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NATIONAL REPORT OF SLOVENIA

B. STOPAR[1], B. KOLER[1], M. KUHAR[1], S. BERK[2], D. RADOVAN[2]

1 Introduction

This paper is the review of activities regarding the adoption the new national reference system in Slovenia, during the period 2007–2008.

2 The Project of the Establishment of the Network of GPS-Stations and European Spatial Reference System in Slovenia

According to the Recording of the Real Estate Act Slovenia established a contemporary national geoinformation infrastructure to support sustainable development in the field of positioning in many economic areas. The purpose of the project is the transition to the European Spatial Reference System (ESRS) as the new national coordinate system.

The establishment and the transition to the European coordinate system depend on financial resources. Because of that the Surveying and mapping Authority of Republic of Slovenia (SMARS) applied to a call for proposals for the European Economic Area and Norwegian Financial Mechanism with the project "The Establishment of the network of GPS Stations and European Spatial Reference System in Slovenia". The main goal of the proposal was to get financial support and to accelerate the implementation of the new coordinate system. The Grant Offer was signed in October 2006 and the project started in February 2007. The duration of the project is 33 months and 23 activites will be completed in this period.

Official date for the establishment of the new national reference system is January 1st 2008. After that date all technical issues regarding land cadastral operations has to be done in the new coordinate system. This means that all newly determined or already existing points in land cadastre obtain coordinates determined and recorded in ETRS89/TM (i.e. D96/TM) coordinate system. All data recorded before January 1st, 2008 stay in the old coordinate system for some time. That is why the land cadastre database will be maintained in both, the old and the new, coordinate system. All new data will be transformed into the new coordinate system according to the instructions for transformation.

3 The Network of permanent GPS Stations – SIGNAL

The national network of GPS stations represents the most important (fundamental) infrastucture of the new horizontal coordinate system, based on ETRS89. It covers the entire territory of Slovenia. Currently, the system is in use free of charge by nearly 440 registered users. In 2008 95 new users of SIGNAL network data were registered.

Currently we are in process of renovation of the equipment at permanent stations where GPS receivers are substituted with the GNSS ones. At new station in Idria will be installed new GNSS receiver with the main purpose of testing and control VRS positioning at the area (Rover Integrity monitor). In the future also the set up of new permanent station in Idria is in plans. Beside hardware renovation at the

[1] University of Ljubljana, Faculty of Civil and Geodetic Engineering
[2] Geodetic Institute of Slovenia

stations also upgrade of software for GNSS service and parallel GNSS server was established. We should emphasize that we are just before start of automatized daily processing of data from the whole GNSS network. Establishment of the parallel server was performed with two main purposes: it will operate as the spare server in the case of breakdown of primary (production) server and for network testing purposes, especially the quality of real time positioning in the VRS mode.

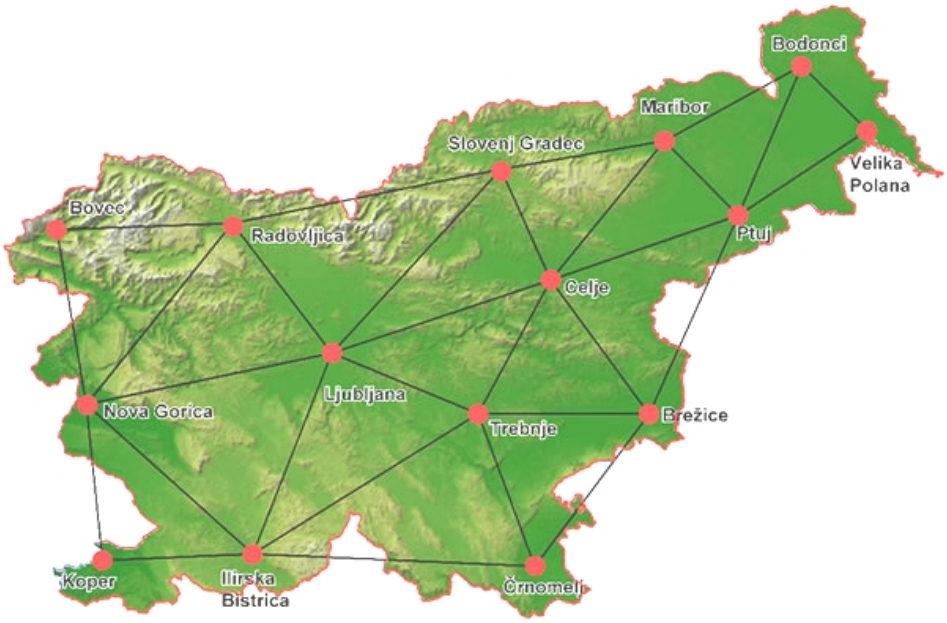

Fig. 1: The SIGNAL network

4 Mini EUREF 2007 Campaign

In 2007 Surveying and Mapping Administration of Slovenia (SMARS) organized so called "Mini EUREF 2007 Campaign". Two main purposes of the campaign were to establish the connection of national "EUREF non permanent network" and "permanent network SIGNAL" and determination ETRS89 coordinates of SIGNAL network sites. Observations in the duration of 72 hours were performed at 5 official EUREF sites in Slovenia, 15 sites of SIGNAL permanent network and 5 sites of APOS (Austrian POsitioning System) permanent network. Computations were performed twice independently at the University of Ljubljana, Faculty of Civil and Geodetic Engineering and at the Geodetic institute of Slovenia. For the coordinate computations we used the following procedure:

- computation in ITRF2005 (2007.258)
- transformation from ITRF2005 (2007.258) to ITRF96 (2007.258)
- transformation from ITRF96 (2007.258) to ITRF96 (1995.554) (NNR-NUVEL-1A)
- 7-parameter transformation of coordinates from ITRF96 (1995.554) to ETRF89 which was performed at 5 common points (official EUREF sites).

TC	ΔX [mm]	ΔY [mm]	ΔZ [mm]	Δφ [mm]	Δλ [mm]	Δh [mm]	ΔP [mm]
DONA	-12.1	4.3	-2.2	6.1	7.4	-8.8	13.0
KORA	-26.2	-2.8	7.4	23.9	3.4	-12.8	27.3
KUCE	-17.5	-7.1	7.1	18.4	-2.4	-7.9	20.2
MALJ	-41.4	-7.5	4.0	32.8	2.5	-26.6	42.3
VEKO	-16.2	4.4	-10.8	3.1	8.5	-17.8	20.0

Table 1: Differences between official EUREF coordinates
and coordinates computed with above mentioned "our procedure".

Results were computed also with the procedure as proposed with Boucher and Altamimi (Boucher, C., Altamimi, Z., 2007). Differences between both computations are smaller than of 2 cm (compare Table 1 and Table 2).

TC	ΔX [mm]	ΔY [mm]	ΔZ [mm]	Δφ [mm]	Δλ [mm]	Δh [mm]	ΔP [mm]
DONA	10.6	15.2	25.4	7.1	12.1	28.3	31.6
KORA	-7.3	7.2	34.9	28.2	8.8	21.4	36.5
KUCE	4.7	3.0	36.4	21.7	1.8	29.9	37.0
MALJ	-22.9	1.6	31.6	38.2	7.0	7.2	39.5
VEKO	6.0	15.6	17.3	4.7	14.0	19.4	24.4

Table 2: Differences between official EUREF coordinates for 5 official EUREF sites and coordinates computed with Boucher and Altamimi (Boucher, C., Altamimi, Z., 2007) procedure.

We should repeat that the primary goal of the Mini EUREF 2007 Campaign was to establish coordinate connection between official EUREF sites and SIGNAL network. After long discussions we decided to use for the SIGNAL network sites coordinates computed by "our procedure". Differences between official EUREF coordinates for 5 official EUREF sites and coordinates computed with Boucher and Altamimi (Boucher, C., Altamimi, Z., 2007) procedure are given in Table 1, and differences between official EUREF coordinates and coordinates computed with "our procedure" are given in Table 2.

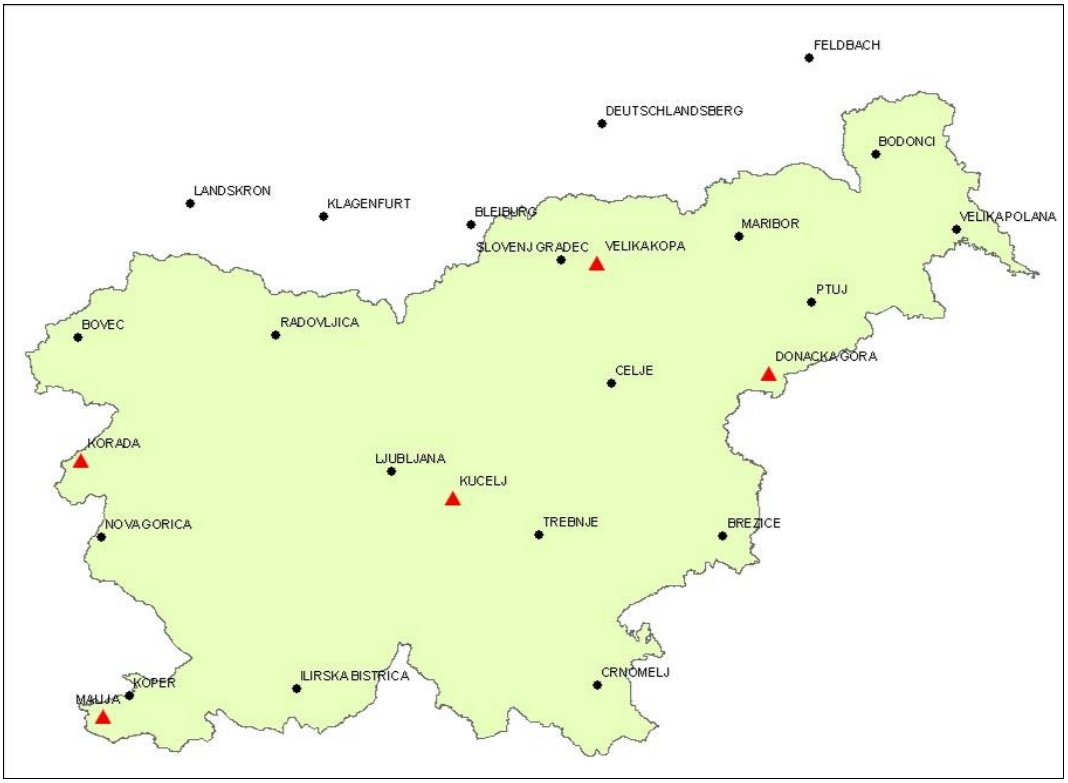

Figure 2: Official EUREF sites in Slovenia (triangles) and SIGNAL network sites (dots)

5 Transformations between Old and New National Reference System

Within the project "The Establishment of the network of GPS Stations and European Spatial Reference System in Slovenia" activities for the transformation the official SMARS data sets from the

old to the new national reference system included many research activities. Performed research was focused to the following important issues:

- identification of data sets to be transformed,
- identification of data sets not to be transformed,
- definition of the required quality of transformed coordinates,
- definition of duration of transformation activities:
  - permanent,
  - one step (single) transformation,
- definition of appropriate transformation models.

Similar research was performed for the transformation of data sets outside SMARS, where we prepared:

- determination of the required quality of transformed coordinates,
- definitions of appropriate transformation models,
- identification of possible consequences for data providers,
- identification of supporting activities.

Various transformations between the old and new national horizontal coordinate systems have been tested, particularly:

- spatial similarity (7-parameter) transformations and plane similarity (4-parameter) transformations, both for various regionalisations of the country (3, 7, and 24 regions),
- triangle-based piecewise affine plane transformation (on the whole country territory).

Because of the inhomogeneous accuracy of the old coordinate system, the similarity transformations (7-parameter or 4-parameter) on the national level reach the accuracy of about 1 m. For 3-region parameter sets the accuracy is about 50 cm, for 7-region sets about 30 cm, and for 24 region sets better than 20 cm.

The triangle-based transformation will be used for transformation of national spatial databases. The transformation preserves continuity and paralellism. About 1200 triangular regions (Delaunay triangles) cover the whole country territory. About 600 tie points represents edges of these triangles. The minimal triangle side length is 3 km. The average accuracy of the transformation is about 10 cm. Area changes for this transformation reach up to 0,02 % (i. e. 1 m^2 for 0,5 ha parcel of land). The main reason for area changes is old coordinate system inhomogeneity elimination. Some densifications of tie points will be realized in 2008.

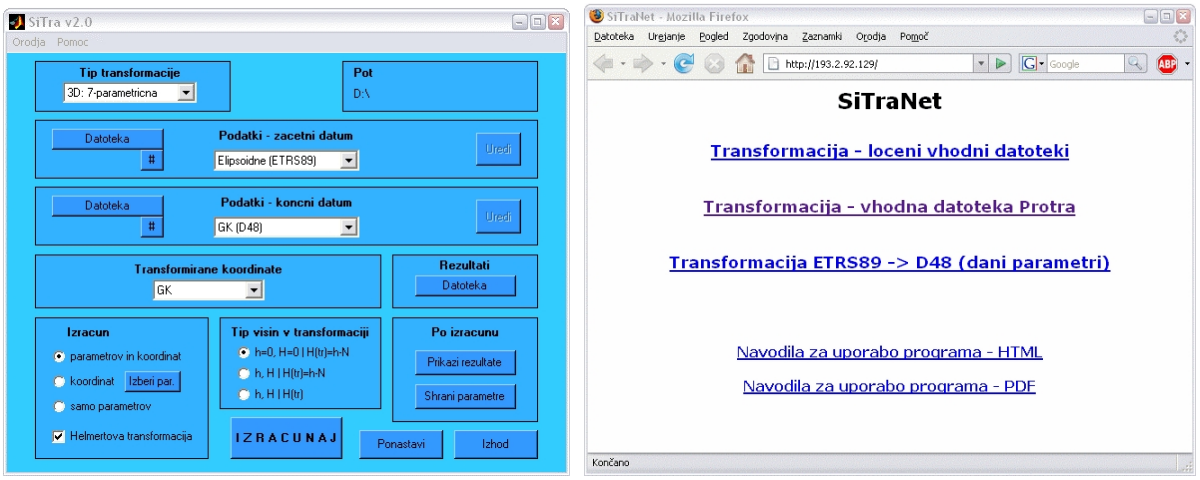

Figure 3: Starting screens of SiTra (left) and SiTraNet (right) applications

The proces of transformation data into the new national coordinate system has already started. Digital orthophoto has been transformed in 2007 (*.tif, 14000 files). New geolocation for each orthophoto (2.25 × 3 km) is realized with shifts only. Optimal shifts were estimated for each individual orthophoto area and resulted new world files (*.tfw). Transformation of maps at scales 1:25,000 and 1:50,000 in raster and vector formats will be realized in 2008.

Two software packages for the coordinate transformation between old and new coordinate transformations were prepared. Software packages enable few transformation models in two and three dimensional space with the purpose to be used in surveyor's everyday practice. First one is named SiTra and is available free of charge for licensed surveyors in Slovenia. The second one is named SiTraNet and is prepared as web application available free of charge. It is accessible at IP address: 193.2.92.129. They are basically the same and differ only in graphical representations of performed transformations which are not supported in web application. Starting screens of both applications are presented at Figure 3.

6 The Height System

Many research activities were performed also at the field of implementing a new vertical reference system. Together with a newly determined geoid it should enable GNSS-leveling with cm accuracy. The schedule of implementation is made in 2007 and it comprises several phases:

- the selection of the normal bench mark as the origin of the leveling network,
- renewal of ruined and stabilization of new fundamental bench marks based on the geologic expertise,
- tie of the zero and first order gravity stations to the national leveling network,
- leveling of the new network is foreseen in the period 2008 – 2019,
- densification of EUVN points with the use of permanent GPS-stations of the SIGNAL network, gravity points of the national gravity network and available benchmarks,
- final adjustment of the observations in the new network with the simultaneous transformation of low order leveling lines into new system

Distribution of the permanent GNSS stations network SIGNAL and High Precision leveling network lines is presented in Figure 4.

Figure 4: Distribution of High Precision leveling network lines and SIGNAL stations

Heights of benchmarks within the existing Slovenian leveling network are given in so called "Vertical Datum Trieste". Vertical Datum Trieste represents the mean sea level determined in 1875 form only one year of observations of sea level at the pier Sartorio in Trieste in Italy. Present-day leveling network has its origin at the fundamental bench mark No 349 (FR 1049) stabilized in Ruše at the foothills of the mountain Pohorje in the NE Slovenia. Its height was determined in the 19th century during the old Austro-Hungarian leveling and it is located at the tectonically most stable part of the Slovenian territory.

Figure 5: New building of the tide gauge station and SIGNAL station Koper (KOPE)

Considering Height Datum there are in the prospects of the new vertical reference system of Slovenia several proposals.

- Introduction of a new national height datum
  Environmental Agency of Slovenia within the FP5 ESEAS-RI (Framework Programme 5 European Sea Level Service – Research Infrastructure) renewed old tide gauge station at Koper. Completely new tide gauge station was established in Koper in the year 2005. It suits all modern standards for monitoring and measurement of mean sea level. Geodetic fixing of the tide gauge bench marks was carried out according to the standards of IOC (Intergovernmental Oceanographic Commission) (Manual on Sea level Measurement and Interpretation, 1985, 1994, 2002), by the use of GPS, classical terrestrial and gravimetric measurements. We will consider the possibility to use tide gauge station in Koper as a reference point for the new national height system.

- Introduction of an European datum
  Adoption of the tide gauge in Amsterdam (NAP) as the national height datum reference point would bring offset of approximately 40 cm in heights at the whole national territory.

The choice of the vertical datum depends also on consequences for the users which larger height changes can cause. It is expected that adoption of the new height datum (whether national or European) would cause more offset in the heights then the implementation of the new height system.

The adoption of the new height datum will be performed gradually:
- estimation of the influence on the users of the adoption of the new Vertical Datum based on the differences between different datums (national, European),
- analysis of the mean sea level data from the tide gauge station Koper.

In the year 2007 analysis of the existing leveling connections to the neighboring countries was performed and the plan for the new connections was elaborated.

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