Accuracy Testing of RTK Service of the Permanent Station Network in the Republic of Serbia

Siniša DELČEV, Vukan OGRIZOVIĆ,
Violeta VASILIĆ and Jelena GUČEVIĆ,
Faculty of Civil Engineering
Department of Geodesy and Geoinformatics
Belgrade, Serbia

INTRODUCTION

Reference networks for the territory of the Republic of Serbia was initiated towards the end of XIX century.

Trigonometric Network of the 1st order was developed on the ellipsoid *Bessel* and was finished 1949.

For the purpose of integrating into EUREF, GPS observations were performed in the former FR of Yugoslavia in 1998, forming Yugoslav Reference Frame (YUREF).

The new Serbian Reference Network (SREF) has been developed for the purpose of replacement of the existing classic trigonometric networks. The network covers the entire territory of Serbia, on average 10 km apart them.

The next step in the development of reference networks of the Republic of Serbia was the replacement of the passive SREF network with a new, active one - the Serbian Active Geodetic Reference Frame (AGROS), a permanent stations network.

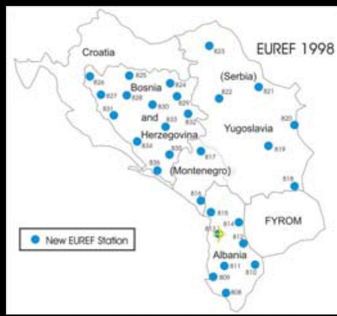
YUREF

The YUREF network, evenly distributed along the entire territory of SRY, out of which seven were points of the trigonometric network of the 1st order and one from the monitoring network of the dam of "Ćelije" lake.

GPS observations were performed in the period September 4 to 9, 1998 with the receivers *Trimble 4000SSE*, in 5 sessions, with the data rate of 15s.

The obtained accuracy of the coordinates is: 2 mm in latitude and longitude and 6,5 mm in altitude.

The coordinates were calculated in the epoch campaign - ITRF96 for 1998.7 epoch, but the definite values were obtained by transforming them into the ETRS89.



EUREF - BALKAN98

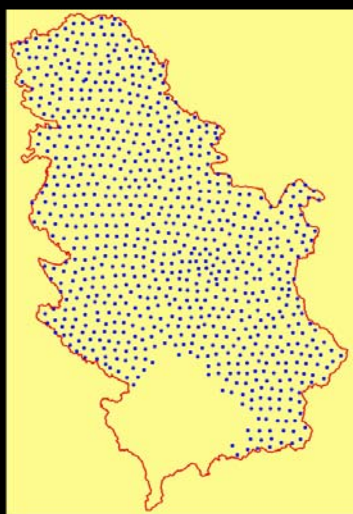
SREF

The main goals of the network were gradual replacement of trigonometric networks of higher orders.

The network have a 838 points and 1662 GPS vectors.

The dynamics of the realisation of the network was from 1998 to 2003.

The average standard of relative positions:
(3D / 2D / 1D): 9 mm / 5 mm / 8 mm .

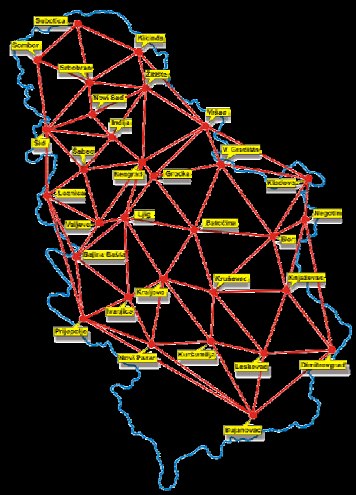


AGROS (1)

AGROS is a permanent service of precise satellite positioning in the territory of the Republic of Serbia and it was being established in phases, from 2002 to 2005, and on December 16, 2005 its economic use began .

The activities on establishing the network began in December 2001 with the preparation of the necessary technical documentation.

In February 2002 it was decided that after the harmonisation of technical standards, the existing AGROS project would become a sub-project of the EUPOS system.

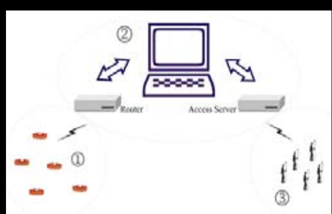


AGROS (2)

Nr.	Service	Accuracy [m]	Description
1.	AGROS RTK	0,02- 0,03	Positioning using the real time kinematics method
2.	AGROS DGPS	0,5 - 3,0	Positioning using the differential method
3.	AGROS PP	0,01	Positioning using the static method

The network concept:

1. segment comprised of permanent stations,
2. communication segment, and
3. user segment.



AGROS (3)

The network realisation:

- maximum distance between the stations of 70 km,
- the equipment at permanent stations comprises of geodetic GPS two-frequency receivers *Trimble* (models *4400* and *5700*) with corresponding antennas (*Choke Ring* and *Zephyr Geodetic*).

Determining coordinates:

- GPS measurements are performed by the method of relative static positioning,
- the measuring for connecting with the national datum and vectors in the permanent station network was carried out in 2005 with the receivers *Trimble 5700*. Duration of the session is 3 (24) hours with a data rate of 15 seconds,
- The obtained average accuracy of the adjusted coordinates was: 3D/2D/1D 9 mm/ 4 mm / 8 mm.

TESTING ACCURACY OF RTK SERVICE (1)

In the exploitation of the AGROS network so far, RTK service has been the most used service.

The testing requires points with known coordinates in the ETRS89 system, and in this paper they are points of SREF.

The testing of the RTK service quality of the AGROS network was carried out on the previously selected points of the SREF network (17 to 49 km apart from permanent stations).

The measurement was conducted with the receivers *Trimble 5700*.

Each point had 21 observations with the repetition interval of 15 minutes. Each observation consisted of three successive 30 seconds long data registrations.

FIG Working Week 2009 - Surveyors Key Role in Accelerated Development, Eilat, Israel, 3-8 May 2009

TESTING ACCURACY OF RTK SERVICE (2)

The measurement data (name of the point, antenna height, measuring time, initialisation time, number of satellites, PDOP) were filled in the field book formed for each point per observation.

The analysis of the obtained results encompassed:

- calculating a B, L and H coordinates,
- forming differences according to coordinates:

$$\Delta B_i = B_i - B_0 \quad \Delta L_i = L_i - L_0 \quad \Delta H_i = H_i - H_0$$

- calculating mean values of deviation by coordinates:

$$\left(\Delta\bar{B}\right) = \frac{1}{n}\sum_{i=1}^{n}\Delta B_i \quad \left(\Delta\bar{L}\right) = \frac{1}{n}\sum_{i=1}^{n}\Delta L_i \quad \left(\Delta\bar{H}\right) = \frac{1}{n}\sum_{i=1}^{n}\Delta H_i$$

- pointing extreme values for each point.

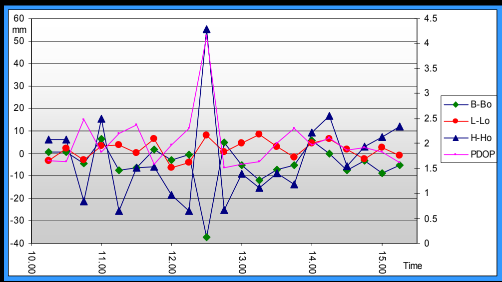
TESTING ACCURACY OF RTK SERVICE (3)

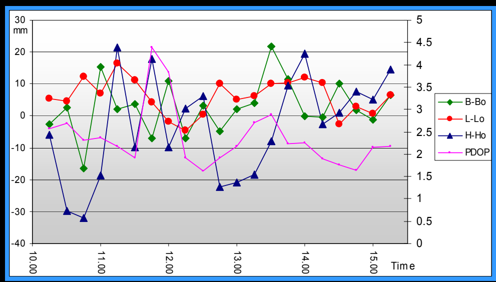
Differences from conditionally accurate values

Point no.	$(\Delta\bar{B})$ [mm]	$(\Delta\bar{L})$ [mm]	$(\Delta\bar{H})$ [mm]	$(\Delta B_i)_{min;max}$ [mm]	$(\Delta L_i)_{min;max}$ [mm]	$(\Delta H_i)_{min;max}$ [mm]	$PDOP_{avg}$
R365	-7.0	5.3	-7.6	-34.8; 20.3	-4.2; 21.4	-36.6; 42.3	2.12
R419	-4.4	1.6	-2.4	-37.1; 6.7	-6.4; 8.6	-25.4; 55.5	2.02
R754	6.2	-10.1	-2.4	-14.4; 22.4	-18.6; 7.0	-21.4; 45.5	2.90
R769	2.6	6.0	-3.5	-16.4; 21.6	-4.5; 16.4	-31.9; 21.4	2.36

- The majority of coordinate differences on the all tested points are below 25 mm for position and 40 mm for height, except on certain points where differences go even up to 37 mm, and 56 mm for height.
- With all big coordinate differences (>25 mm, and 40 mm for height) PDOP is also excessive (from 4,5 to 13,5).
- Since the declared accuracy of coordinates for the RTK service is 20-30 mm, it means that the confidence interval for 95% probability is 40-60 mm, which points to the conclusion that all coordinate differences are within the accuracy range of the RTK service, even in the case of excessive PDOP (37.1 horizontally, and 55.5 mm vertically).

TESTING ACCURACY OF RTK SERVICE (4)





TESTING ACCURACY OF RTK SERVICE (5)

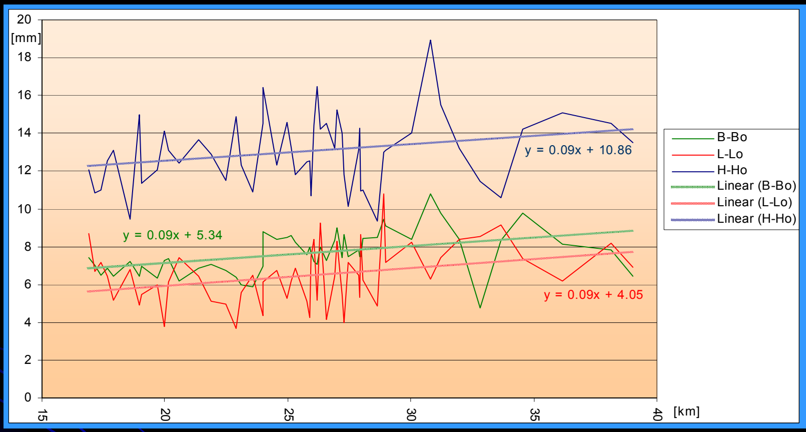
For each measured point, the average of coordinate differences was determined for all conducted series. All differences are below 11 mm for all coordinates. The measurement errors have the character of random errors with positive and negative values, which in the total sum are close to zero.

Having that fact in mind, an analysis of absolute values of coordinate differences was carried out.

The measured data indicate that the biggest differences are in height and that all the values of the coordinate differences are within the declared accuracy of the RTK service (30 mm).

Point no.	$(\Delta\bar{B})$ [mm]	$(\Delta\bar{L})$ [mm]	$(\Delta\bar{H})$ [mm]	$PDOP_{avg}$
R041	4.8	8.6	11.5	2.02
R058	8.5	4.9	9.4	2.06
R365	10.8	6.3	18.9	2.12
R754	9.5	10.8	13.0	2.90

TESTING ACCURACY OF RTK SERVICE (6)



The highest coefficient of linear regression that points to this correlation is 0,095 mm/km.

No correlation between the absolute differences of coordinates and the distance to the permanent stations.

CONCLUSION

Based on the conducted measurement and analysis of the obtained results, the following conclusions can be drawn:

- the accuracy of the RTK service of the permanent station network is within the projected and declared accuracy, i.e. 2-3 cm;
- differences bigger than expected can occur only in cases of poor geometry of satellites, i.e. when PDOP is bigger than 4;
- there is no accuracy correlation (i.e. difference of measured coordinates) related to the point’s distance from permanent stations;
- the accuracy of the RTK service is the same for all the points in the network, i.e. for the entire territory of the Republic of Serbia.

THANK YOU!