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National Report of Slovenia
to the EUREF 2017 Symposium in Wrocław

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1 Introduction

This report is a short review of activities regarding national geodetic reference frames, CORS networks and activities related to EUREF in Slovenia for the period 2016–2017, i.e., after the last EUREF Symposium held in Donastia/San Sebastián.

2 Terrestrial Reference Frame

“EUREF Slovenia 2016” GNSS campaign was conducted from August 22 to November 10, 2016 (i.e., 80 consecutive daily sessions), with the mean epoch of 2016.75. A total of 46 passive GNSS sites in Slovenia were included within nine series of observations. Each site was occupied for at least 72 hours. The same points were observed in the “EUREF Slovenia&Croatia 1994”, “EUREF Slovenia 1995”, and “EUREF Croatia 1996” campaigns – resulted in the combined “EUREF Slovenia 94/95/96” solution, which represents in Slovenia the official realization of the ETRS89 (Medved, 2016).

Besides the passive GNSS sites, 23 continuously operating Slovenian reference stations are also included. These stations form the so called zero-order combined geodetic network and the SIGNAL network, which is a national GBAS network. Data from neighbouring network stations (APOS, CROPOS, Rete GNSS FVG, and GNSSnet.hu), EPN stations and IGS stations in the wider area (central and south-east Europe) were also collected. A total of 74 continuously operating reference stations are planned to be used in the computation (Figures 1 and 2).

The median GNSS baseline length for passive GNSS sites (with 72 hours of observations) is ~12 km, the median GNSS baseline length for permanent GNSS stations in Slovenia is ~28 km, and the median GNSS baseline length for EPN and IGS stations is ~178 km.

Nine nearby IGS08 core stations (Bucharest, Grasse, Graz, Józefosław, Matera, Sofia, Uzhgorod, Wettzell, and Zimmerwald) are planned to be used as reference stations. These are EUREF Class A stations in the IGb08 cumulative solution, which includes the period of the campaign. For the selected nine stations, there are no gaps in observations for the period of the campaign (i.e., complete sets of 80 daily RINEX files).

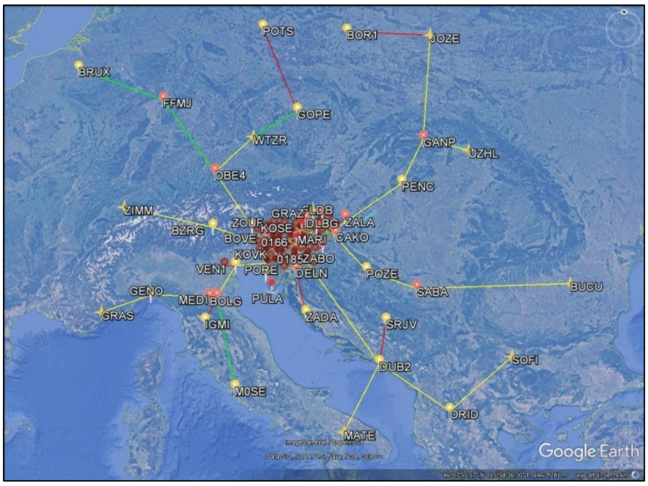

Figure 1: Selected reference and control GNSS stations in the EUREF Slovenia 2016 GNSS campaign.

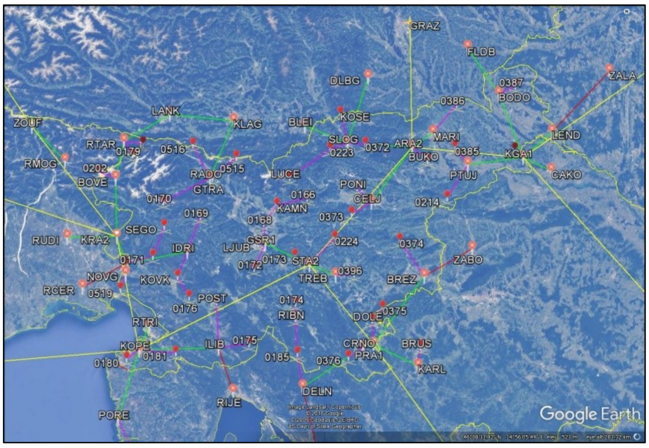

Figure 2: Occupied GNSS sites and CORS networks sites in Slovenia and nearby around.

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Additional 18 IGS and EPN stations, which are EUREF Class A stations in the IGb08, are planned to be used as control stations in the EUREF Slovenia 2016 GNSS campaign. The campaign is going to be processed after this EUREF symposium in Wrocław (i.e., after considering the questions concerning the ETRS89 realization).

The lifetime of the current realization of ETRS89 in Slovenia has expired (e.g. Sterle and Stopar, 2017). Therefore, the aim of the project is a new realization of ETRS89 and a comprehensive analysis of the consistency of coordinates with the current realization of ETRS89 in Slovenia. After having these results, a discussion will be held regarding the realization of ETRS89 in Slovenia.

3 National Combined Geodetic Network

As one of the results of the project of Modernization of Spatial Data Infrastructure to Reduce Risks and Impact of Floods, a national zero-order combined geodetic network was established (Režek, 2017). This network is operational since January 1, 2016. Now, eight continuously operating reference stations are installed on six locations – Prilozje and Šentvid pri Stični are double GNSS stations (Figure 3). Two more zero-order sites, which are currently still single GNSS stations, are planned to be double GNSS stations, i.e., in Areh and Korada. These double GNSS stations are designed following the Swiss example (Brockmann et al., 2010), especially in order to achieve well performance in a long term (e.g. major equipment upgrades), which is a desired characteristics for the EPN station (EPN, 2017). Zero-order station in Koper is also included into the SIGNAL network (Figure 4).

Figure 3: Zero-order site in Prilozje with two continuously operating GNSS stations.

Activities for establishing a local analytical centre have focused on the daily processing of RINEX data from the zero-order network stations and the SIGNAL network stations according to the rules for EPN stations. The resulted time series of coordinates will be used to develop and maintain a national geokinematic model. After confirming the quality (local stability) of monuments (pillars) of the zero-order network stations, they will be proposed to be included to the EPN.

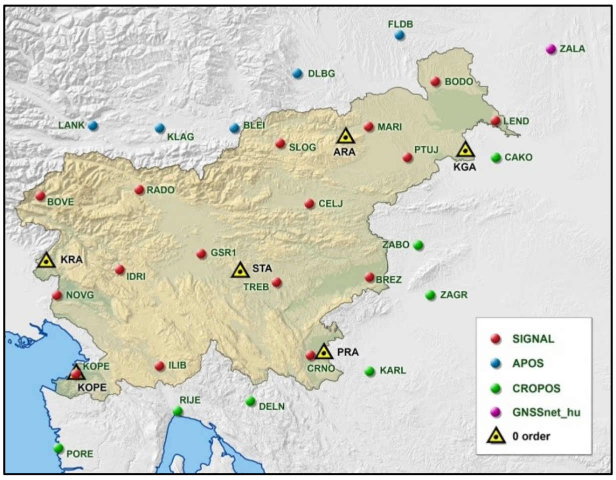

Figure 4: Combined (zero-order) geodetic network, SIGNAL, and neighbouring GBAS networks.

4 SIGNAL Network

The SIGNAL network operator has in the last year launched its own real-time services for end users. Currently, 16.5% of all real-time users are using these new real-time services. Network integrity and real-time service availability monitoring software has also been set up, which should shorten our response time in case of an error.

In the last year, the number of SIGNAL users has not grown significantly. We have seen a big decline in the usage of real-time services via CSD modem connections (30.2% in 2016 in comparison to the 42% in 2015 and 49% in 2014). At the same time an increase in the use of MAC (Master Auxiliary Concept) access points (28.8% in 2016 in comparison to the 15% in 2015 and 2% in 2014). Overall, there was a slight decrease in the usage of real-time data from the SIGNAL network (54,720 hours in 2016 in comparison to the 60,709 hours in 2015).

The quality of the SIGNAL network RTK services is going to be systematically supervised by the Surveying and Mapping Authority of the Republic of Slovenia. A special network of control points (evenly distributed over Slovenia) will be established for this purpose. Their coordinates will be determined with centimetre-level or better accuracy (i.e., EUREF Class B). Various RTK services and products (e.g. VRS, MAC) will be periodically tested with various GNSS equipment. This control network will also be available to the professional land surveyors to check their equipment performance (Sterle et al., 2017).

5 Local to ETRS89 Datum Transformation Model

A country-wide seven-parameter spatial similarity transformation model between the local system and ETRS89 in Slovenia can only provide metre-level accuracy. Consequently, this simple approach to transformation can only be used in the geographically limited area or in case of limited accuracy requirements, e.g. in GIS community (Berk and Boldin, 2017).

As already presented at the EUREF Symposium in Leipzig (Medved et al., 2015), a country-wide project has been undertaken to verify the national local to ETRS89 datum transformation model. The quality of the so called triangle-based transformation model was evaluated for about 2500 cadastral boundary points located in 80 test areas all over the country (mainly in urban areas with best-quality cadastral data). In 24 test areas with insufficient accuracy of transformation, almost 1600 additional tie points were determined in the second phase of the project (an 80% increase of the dataset). The current version of the transformation model (4.0) provides sub-decimetre accuracy for most of the country. However, in some test areas this transformation model cannot be verified because of the problems with the homogeneity of the various (adjoining or overlapping) detailed surveys in the past. These inhomogeneity problems should carefully be considered in the future maintaining of the land cadastre database (Berk et al., 2016).

The 2014 adopted National Geodetic Reference System Act requires transformation of spatial databases of the Surveying and Mapping Authority of the Republic of Slovenia into the new national coordinate reference system before 2018 and transformation of all other national spatial databases in the country before 2019. The national triangle-based transformation model is now ready to be used for this purpose (Berk et al., 2017).

6 Vertical Reference Frame

As already announced in the previous national report (Medved et al., 2016), a new height system is going to be implemented in Slovenia, with new normal heights related to the national tide gauge station in Koper, replacing the old normal orthometric heights related to the Italian (Austro-Hungarian) tide gauge station in Trieste (Koler et al., 2017).

The first-order levelling network has been completely renewed – new levelling lines have been set up, new levelling and new gravimetric measurements have been done. An adjustment by geopotential numbers was performed for the complete levelling network, with 2030 benchmarks connected in ~1800 km levelling lines. Additionally, all lower order levelling lines with old measurements were adjusted and connected to the new system. Over 12,000 benchmark heights were newly determined or recalculated (Stopar et al., 2016).

Presently, the new height system is not officially implemented in practical use, this is still a future challenge.

Based on new measurement data of the first order levelling network and new regional gravimetric measurements (Figure 5), which covered half of the national territory, and of course all other necessary data, a new Slovenian quasi-geoid model was generated (Figure 6). After fitting to the new heights of points (normal heights in the Koper height datum), accuracy estimates (based on over 800 control points) show very good results, with average standard deviation of computed geoid heights of 2.6 cm (Omang, 2016).

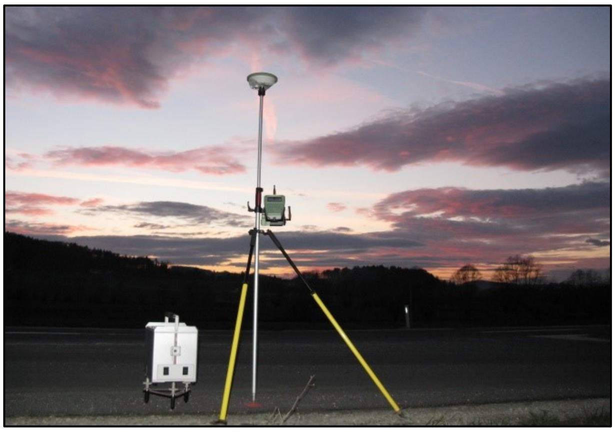

Figure 5: Regional gravimetric survey.

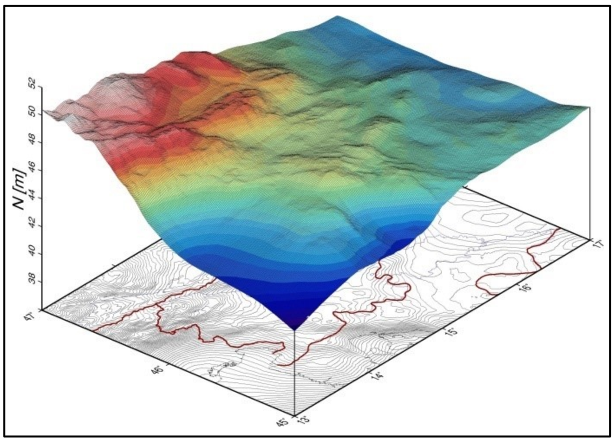

Figure 6: New Slovenian quasi-geoid.

Realization of the new height reference system and the new quasi-geoid model of Slovenia are some of the results of the project of Modernization of Spatial Data Infrastructure to Reduce Risks and Impact of Floods, which was successfully completed in 2016 (Režek, 2017).

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