NATIONAL REPORT OF SLOVENIA

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1 Introduction

This paper is the review of geodetic activities in Slovenia during the period 2000–2001, with special emphasis on activities and participation of Slovenia within European projects.

2 The EUREF network in Slovenia

The development of a new terrestrial reference coordinate system in Slovenia, started with the EUREF-CRO-SLOV '94 GPS observation campaign, followed by second EUREF campaign, under the name SLOVENIA '95 campaign and finished with another GPS observation campaign CROREF-CRODYN '96. All the campaigns were performed with the substantial contribution of the Institute for Applied Geodesy (Institut für Angewandte Geodäsie), Frankfurt now federal Agency for Cartography and Geodesy (Bundesamt für Kartographie and Geodäsie) to the Surveying and Mapping Authority of the Republic of Slovenia (Geodetska uprava Republike Slovenije).

The first EUREF-CRO-SLOV '94 GPS observation campaign was performed at 8 first order trigonometric points (among theese were 5 points choosen as "real" EUREF points) during the 5 days of permanent GPS observations. The final coordinates of the EUREF-CRO-SLOV '94 GPS campaign are given in the ITRF92 (1994.4) with the conversion to ETRS89 (1989.0). The results were published in 1995 (Altiner et al., 1995).

The purpose of the second EUREF SLOVENIA '95 Campaign, was to densify the existing EUREF network at the territory of Slovenia. This campaign was performed at all 34 first order points, at 2 stations of the triangulation base lines network, at 1 second order trigonometric point, and at 12 newly stabilized geodynamic points. GPS observation were carried out for six days, in two blocks with 3 day of 24 hours of observations each. 8 EUREF stations observed in 1994 were in this campaign observed for the second time. The coordinates of the Slovenia '95 Campaign are given in the ITRF93 epoch 1995.7, respectively in the ETRS 89 epoch 1989.0.

In 1996 CROREF-CRODYN '96 campaign was carried out, with the duration of 15 days, where 68 points were observed. The purpose of this campaign was the enlargement the EUREF reference frame into the continental part of Croatia. At this campaign 5 EUREF points in Slovenia were observed once more; 4 points were observed for the third time and 1 was observed for the second time. Coordinates of this campaign are given in ITRF94 (1996.7) and were not converted to ETRS89.

2.1 Need for the recomputation of the 'EUREF' campaigns in Slovenia

Three EUREF campaigns were carried out at the Slovenian territory, and only coordinates of 8 points computed in the frame of the first EUREF 1994 Croatia and Slovenia campaign, were officially accepted by the EUREF Technical Working Group (TWG) (Resolution No. 1, EUREF Symposium, Helsinki, 1995). The second EUREF campaign in 1995 was thought as a densification campaign for the Slovenia, and should be computed with the fixed EUREF coordinates of 8 points, observed for the second time. In the computation these points were handled as new points, and the resulting

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coordinates differ from the official EUREF coordinates up to 42 mm (Altiner et al., 1997-a). These results were never submitted to EUREF TWG for approval. The third EUREF campaign was mainly carried out at the territory of Croatia, but with 5 EUREF points in Slovenia, observed for the second or the third time (Altiner et al., 1997-b). Comparison of coordinates of EUREF points which were observed in more than one EUREF campaign show the differences to 42 mm. The differences which were larger than expected, stimulated the so called "Combined Solution" of the three EUREF '94, '95 and '96 campaigns in ITRF96 coordinate system. The result of the "Combined Solution" are new coordinates of already mentioned 5 "real" EUREF points. Coordinates of 5 EUREF points has differences between the official and newly computed coordinates in ETRS89 (1989.0) up to 43 mm. The differences between coordinates of these 5 points computetd in EUREF SLOVENIA '95 campaign in ETRS89 (1989.0) up to 11 mm (Altiner et al., 1999). In the time when the results of the "Combined Solution" are going to became the official EUREF solution for Slovenia, a new problem was identified by M. Marjanoviæ from the State Geodetic Administration of Croatia (Seeger, 2001). The problem which was identified is the fact that "Combined Solution" produced the new coordinates only for points which were observed in more than one campaign. Coordinates of all other points remained unchanged. This problem was the motivation for a completely new computation of the "Combined Solution" of EUREF GPS campaigns in the Republic of Croatia, which produced new coordinates in ITRF96 (1995.55), for all points observed in all EUREF campaigns in Croatia (Marjanović, Bačić, 2001). Since the new "Combined Solution" for Croatia is accepted as official EUREF solution, where only points observed at Croatian territory were recomputed, Slovenia should realize its own "Combined Solution" where all EUREF campaigns at Slovenian territory would be handled properly. At this time the solution within ITRF93 epoch 1995.7, or within ITRF96 epoch 1995.55, where the EUREF SLOVENIA '95 campaign would be emphasized, seems to be the appropriate ones.

3 Densification and geodynamic GPS networks in Slovenia

Since 1991/92 GPS measurements were used as a checkup for the existing national trigonometric network. In the first few years the usage of GPS measurements was mainly connected with the establishment of the so called densification networks in a frame of existing national trigonometric network. Result of such usage of GPS measurements in that time was a minimum constrained network which was transformed into existing national control.

Since 1996 all the densification networks were connected to the 1st order triangulation network, where ETRS89 coordinates computed in the Slovenia '95 GPS campaign were used. App. 300 points were determined in last five years with the usage of ETRS89 coordinates. For the usage of ETRS89 coordinates in the national coordinate system the transformation of ETRS89 coordinates to the national trigonometric network was performed. In all that years for the transformation purposes the relative 1992 geoid solution (Bessel ellipsoid) (Čolić et al., 1992) was used. In the period when new absolute geoid solution (GRS-80 ellipsoid) (Pribičević, et al., 2000) became available, we started to use it for testing purposes. Some tests show, that the transformation procedure could obtain better results (smaller residulas on control points) when we use the normal orthometric heights in the national control network and of course the ellipsoid heights in the GPS network. With the use of absolute geoid heights with the connection of ellipsoid heights, computed normal orthometric heights of the transformed points could also be of better quality.

In the period after 1996 four geodynamic networks, with app. 35 points, were established and computed according to the coordinates of points computed in the Slovenia '95 EUREF GPS campaign.

4 Levelling networks in Slovenia

In last few years the activities concerning the computation of the new geoid model as well as activities connected with the levelling networks were intensified. Here we should mention activities which started few years ago and are of significant importance for EUREF as well. Since 1998 Precise levelling network of Slovenia was connected to the levelling networks of the neighbouring countries. This connection was made possible with precise levelling lines connecting Italian leveling network over one border crossing, Austrian levelling network over seven border crossings and Hungarian levelling network over one border crossing.

In last few years five absolute gravimetric points were observed in Slovenia, three of them (Socerb, Bogenšperk, St. Areh) were connected to the Slovenian precise levelling network, another 2 should be in the near future.

In the last year the analysis of Slovenian precise levelling network (type of stabilization, period of stabilisation, status of the bench marks etc.) was done. The most important work in this area was the recomputation (adjustment) of whole Slovenian precise levelling network, where the normal orthometric heights were used. The vertical datum was defined according to the tide gauge Triest, and fundamental bench mark in Ruše. For the precise levelling loops, which could not be closed at the territory of Slovenia, the data from Croatian precise levelling network was used. All together 7 loops with the lengths between 202-546 km were used. A-posteriori reference variance computed from the levelling loops closures is $\hat{\sigma}_0^2 = 0.69$ mm, and from the adjustment of the whole net is $\hat{\sigma}_0^2 = 0.88$ mm. As a result we acquired newly computed normal orthometric heights of bench marks which differ from the old ones in the range from –80 to +80 mm (Vardjan, 2001).

For the practical usage of levelling data it is important that the data base of Precise slovenian levelling network became operational.

5 Permanent GPS network in Slovenia

Another important area where the activities in the next few years should minimize the gap between Europe and Slovenia is the establishment the Permanent GPS network of Slovenia. At the beginning of 2001 the project for the "Establishment of a permanent GPS station" (Mišković et al., 2001) was finished, where some ideas and guidelines for the Permanent GPS network were given. We should mention that this project started in 1997 our colleague the late Dušan Mišković. The network should be part of the GPS service, where 15 permanent GPS stations should be organized in 3 orders: EPN, 1st order, 2nd order, with the distances between stations up to 70 km (Figure 1).

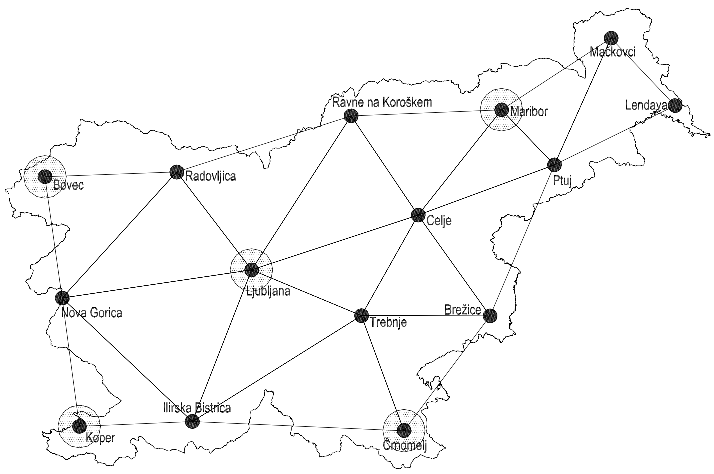

Figure 1: Planed Permanent GPS network of Slovenia
(larger circles-EPN and 1st order stations)

The Permanent GPS network should be so called active GPS network, based or either on the concept of the so called 'Virtual reference station', or on the so called concept GNSS-SMART. It should be a 'multipurpose' GPS network (navigation, GIS, geodesy), with the possible densification of the network. Realization of the network depends on funds available, but the network should be finished in few years.

We should mention also that since february 2001 permanent GPS station in Ljubljana is a part of EUREF Permanent Network, and that since october 2000 permanent GPS station in Koper is operational.

6 References

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