A zero order network of permanent GNSS stations for the positioning services in Italy: some hypotheses and tests

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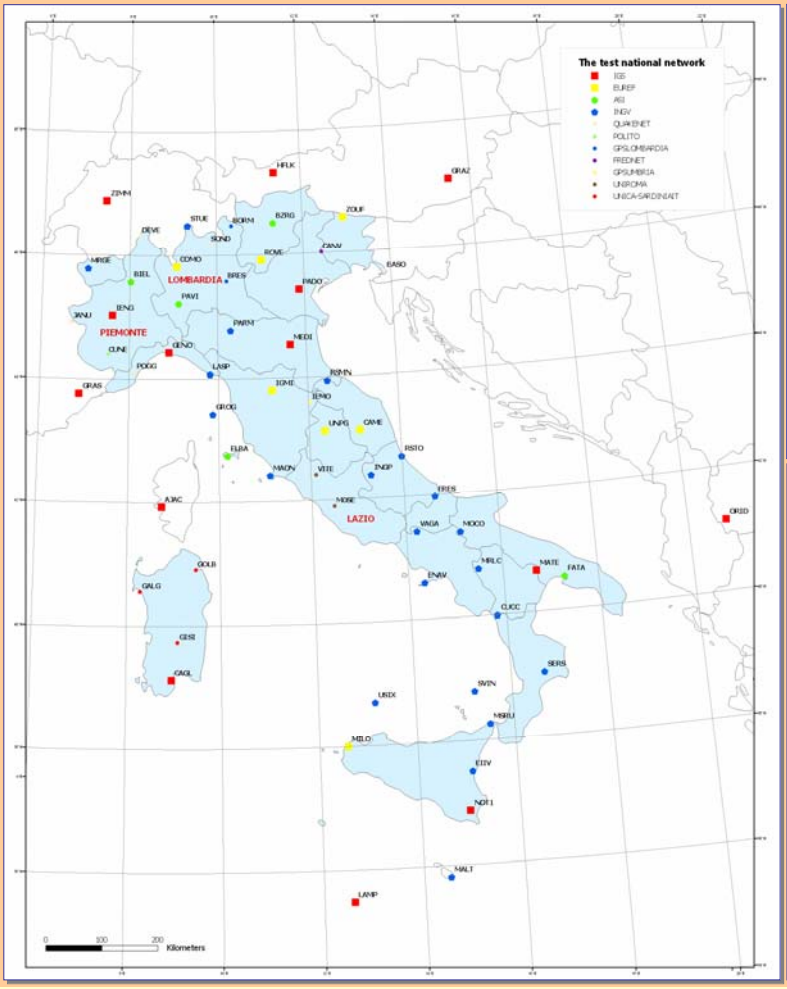
In these years, GNSS Permanent Networks finalized to real time and post processing positioning services are under development in Italy; for administrative reasons, these PN's are designed, created and managed at a local scale, corresponding to Italian Regions. At present less than 10 (of 20 regions) are already operating and distributing data to the user community: the authors of the present work have been involved in the design, the establishment and the monitoring of the first three services, in Piemonte, Lombardia and Lazio Regions (Fig. 1). A positioning service materializes and distributes the reference frame to the user community; in order to guarantee that local neighbouring positioning services distribute the same reference frames, they should share a common infrastructure, i.e. they should be adjusted and monitored in a common zero order PN, by following a common set of adjustment rules.



The national zero order PN needs and mission

From a theoretical point of view, the global IGS PN and the IGS adjustment guidelines constitute the natural shared infrastructure for the local PN's; from a practical point of view, the IGS PS's alone cannot be the zero order PN for Italy, because they are too sparse and not homogeneously distributed, particularly in southern regions (Fig. 1, red squares); the same holds for the EPN PN (blue squares). Moreover IGS and EPN have not the scope of monitoring local subnetworks, while a national zero order PN could and should also provide a sort of "governing board" for them.
In the authors opinion there is the need of a new initiative toward a national zero order PN, with the following minimal characteristics:
1) adjusted and monitored in IGS and EPN,
in order to provide the link between them and the local positioning services;
2) adjusted and monitored by more than one analysis centres,
in order to provide a minimal consistency check;
3) homogeneously distributed over the whole region, with a reasonable PS's density;
3) including the main (not duplicated in the same town!) PS's of EPN and IGS;
4) including the PS's of the main national networks (ASI and INGV);
5) including at least 2 PS's for each already operating local PN,
6) composed only by PS's whose data are freely and automatically downloadable;
7) composed only by PS's whose responsible agencies subscribe
proper consistency and quality guidelines, like for IGS and EPN PN's.

The processing strategies

A national zero order PN should be adjusted according to the following minimal rules:
1) independent adjustments performed on a daily basis,
after IGS final products are available;
2) IGS PS's stochastically constrained to their IGS estimated coordinates,
with realistic covariances assigned to the constraints;
3) adoption, without any further parameters estimation,
of the final IGS products: EOP, EPH and PCV;
4) adoption of the IGS and EPN guidelines to the adjustment of regional PN's;
5) accurate data consistency and quality check by automated analysis;
6) analysis and comparison of the time series produced by the independent centres.

Additional products of the national PN

A national PN at first materializes and distributes the global reference frame.
At a second level, it should provide the following services:
1) a continuous consistency check between
the global reference frame and the local positioning services coordinates;
2) the estimation of the transformation between
the global reference frame and the national cartographic reference frame.

To fulfil these objectives, a national zero order PN has to be governed by a scientific board and a national authority; in the present Italian ambiguous situation, the authors have just tried the scientific and technical experiment of defining, adjusting and analysing a test PN.

The test PN and the analyzed data

The test network is composed of a selection from the PS's operating in Italy at the end of 2006, chosen by minimizing the compromises with the above guidelines; particularly, not all the PS's data are freely accessible to the community, but they could become such in case of inclusion in a zero order PN.

Number of PS's: 62; Mean distance: 100 km; Mean age: 5 years (in the range from 1 to 7).

IGS: 14	EUREF: 6	ASI: 5	INGV: 21	QUAKENET: 5	POLITO: 1
GPSLOMBARDIA: 3	FREDNET: 1	GPSUMBRIA: 1	UNIROMA: 2	UNICA-SARDINIAIT: 3	

Three months of data (from January, 1st, 2007 to March, 31, 2007) have been adjusted by the 3 groups, according to the above processing strategies.

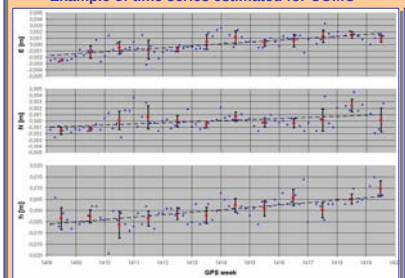
Processing problems

Not all the test PS's fulfil the above guidelines and the resulting PN is not completely homogenous. In any case the scope of this work is not to define an official zero order national PN but just to handle the problem of a test PN monitoring; in the future, more PS's can be included.
From a technical point of view, some PS's exhibit significant data gaps and quality problems, typically due to the reconstruction of RINEX data from real time streams: such a practice has to be avoided and these Ps's will be substituted in the future tests; moreover it is worth to remember that all the 3 groups use Bernese 5.0 software, while the use of at least 2 different software is preferable.

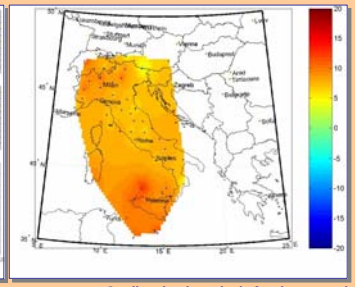
Quality check and results analysis

At present, the following quality indicators are extracted by Bernese 5.0 outputs:
1) residuals in the standard orbit interpolation,
2) residuals in the receivers clocks estimation,
3) RMS of the cycle slip detection process, and the final number of initial ambiguities,
4) RMS of the ambiguity fixing process and the final number of not fixed ambiguities,
5) RMS of the daily estimates and their residual w.r.t. the linear interpolations.
All the data have been processed; the analysis and the comparison of the 3 solutions has just started. After the initial manual analysis of the chosen PS's, the automation of the whole process has been implemented and is under testing.

Example of time series estimated for COMO

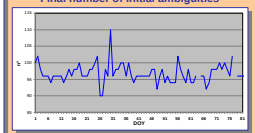


Example of correction to dry Saastamoinen model

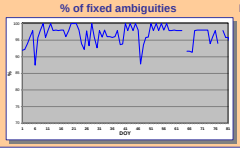


Quality check analysis for an example baseline

Final number of initial ambiguities

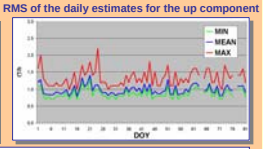


% of fixed ambiguities



Quality check analysis for the network

RMS of the daily estimates for the up component



Aknowledgements. GPS raw data have been provided by the following agencies.
IGS: International GNSS Service (http://igscb.jpl.nasa.gov/)
EUREF: European Permanent Network (http://www.epncb.oma.be/)
ASI: Agenzia Spaziale Italiana (http://www.asi.it/)
INGV: Istituto Nazionale di Geofisica e Vulcanologia (http://www.ingv.it/)
QUAKENET: Alps-GPS Quake Net (http://www.alps-gps.units.it/)
POLITO: Laboratorio Didattico Sperimentale del Politecnico di Torino (http://www.vercelli.polito.it/civili/home.htm)
GPSLOMBARDIA: Rete di Posizionamento GPS della Regione Lombardia (http://www.gpslombardia.it)
FREDNET: Friuli Regional Deformation Network (http://www.crs.inogs.it/frednet/EnglishSite/XFReDNetHomeENG.htm)
GPSUMBRIA: GPS-GLONASS Regione Umbria (http://www.gpsumbria.it/)
UNIROMA: Rete Sperimentale GPS (http://w3.uniroma1.it/resnap-gps/index.asp)
UNICA-SARDINIAIT: Stazioni Permanenti GNSS della Sardegna (http://topografia.unica.it/)\

Poster available at http://geomatica.como.polimi.it/prin/doc/zeronet.pdf