HEPOS
The Hellenic RTK-Network

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Overview

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- Realization Framework
- Realization Strategy
- Timetable
- Preparation related issues
- Establishment related issues
- System Description
- Proven Solutions
- Geodetic Aspects
- Geodynamic Aspects
- First Performance Tests

Realization Framework

- HEPOS is part of the Program for the modernization of the Hellenic Cadastre
- System owner & operator: Ktimatologio S.A. (Hellenic Cadastre)
- System establishment co-funded by the EU

Realization Strategy

Realization Alternatives

- Three tenders
  - Receivers
  - Networking Software
  - Telecommunication network
- One Tender for delivering a complete system

Realization Strategy

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Chosen Approach

One Tender for delivering a complete system

+

Initial operation of the system by the contractor

=

DBO (Design – Build – Operate) Approach

Realization Strategy

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Advantages of DBO Approach

- Technical Specifications are compact (functionality of the system can be directly requested)
- Risk reduction: only one tender
- The good operation of the system is guaranteed to a high degree
- Tuning of system is easier (only one contractor)
- Easier to supervise the contract
- Have control over the running costs of the system, as they are included in the economical offer

Timetable

- 12/2003: Decision made to implement HEPOS
- 07/2005: Completion of system design & tender documents
- 08/2005: Start of public consultation
- 10/2005: Tender announcement
- 01/2007: Contract awarded to Trimble Europe B.V.
- 05/2007: Installation of first Reference Station
- 08/2007: Installation of 98 Reference Stations & Control Center completed
- 11/2007: End of system setup & workout period
- 12/2007: Planned to be available to the users

Preparation related issues

Design and register trademark

HEPOS

HEllenic POsitioning System

Register www site name

www.hepos.gr

Preparation related issues

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Legal Issues

- Modification of Building Regulations to allow installation of the antennas
- Determine the terms of contracts for leasing the buildings of the Reference Stations

Preparation related issues

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Selection of Station Sites

- Rough terrain of Greece implies serious restrictions in the site selection
- A GIS Application has been developed for checking the satellite visibility on a desired site
- The application allowed the selection of sites in the office

Preparation related issues

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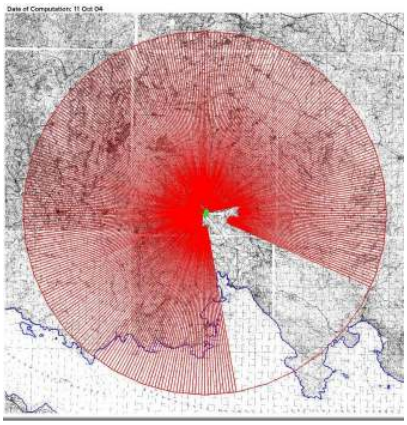
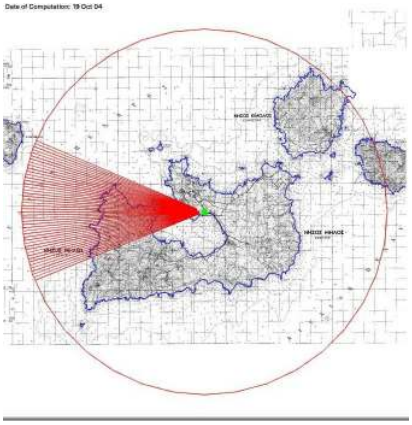
Visibility check (Elevation Mask: 5 deg)

Unacceptable site



Acceptable site



Preparation related issues

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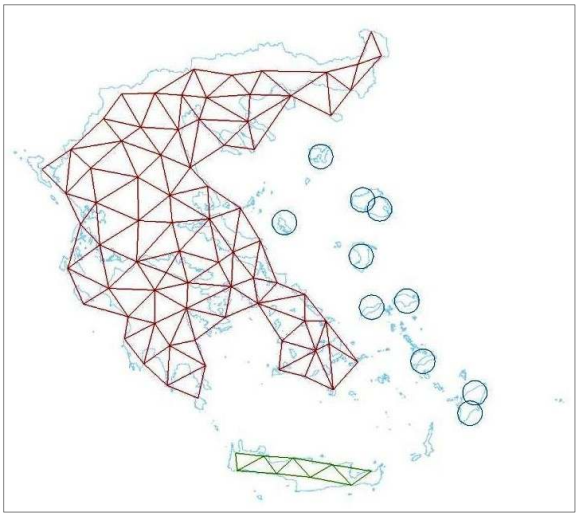

Network design according to the specifications:

- Net 1
- Net 2
- Single Ref. Stations

(Uncovered area in the northern part is deep forest)

Establishment related issues

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Satellite Visibility

Part of the documentation delivered by the contractor to get approval for installation

Establishment related issues

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Antenna mounts

Roof-mounted

Wall-mounted

Establishment related issues

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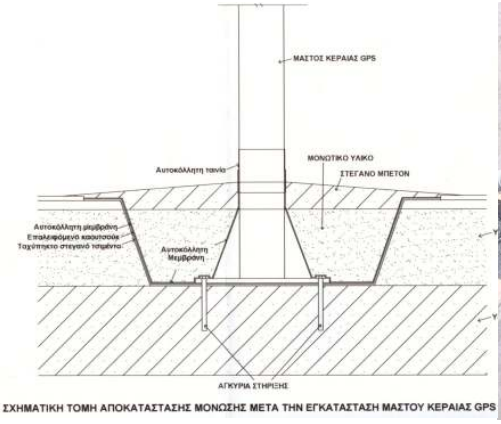
Roof mount: Procedure followed by contractor



ΣΧΗΜΑΤΙΚΗ ΤΟΜΗ ΑΠΟΚΑΤΑΣΤΑΣΗΣ ΜΟΝΩΣΗΣ ΜΕΤΑ ΤΗΝ ΕΓΚΑΤΑΣΤΑΣΗ ΜΑΣΤΟΥ ΚΕΡΑΙΑΣ GPS

Establishment related issues

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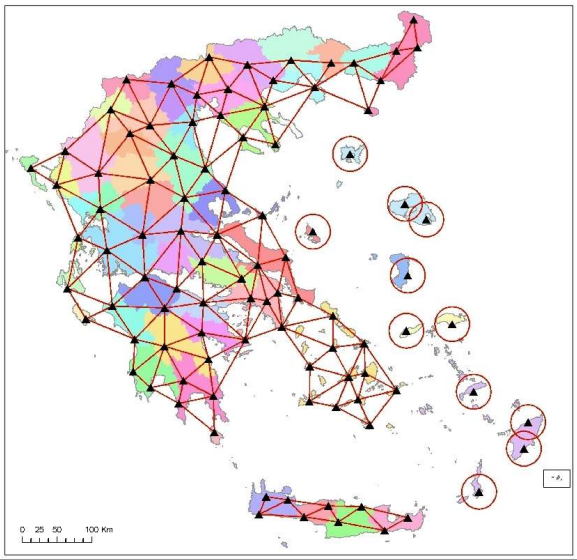
Roof mount: Procedure followed by contractor

System description: Network



HEPOS

Complete Network

Networked RS: 87

Single RS : 11

Total RS : 98

System description: Ref. Stations

Buildings:

controlled access

System description: Ref. Stations

Buildings:

Alarm devices

Lightning protection

System description: Ref. Stations

Mast:

Stainless

Diameter: 10cm

Grounded

Always fixed on concrete

System description: Ref. Stations

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Antennas: Trimble Zephyr Geodetic with Dome

System description: Ref. Stations

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Aluminum tribrach:
Designed by the contractor

System description: Ref. Stations

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Station & contact Info

UPS

System description: Ref. Stations

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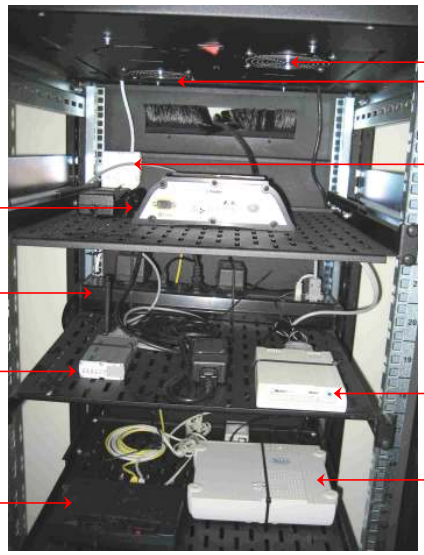

GPS Receiver:

Trimble Net RS

NPS

GSM/GPRS Modem

Router

Cabin Fans

Fans Thermostat

Serial Modem

ISDN Modem

System description: Ref. Stations

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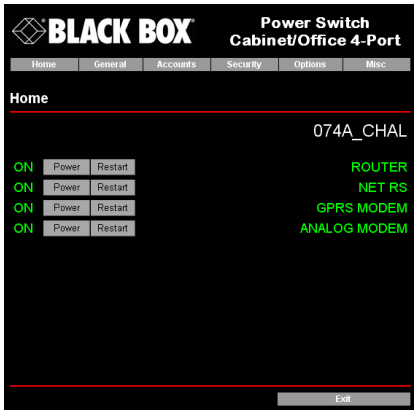
NPS: Network Power Switch



All devices can be powered-up or restarted remotely from the Control Center.

This:

- **Saves expenses for visiting RS**
- **Saves time for visiting RS**
- **Increases availability of services**

System description: Control Center

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- GPS Receiver at CC
- Firewall
- Router
- VPN Concentrator
- Access Server
- Network switch
- Application servers
- Backup device
- Storage server
- UPS
- Battery Packs (2/6)

Terminal

System description

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Telecom Network

- **Main Lines:**
  - MPLS VPN ADSL
  - MPLS VPN ISDN (in few sites without ADSL availability)
- **Back-up lines:**
  - GSM/GPRS
- **GSM users support:**
  - Hardware capable of supporting 480 parallel GSM users
  - Lines for supporting 60 parallel GSM users
- **GPRS users support:**
  - Currently capable of supporting 150 parallel user, as required by the specifications. Expansion capabilities with additional licenses.

System description

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Offered Services

APPLICATION	SERVICE	DATA FORMAT
Post Processing	RS data	RINEX, CRINEX
	VRS data	RINEX, CRINEX
Real Time	Network RTK: VRS	RTCM 2.3 RTCM 3.0 RTCM 3.1 CMR+
	Network RTK: FKP	
	Network RTK: MAC	
	Single Base RTK	
	Network DGPS	RTCM 2.3
	Single Base DGPS	RTCM 2.3

Proven Solutions

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Strategic Decisions

- **Strategic partner for hosting the reference stations**
  reduces delays during installation, facilitates logistics
- **Choosing DBO Approach**
  Profit by all DBO advantages mentioned before

Proven Solutions

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Technical & Practical Issues

- **Rack mounted devices in the control center:**
  Avoiding “computer pool”
- **NPS at the Reference Stations:**
  All devices can be rebooted form Control Center
- **Reference Station at Control Center**
  Good reference for data latencies
- **Contact info on the cabin at the reference sites**
  Avoid unwanted interventions
- **ADSL/ISDN router**
  No need to visit RS when ISDN is replaced by ADSL

Geodetic Aspects

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Requirements

- HEPOS should realize the national Coordinate Reference System (GGRS'87: Greek Geodetic Reference System 1987)
- HEPOS must be able to realize a new geodetic datum that can replace the existing one in the future

Geodetic Aspects

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Steps for fulfilling requirements

- A nation-wide GPS Campaign has been made for establishing transformation parameters between GGRS87 and the reference frame of HEPOS
- Use a realization of ETRS'89 as the reference frame of HEPOS

Geodetic Aspects

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GPS Campaign

- 2500 points of the National Trigonometric Network have been measured, i.e 10% of the total number of points
- Points are evenly distributed all over the country

Geodetic Aspects

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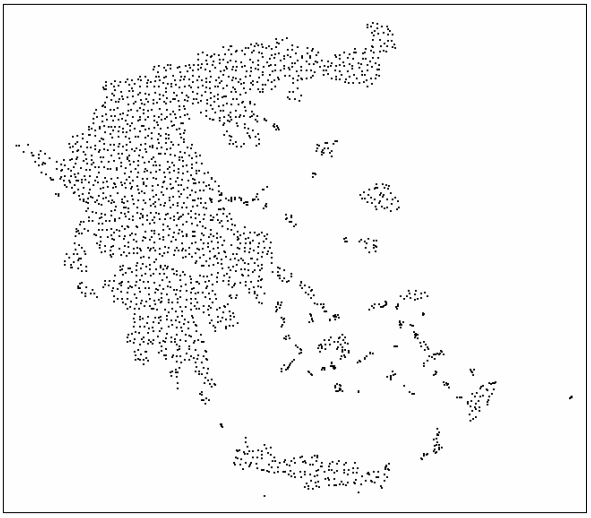
GPS Campaign






Geodetic Aspects



GPS Campaign:

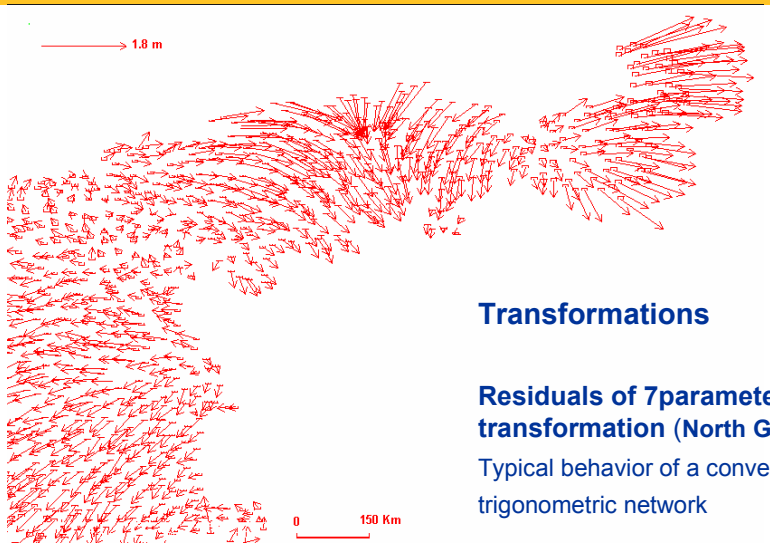
Measured points

Geodetic Aspects

Transformations

- 7 parameter Helmert transformation sets are computed for each map sheet 1:50.000 and 1:100.000 (map sheets chosen due to historical reasons)
- Correction grids are computed over a nation-wide transformation set
- Evaluation of these models will lead to the final transformation model

Geodetic Aspects



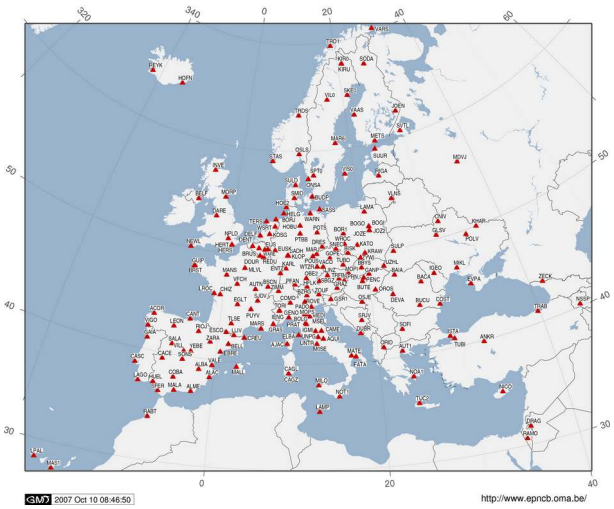
Transformations

Residuals of 7parameter Helmert transformation (North Greece):

Typical behavior of a conventional trigonometric network

Geodynamic Aspects

EUREF Permanent Tracking Network



ETRS89:

By definition is fixed to the stable part of the Eurasian Plate

Geodynamic Aspects

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Velocities of EPN stations (ETRF2005)

STATION	VX_{EPN} (m/y)	VY_{EPN} (m/y)	VZ_{EPN} (m/y)	$\|V\|_{EPN}$ (m/y)
WTZR	0.0001	0.0003	0.0006	0.0007
GRAZ	-0.0003	0.0007	0.0008	0.0011
KOSG	0.0005	0.0003	0.0011	0.0012
AUT1	0.0049	0.0033	-0.0079	0.0099
NOA1	0.0125	-0.0118	-0.0211	0.0272
TUC2	0.0196	-0.0096	-0.0208	0.0301

Geodynamic Aspects

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Remarks

- An initial period of operation of HEPOS is necessary for revealing the rate of change of RS coordinates throughout the country
- The differential rate of change between neighboring stations is of particular importance
- The network should treat the changes in a way that the stability of the planar coordinates is guaranteed

First Performance Tests

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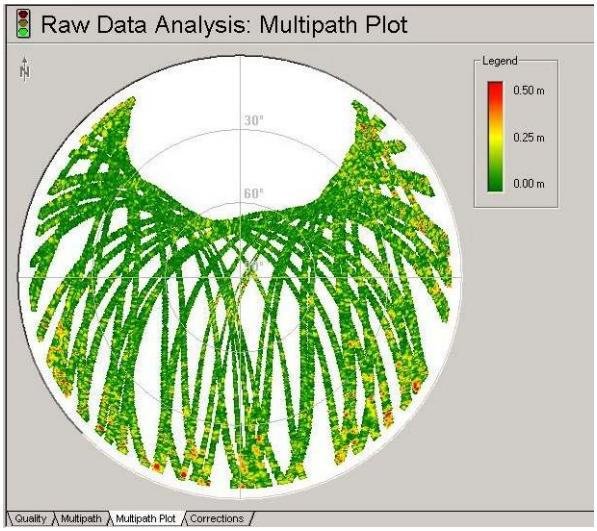

Multipath estimation at RS:

The plots prove very low multipath effect

First Performance Tests

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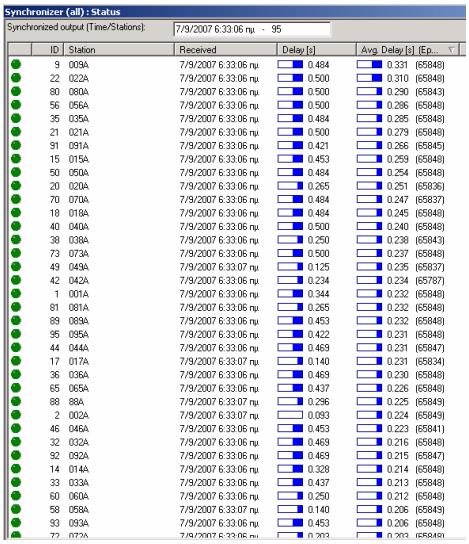

Latency of incoming data:

Highest average values

Even the highest average values are satisfactory.

First Performance Tests

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Synchronizer (all) : Status

Synchronized output (Time/Stations): 7/9/2007 6:35:45 πμ · 95

ID	Station	Received	Delay [s]	Avg. Delay [s] (Ep...
82	082A	7/9/2007 6:35:45 πμ	0.422	0.176 (66006)
12	012A	7/9/2007 6:35:45 πμ	0.391	0.175 (66007)
63	063A	7/9/2007 6:35:45 πμ	0.406	0.175 (66007)
37	037A	7/9/2007 6:35:45 πμ	0.281	0.173 (65996)
67	067A	7/9/2007 6:35:45 πμ	0.219	0.171 (66007)
75	075A	7/9/2007 6:35:45 πμ	0.203	0.168 (66007)
11	011A	7/9/2007 6:35:45 πμ	0.266	0.168 (66007)
10	010A	7/9/2007 6:35:45 πμ	0.375	0.168 (66007)
90	090A	7/9/2007 6:35:45 πμ	0.406	0.168 (66007)
77	077A	7/9/2007 6:35:45 πμ	0.281	0.166 (66007)
29	029A	7/9/2007 6:35:45 πμ	0.406	0.165 (66007)
61	061A	7/9/2007 6:35:45 πμ	0.141	0.165 (66005)
53	053A	7/9/2007 6:35:45 πμ	0.156	0.164 (66005)
84	084A	7/9/2007 6:35:45 πμ	0.250	0.164 (65978)
97	097A	7/9/2007 6:35:45 πμ	0.375	0.163 (66002)
79	079A	7/9/2007 6:35:45 πμ	0.172	0.157 (66007)
26	026A	7/9/2007 6:35:45 πμ	0.391	0.157 (66007)
23	023A	7/9/2007 6:35:45 πμ	0.156	0.154 (66007)
34	034A	7/9/2007 6:35:45 πμ	0.109	0.152 (66007)
28	028A	7/9/2007 6:35:45 πμ	0.375	0.149 (66007)
4	004A	7/9/2007 6:35:45 πμ	0.141	0.148 (66007)
71	071A	7/9/2007 6:35:45 πμ	0.219	0.146 (66006)
39	039A	7/9/2007 6:35:45 πμ	0.250	0.145 (66007)
64	064A	7/9/2007 6:35:45 πμ	0.375	0.144 (66007)
25	025A	7/9/2007 6:35:45 πμ	0.234	0.140 (66007)
6	006A	7/9/2007 6:35:45 πμ	0.172	0.137 (66007)
48	048A	7/9/2007 6:35:45 πμ	0.172	0.137 (66007)
54	054A	7/9/2007 6:35:45 πμ	0.141	0.136 (66007)
3	003A	7/9/2007 6:35:45 πμ	0.141	0.127 (66007)
8	008A	7/9/2007 6:35:45 πμ	0.359	0.125 (66007)
7	007A	7/9/2007 6:35:45 πμ	0.094	0.121 (66007)
98	098A	7/9/2007 6:35:45 πμ	0.000	0.024 (66007)

Latency of incoming data:

Lowest average values

All current values fulfill the specified requirement, that delays must be less than 1 sec.

⟵ RS at Control Center

Thank you for your attention

HEPOS
HEllenic POsitioning System

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