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National Report of Slovenia
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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 2015–2016, i.e., after the last EUREF Symposium in Leipzig.

2 Terrestrial Reference Frame

As already presented last year in Leipzig, a new EUREF GNSS campaign is planned in Slovenia (Medved et al., 2015) and it will take place in Summer/-Autumn this year. Some research has already been carried out regarding the long term maintenance of the national terrestrial reference system (e.g. Sterle, 2015), also in relation to new developments of positioning methods (Sterle et al., 2015). However, our future actions regarding the realization of terrestrial reference system in Slovenia, which is supposed to be out of date, will depend on the analysis of the results of the this year EUREF GNSS campaign.

3 National Combined Geodetic Network

The last three so-called zero-order combined geodetic network stations were built up in 2015 (Režek, 2015), i.e., Areh (Figure 1), Korada (Figure 2), and Šentvid pri Stični (Figure 3).

The network is now fully operational. It was established with the purpose of the high-quality terrestrial reference system realization in a long term. The network consists of six stations (Figure 4). All stations are equipped with permanent GNSS receivers and four of them (Areh, Korada, Prilozje, and Šentvid pri Stični) are equipped with two GNSS antennas/receivers.

Figure 1: Zero-order station of the national combined geodetic network near St. Areh church on the Pohorje hills; an absolute gravity point is located in the church.

Figure 2: Zero-order station of the national combined geodetic network at Korada (hill) – near the location of the old first order triangulation network site (left).

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Figure 3: Zero-order station of the national combined geodetic network in Šentvid pri Stični, Central Slovenia.

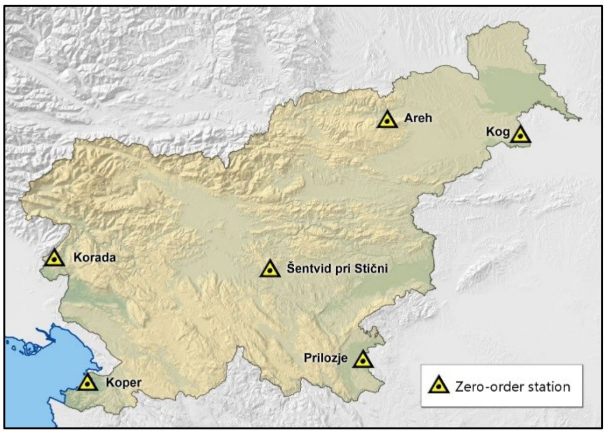

Figure 4: Locations of the zero-order combined geodetic network stations in Slovenia.

Each zero-order station consists of the main pillar, mounted on a well-founded platform and a micro-network consisting of three to four additional points (at the distances up to 150 m), enabling periodic checks of the local stability of the pillar (Figure 5).

Figure 5: A micro-network point of one of the zero-order combined geodetic network stations.

The main reference point, which is also the reference point for gravity and levelling measurements, is located on the platform of the pillar. On the top of the pillar there are one or two GNSS reference points and a reference point for precise terrestrial measurements in the middle (Figure 6). There are four additional reference points for precise terrestrial/levelling measurements on the platform of the pillar.

Figure 6: Reference points on the pillar of the zero-order combined geodetic network station in Prilozje.

Precise terrestrial measurements and levelling were conducted at each micro-network soon after the completion of construction. The accuracy of computed coordinates and heights and the accuracy of the elements of eccentricities (according to the main reference points) in the local geodetic datum is at the level of tenths of a millimetre (Stopar et al., 2015).

The second remeasurement (after half a year period) has also already been conducted, but is not processed yet. All the zero-order stations are connected to the first order levelling network and are intended to be used for the absolute orientation of a new national quasi-geoid model.

Precise coordinates of all GNSS reference points (6 + 4 collocated = 10 stations) were computed by using one month data span (the period from January 1–31, 2016; the mean epoch is 2016.042). Bernese GNSS software, Version 5.0, was used. The computation was performed in ITRF2008. Finally, the results were transformed into ETRS89 (Stopar et al., 2015).

For GNSS data management, quality control, and service performance monitoring of the zero-order combined geodetic network, Alberding GNSS Status Software (Hauschild and Kwast, 2015) is used.

4 New Services in the SIGNAL Network

To enable further developments of the national CORS network to support GNSS positioning in real time (SIGNAL network), the Surveying and Mapping Authority of the Republic of Slovenia (SMARS) introduced some changes in 2015. The RINEX data are not free of charge any more for commercial users. SMARS also started with its own distribution of RTK and DGNSS data.

The price for RINEX data is 1.20 € for each individual purchase order plus 0.10 € per one-minute data span. The prices for RTK services starts from 630.42 € a year (flat rate) or 1.01 € each day plus 0.10 € per minute.

Data transfer is available via mobile internet or over CSD. Phasing out CSD technology is expected in the future and users, which are still widely using this technology (Figure 7), are asked to change to the mobile internet as much as possible (Režek et al., 2016).

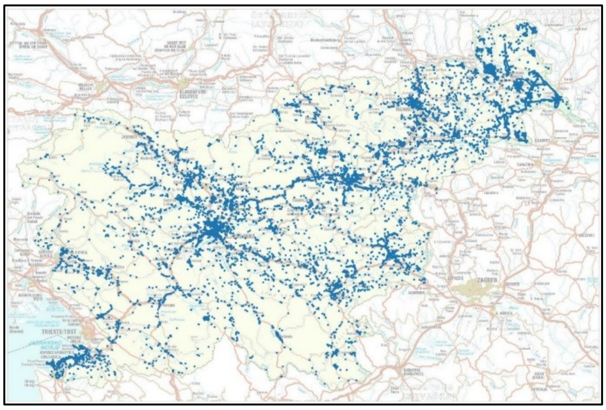

Figure 7: The use of CSD access to RTK data in Slovenia (areas in blue) shows mostly urban areas where GPRS is available.

5 Computation of the Remeasured First Order Levelling Network

The Project on the Modernization of Spatial Data Infrastructure to Reduce Risks and Impacts of Floods is well under way (Režek, 2015; Režek et al. 2015). One of the most important goals of the project is the implementation of the new national height reference system in Slovenia. After 10 years of field work on levelling, GNSS and gravity measurements, it is now completed. Gravity measurements were conducted on 86.1% of benchmarks of the first order levelling network. Accuracy of levelling computed on the basis of levelling loop closure is 0.43 mm/km and 0.50 mm/km from the adjustment. The standard deviation of normal heights for the benchmarks may vary between 1.6 mm and 4.3 mm; the average standard deviation is 2.8 mm.

The new height system in Slovenia will be based on normal heights which will be introduced to replace the former normal orthometric heights. The current height datum is tied to tide gauge station in Trieste, but the new height datum will be tied to the tide gauge station in Koper (one of the zero-order combined geodetic network stations). Preliminary results of the new adjustment of the first order levelling network are already available. The differences between the actual normal orthometric heights (datum Trieste) and future normal heights (datum Koper) of benchmarks are in a range from 9 cm to 14 cm.

6 Nationwide Aerial Laser Scanning

A nationwide aerial laser scanning for 3D acquisition of water surfaces in Slovenia was finished in August 2015 (Triglav Čekada and Bric, 2015). Aerial laser scanning was performed with first return point densities of 2–5 points/m^2 (Figure 8). The following products are freely available: classified point clouds, ground point clouds, digital terrain models) with grid cell size of 1 m × 1 m (DTM1), and georeferenced images of the resulting DTMs (Figure 9). A complete quality control of the data was performed and vertical accuracy of 15 cm and horizontal accuracy of 30 cm (RMSE) of all the products was confirmed (Triglav Čekada et al., 2015).

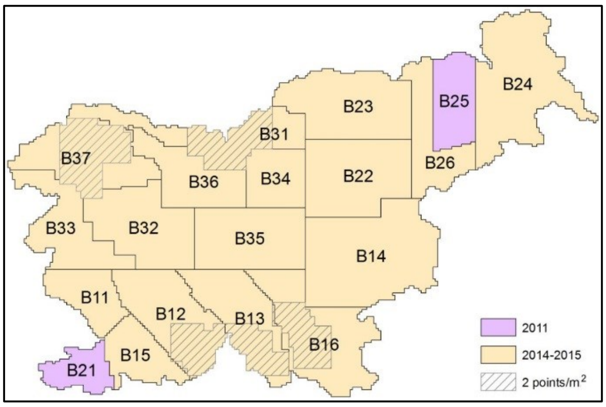

Figure 8: Laser scanning blocs by the year of scanning and by the first return point density.

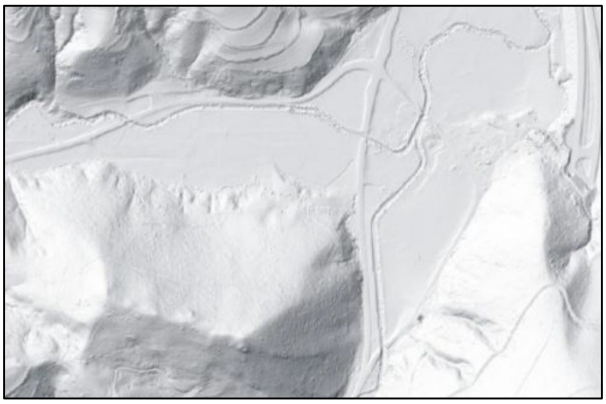

Figure 9: Visualisation of the DTM1 by analytical shading (Triglav Čekada et al., 2015).

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