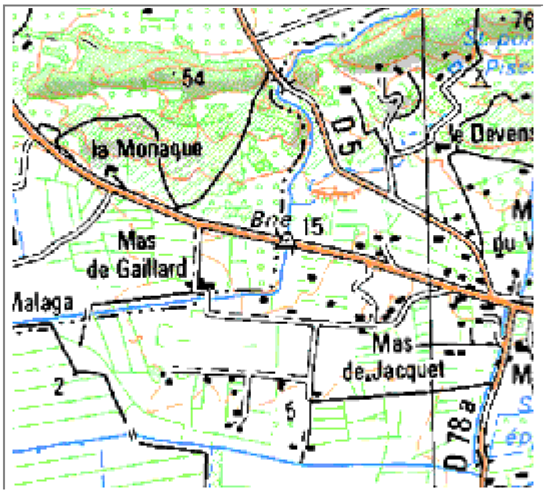
A.4.2. Geodetic point no. 1306503

Réseau **G**éodésique **F**rançais

Service Géodésie Nivellement
Site géodésique

MOURIES III

Département :	**BOUCHES-DU-RHONE (13)**	*N° Site:* **1306503**
Commune :	**MOURIES**	
Lieu-dit :		**site NTF d'ordre 4**

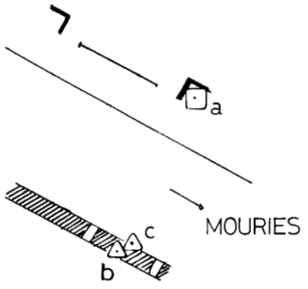
	
Azimut de la prise de vue : 340 gr	**Extrait de la carte n° 3043 EYGUIERES**

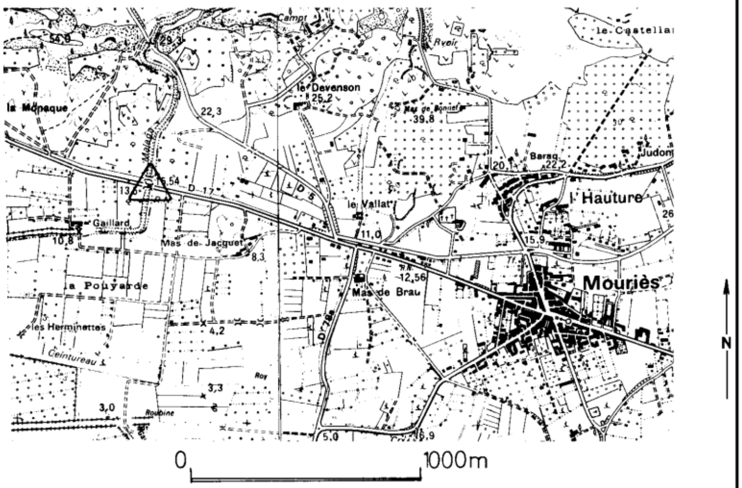
Points du site :	*(Cliquez sur la désignation des points ci-dessous pour obtenir les coordonnées)*
(A)	**Borne en granit gravee IGN**
(B)	**Pont : Parapet Sud : Repere en fer scelle (Point détruit)**
(C)	**Pont : Parapet Sud : Repere en bronze PM scelle a la base (non retrouve en 2002)**

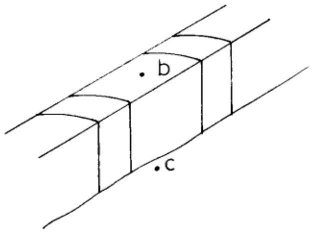
Orientement au sol à partir de la borne

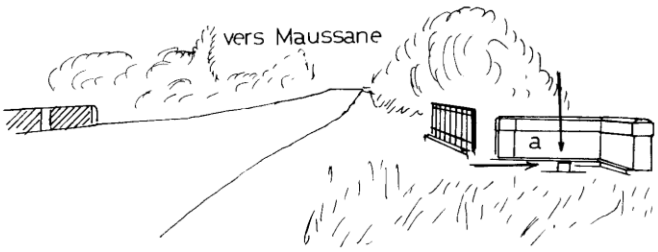
St MARTIN DE CRAU
5e ordre : Moulin

V = . . . G . . .









Situation topo: 2,0 km O

Avertissement

Compte-tenu des risques de destruction ou de déplacement des bornes ou repères, il est indispensable de procéder avant usage à un contrôle de stabilité avec les repères voisins. La responsabilité de l'IGN ne saurait être engagée en l'absence d'un tel contrôle.
Toute remarque concernant la disparition ou le mauvais état des repères doit être signalée au Service de la géodésie : sgn@ign.fr

01

Site	Point	Désignation
1306503	**A**	**Borne en granit gravee IGN**

Remarque(s) : **- Point vu en place en 2002**

Système RGF93 - Ellipsoïde : IAG GRS80 - Méridien origine : Greenwich				
T	*Longitude*	*Latitude*	*Hauteur sur l'ellipsoïde (m)*	
	4° 50' 59,1310'' E	**43° 41' 39,9002'' N**	**64,9**	
Système RGF93 - Projection LAMBERT - 93			**NGF - IGN1969 Altitude normale (m)**	
T	*E (m)*	*N(m)*		
	849 143,92	**6 290 122,95**	**15,48**	**C**
Système NTF - Projection LAMBERT 3				
	E(m)	***N(m)***		
	802 554,61	**158 031,60**		

Azimut de la prise de vue : 350 gr

T: Coordonnées obtenues par transformation / **M** : Précision métrique / **D** : Précision décimétrique / **C** : Précision centimétrique

http://geodesie.ign.fr/fiche_geodesie.asp?num_site=1306503&X=849100&Y=6290100

European Commission

EUR 24133 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: Maussane GPS field campaign: Methodology and Results
Author(s): Cozmin Lucau and Joanna Krystyna Nowak Da Costa
Luxembourg: Office for Official Publications of the European Communities
2009 – 37 pp. – 21.0 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-14626-8
DOI 10.2788/52772

Abstract
The report summaries the methodology and results of the GPS field measurement in the JRC MARS Maussane Test Site located in southern France. The main objective of the mission was the GPS measurements of the objects preliminary chosen as Ground Control Points (GCPs) used for satellite images geo-correction and orthorectification, and the external quality control. Their identifiability conditions were checked on several existing images over this area (e.g. WV1, GE-1, EROSB, Cartosat2, RE, Cartosat1, ortoADS40 b-w). The second objective was to assess the impact of GCP position accuracy on orthorectification quality since most of these points are identifiable on the Leica Geosystems ADS40 Digital Airborne Camera Orthoimagery. The third objective was the GeoXH accuracy testing.

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