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# National Report of Slovenia
## to the EUREF 2018 Symposium in Amsterdam

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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 2017–2018, i.e., after the last EUREF Symposium held in Wrocław.

## 2 Terrestrial Reference Frame

Twenty years after the last EUREF GPS campaign in Slovenia, the decision for a new realization of ETRS89 had been implemented (Medved and Berk, 2017). First computations of the EUREF Slovenia 2016 GNSS Campaign have been carried out. The basic facts about the campaign were presented in the last-year national report (Medved et al., 2017).

The preliminary results of the campaign computation were presented to the members of the EUREF Governing Board at the 76th EUREF GB Meeting, which took place from February 27th to 28th, 2018, in Padua, Italy.

Figure 1: The Golica triangulation point – also included in the previous EUREF GPS campaigns

The final results of the computations are to be presented here in Amsterdam as a separate contribution (Berk et al., 2018). Only subsets of all the sites and daily sessions of the campaign were included in this computation for the purpose of the validation by the EUREF GB. A total of 57 points – 10 passive (used also in the previous EUREF campaigns) and 47 active network points – were selected. One of the passive points included in the computation can be seen in Figure 1.

The solution was delivered in the IGb08/ETRF2000, which is considered a EUREF densification (improvement) of the ETRS89 in Slovenia referred to as the ETRS89/D17 (the mean epoch of the campaign was 2016.75). The coordinates from the final network solution in the IGb08/ETRF2000 (ETRS89/D17) were compared with the (official) coordinates in the ITRF96/-ETRF96 (ETRS89/D96). Ten points were used, which have both (D96 and D17) triplets of coordinates. The direct comparison of the two realizations showed coordinate differences exceeding 8 cm. However, when applying the best-fit similarity transformation, coordinate differences between the two realizations of the ETRS89 in Slovenia reached up to 24 mm in all three components (N, E, U).

The main goals of the EUREF Slovenia 2016 GNSS Campaign were to check the consistency and to reconnect the national CORS networks with the passive (EUREF) network.

## 3 National CORS Networks

Two national CORS networks have been established in Slovenia: the Zero-Order Network and the SIGNAL Network, see Figure 2.

The National Combined Geodetic Network – also referred to as the **Zero-Order Network** – is fully operational since 2016 (Ritlop et al., 2018). It consists of 10 permanent stations, including the Koper station, which is also one of the SIGNAL Network stations. These zero-order stations were set up on six locations – four of them as double stations.

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The antennas at the zero-order GNSS stations are installed on the concrete pillars and have absolute individual antenna calibration models. Last year, DOMES numbers were assigned to all zero-order stations. The procedure of including these stations to the EPN is going to be started in the near future.

Zero-order GNSS stations are co-located with reference points for other measurement techniques: an absolute gravity benchmark at the Areh station, a seismic station near the Kog station, a tide gauge station near the Koper station, and an official EUREF site (an old 1st order triangulation point) at the Korada station. Local ties were determined with sub-millimetre accuracy within the precise terrestrial micro-networks, which were established for all Zero-Order Network sites (Medved et al. 2016). Also, all zero-order stations have benchmarks, which were levelled within the 1st Order Levelling Network. Furthermore, levelling micro-networks have been used for monitoring local stability of the stations (e.g. Sterle et al. 2017b).

This network form a modern geodetic infrastructure for the future national spatial reference system realizations (Sterle et al., 2018). The purpose of the network is also providing high-quality GNSS data for interdisciplinary research in geosciences.

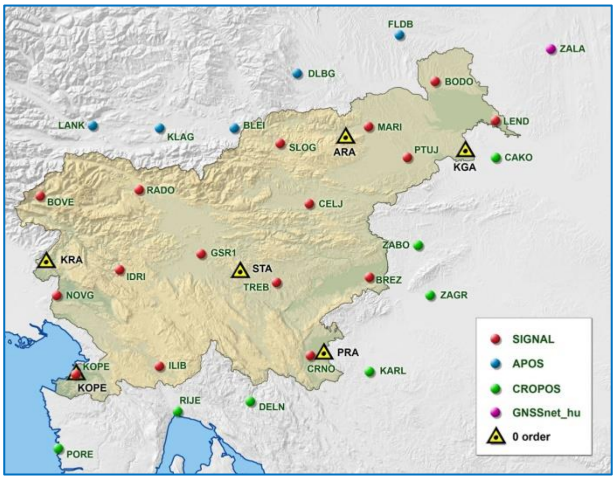


Figure 2: SIGNAL with neighbouring GBAS and Combined (Zero-Order) Geodetic Networks

The **SIGNAL Network** is a GBAS network, which is fully operational since 2006. It consists of 16 permanent stations. The Ljubljana station, which is operating since 2000, is also an EPN station.

Permanent stations from three neighbouring GBAS networks are included into the SIGNAL Network through the bilateral data exchange agreements: five stations from the APOS Network (Austria), one station from the GNSSNet.hu (Hungary), and seven stations from the CROPOS Network (Croatia).

The aim of the SIGNAL Network is supporting GNSS-based positioning with real-time and post-processing services, especially for georeferencing of real estate datasets (Sterle et al., 2017a).

Since September 2017, the SIGNAL Network has been upgraded with an identical redundant system for testing purposes and to be used as a backup system in case the main servers experience a problem.

## 4 Local to ETRS89 Datum Transformation

A new version (4.0) of the local to ETRS89 datum transformation model was made public in 2017, together with a freeware tool supporting well established vector and raster data formats, see Figure 3.

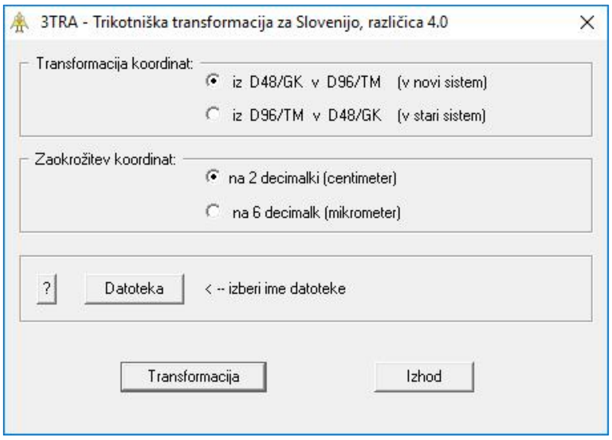


Figure 3: 3tra – a dialog-based application for datum transformations of spatial data (Berk, 2017)

The verification of the transformation model was presented in the last-year national report (Medved et al., 2017). This transformation has to be performed until the end of 2018 for all spatial data in Slovenia, including cadastral data (Berk et al., 2017).

## 5 Vertical Reference Frame

The new Slovenian height system and height datum are going to be implemented in Slovenia until the end of 2018. All the heights of the benchmarks have been recalculated and their new heights put into the database of geodetic points. The average vertical shift between the old height system (denoted as SVS2000) with normal-orthometric heights in the Trieste datum, epoch 1875, and the new height system (denoted as SVS2010) with normal heights in the Koper datum, epoch 2010, is −128 mm (Koler et al., 2018). Shifts vary between −215 mm and −9 mm and are not evenly distributed over the country. Only the First Order Levelling Network has been completely relevelled; all the lower-order networks have only been recalculated by using old levelling data. As some of these data are over 60 years old, there are some inconsistencies in the networks. Furthermore, an overview of the situation in the field has shown that around 30% of benchmarks are ruined. So, the plan is to renew some lower-order networks, especially in urban areas. The data of the new first order levelling have already been sent to contribute to a new UELN (United European Levelling Network) realization.

The national char datum was analysed and the new national coordinate reference system for depth measurements on sea was connected to the new height reference system on land (Radovan et al., 2018).

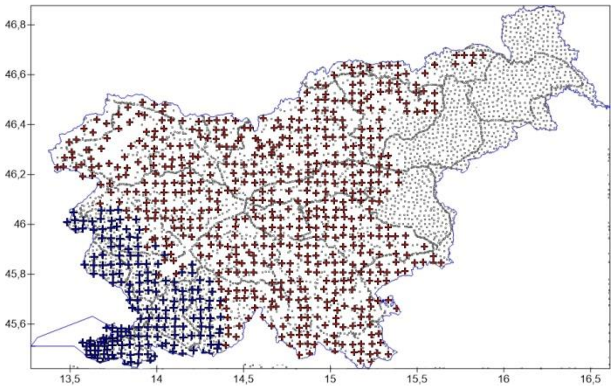


Figure 4: Regional gravimetric survey with red points measured in 2015 and blue points measured in 2017

A regional gravimetric survey of Slovenia is in progress. After finishing the measurements in the central part of the country, the south-west part was measured in 2017 with additional 200 points, see Figure 4. A pre-planned 4-km grid of points was used (Medved et al. 2015), which was densified at the coastal area to 2-km grid.

A project of determining new geoid on the sea is in progress, too. Some efforts have been devoted to improve data at the coastline. The goal is to cover the whole country with new (or remeasured) gravimetric points in order to improve geoid model, as some elderly data are of poor quality (Kuhar, 2017).

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