



KTIMATOLOGIO S.A.
(Hellenic Cadastre)



EUREF GR 2007 Campaign

Final Report

Final report on the processing and results of the EUREF GR 2007 campaign
submitted to the Technical Working Group of EUREF

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Acronyms

AUTH	Aristotle University of Thessaloniki
ERDF	European Regional Development Fund
GRS	Geodetic Reference System
HEPOS	Hellenic POSitioning System
HGRS87	Hellenic Geodetic Reference System 1987
HTRS07	Hellenic Terrestrial Reference System 2007
RS	Reference Station

1. Introduction

The establishment of HEPOS is a part of the project “Information and Technology Infrastructure for a modern Cadastre” which was run by KTIMATOLOGIO S.A., a state-owned firm that is in charge for establishing and operating the Hellenic Cadastre. The project was run within the CSF-III (3rd Community Support Framework) and was co-funded by the European Regional Development Fund.

The establishment of HEPOS started in January 2007. The system was fully functional at the end of 2007, allowing network-based positioning in HTRS07. This tight time-plan was discussed with JRC (Joint Research Center) and was a necessity, because other projects (production of orthophoto maps for whole Greece) were based on HEPOS.

2. The HEPOS Network

HEPOS consists of 98 permanent GPS reference stations distributed throughout Greece. The locations of the stations are depicted in Figure 1. HEPOS supports all common GPS-techniques for post-processing and real-time surveying, including VRS, FKP and MAC. Details on HEPOS can be found in Gianniou (2009) and on www.hepos.gr.

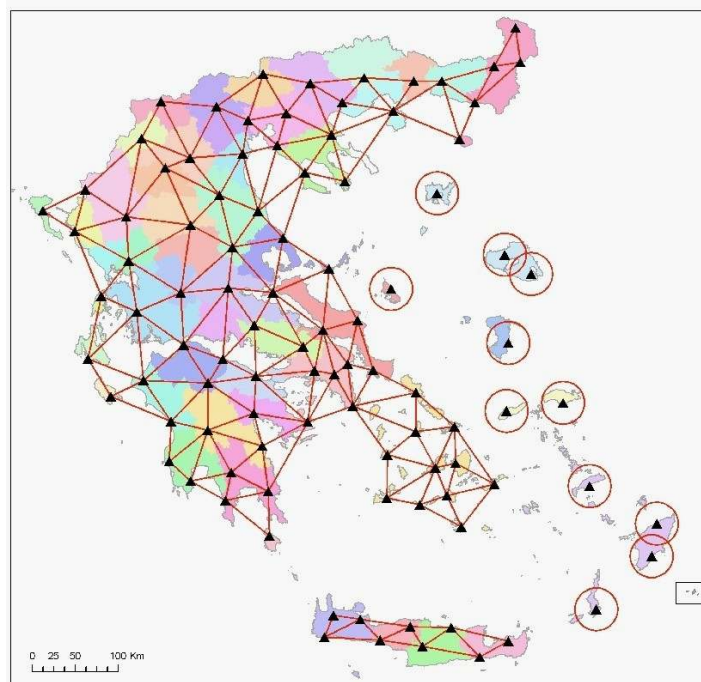


Figure 1: The HEPOS network (98 stations).

3. Densification project

KTIMATOLOGIO S.A. procured the establishment of HEPOS as a turn-key solution including the computation of the station coordinates. This task was assigned by the contractor (Trimble Europe B.V.) to IGN-Spain.

The geodetic reference system (GRS) of HEPOS is called HTRS07 (Hellenic Terrestrial Reference System 2007) and is a realization of ETRS89 in Greece. Prof. K. Katsambalos and C. Kotsakis (AUTH: Aristotle University of Thessaloniki) assisted KTIMATOLOGIO S.A. in the definition of HTRS07 and the computation of a transformation model between HTRS07 and the official Hellenic Geodetic Reference System 1987 (HGRS87) (Katsampalos et al., 2009). HTRS07 was defined and realized in 2007. The coordinates of the HEPOS stations refer to HTRS07.

In order to get the HEPOS campaign validated by the TWG of EUREF, the campaign has been reprocessed following the current EUREF standards, i.e. the *B/A memo ver. 7* and the *Guidelines for EUREF Densifications ver. 1: 26-05-2009*. This solution is described in section 4.

The documentation is based on the “*Guidelines for EUREF Densifications*” ver. 1: 26-05-2009.

4. EUREF GR 2007 campaign

4.1 Description of the project

A total number of 113 permanent Reference Stations were involved in the densification project; namely the 98 RSs of HEPOS and 14 additional EPN/IGS stations¹. The full names of the stations, 4-char IDs, dome numbers etc. are given in Table 1. The locations of the stations are depicted in Figure 2.

All HEPOS stations are equipped with the same GPS equipment, which is described in Table 2. All HEPOS stations are installed using steel masts either on the roof or on side of buildings (Figure 3). In all cases the mast is mounted on the concrete frame of the building. In the case of installations on the roof of buildings, the insulation was temporarily removed in order to access the concrete slab. An example of this procedure is shown in Figure 4. The GNSS equipment and the monumentation of each station is given in Table 3.

The HEPOS network was computed using 14 days of observations (7-20 October 2007, i.e. from 07:280:00000 to 07:293:86370). In addition, 3 days (17-19 November 2007, i.e. from 07:321:00000 to 07:323:86370) were also used in order to include in the solution station 018B, which replaced station 018A. Considering the first and the last day of observations (07:280 and 07:323, respectively) the central epoch of the project is set to 2007.83.

Table 1: The 113 stations involved in the project.

	4-char ID	Full Name	Country	Domes No.	Network
1	GLSV	KIEV	UKRAINE	12356M001	EPN class A, IGS
2	JOZE	JOZEFOSLAW	POLAND	12204M001	EPN class A, IGS
3	MATE	MATERA	ITALY	12734M008	EPN class A, IGS
4	NICO	NICOSIA	CYPRUS	14302M001	EPN class A, IGS
5	NOT1	NOTO	ITALY	12717M004	EPN class A, IGS
6	TRAB	TRABZON	TURKEY	20808M001	EPN class B, IGS
7	WTZR	BAD KOETZTING	GERMANY	14201M010	EPN class A, IGS
8	RAMO	MITZPE RAMON	ISRAEL	20703S001	EPN class A, IGS

¹ One station appears twice: as 018A (initial location) and as 018B (final location).

9	ANKR	ANKARA	TURKEY	20805M002	EPN class A, IGS
10	GRAZ	GRAZ	AUSTRIA	11001M002	EPN class A, IGS
11	AUT1	THESSALONIKI	GREECE	12619M002	EPN class A
12	NOA1	ATHENS	GREECE	12620M001	EPN class A
13	TUC2	CHANIA	GREECE	12617M003	EPN class A
14	ORID	OHRID	FYROM	15601M001	EPN class A, IGS
15	001A	MACHAIRA	GREECE	-	HEPOS
16	002A	NEA KIOS	GREECE	-	HEPOS
17	003A	MEGAOPOLI	GREECE	-	HEPOS
18	004A	PARALIA TIROU	GREECE	-	HEPOS
19	005A	PETA	GREECE	-	HEPOS
20	006A	SOUNIO	GREECE	-	HEPOS
21	007A	ELEUSINA	GREECE	-	HEPOS
22	008A	MARATHON	GREECE	-	HEPOS
23	009A	KYTHIRA	GREECE	-	HEPOS
24	010A	POROS	GREECE	-	HEPOS
25	011A	AKRATA	GREECE	-	HEPOS
26	012A	RIO	GREECE	-	HEPOS
27	013A	KLEITORIA	GREECE	-	HEPOS
28	014A	NEOCHORAKI	GREECE	-	HEPOS
29	015A	DAULEIA	GREECE	-	HEPOS
30	016A	VATOLAKKOS	GREECE	-	HEPOS
31	017A	CHORISTI	GREECE	-	HEPOS
32	018A	SAMOTHRAKI	GREECE	-	HEPOS
33	018B	SAMOTHRAKI	GREECE	-	HEPOS
34	019A	MARKI	GREECE	-	HEPOS
35	020A	LAVARA	GREECE	-	HEPOS
36	021A	PLATI	GREECE	-	HEPOS
37	022A	MEGA DEREIO	GREECE	-	HEPOS
38	023A	MARMARI	GREECE	-	HEPOS
39	024A	AGIA ELEOUSA	GREECE	-	HEPOS
40	025A	OXYLITHOS	GREECE	-	HEPOS
41	026A	GIALTRA	GREECE	-	HEPOS
42	027A	MIKRO CHORIO	GREECE	-	HEPOS
43	028A	ZAKYNHTOS	GREECE	-	HEPOS
44	029A	ZACHARO	GREECE	-	HEPOS
45	030A	ANDRAVIDA	GREECE	-	HEPOS
46	031A	ADENDRO	GREECE	-	HEPOS
47	032A	MESIMERI	GREECE	-	HEPOS
48	033A	KOLCHIKO	GREECE	-	HEPOS
49	034A	DROSOCHORI	GREECE	-	HEPOS
50	035A	KTISMATA	GREECE	-	HEPOS
51	036A	THASOS	GREECE	-	HEPOS
52	037A	PALAIOKOMI	GREECE	-	HEPOS
53	038A	PENTAVRYSOS	GREECE	-	HEPOS
54	039A	KERKYRA	GREECE	-	HEPOS
55	040A	KEFALLONIA	GREECE	-	HEPOS
56	041A	DROSSATO	GREECE	-	HEPOS
57	042A	KROKOS	GREECE	-	HEPOS
58	043A	VELO	GREECE	-	HEPOS
59	044A	ANDROS	GREECE	-	HEPOS
60	045A	MYKONOS	GREECE	-	HEPOS
61	046A	NAXOS	GREECE	-	HEPOS
62	047A	AMORGOS	GREECE	-	HEPOS

63	048A	SANTORINI	GREECE	-	HEPOS
64	049A	IOS	GREECE	-	HEPOS
65	050A	MILOS	GREECE	-	HEPOS
66	051A	SERIFOS	GREECE	-	HEPOS
67	052A	SYROS	GREECE	-	HEPOS
68	053A	PAROS	GREECE	-	HEPOS
69	054A	AREOPOLI	GREECE	-	HEPOS
70	055A	XYROKAMPI	GREECE	-	HEPOS
71	056A	SYKIA LAKONIAS	GREECE	-	HEPOS
72	057A	TSARITSANI	GREECE	-	HEPOS
73	058A	AGIA	GREECE	-	HEPOS
74	059A	VAMVAKOU	GREECE	-	HEPOS
75	060A	LEFKADA	GREECE	-	HEPOS
76	061A	SKOPELOS	GREECE	-	HEPOS
77	062A	ZAGORA	GREECE	-	HEPOS
78	063A	GARGALIANOI	GREECE	-	HEPOS
79	064A	AGIOS ANDREAS	GREECE	-	HEPOS
80	065A	DIOMIDEIA	GREECE	-	HEPOS
81	066A	PROFITIS ILIAS	GREECE	-	HEPOS
82	067A	KATO AGIOS IOANNIS	GREECE	-	HEPOS
83	068A	PLATARIA	GREECE	-	HEPOS
84	069A	AIGEIROS	GREECE	-	HEPOS
85	070A	MITROUSI	GREECE	-	HEPOS
86	071A	MEGALOCHORI	GREECE	-	HEPOS
87	072A	STAUROS	GREECE	-	HEPOS
88	073A	KATO KLINES	GREECE	-	HEPOS
89	074A	NEA FOKEA	GREECE	-	HEPOS
90	075A	STRATONIKI	GREECE	-	HEPOS
91	076A	SYKIA CHALKIDIKIS	GREECE	-	HEPOS
92	077A	GERGERI	GREECE	-	HEPOS
93	078A	GOUBES	GREECE	-	HEPOS
94	079A	NEA ANATOLI	GREECE	-	HEPOS
95	080A	SKOPI	GREECE	-	HEPOS
96	081A	GARAZO	GREECE	-	HEPOS
97	082A	MYRTHIOS	GREECE	-	HEPOS
98	083A	NEO CHORIO	GREECE	-	HEPOS
99	084A	VOUKOLIES	GREECE	-	HEPOS
100	085A	PALATIOCHORA	GREECE	-	HEPOS
101	086A	KOS	GREECE	-	HEPOS
102	087A	RHODES-SORONI	GREECE	-	HEPOS
103	088A	RHODES-GENADI	GREECE	-	HEPOS
104	089A	LIMNOS	GREECE	-	HEPOS
105	090A	LESVOS-PAPADOS	GREECE	-	HEPOS
106	091A	LESVOS-ANEMOTIA	GREECE	-	HEPOS
107	092A	SKYROS	GREECE	-	HEPOS
108	093A	SAMOS	GREECE	-	HEPOS
109	094A	IKARIA	GREECE	-	HEPOS
110	095A	CHIOS	GREECE	-	HEPOS
111	096A	KARPATHOS	GREECE	-	HEPOS
112	097A	FOLEGANDROS	GREECE	-	HEPOS
113	098A	KTIMATOLOGIO S.A.	GREECE	-	HEPOS

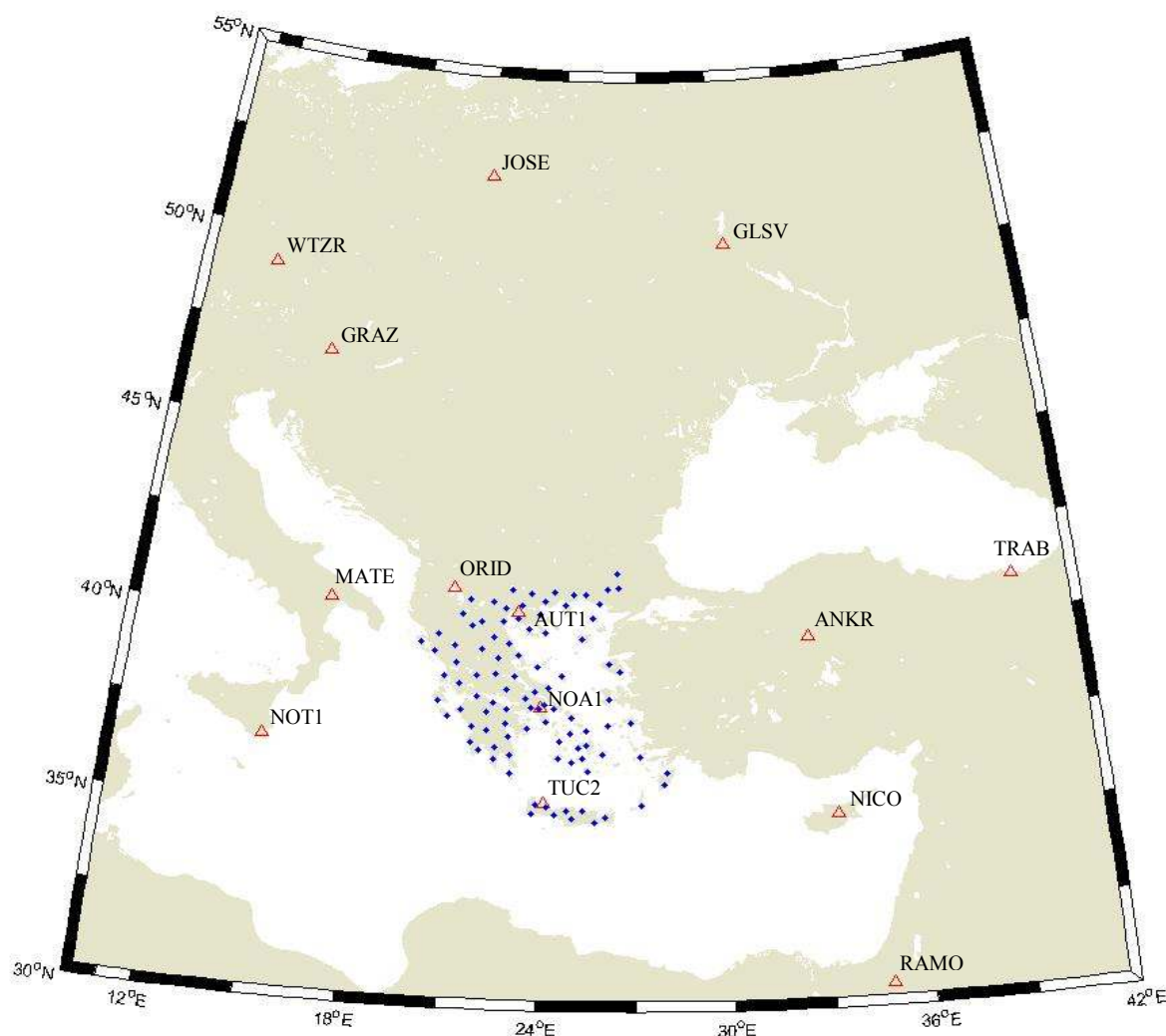


Figure 2: Map of the stations involved in the project.

Table 2: GPS equipment used at the 98 HEPOS stations.

Equipment	IGS code	IGS description
Trimble NetRS receivers	TRIMBLE NETRS	L1/L2+L2C with Maxwell-5 ASIC, ethernet, ext freq.
Trimble Zephyr geodetic Antennas	TRM41249.00	Zephyr 4-point feed antenna - Stealth Ground Plane
Trimble spherical domes	TZGD	Trimble Hemisph. Dome for Zephyr Geodetic 41249.00



Figure 3: Typical installations of HEPOS stations: on roof (left) and on the side of the building (right).



Figure 4: Typical procedure for the installation of a HEPOS station on the roof of a building.

Table 3: Equipment and monumentation of the reference stations.

	4-char ID	Receiver	Antenna and radome		Monument type
1	GLSV	TRIMBLE 4000SSI *	TRM29659.00	NONE *	Steel pillar on roof
2	JOZE	TRIMBLE 4000SSE *	TRM14532.00	NONE *	Stable geodynamical pillar
3	MATE	TRIMBLE 4000SSI *	TRM29659.00	NONE *	Stable pillar on buidling roof
4	NICO	AOA SNR-8000 ACT *	AOAD/M_T	NONE *	Pillar on concrete foundation
5	NOT1	TRIMBLE 4000SSI	TRM29659.00	NONE	Pillar on concrete foundation
6	TRAB	ASHTECH Z-XII3	ASH700936D_M SNOW		Concrete pillar on building roof
7	WTZR	TPS NETG3 *	AOAD/M_T	NONE *	Pillar on concrete survey tower

8	RAMO	LEICA RS500	ASH701945B_M SNOW	Brass nail fixed 4 meters into the ground
9	ANKR	AOA SNR-8000 ACT *	AOAD/M_T NONE *	Pillar on concrete foundation
10	GRAZ	TRIMBLE NETRS	TRM29659.00 NONE	Steel pyramide on building roof
11	AUT1	LEICA GRX1200PRO	LEIAT504 LEIS	Inox metal pillar on building roof
12	NOA1	LEICA GRX1200PRO	LEIAT504 LEIS	Steel mast on building roof
13	TUC2	LEICA RS500 *	LEIAT504 NONE	Pillar on concrete foundation
14	ORID	AOA SNR-8000 ACT *	AOAD/M_T NONE *	Pillar on concrete foundation
15	001A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
16	002A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
17	003A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
18	004A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
19	005A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
20	006A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
21	007A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
22	008A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
23	009A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
24	010A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
25	011A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
26	012A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
27	013A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
28	014A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
29	015A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
30	016A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
31	017A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
32	018A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
33	018B	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
34	019A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
35	020A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
36	021A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
37	022A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
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43	028A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
44	029A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
45	030A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
46	031A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on side of building
47	032A	Trimble NetRS	TRM41249.00 TZGD	Steel mast on building roof
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58	043A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
59	044A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
60	045A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
61	046A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
62	047A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
63	048A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
64	049A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
65	050A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
66	051A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
67	052A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
68	053A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
69	054A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
70	055A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
71	056A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
72	057A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
73	058A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
74	059A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
75	060A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
76	061A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
77	062A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
78	063A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
79	064A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
80	065A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
81	066A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
82	067A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
83	068A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
84	069A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
85	070A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
86	071A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
87	072A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
88	073A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
89	074A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
90	075A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
91	076A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
92	077A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
93	078A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
94	079A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
95	080A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
96	081A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
97	082A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
98	083A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
99	084A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
100	085A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
101	086A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
102	087A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
103	088A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
104	089A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
105	090A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
106	091A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
107	092A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
108	093A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building

109	094A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
110	095A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
111	096A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
112	097A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on building roof
113	098A	Trimble NetRS	TRM41249.00	TZGD	Steel mast on side of building
(*) At the time of the project. Afterwards, the equipment has been changed.					

4.2 Data used in the processing

Fiducial stations

A total of 13 stations have been used to constrain the solution in ITRF2005. The fiducial stations are listed in Table 4 and their locations are depicted in Figure 2. These stations were selected because they are surrounding the densification area and are in reasonable distances from the HEPOS stations. The aim when selecting the European fiducial stations was to try use as many of the stations that are used to define the reference frame of the combined EPN solution (see table at http://www.epncb.oma.be/_dataproduts/products/combinedeurefsolution.php)

The "Guidelines for EUREF Densifications" (Bruyninx et al., 2009) state that EPN A stations within the densification region must be selected as fiducials. Three of the fiducial stations (AUT1, NOA1 and TUC2) are situated in the densification zone.

All fiducial stations are EPN class A stations. It is noted that station TRAB, which is shown in Figure 2 is not used in the solution as a fiducial point because it is not included in the latest EUREF realization of the ITRS (EPN_A_ITRF2005.SCC).

The EPN raw station coordinate time series (http://epncb.oma.be/_dataproduts/products/timeseriesanalysis/residual.php) for each chosen fiducial station was checked to make sure none of the stations had a noisy time series or recent coordinate jumps.

Table 4: Fiducial stations in the network.

	4-char ID	Country	Network	Comment
1	AUT1	GREECE	EPN class A	In the densification zone
2	ANKR	TURKEY	EPN class A, IGS	
3	GLSV	UKRAINE	EPN class A, IGS	
4	GRAZ	AUSTRIA	EPN class A, IGS	
5	JOZE	POLAND	EPN class A, IGS	
6	MATE	ITALY	EPN class A, IGS	
7	NICO	CYPRUS	EPN class A, IGS	
8	NOT1	ITALY	EPN class A, IGS	
9	NOA1	GREECE	EPN class A	In the densification zone
10	ORID	FYROM	EPN class A, IGS	
11	RAMO	ISRAEL	EPN class A, IGS	
12	TUC2	GREECE	EPN class A	In the densification zone
13	WTZR	GERMANY	EPN class A, IGS	

Orbits and ERPs

IGS final orbit and ERP information have been used.

Datum definition

The solution has been obtained using minimal constraints on three translation parameters on the network's barycentre. This strategy has the advantage that small errors in the coordinates of a reference site do neither distort the network geometry nor significantly degrade the datum definition per se. The computed ITRF2005 coordinates are given in paragraph 4.4.2.

Antenna calibrations – stations

Absolute antenna phase center corrections based on IGS05 model have been used (exceptions for stations with individual absolute calibrations listed in epnc_05.atx) considering antenna radome codes. If antenna/radome pair had no available calibrations, the corresponding values for the radome code "NONE" have been used.

Antenna calibrations – satellites

Absolute antenna phase centre corrections based on IGS05 model calibrations have been used.

4.3 Processing strategy

The network has been processed using Bernese version 5.0.

4.3.1 Measurement models

Preprocessing

Phase preprocessing in a baseline by baseline mode using triple differences. In most cases cycle slips are fixed looking simultaneously at different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up.

Basic Observable

Carrier phase, code only used for receiver clock synchronization.

Elevation angle cutoff

3 degrees + elevation dependent weighting with cos-z

Data sampling

For ambiguity resolution: 30 s.

For final processing: 180 s.

Modeled observable

Double-differences, ionosphere-free linear combination.

Ground antenna phase center calibrations

Absolute antenna phase center corrections based on IGS05 model (exceptions for stations with individual absolute calibrations listed in epnc_05.atx) considering antenna radome codes. If antenna/radome pair has no available calibrations, the corresponding values for the radome code "NONE" are used.

Satellite antenna phase center calibrations

Absolute antenna phase centre corrections based on IGS05 model calibrations.

Troposphere

Dry-Niell as a priori model, estimation of zenith delay corrections at 1 hour intervals for each station, using the wet-Niell MF, no a priori sigmas. Horizontal gradient parameter estimated/day/station (TILTING), no a priori constraints. Compute daily TRO files with fixed cumulative. Coordinates input from weekly solution.

Ionosphere

Regional ionospheric model calculated. Only used for QIF ambiguity resolution. Not modeled in final solution (ionosphere eliminated by forming the ionosphere-free linear combination of L1 and L2).

4.3.2 Estimated parameters

Adjustment

Weighted least-squares algorithms.

Rejection Criteria

Daily RINEX observation files containing less than 10 percent of possible observation are ignored. The threshold value concerning data screening is 2.5 mm, specifically for a normalized, or L1 zero difference zenith residual. Station where baseline data exceeding the overall sigma level of 5 millimeters is excluded.

Troposphere

Absolute constraints: 5.0 m, Relative constraints: 5.0 m.

Ionosphere

Regional ionospheric model for QIF ambiguity resolution.

Ambiguity resolution

Ambiguity resolution is performed by using the quasi-ionosphere-free (QIF) strategy with regional TEC information. Elevation angle cutoff: 10 degrees.

Satellite clock bias

Satellite clock biases are not estimated but eliminated by forming double-differences.

Receiver clock bias

Receiver clock corrections are estimated as part of the biases preprocessing using code measurements. They are finally eliminated by forming double differences.

Planetary Ephemeris

DE200

Tidal

Solid earth tidal displacements are modeled according to displacements IERS conventions 1996.

Ocean loading

Using Ocean-Loading-Model computed by H.G.Scherneck Onsala Space Observatory FES2004 model for each station.

Atmospheric loading

No atmospheric loading corrections are taken into account.

4.4 Processing results

4.4.1 Repeatability values

The coordinate repeatability values are given in Table 5. To offer a better overview of the results, the repeatability values are also given in charts in the Figures 5 to 7.

Table 5: Coordinate repeatability values.

Stn	N (mm)	E (mm)	U (mm)
ANKR	0.96	1.55	4.47
AUT1	0.00	0.01	0.00
GLSV	2.13	1.94	3.91
GRAZ	1.41	1.86	3.88
JOZE	1.55	2.23	5.19
MATE	1.33	2.20	4.10
NICO	0.69	1.91	4.64
NOA1	1.40	2.91	4.73
NOT1	0.44	1.88	5.12
ORID	3.86	2.65	4.60
RAMO	1.71	2.40	6.78
TRAB	1.23	2.07	5.17
TUC2	1.86	2.54	5.08
WTZR	2.35	2.13	5.09
001A	1.15	1.74	3.32
002A	1.32	1.98	4.71
003A	0.60	1.97	3.28
004A	1.24	1.75	3.35
005A	1.11	1.86	6.05
006A	0.92	1.76	4.34
007A	1.46	1.91	5.26
008A	1.19	1.74	5.39
009A	1.68	1.94	5.95
010A	1.61	2.01	4.03
011A	1.01	1.86	4.05
012A	1.15	2.31	5.37
013A	0.92	1.84	4.70
014A	1.07	2.09	4.67
015A	1.33	1.47	3.77
016A	1.15	2.11	6.25
017A	1.09	1.70	4.53
018A	1.02	2.51	7.64
018B	1.93	0.89	1.43
019A	1.24	1.54	4.07
020A	1.10	1.58	4.91

Stn	N (mm)	E (mm)	U (mm)
043A	1.41	1.68	6.23
044A	1.56	2.00	6.54
045A	1.20	2.11	5.84
046A	1.65	1.77	5.46
047A	1.39	2.28	7.98
048A	1.56	2.13	7.69
049A	1.22	2.01	4.41
050A	1.48	2.09	3.84
051A	1.38	2.07	4.96
052A	1.38	1.81	5.14
053A	1.06	1.95	4.09
054A	1.53	2.01	4.58
055A	1.08	2.01	6.17
056A	1.40	1.80	5.16
057A	1.21	1.94	4.93
058A	1.54	1.76	4.91
059A	1.29	2.20	6.31
060A	1.26	2.00	4.47
061A	1.26	1.86	4.83
062A	1.45	2.31	6.62
063A	0.94	1.44	6.20
064A	1.46	2.22	7.14
065A	1.11	1.41	4.20
066A	1.22	1.69	4.24
067A	0.91	1.80	3.52
068A	1.89	1.84	3.26
069A	1.66	1.59	4.88
070A	1.01	1.55	4.45
071A	1.44	1.65	4.16
072A	1.14	1.93	4.15
073A	0.97	1.75	5.08
074A	1.31	1.80	3.71
075A	1.22	1.74	4.04
076A	1.21	2.12	4.09
077A	1.23	2.39	4.23

021A	0.84	1.60	5.01
022A	1.28	1.59	4.82
023A	1.70	2.54	5.88
024A	1.35	1.82	4.05
025A	2.36	1.53	4.38
026A	1.09	1.71	4.41
027A	1.17	2.11	6.88
028A	1.36	2.30	5.19
029A	1.33	1.84	4.33
030A	1.13	1.76	4.63
031A	0.93	1.69	4.78
032A	1.12	1.61	4.71
033A	1.03	1.63	3.89
034A	1.03	1.96	4.85
035A	0.86	1.56	4.76
036A	1.40	1.78	4.79
037A	1.00	1.62	4.02
038A	1.33	1.97	6.09
039A	1.32	2.11	3.84
040A	1.15	1.78	4.74
041A	0.84	1.75	4.37
042A	1.11	1.93	4.63

078A	1.24	1.76	6.49
079A	1.68	2.35	6.63
080A	2.08	1.95	5.53
081A	1.05	2.00	5.13
082A	3.57	2.14	6.74
083A	1.78	3.04	6.54
084A	1.05	2.03	6.76
085A	1.43	2.11	5.64
086A	1.20	1.74	5.64
087A	1.33	1.86	5.45
088A	1.60	1.54	8.58
089A	1.43	1.75	4.65
090A	1.72	2.18	6.45
091A	1.40	1.97	3.99
092A	1.39	1.80	4.77
093A	1.39	2.21	8.26
094A	1.52	1.73	5.16
095A	1.24	1.44	3.87
096A	1.21	2.05	5.83
097A	0.72	2.19	6.50
098A	1.21	1.43	5.53

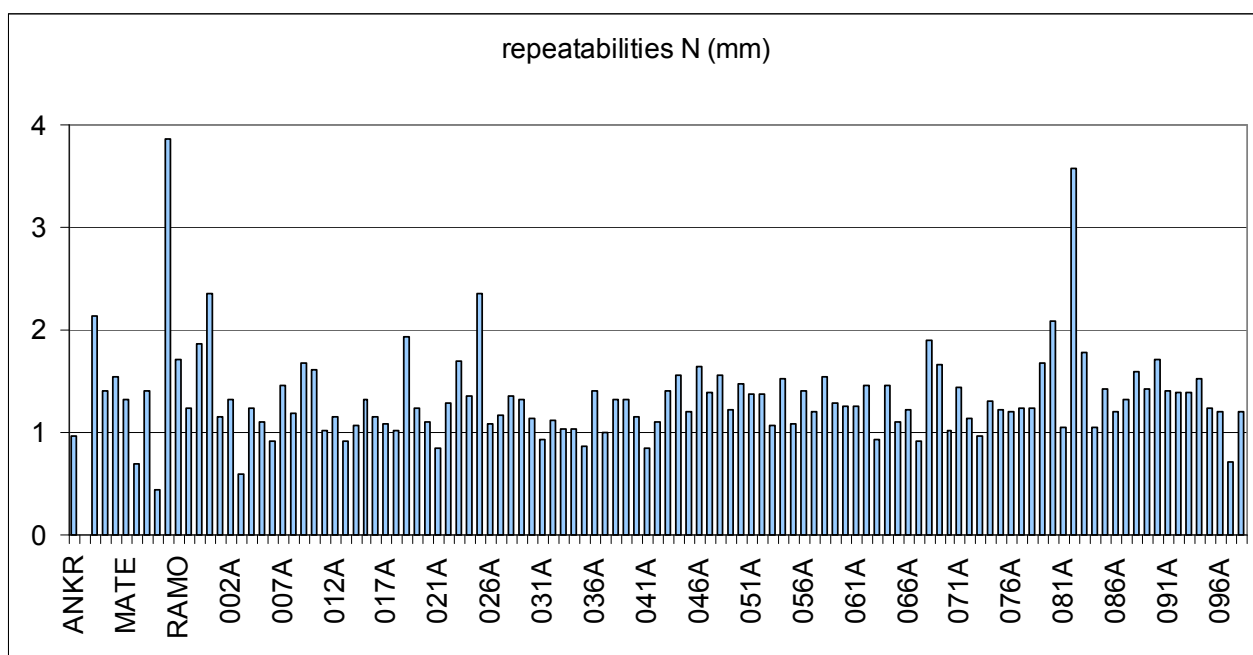


Figure 5: Coordinate repeatability values (North)

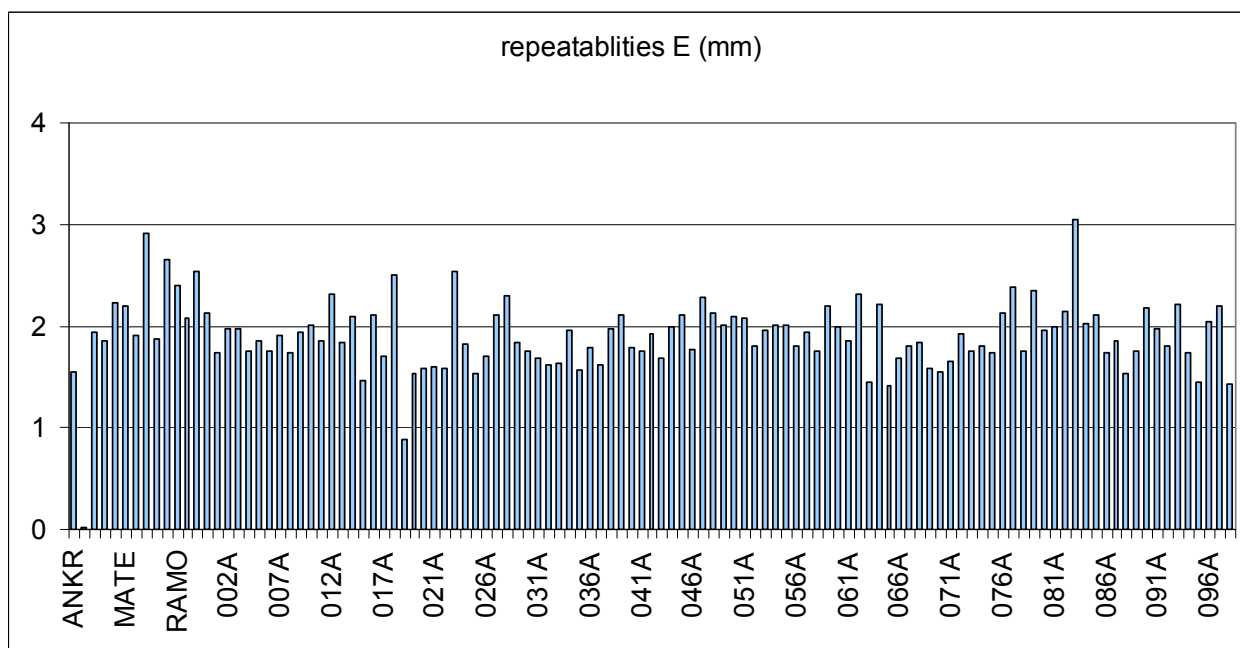


Figure 6:. Coordinate repeatability values (East)

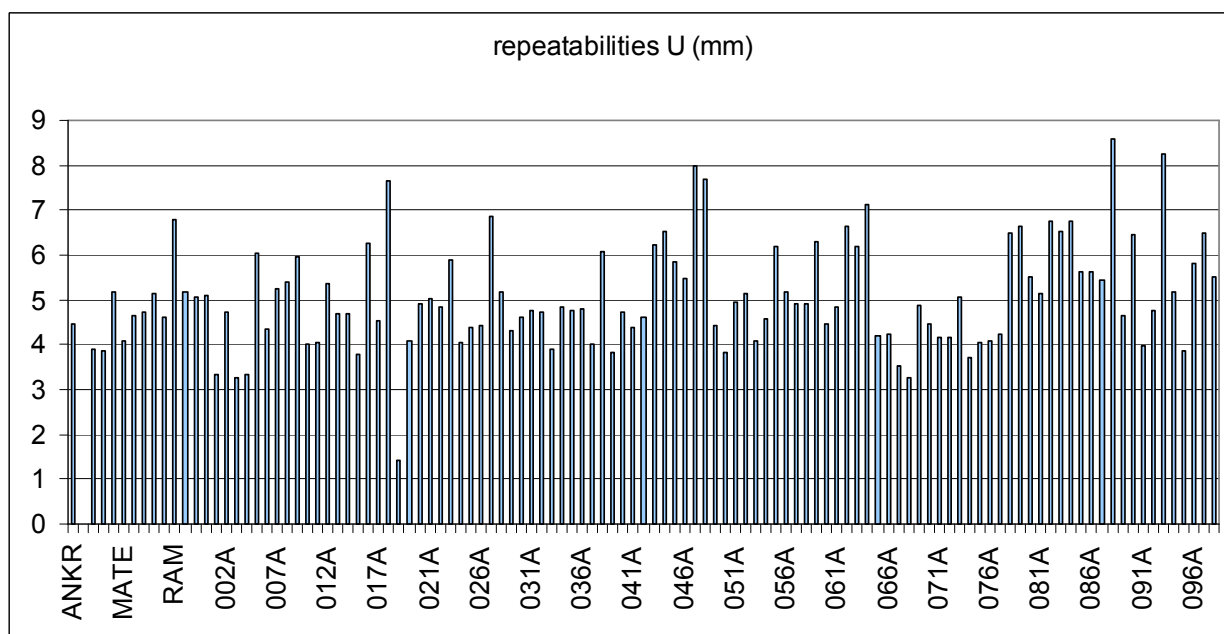


Figure 7:. Coordinate repeatability values (Up)

4.4.2 Estimated ITRF2005 coordinates

The estimated ITRF2005/2007.83 coordinates are given in Table 6.

Table 6: Estimated ITRF2005/2007.83 coordinates.

Stn	X	Y	Z
ANKR	4121948.5190	2652187.9031	4069023.7896
AUT1	4466283.3895	1896166.9358	4126096.7960
GLSV	3512888.8987	2068979.9191	4888903.2319
GRAZ	4194423.7717	1162702.7435	4647245.4442
JOZE	3664940.1135	1409153.9062	5009571.4134
MATE	4641949.5074	1393045.4823	4133287.5068
NICO	4359415.6675	2874117.1034	3650777.8562
NOT1	4934546.1794	1321265.0583	3806456.1636
NOA1	4599641.9428	2034827.3433	3909890.6185
ORID	4498451.6483	1708267.0397	4173591.8938
RAMO	4514721.7960	3133507.8799	3228024.7546
TUC2	4744543.7863	2119411.9239	3686258.8173
WTZR	4075580.5095	931853.8435	4801568.1658
TRAB	3705250.3099	3084421.7384	4162044.8040
001A	4652928.6133	1800366.1690	3960523.2046
002A	4667054.8592	1956061.1396	3869452.4988
003A	4699506.6651	1911568.0647	3853190.3225
004A	4684628.7721	1974427.0843	3839079.6498
005A	4622226.9474	1776259.3049	4006676.4340
006A	4616137.6751	2059760.6135	3876699.8613
007A	4611005.8941	2008856.2958	3909149.4529
008A	4591018.4137	2042230.0000	3915330.5309
009A	4738874.7035	2008035.1288	3755149.0330
010A	4647889.2895	2016373.1948	3861626.2757
011A	4645937.3024	1907011.9026	3918883.6889
012A	4654138.0391	1860563.9109	3931262.5115
013A	4668680.5880	1898110.4815	3896938.8805
014A	4600720.3950	1989592.1939	3931385.3014
015A	4609055.1767	1931055.9915	3950707.6795
016A	4543118.8416	1787921.9036	4091357.6078
017A	4387956.8392	1972924.4747	4173574.8291
018A	4384706.1828	2093640.4102	4118349.1808
018B	4384712.5531	2093636.6730	4118344.1558
019A	4351639.6782	2098545.0450	4150338.5281
020A	4300660.3491	2133817.5209	4185046.0155
021A	4278863.6018	2117731.8306	4215295.9617
022A	4316917.6661	2107535.3126	4182191.0869
023A	4582897.1103	2071411.4857	3909553.5709
024A	4580192.8749	2005682.6169	3946577.1498
025A	4557387.4430	2039873.5161	3955561.0203
026A	4578469.0513	1941238.4185	3980607.1290

Stn	X	Y	Z
043A	4642072.0728	1947623.4146	3903423.6243
044A	4577018.6698	2123302.0772	3889085.5664
045A	4580335.9572	2174060.6904	3856968.1074
046A	4603492.7338	2185789.8523	3822830.5587
047A	4597987.5750	2232871.0071	3802726.5555
048A	4641322.2188	2210169.0495	3762980.6692
049A	4628538.5870	2185959.8278	3792621.1293
050A	4659221.1674	2122704.1706	3790818.9588
051A	4631240.1122	2111036.5782	3831488.8944
052A	4602471.2933	2134196.6268	3852753.2979
053A	4616311.8014	2165653.3250	3818783.9661
054A	4736490.3359	1950656.2095	3787913.4284
055A	4716078.6724	1948875.9328	3814009.8298
056A	4711108.7128	1994031.4826	3796697.0528
057A	4537319.0519	1854276.0000	4067914.4993
058A	4530404.5627	1900461.2883	4054205.5140
059A	4566605.0248	1884121.4574	4021225.2767
060A	4658533.5856	1757145.9879	3973716.2614
061A	4536020.2151	1993752.3169	4002861.7288
062A	4537339.3973	1935583.8826	4030383.8979
063A	4736778.6894	1879176.4600	3823310.5899
064A	4739879.3544	1907506.1171	3805057.6828
065A	4366396.6977	2026953.7668	4170200.3850
066A	4477002.9249	1823650.2262	4146874.8677
067A	4497876.8192	1866287.1471	4105434.0894
068A	4625881.5706	1709107.0193	4031347.8857
069A	4352712.7877	2056454.0477	4170037.6187
070A	4417194.7813	1917186.9753	4168587.0760
071A	4570576.2622	1832140.2117	4040483.1769
072A	4596077.1867	1891693.2815	3984085.4580
073A	4498891.9528	1762796.6712	4150371.0361
074A	4481773.6827	1939023.4997	4089344.2736
075A	4443689.8403	1955903.3296	4123220.8864
076A	4469149.4415	1984586.8058	4081341.0048
077A	4735441.6262	2202377.8393	3650161.8161
078A	4709410.5014	2227222.6564	3667649.2653
079A	4713360.8086	2265535.0322	3639151.1242
080A	4689420.7925	2291403.3437	3654098.7029
081A	4728856.6846	2183644.6108	3669216.6768
082A	4751723.0720	2155409.0332	3656304.6377
083A	4748474.9001	2128324.0216	3676064.7926

027A	4621306.0441	1842074.7083	3979230.2453	084A	4758421.5852	2098625.6888	3680258.7858
028A	4720317.0513	1797292.9469	3881778.2897	085A	4776189.8023	2095155.7251	3659113.6015
029A	4710031.0578	1869466.2658	3860256.7197	086A	4550841.4429	2333566.7305	3798453.1224
030A	4695504.4738	1827746.6104	3897484.6721	087A	4540046.7499	2414483.7112	3760862.0593
031A	4472292.1330	1861913.6960	4134967.3132	088A	4563275.4566	2418284.6643	3730428.2840
032A	4476241.0239	1900943.2001	4113187.4208	089A	4433023.0224	2086106.2153	4070183.3195
033A	4449567.3819	1900755.5848	4141947.9389	090A	4441307.4570	2210069.3690	3995625.9238
034A	4594021.5324	1760643.7138	4046428.8797	091A	4441648.3760	2176471.9034	4013982.4006
035A	4592975.5215	1707979.0800	4069682.1663	092A	4520187.5905	2066263.8085	3984160.8059
036A	4397396.7108	2014369.9305	4143761.5980	093A	4510706.3706	2281819.9272	3876825.7138
037A	4415739.2630	1957234.8611	4151798.5154	094A	4544715.5379	2224737.1529	3870709.5245
038A	4533403.3496	1753220.2861	4117205.9108	095A	4498770.8388	2206503.6748	3933149.7681
039A	4625802.7780	1668232.7488	4048462.4835	096A	4625232.8073	2375202.8227	3682028.2325
040A	4705726.7704	1761538.4018	3915539.7369	097A	4647712.2081	2159623.7935	3784451.2214
041A	4432909.6697	1863642.4524	4176412.6607	098A	4604061.2005	2030937.6259	3906256.6500
042A	4525121.2318	1811348.1228	4100960.2349				

4.4.3 Comparison between estimated ITRF2005 coordinates and EUREF values

The estimated ITRF2005 coordinates are compared to the coordinates resulting from the values of the EPN_A_ITRF2005_C1570 solution. Table 7 summarizes the computation of coordinates at 2007.83 using coordinates (at 2005.00) and velocities obtained from the EPN_A_ITRF2005_C1570.SSC file.

The estimated ITRF2005/2007.83 coordinates are compared to the coordinates resulting from the EPN_A_ITRF2005_C1570 solution. The comparison results are given in Table 8 (in XYZ) and in Table 9 (in NEU).

Table 7: Computation of ITRF2005/2007.83 coordinates using the EPN_A_ITRF2005_C1570 solution.

Stn	Coordinates and velocities at to = 2005.00 (EPN_A_ITRF2005_C1570)							Computed coordinates at tc = 2007.83		
	Data Start - Data End DOY/year - DOY/year	X	Y	Z	Vx	Vy	Vz	X	Y	Z
ANKR	309/2006 - 131/2008	4121948.539	2652187.914	4069023.767	-0.0080	-0.0045	0.0084	4121948.5164	2652187.9013	4069023.7908
AUT1	309/2006 - 044/2010	4466283.433	1896166.881	4126096.790	-0.0149	0.0204	0.0028	4466283.3908	1896166.9387	4126096.7979
GLSV	309/2006 - 312/2007	3512888.957	2068979.880	4888903.212	-0.0190	0.0141	0.0091	3512888.9032	2068979.9199	4888903.2378
GRAZ	309/2006 - 044/2010	4194423.823	1162702.697	4647245.416	-0.0167	0.0176	0.0108	4194423.7757	1162702.7468	4647245.4466
JOZE	309/2006 - 044/2010	3664940.167	1409153.865	5009571.389	-0.0173	0.0153	0.0098	3664940.1180	1409153.9083	5009571.4167
MATE	309/2006 - 334/2008	4641949.555	1393045.429	4133287.461	-0.0176	0.0189	0.0155	4641949.5052	1393045.4825	4133287.5049
NICO	077/2007 - 044/2010	4359415.718	2874117.073	3650777.826	-0.0193	0.0105	0.0123	4359415.6634	2874117.1027	3650777.8608
NOA1	309/2006 - 044/2010	4599641.930	2034827.315	3909890.640	0.0030	0.0093	-0.0094	4599641.9385	2034827.3413	3909890.6134
NOT1	309/2006 - 044/2010	4934546.229	1321265.012	3806456.119	-0.0186	0.0169	0.0150	4934546.1764	1321265.0598	3806456.1615
ORID	212/2000 - 293/2007	4498451.692	1708266.984	4173591.865	-0.0149	0.0202	0.0095	4498451.6498	1708267.0412	4173591.8919
RAMO	309/2006 - 044/2010	4514721.846	3133507.840	3228024.701	-0.0210	0.0131	0.0181	4514721.7866	3133507.8771	3228024.7522
TRAB	345/2006 - 331/2007	n/a	n/a	n/a	n/a	n/a	n/a	-	-	-
TUC2	309/2006 - 044/2010	4744543.776	2119411.896	3686258.843	0.0027	0.0098	-0.0103	4744543.7836	2119411.9237	3686258.8139
WTZR	309/2006 - 024/2009	4075580.558	931853.799	4801568.139	-0.0156	0.0168	0.0103	4075580.5139	931853.8465	4801568.1681

Table 8: Comparison of ITRF2005/2007.83 coordinates in XYZ
(estimated coordinates vs. EUREF C1570).

Stn	Estimated coordinates			EUREF C1570 ITRF05/2007.83			DIFFERENCES [m]			
	X	Y	Z	X	Y	Z	DX	DY	DZ	DS
ANKR	4121948.5190	2652187.9031	4069023.7896	4121948.5164	2652187.9013	4069023.7908	-0.0026	-0.0018	0.0012	0.0034
AUT1	4466283.3895	1896166.9358	4126096.7960	4466283.3908	1896166.9387	4126096.7979	0.0013	0.0029	0.0019	0.0038
GLSV	3512888.8987	2068979.9191	4888903.2319	3512888.9032	2068979.9199	4888903.2378	0.0045	0.0008	0.0059	0.0074
GRAZ	4194423.7717	1162702.7435	4647245.4442	4194423.7757	1162702.7468	4647245.4466	0.0040	0.0033	0.0024	0.0057
JOZE	3664940.1135	1409153.9062	5009571.4134	3664940.1180	1409153.9083	5009571.4167	0.0045	0.0021	0.0033	0.0060
MATE	4641949.5074	1393045.4823	4133287.5068	4641949.5052	1393045.4825	4133287.5049	-0.0022	0.0002	-0.0019	0.0029
NICO	4359415.6675	2874117.1034	3650777.8562	4359415.6634	2874117.1027	3650777.8608	-0.0041	-0.0007	0.0046	0.0062
NOA1	4599641.9428	2034827.3433	3909890.6185	4599641.9385	2034827.3413	3909890.6134	-0.0043	-0.0020	-0.0051	0.0070
NOT1	4934546.1794	1321265.0583	3806456.1636	4934546.1764	1321265.0598	3806456.1615	-0.0030	0.0015	-0.0022	0.0040
ORID	4498451.6483	1708267.0397	4173591.8938	4498451.6498	1708267.0412	4173591.8919	0.0015	0.0015	-0.0019	0.0029
RAMO	4514721.7960	3133507.8799	3228024.7546	4514721.7866	3133507.8771	3228024.7522	-0.0094	-0.0028	-0.0024	0.0101
TUC2	4744543.7863	2119411.9239	3686258.8173	4744543.7836	2119411.9237	3686258.8139	-0.0027	-0.0002	-0.0034	0.0044
WTZR	4075580.5095	931853.8435	4801568.1658	4075580.5139	931853.8465	4801568.1681	0.0044	0.0030	0.0023	0.0058

Table 9: Comparison of ITRF2005/2007.83 coordinates in North East Up
(estimated coordinates vs. EUREF C1570).

Stn	North (mm)	East (mm)	Up (mm)
ANKR	2.8	-0.2	-1.8
AUT1	-0.2	2.0	3.0
GLSV	0.4	-1.8	7.2
GRAZ	-2.0	2.0	5.0
JOZE	-2.0	0.2	5.8
MATE	-0.2	0.6	-2.8
NICO	5.8	1.6	-0.6
NOT1	-0.4	2.2	-3.4
NOA1	-1.0	0.0	-6.8
ORID	-2.8	0.6	0.2
RAMO	2.6	3.0	-9.2
TUC2	-1.2	1.0	-4.0
WTZR	-2.4	1.8	5.0

4.4.3 Transformation to ETRS89

The transformation of the ITRF2005/2007.83 coordinates to ETRF2000/2007.83 was done using the EPN web page tool. The coordinates in ETRF2000/2007.83 are given in Table 10.

Table 10: Estimated ETRF2000/2007.83 coordinates.

Stn	X	Y	Z	Stn	X	Y	Z
ANKR	4121948.9495	2652187.6287	4069023.5611	043A	4642072.4455	1947623.1031	3903423.3672
AUT1	4466283.7683	1896166.6353	4126096.5466	044A	4577019.0545	2123301.7707	3889085.3135
GLSV	3512889.3231	2068979.6821	4888903.0272	045A	4580336.3442	2174060.3839	3856967.8547
GRAZ	4194424.1205	1162702.4580	4647245.2020	046A	4603493.1201	2185789.5444	3822830.3050
JOZE	3664940.4958	1409153.6566	5009571.1971	047A	4597987.9638	2232870.6998	3802726.3023
MATE	4641949.8503	1393045.1685	4133287.2458	048A	4641322.6042	2210168.7393	3762980.4139
NICO	4359416.0956	2874116.8151	3650777.6183	049A	4628538.9720	2185959.5183	3792620.8744
NOT1	4934546.5028	1321264.7257	3806455.8886	050A	4659221.5478	2122703.8589	3790818.7021
NOA1	4599642.3221	2034827.0349	3909890.3639	051A	4631240.4935	2111036.2682	3831488.6389
ORID	4498452.0157	1708266.7363	4173591.6416	052A	4602471.6772	2134196.3187	3852753.0439
RAMO	4514722.2241	3133507.5838	3228024.5112	053A	4616312.1861	2165653.0162	3818783.7116
TUC2	4744544.1618	2119411.6068	3686258.5566	054A	4736490.7038	1950655.8920	3787913.1669
WTZR	4075580.8484	931853.5653	4801567.9274	055A	4716079.0413	1948875.6166	3814009.5693
TRAB	3705250.7754	3084421.4939	4162044.5974	056A	4711109.0842	1994031.1669	3796696.7928
001A	4652928.9779	1800365.8561	3960522.9459	057A	4537319.4251	1854275.6947	4067914.2463
002A	4667055.2310	1956060.8265	3869452.2406	058A	4530404.9386	1900460.9837	4054205.2617
003A	4699507.0330	1911567.7494	3853190.0625	059A	4566605.3981	1884121.1504	4021225.0226
004A	4684629.1439	1974426.7702	3839079.3909	060A	4658533.9477	1757145.6745	3973716.0022
005A	4622227.3123	1776258.9939	4006676.1766	061A	4536020.5955	1993752.0124	4002861.4769
006A	4616138.0547	2059760.3042	3876699.6061	062A	4537339.7747	1935583.5777	4030383.6455
007A	4611006.2715	2008855.9866	3909149.1976	063A	4736779.0537	1879176.1422	3823310.3279
008A	4591018.7937	2042229.6922	3915330.2768	064A	4739879.7199	1907505.7992	3805057.4209
009A	4738875.0741	2008034.8114	3755148.7718	065A	4366397.0878	2026953.4733	4170200.1411
010A	4647889.6653	2016372.8832	3861626.0188	066A	4477003.2994	1823649.9247	4146874.6173
011A	4645937.6729	1907011.5907	3918883.4313	067A	4497877.1949	1866286.8444	4105433.8383
012A	4654138.4068	1860563.5982	3931262.2532	068A	4625881.9318	1709106.7078	4031347.6277
013A	4668680.9569	1898110.1681	3896938.6218	069A	4352713.1799	2056453.7552	4170037.3756
014A	4600720.7720	1989591.8852	3931385.0465	070A	4417195.1635	1917186.6781	4168586.8290
015A	4609055.5503	1931055.6820	3950707.4238	071A	4570576.6326	1832139.9042	4040482.9222
016A	4543119.2111	1787921.5977	4091357.3541	072A	4596077.5589	1891692.9727	3984085.2026
017A	4387957.2256	1972924.1796	4173574.5838	073A	4498892.3231	1762796.3680	4150370.7843
018A	4384706.5754	2093640.1159	4118348.9365	074A	4481774.0630	1939023.1984	4089344.0238
018B	4384712.9457	2093636.3787	4118343.9115	075A	4443690.2233	1955903.0308	4123220.6384
019A	4351640.0726	2098544.7528	4150338.2853	076A	4469149.8247	1984586.5055	4081340.7559
020A	4300660.7475	2133817.2322	4185045.7753	077A	4735442.0061	2202377.5232	3650161.5564
021A	4278864.0004	2117731.5432	4215295.7224	078A	4709410.8839	2227222.3420	3667649.0070
022A	4316918.0625	2107535.0227	4182190.8458	079A	4713361.1926	2265534.7178	3639150.8660
023A	4582897.4922	2071411.1785	3909553.3173	080A	4689421.1790	2291403.0310	3654098.4459
024A	4580193.2537	2005682.3096	3946576.8959	081A	4728857.0640	2183644.2950	3669216.4173
025A	4557387.8246	2039873.2104	3955560.7677	082A	4751723.4488	2155408.7158	3656304.3769
026A	4578469.4270	1941238.1110	3980606.8747	083A	4748475.2758	2128323.7043	3676064.5318
027A	4621306.4126	1842074.3976	3979229.9884	084A	4758421.9590	2098625.3707	3680258.5243
028A	4720317.4123	1797292.6297	3881778.0279	085A	4776190.1749	2095155.4058	3659113.3392
029A	4710031.4230	1869465.9496	3860256.4589	086A	4550841.8387	2333566.4268	3798452.8721
030A	4695504.8376	1827746.2949	3897484.4117	087A	4540047.1499	2414483.4086	3760861.8100

031A	4472292.5097	1861913.3950	4134967.0633	088A	4563275.8555	2418284.3602	3730428.0337
032A	4476241.4025	1900942.8990	4113187.1710	089A	4433023.4124	2086105.9178	4070183.0729
033A	4449567.7617	1900755.2854	4141947.6903	090A	4441307.8526	2210069.0716	3995625.6777
034A	4594021.8980	1760643.4045	4046428.6235	091A	4441648.7700	2176471.6058	4013982.1542
035A	4592975.8843	1707978.7706	4069681.9098	092A	4520187.9753	2066263.5053	3984160.5552
036A	4397397.0989	2014369.6350	4143761.3525	093A	4510706.7662	2281819.6257	3876825.4650
037A	4415739.6473	1957234.5641	4151798.2687	094A	4544715.9291	2224736.8490	3870709.2737
038A	4533403.7177	1753219.9807	4117205.6573	095A	4498771.2314	2206503.3737	3933149.5193
039A	4625803.1370	1668232.4371	4048462.2252	096A	4625233.2010	2375202.5145	3682027.9791
040A	4705727.1303	1761538.0854	3915539.4756	097A	4647712.5908	2159623.4827	3784450.9655
041A	4432910.0483	1863642.1539	4176412.4126	098A	4604061.5793	2030937.3172	3906256.3952
042A	4525121.6034	1811347.8181	4100959.9822				

4.5 Comparison of estimated and internal HEPOS network coordinates

In Table 11 the computed ETRS89 coordinates are compared to the internal coordinates of the HEPOS network. The biggest differences (marked bold) are: 13.4 mm in North (station 087A), 26.0 mm in East (station 085A) and 39.8 mm in Up (station 040A). The mean difference in the horizontal plane (dS) amounts 18.5 mm whereas the mean value of the differences in Up (absolute values) is 19.9 mm.

Concluding, it can be stated the mean differences are below 2 cm both in the horizontal and in the vertical component. This level of agreement is considered acceptable.

Table 11: Comparison of ETRS89 coordinates (estimated vs. internal HEPOS network coordinates).

Stn	North (mm)	East (mm)	Up (mm)	Stn	North (mm)	East (mm)	Up (mm)	Stn	North (mm)	East (mm)	Up (mm)
001A	0.8	-18.0	-34.0	033A	-2.4	-10.8	-13.2	066A	-0.2	-10.8	-18.4
002A	-3.2	-20.2	-28.8	034A	1.8	-15.2	-30.6	067A	-1.4	-12.2	-18.4
003A	-2.2	-21.0	-33.2	035A	3.4	-14.6	-32.6	068A	3.2	-16.0	-35.2
004A	-3.8	-21.2	-29.6	036A	-6.0	-10.4	-4.6	069A	-7.4	-9.4	0.6
005A	1.4	-16.6	-32.2	037A	-4.2	-10.2	-8.2	070A	-3.4	-9.6	-9.8
006A	-5.8	-19.4	-20.6	038A	2.0	-12.4	-25.8	071A	-0.2	-15.0	-25.8
007A	-4.6	-18.6	-22.0	039A	4.4	-15.6	-37.0	072A	-1.6	-16.6	-25.4
008A	-5.4	-18.4	-19.2	040A	1.8	-20.0	-39.8	073A	1.6	-11.0	-22.8
009A	-4.6	-23.8	-32.8	041A	-1.6	-9.4	-13.4	074A	-3.4	-12.8	-14.2
010A	-4.8	-20.4	-25.0	042A	0.2	-12.8	-22.8	075A	-4.0	-11.4	-10.6
011A	-2.0	-18.8	-29.0	043A	-3.0	-19.2	-27.0	076A	-4.6	-12.8	-11.2
012A	-0.8	-18.8	-31.6	044A	-7.4	-19.0	-14.8	077A	-8.8	-25.6	-25.2
013A	-1.8	-19.8	-31.2	045A	-8.4	-19.8	-13.2	078A	-9.2	-25.2	-22.2
014A	-4.0	-18.0	-22.0	046A	-8.6	-20.8	-14.6	079A	-9.8	-25.6	-21.2
015A	-2.8	-17.8	-25.0	047A	-9.6	-21.4	-12.6	080A	-10.4	-25.2	-18.2
016A	1.0	-13.2	-25.2	048A	-9.0	-22.6	-17.0	081A	-8.4	-25.2	-25.4
017A	-5.0	-9.4	-5.4	049A	-8.6	-21.8	-16.8	082A	-7.8	-25.6	-28.4
018A	-8.0	-11.2	-0.4	050A	-7.2	-22.0	-21.8	083A	-7.2	-25.2	-29.2
018B	-8.0	-11.2	-0.4	051A	-6.8	-20.8	-19.8	084A	-6.6	-25.4	-31.2
019A	-8.4	-10.2	2.4	052A	-7.4	-20.0	-16.6	085A	-6.6	-26.0	-32.8
020A	-9.8	-9.0	7.8	053A	-8.2	-21.0	-16.6	086A	-11.8	-21.2	-5.0
021A	-9.8	-7.8	9.0	054A	-3.2	-23.2	-34.8	087A	-13.4	-22.4	-1.0

022A	-9.0	-9.0	5.6
023A	-6.2	-18.6	-17.4
024A	-4.6	-17.4	-19.8
025A	-5.6	-17.0	-16.6
026A	-3.0	-16.6	-22.0
027A	-0.4	-17.2	-29.4
028A	0.6	-21.0	-39.6
029A	-1.2	-21.2	-35.8
030A	0.0	-20.2	-36.4
031A	-1.4	-11.0	-16.6
032A	-2.4	-12.0	-15.4

055A	-3.0	-22.2	-33.2
056A	-4.2	-22.6	-31.0
057A	-0.8	-13.8	-22.2
058A	-2.0	-14.0	-19.6
059A	-1.6	-15.4	-23.4
060A	2.0	-18.0	-36.0
061A	-4.4	-15.6	-16.4
062A	-3.0	-14.8	-19.0
063A	-1.4	-22.4	-37.6
064A	-2.2	-22.8	-36.8
065A	-6.4	-9.4	-1.4

088A	-13.2	-23.2	-3.0
089A	-7.4	-13.0	-4.6
090A	-10.2	-15.4	-0.4
091A	-9.4	-15.0	-1.8
092A	-6.2	-16.0	-12.4
093A	-11.0	-19.2	-3.4
094A	-9.8	-19.4	-8.4
095A	-9.6	-17.4	-5.2
096A	-12.2	-24.2	-9.8
097A	-7.8	-22.0	-19.4
098A	-5.2	-18.8	-20.6

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