

NATIONAL REPORT OF SLOVENIA to the EUREF 2010 Symposium in Gävle

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1 Introduction

This paper is the review of activities regarding the adoption of the ESRS and other related activities in Slovenia, during the period 2009–2010. The ongoing development of the national GNSS positioning service and activities on the horizontal, height, and gravimetric systems are presented.

2 The SIGNAL positioning service

The SIGNAL (SlovenIa-Geodesy-Navigation-Location) permanent GNSS network consists of 15 Slovenian stations, 5 Austrian stations, 1 Hungarian station, and (from 2010 newly) 6 Croatian (Čakovec, Zabok, Zagreb, Karlovac, Delnice, Rijeka, and Poreč), and 5 Italian (Trieste, Gorizia, Udine, Moggio Udinese, and Tarvisio) stations. The whole national border is now covered with the stations from neighbouring countries, too (Figure 1).

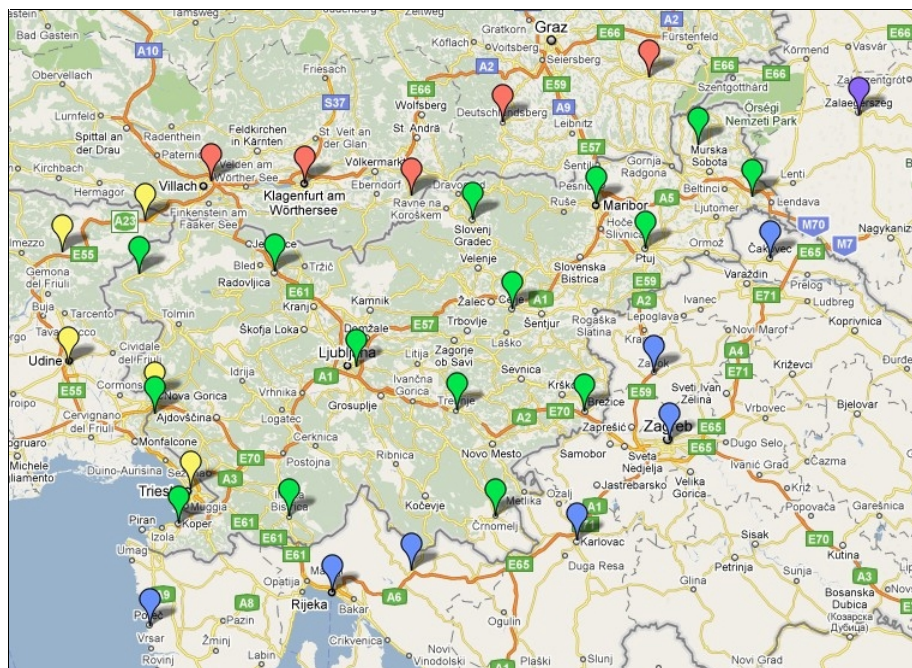


Figure 1: SIGNAL network GNSS stations (in green) and cross-border stations included by agreements with neighbouring stations: Austrian (in red), Hungarian (in violet), Croatian (in blue), and Italian (in yellow).

Coordinates of the 11 new permanent stations included into the SIGNAL network were determined from GNSS observations of one week period. The mean epoch was 2009.55. The final coordinates of these cross-border stations used within the SIGNAL network are harmonized with the national geodetic datum D96, which is the Slovenian realization of ETRS89.

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Real-time correction data assured by the SIGNAL GPS Service have been payable since 1st April, 2010. At the moment, two companies are licensed for the data distribution. The prices for unlimited access are 70 €/month or 100 €/month. At the end of June 2010, there were nearly 300 registered users of the SIGNAL network RTK- and DGPS services.

The complete archive of RINEX data for the SIGNAL network permanent stations for years 2002–2009 was arranged in 2009 and the archive maintenance is now compatible with the international standards (file-naming convention etc.).

3 Horizontal reference system

At the moment in Slovenia two horizontal reference systems are in practical usage. The “old”, and still official horizontal reference system for general purposes, is so called D48, which is based on old triangulation network with the coordinates computed according to the Bessel reference ellipsoid. On the other side, the official horizontal reference system for all real estate registration purposes is from January 1st 2008, the reference system ETRS89, with its realization ETRF. Our activities in the last period were therefore focused into the realization of two main tasks: to define and realize the transformation procedure from D48 to ETRS89 for all official spatial data, and to establish the first geokinematic model of Slovenian territory. Its main purposes are the preliminary definitions of procedures for incorporation local geokinematics into the realization of new slovenian reference system.

Local to ETRS89 datum transformation

A new version of transformation between the official national horizontal datum D48 and ETRS89 was released in 2009. A rubber sheeting technique based on Delaunay triangulation was used to preserve the quality of spatial data. The improved triangle-based transformation, Version 3.0, was created for transformation of all spatial databases which continuously cover the entire territory of the country and require transformation accuracy of better than one metre. A high-quality datum transformation is needed to meet the INSPIRE Directive recommendations on using ETRS89 as a common European coordinate reference system.

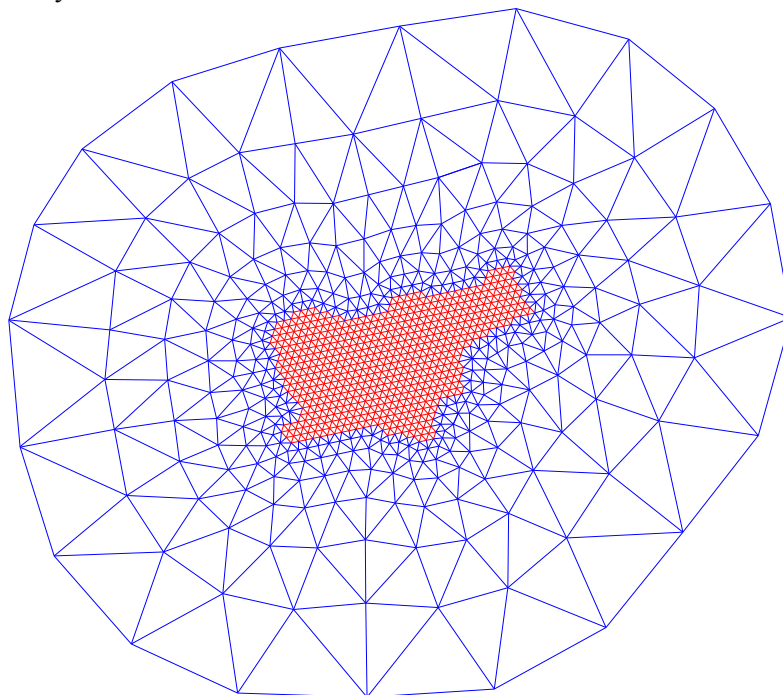


Figure 2: A regular triangular network of virtual tie points (in red) expanded by reducing its density (in blue).

Virtual tie points were used instead of any selection of observed control points. In order to enable extrapolation of transformation, a regular triangular network of virtual tie point was expanded, thereby reducing its density. The final network consists of 899 virtual tie points (see Figure 2).

The triangle-based transformation is a direct grid-to-grid transformation. The final transformation data set is a list of quadruplets of coordinates (pairs for both systems) for a total of 899 virtual tie points. Coordinates of each individual virtual tie point in the target system were determined using best-fit transformation in its immediate neighbourhood. A total of about 2,000 control points coordinated in both systems (local and ETRS89) were available for these fitting calculations. For most of the territory of the country, subdecimeter accuracy was achieved. The positional accuracy at the 1σ level is 4.2 cm.

Geokinematic model of national territory

With the establishment of ETRF coordinate reference frame, a necessity of geokinematic model of Slovenia has emerged. Possible movements of geodetic stations can deteriorate precision and accuracy of coordinate reference frame. Preliminary GNSS data processing has therefore been done in order to estimate velocity vectors on geodynamic GNSS stations on a territory of Slovenia. GNSS data were collected in various GNSS campaigns with various purposes (EUREF GNSS comapigns, local high quality coordinate frame establishment, local geodynamic GNSS networks etc.) in years from 1994 untill 2009. Velocity vectors on approximately 70 stable GNSS stations were estimated on a basis of repeated GNSS compaigns in ITRF coordinate frame and transformed into ETRF frame.

To increase accuracy and precision of geokinematic model of Slovenia data from GNSS permanent network SIGNAL have to be included in processing. In order to do so, majority of data were collected and prepared for processing. All RINEX files for all stations have to be stored on a server and checked, weather they are compatible with Bernese GPS Software. Preparation of RINEX files is done with proper antenna and receiver notation. Due to huge amount of data preparation was time consuming and is still not finished.

4 The Height and Gravimetric System

For the purpose of establishment of the new height system, 498 km of the first order levelling lines were reobserved from 2007 till the end of 2009. Gravimetric surveys were also performed along these new leveling lines for the purpose of determination of geopotential numbers.

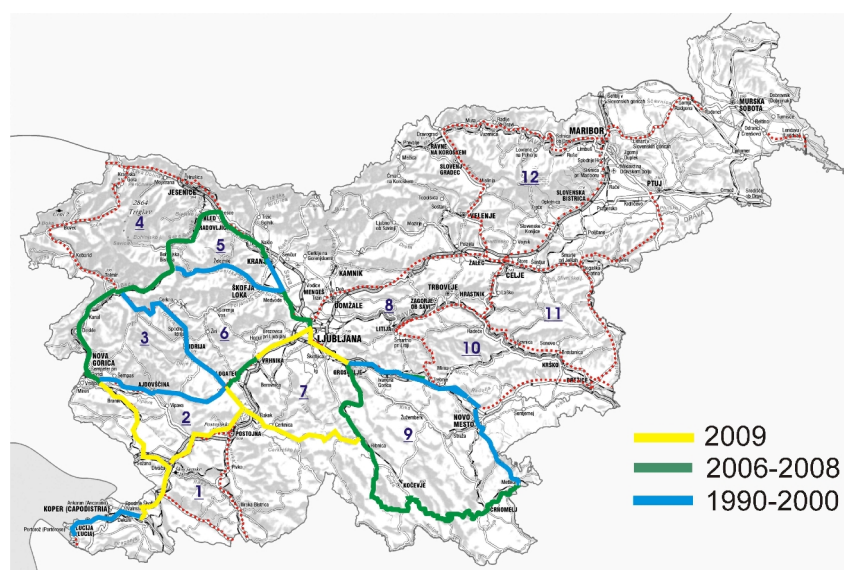


Figure 3: Relevelled first order levelling lines

New geoid input data arrangement

Digital elevation model – DEM

Two new DEMs were prepared for the new geoid computation, referred here as ‘narrow-area’ DEM and ‘wide-area’ DEM. As a result of SRTM data versus national DEM quality comparison, two basic input databases were chosen for the new geoid computation purposes:

- national DEM 12.5 for the entire country area and
- SRTM-3 V2.1 data for the buffer-area around the country.

The associated reference surface for the SRTM data is WGS84 ellipsoid. The national DEM with the resolution of 12.5 metres, which was in the old national grid coordinate system (D48/GK), was first transformed into the new national grid coordinate system (D96/TM) using the triangle-based transformation, Version 3.0 (see Chapter 3). After that, the conversion into GRS80 $\approx$ WGS84 ellipsoidal coordinates was carried out. Finally, both data layers were merged together and two new DEMs were generated, using linear interpolation:

- a ‘narrow-area’ DEM ($45^\circ \leq \varphi \leq 47^\circ$ and $13^\circ \leq \lambda \leq 17^\circ$, with cell size of $3'' \times 4,5''$, which is adequate to square cell size of about $93 \text{ m} \times 93 \text{ m}$), and
- a ‘wide-area’ DEM ($43^\circ \leq \varphi \leq 49^\circ$ and $11^\circ \leq \lambda \leq 19^\circ$, with cell size of $30'' \times 45''$, which is adequate to square cell size of about $926 \text{ m} \times 926 \text{ m}$).

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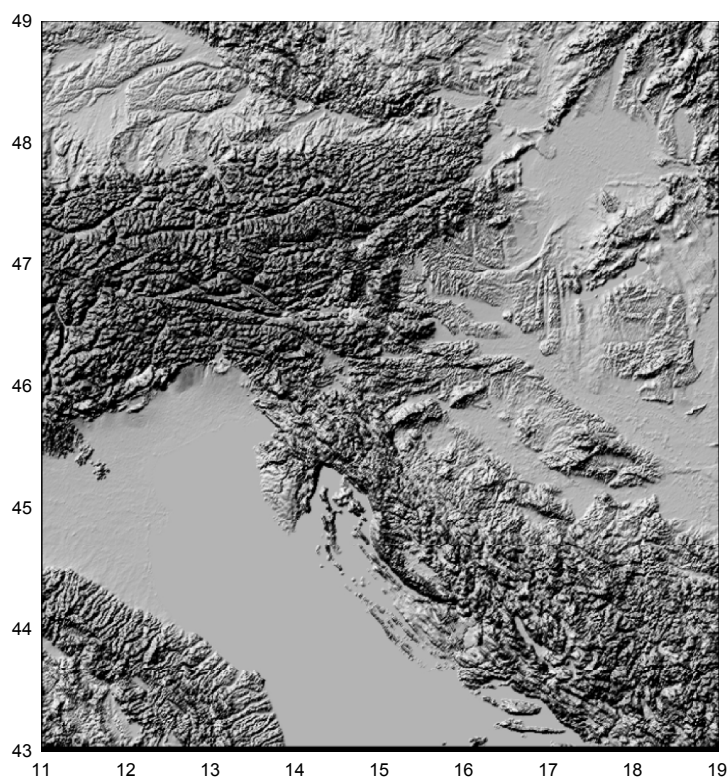


Figure 4: A ‘wide-area’ DEM ($43^\circ \leq \varphi \leq 49^\circ$ and $11^\circ \leq \lambda \leq 19^\circ$) combined from national DEM and SRTM data.

SRTM data were taken into consideration only for areas outside the national DEM coverage. The ‘wide-area’ DEM spatial range was adopted by the criteria for digital density model (see below).

Digital density model – DDM

Two new DDMs were generated with the same resolutions and spatial ranges as the two DEMs. The existing DDM based on the digitalization of geological maps was the only input data. The spatial range was defined so that at least 176 km buffer around the country borders was assured (see Figure 4). The associated reference surface for the final DDMs is GRS80 ellipsoid.

The two DEMs and the two DDMs were generated in SURFER grid format.

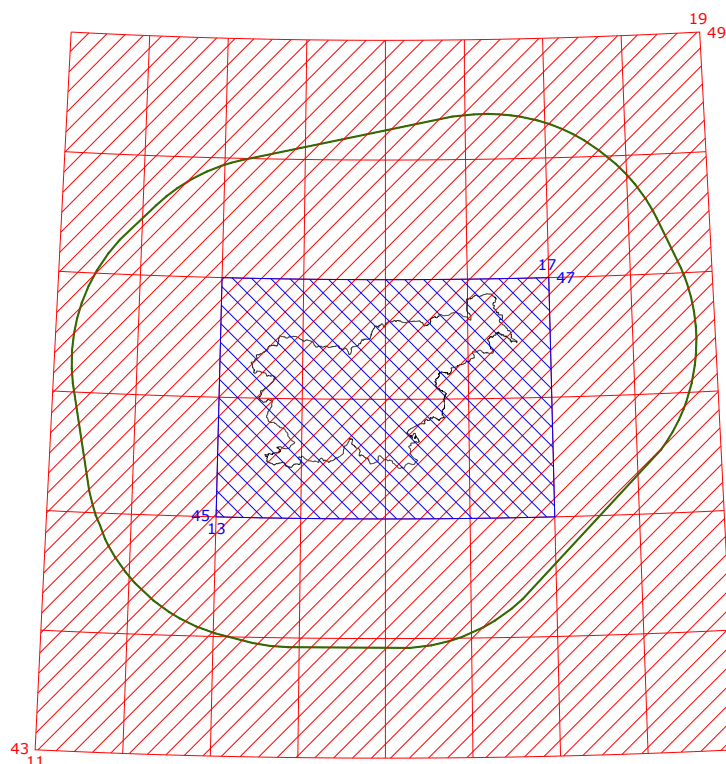


Figure 5: A national territory expanded with 167 km buffer-area and wide-area model (hatched in red) and narrow-area model (hatched in blue).

Surveying and Mapping Authorities of Slovenia is in the process of exchange gravity data with neighbouring countries. We expect first computation of new test geoid to be performed till the end of the year 2010.

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