

Historical Overview, Quality and Current Condition of the Geodetic Networks in Macedonia

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Key words: trigonometric network, leveling network, gravimetric network, GNSS network

SUMMARY

This paper contains the characteristics of the geodetic networks in Macedonia of all levels, basic data, methods of stabilization, accuracy, and some other characteristics of state and urban trigonometric networks, as well as details for leveling, gravimetric, astronomic, and GPS-GNSS networks in Macedonia.

At the beginning, the subject of research was two-dimensional reference system (trigonometric network) of first order. After the conducted analysis, it was identified that there is an unequal accuracy achieved during the measurement of the angles in relation to the accuracy of the lengths of the sides, so local scale deformations in the network tend to appear. Afterwards, the urban trigonometric networks were researched also, as a special segment of the local horizontal (two-dimensional) reference system, which represents the basis for all geodetic works in cities and its surroundings, considered as especially important.

During the analysis of the Leveling Network, as one-dimensional reference system, which defines the elevation of the points in the territory of Macedonia, it has been identified that the initial leveling benchmark for the both basic leveling traverses are not located on the territory of Macedonia, therefore there is a need for additional measurements in order to define a new initial traverse.

It is a well-known fact that the astro-geodetic and the gravimetric network of Macedonia are outdated and it is necessary their upgrade as soon as possible by using of the latest modern methods and technology.

The established GPS network, as a three-dimensional reference system, represents a good basis for mass use for the GPS technology in Macedonia. The present passive GPS network has been defined through two GPS campaigns organized on years 1996 and 2004. Nowadays Macedonia has operational active GNSS network, densities properly, with the establishment of fourteen permanent stations, equally positioned on whole territory of Macedonia, named MAKPOS.

At the end of this paper, there are recommendations for solving the current unfavorable condition of the geodetic networks, by calculation of local transformation parameters with higher relative accuracy, as well as by introduction of a new reference system, and precise calculation of local geoid.

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1. PREFACE

The basic geodetic networks in Republic of Macedonia are comprised of: trigonometric network (TN), urban trigonometric networks (UTN), leveling network (LN), gravimetric network (GN), astronomic (AN) and the GNSS network. Each of these networks has individual characteristics and marks, and for these reasons, in the text below, they will be subject of extended elaboration.

In general the geodetic works related to geodetic referent networks of Macedonia can be dividing in two periods:

- up to year 1991, when Macedonia was the part of former Yugoslavian federation, and
- from year 1991 to 2010, after the independence of Macedonia.

In a period before year 1991, during almost one century, has been developed the geodetic networks in four orders, high leveling networks 1 and 2, gravimetric networks in two orders, as well the basic gravimetric network. In a next period after Macedonian independence, have been undertaken several works-projects aimed to establish the GNSS network and to link the Macedonian network with the European one, i.e. they are:

- EUREF campaign, year 1996, were defined seven points as EUREF MAK96,
- EUREF MAK96 point with ID number 0803 has been linked with the European leveling network,
- passive GNSS network established in year 2004, and
- GNSS network with virtual referent stations (2007-2009), named as MAKPOS.

It is so clear that after year 1991 there are no activities related to gravimetric, leveling and astrogeodetic networks.

The state reference coordinate system of Macedonia is almost based on Bessel ellipsoid, obtained from the former Yugoslavia's system (Idrizi B., et al, 2003). Parameters are shown in next table 1.

Table 1. Parameters of Macedonian state coordinate system

Datum	Hermannskogel
Ellipsoid	Bessel (1841)
Map projection	Gauss-Krüger (3° zones)
Central meridian	21° E
Prime meridian	Greenwich
Prime parallel	Equator
Scale factor	0.9999
False easting	500000m
False northing	0m
Elevation origin	Mean sea level – Molo Sartorio, Trieste, Italy.
Units	Meter (m)

In year 2009, the Agency for Real Estate Cadastre (AREC) of Macedonia, as responsible governmental institution for geodetic works in Macedonia, has been published “the study for the leveling and gravimetric networks in Macedonia”. In this document can be seen many variants for defining and establishing of the leveling and gravimetric networks in state level.

2. TRIGONOMETRIC NETWORK

The Trigonometric Network (TN) is a horizontal (two-dimensional) reference system which actually is a basic mathematic basis for execution of the survey. In order to be maximally used, the network completely covers the territory of R. Macedonia. In order to avoid the accumulation of the survey errors, the TN in our country is developed according the well-known geodetic principle “from bigger towards smaller”. This means that the works with the bigger scope and with higher accuracy are performed prior the works with smaller scope and with smaller accuracy. Completely applying this principle, the TN in our country is divided in four basic and two additional orders (table 2).

Table 2. Trigonometric networks categories and the length of triangle sides (SAGW, 2007a)

<i>Network order</i>	<i>Length of triangle sides</i>
<i>TN 1st order</i>	more than 20km
<i>TN 2nd order – basic</i>	15-25km
<i>TN 2nd order – additional</i>	9-18km
<i>TN 3rd order – basic</i>	5-13km
<i>TN 3rd order – additional</i>	3-7km
<i>TN 4th order</i>	1-4km

The trigonometric network from first order (TN1) is a basic network of interconnect-ed triangles with long sides, which uninterruptedly cover the territory of our country, while the measuring and the calculations are executed with the highest possible accuracy.

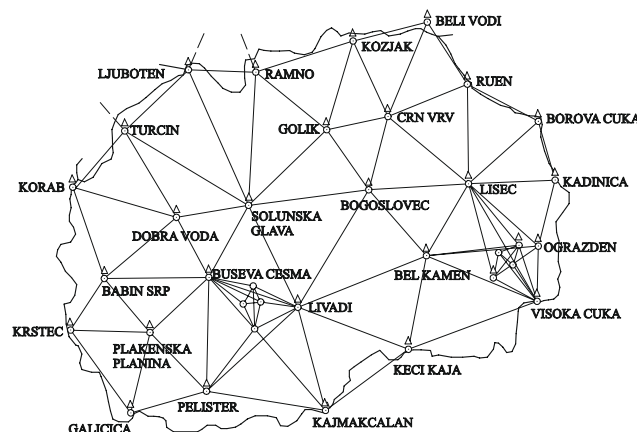


Figure 1. Trigonometric Network in Republic of Macedonia - 1st order

The works regarding the establishment of the trigonometric network from 1 and 2 order were initiated in 1920, while the measuring ended in 1923. In the TN1, on the territory of our country two base lengths (Prilep and Strumica) were projected and measured in 1922 (Nasevski M., 2006). In 1926, the adjustment of the TN1 was finished for all points on the territory of our country, with mean error of directions $m_p=0.8''$. The coordinates of all 27 points (out of which one is located in Serbia), along with the 8 points from the founding networks, are calculated in Macedonian state coordinate system (table 1). The points in TN1 are closing 35 triangles with average side length - 39.7 km, covering an area of 2.571.300 ha, which means that one point covers an area of approximately 100.000 ha (figure 1).

On the territory of Macedonia, besides the 26 points in the TN1, there are additional 218 points of second order, 2174 of third order and 12962 points of fourth order. This means that there are total of 15.380 trigonometric points on the territory of R. Macedonia.

The points in TN1 on the field were stabilized with massive concrete monuments with the following dimensions: 0.45 x 0.45 x 1.40m, positioned on top of concrete layers and 1.10 m height above the ground. The points from the lower orders were stabilized with rocks and concrete marks, having the following dimensions: 0.25 x 0.25 x 0.75 m and with 3-5 cm height above the ground (figure 2) (SAGW, 2007a).

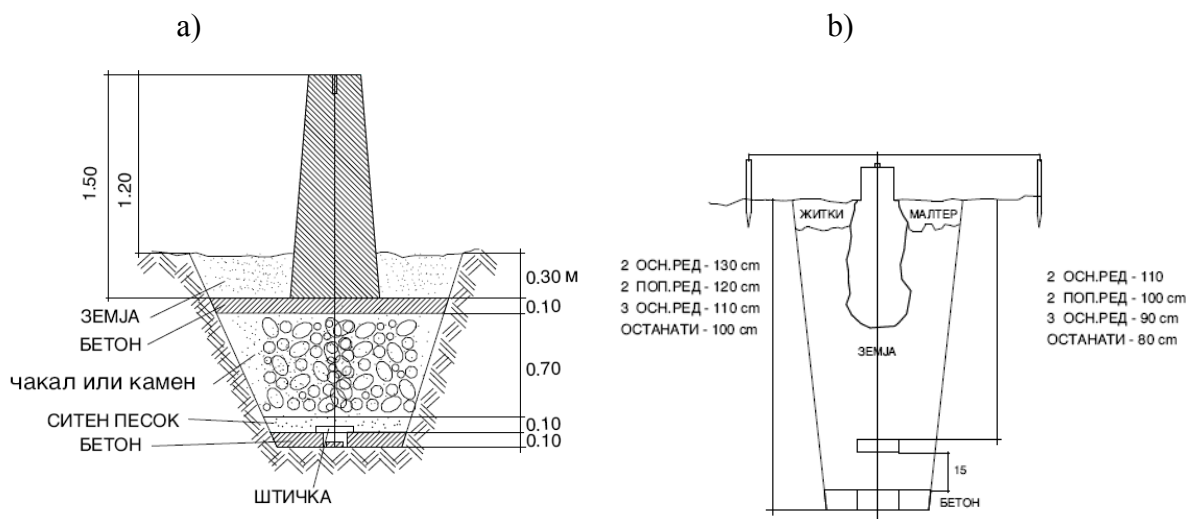


Figure 2. Dimensions and structure of TN points of all orders (a-1st order; b-other orders)

The accuracy of TN1 (before the adjustment) can be evaluated on the basis of the errors from the angular closing of the triangles. In our TN1 – (14) triangles are closed with an error smaller than 1'', (9) triangles with error smaller than 2'', (11) angles with error smaller than 3'' and only one triangle (Ramno-Ljuboten-Solunska Glava) has an error of 3,081''. According to this, the MSE resulting from the closing of the triangles, according the Ferrier formula amounts $\pm 1,703''$. From the 35 investigated errors, 17 errors are positive and 18 are negative, which shows that during the measuring there was no presence of systematic errors, i.e. the errors occur accidentally and belong to the normal distribution. During the re-measuring of the angles (from 1937 - 1948), conducted according the Schreiber method and with modern

instruments for those period, the accuracy was increased, where the MSE calculated according the same Ferrier formula, amounted $\pm 0,97''$.

Regarding the accuracy achieved during the direct measuring of the lengths of the two base lengths (Strumica and Prilep), the accuracy has an average relative error of 1:104000, which is an accuracy adequate to a network from first order, but the difference in the measuring accuracy of the separate base lengths (1: 83560 for Strumica and 1:124350 for Prilep) indicates that there is a non-homogenous accuracy in the entire TN1. Having in mind that the angles in the network are measured with higher accuracy in comparison with the lengths of the sides, certain local deformation in the scale appears in the network. A similar method is used to evaluate the accuracy and the network from lower orders.

3. URBAN TRIGONOMETRIC NETWORK

The Urban Trigonometric Networks (UTN), as a special segment of the local horizontal (two-dimensional) reference system are the basis for all geodetic works for one city and for its surroundings. They include the area of the wider city region, in a shape on inter-connected triangles without diagonal connections, with distances between neighboring points which need to be from 1 to 4 km (Paunovski B., 1980).

UTN is developed for the needs of the survey of the urban areas, and they are not divided in orders, but they are obligatory connected with the state trigonometric network from first and second order. During the projection and the recognition, a simple connection of the closest points with two-side measured angle directions is taken into account. At the same time, they are individually projected (in local coordinate system), they are adjusted as unique and complete (by intermediate and conditional measuring), and then they are incorporated in the state coordinate system. During the adjustment of the coordinates of the UTN points, the curved form of the Earth is also taken into consideration, while the maximum modifications of the directions, as well as the maximum values of the larger semi-axis of the ellipse of the errors depend on the adopted accuracy scale, which is taken from the Regulation for state survey II-A (the part for the urban trigonometric networks).

The stabilization and the signalization of the UTN points are performed for the points to be permanent for longer time period and to reduce the observed angular directions to precise defined points, which are apexes of the separate triangles. The stabilization is usually performed with concrete monuments of 1,20 m height over the ground. Usually, they are positioned on a solid ground, which is formerly geologically examined; the good positioning of the monuments in depth of 0,6-0,8m will avoid the freezing zone, which may cause positional movement (figure 3).

The first UTN in Macedonia, developed in a strict compliance to the Regulations' provisions, was established in Skopje in 1951 for the purposes of reambulation in the built up part of the city, after the catastrophic earthquake in 1958. Until 1968, the UTN for the cities of Ohrid, Struga and Stip were developed in a very modern and conceptual manner, while today, in almost every cities and in some larger regions, there are urban trigonometric networks (figure 3).

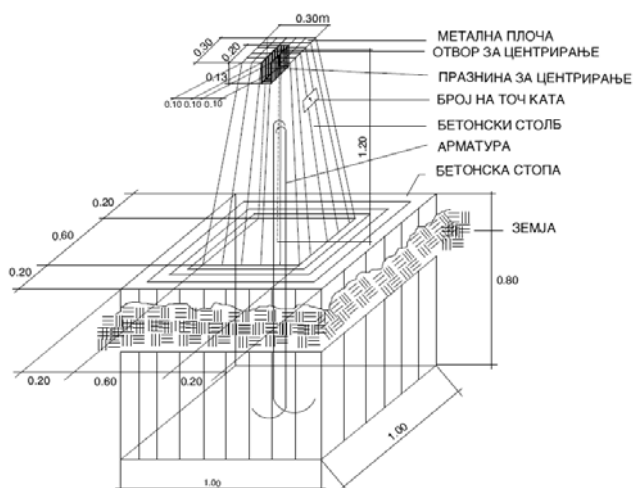


Figure 3. Dimensions and structure of UTN points (SAGW, 2007a)

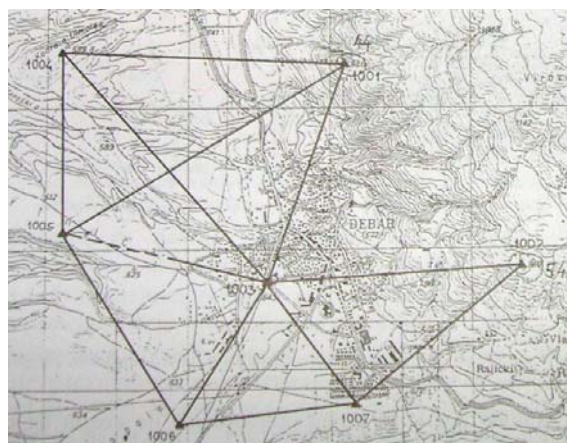


Figure 4. Urban Trigonometric Network of the city Debar

The basic modules, through which the accuracy of an urban trigonometric network is characterized and evaluated, are: mean square error from closing of the triangles, mean square error from the adjustment data and an average relative error from the sides. From the experience we had in our country, it is recommended that the MSE from closing of the triangles to be circa 1" i.e. to be smaller than 1,5"; the MSE of a measured angle from the adjustment to be below 1", while, the relative error of 2 km average side length to be circa 1:100 000. In order to achieve this, the MSE of the measured distance should range from 2" to 2,5". These indicators result from the necessity for the UTN to serve as a good basis for connecting the urban polygonometric network, where the maximum relative error for an average length traverse of 1.0 km should be 1:10 000.

Despite these indicators resulting from the evaluation of the accuracy, the quality of an UTN is also evaluated according to the geometric shape of the network, the density of the points, the number and the arrangement of directions, as well as the accuracy of measuring the angles and the lengths, which are the basic factors for providing the required accuracy.

4. LEVELING NETWORK

The Leveling Network (LN) is one-dimensional reference system through which the elevations are defined. The high accuracy leveling network in R. Macedonia is actually a part of the high accuracy leveling network of former Yugoslavia, which defines the basic elevation system in our country. Hence, in regard to the period of establishment, two high accuracy levels can be defined, such as: first high accuracy leveling network (HAL 1) and second high accuracy leveling network (HAL 2).

As a first high accuracy leveling network (HAL 1) are considered all leveling measurements and calculations in former Yugoslavia up to 1968. In this period, the procedure for establishing the second high accuracy leveling network (HAL 2) has been initiated in our country through stabilization of the benchmarks in the new leveling network (Ribarovski R., et al, 2007).

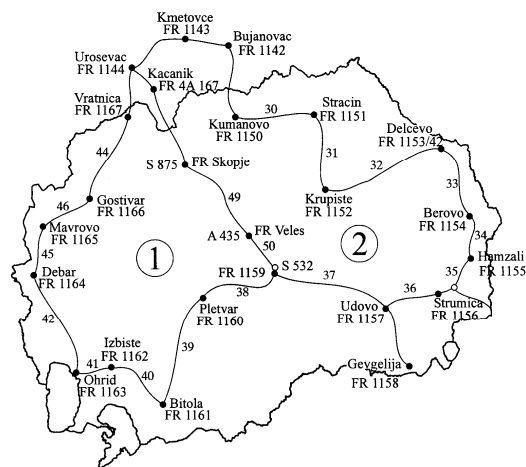


Figure 5. Leveling Network in Republic of Macedonia

The field measurements for determining the height differences among the separate traverses in the second high accuracy leveling network (HAL 2) started in 1970 and lasted for almost three years. For the leveling were used Wild No.3 leveling instrument with appropriate team; the resulting MSE (Mean Square Error) of a both sided measurement (forth and back) was 0.6 mm/km. The automatic field data processing was completed in 1983, after which the heights were finally determined by taking into consideration certain physical properties of the Earth, which ultimately, in a form of corrections, were added to the measurement results.

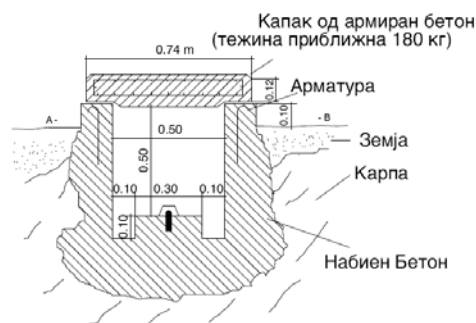


Figure 6. Dimensions and structure of the LN fundamental benchmarks (SAGW, 2007a)

The area of R. Macedonia with (HAL 2), as new and sophisticated height foundation was covered with 2 large leveling traverses (traverse no.1 in the western part, with length of 545 km and traverse no.2 in the eastern part of Macedonia, with length of 625 km with a common starting point for the both traverses in the point FR-1144 (Ferizaj). From today's point of view, the height foundation, defined by the more sophisticated second high accuracy level, is not very favorable for R. Macedonia, because the starting benchmark, to which the two basic traverses are complemented, is located outside the borders of R. Macedonia (figure 5). Despite the MSE of a two-sided leveling (forth and back), the accuracy evaluation of the leveling measurements was also performed by MSEs, as a result of the unclosed leveling traverses, as well as, through the MSE for the separate leveling surveys, resulting from the adjustment. Dimensions of the fundamental repers (leveling network fundamental benchmarks) can be seen in the figure 6.

Within the "Study for leveling and gravimetric networks in Macedonia" have been defined five variants of new leveling network of first order (high accuracy leveling network), with the options for its link with the neighbor countries leveling networks. The differences between the variants are in number of polygons (from 2 up to 17 polygons) and number of leveling benchmarks (422 up to 1161 benchmarks).

5. GRAVIMETRIC AND ASTRONOMIC NETWORKS

The gravimetric and astronomic network in the territory of R. Macedonia are in separately connected to the gravimetric and astronomic measurements, performed in the second half of the last century, when Macedonia was a part of former Yugoslavia.

The first systematic approach towards the basic gravimetric works and surveys dates from 1951, when the Geographic Institute and the Head Geodetic Authority of Yugoslavia initiated a systematic approach in the establishment of gravimetric networks, the regional and local gravimetric measurements, and ultimately, the production of gravimetric maps, produced as a result of those measurements (Odalovic O., 2009).

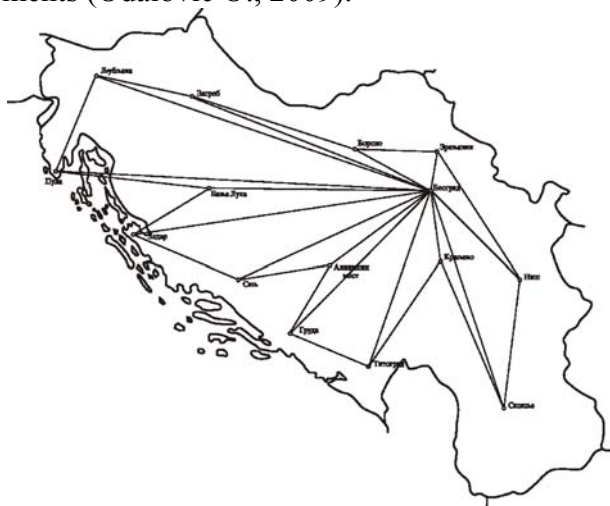


Figure 7. Gravimetric Network of 1st order of the former Yugoslavia

For the purpose to be achieved, a primary requirement was to undertake calibration works for defining the absolute gravimetric level and the scale of the basic geodetic networks. For providing unique gravimetric scale, the large base Belgrade – Skopje was established, which afterwards was expanded towards north to Subotica and towards south to Bitola. The works regarding the establishment of the gravimetric network of first order were performed in parallel to the works for the calibration bases. The network of first order had 15 points and was developed in a shape of a central system, with 14 closed triangles and its central point was located in the gravimetric point Belgrade (figure 7). The overall points were stabilized with concrete monuments, positioned in the proximity of adequate airports; in order to perform the measurements in a shorter time-period, the experts and the adequate instruments were transported by airplane. It should be emphasized that the values of the absolute accelerations were determined in regard to the Potsdam system.

For the purpose of performing several local and regional re-measurements, it was necessary to develop a gravimetric network of second order. The network was developed in a shape of closed polygons with length of 150 to 250 km, with several knot points and an average distance of 10 km. Because the network from second order was partially developed without a prior agreed plan, it was concluded that a new and more homogenous gravimetric network, with a larger point density, should be established. Thus, the so-called *Basic Gravimetric Network* was established (figure 8).



Figure 8. Basic Gravimetric Network in Republic of Macedonia (Odalovic O., 2009)

All measurements in the newly-established Basic Gravimetric Network were performed in the period of 1964-1967. The network was also developed, in a shape of closed polygons, and included the large base Belgrade - Skopje and the basic gravimetric point Belgrade. Hence, the Basic Gravimetric Network provided an accurate, stable and permanent gravimetric foundation for all the practical and scientific purposes in our country (picture 4). Unfortunately, since then, on the territory of R.M no basic gravimetric surveys were performed.

To the accuracy, evaluated through the measurement standard of one range of one unclosed polygon, in the basic gravimetric network was 0,021 mgal, which shows that the network was very homogenous and accurate.

The *geodetic astronomic measuring* in our country included determining of geographic coordinates (φ , λ) for 4 La Place's points and the azimuths (α) between those points. The four Laplace's points are trigonometric points of I order, such as: "Bel Kamen", "Ograzden", "Livade" and "Buseva Cesma". The specified astronomic measurements were performed in 1959 i.e. 1960 by the Military–Geographic Institute of the Yugoslavian Army. Since then, no astronomic surveys were performed in our country.

In a "Study for the leveling and gravimetric networks in Macedonia" are defined two variants of the 1st order gravimetric network of Macedonia. In both variants is projected the basic (zero) gravimetric network defined with three absolute gravimetric points, which should be measured by the absolute gravimeters. The first variant is composed by 32 points that form the 27 polygons, and the second variant with 24 points that form 19 polygons, which should be measured by the relative gravimeters. In the study the methodology of connecting with the neighbor countries gravimetric networks were defined also.

6. GNSS NETWORK

The Basic GNSS Network is a three-dimensional reference system, defined by three separate campaigns in Macedonia, in a period from year 1996 to 2009.

Those first GPS surveys in R. Macedonia were conducted in the period from 12-17th August, 1996 by the former Republic Geodetic Authority, and in collaboration with the Authority for Geodesy and Cartography of R. Slovenia and the Bundes Authority for Geodesy and Cartography in Frankfurt (Germany).

For international connection of the points in Macedonia with the international reference network ITRF 94 (International Terrestrial Reference Frame) were undertaken GPS observations of additional seven basis points. Besides those seven points, additional GPS observations of 25 additional points were performed, that belong to the zero GPS series, out of which two (at the Skopje and Ohrid airports) serve as a GPS control of the air-transport in R. Macedonia (figure 9).

The GPS observations in the 1996 campaign were undertaken in 5 sessions with Trimble 4000 SSE receivers; the total time of the session was 24 hours and the recording of the received signals was at every 15 seconds. Prior to processing the observation results, they were reformatted from Trimble to RINEX format (Receiver Independent Exchange), while the field measured heights of the antenna were corrected on the basis of the L1/L2 antenna phase centre. The processing and the analysis of the results from the EUREF 1996 GPS campaign for R.M was conducted in the Bundes Authority for Geodesy in Frankfurt (Germany), where Macedonian experts from the Republic Geodetic Authority in Skopje were included during the data processing. In the procedure, the appropriate (Bernese) GPS software was used as well as IGS orbits for the GPS Week 866. Thus, the determined coordinates for the ITRF stations refer to the ITRF 94 reference system, epoch 1996.6. At the same time, for determining the base lines was applied the so-called QIF (Qasi Ionosphere Free Ambiguity Resolution) for the longer bases and SIGMA (Sigma- Dependent Ambiguity Resolution) for the short base lines.



Figure 9. Connecting of Macedonian GPS network with EUREF – year 1996 (Ribarovski R., 2005)

Determining the ITRF 94 system datum and the epoch - 1996.6 was achieved by orienting the measurements towards the four ITRF stations (Wetzell-1202, Matera, Grac-Lustbuehel and Zimmerwald), which belong to the same reference system and datum. Besides the four ITRF points (Wetzell-1202, Matera, Grac-Lustbuehel and Zimmerwald), the EUREF 1996 GPS campaign for R. Macedonia also included the points Penc (Hungary), Ankara (Turkey), Donyasis (Greece) and Ilin Vrh (Croatia), which in that time period were part of the EUREF weekly combined solutions, computed in Bern and presented in Sinex form.

The comparison of the results from the EUREF 1996 GPS campaign for R. Macedonia with the EUREF weekly combined solutions in Bern, resulted in congruency (for the Penc and Ancara points), while for the point *Ilin Vrh* were determined positional differences of 5 mm and height deviation of 9 mm; while the differences in the Dionysis station exceeded the prescribed limits, and were to be sent for additional analysis.

During the first GPS campaign as a part of the European GPS Network, a permanent station was established in Ohrid (figure 10).



Figure 10. Permanent GNSS station in Ohrid (Ribarovski R., 2005)

Other GPS surveys in R. Macedonia were undertaken in the beginning of 2004, and were performed for the purposes of producing new topographic maps in scale 1:25 000. They comprise 9 points of the trigonometric network of I order, 17 points of the urban trigonometric network and 24 newly defined points on the territory of R. Macedonia. However, the surveys were accurate for their purpose only i.e. daily three hour sessions were undertaken. The form and dimensions of the 24 new benchmarks are shown in a next figure 11.

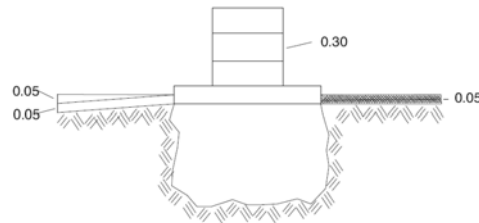


Figure 11. Dimensions and form of the GPS points established in year 2004 (SAGW, 2007a)

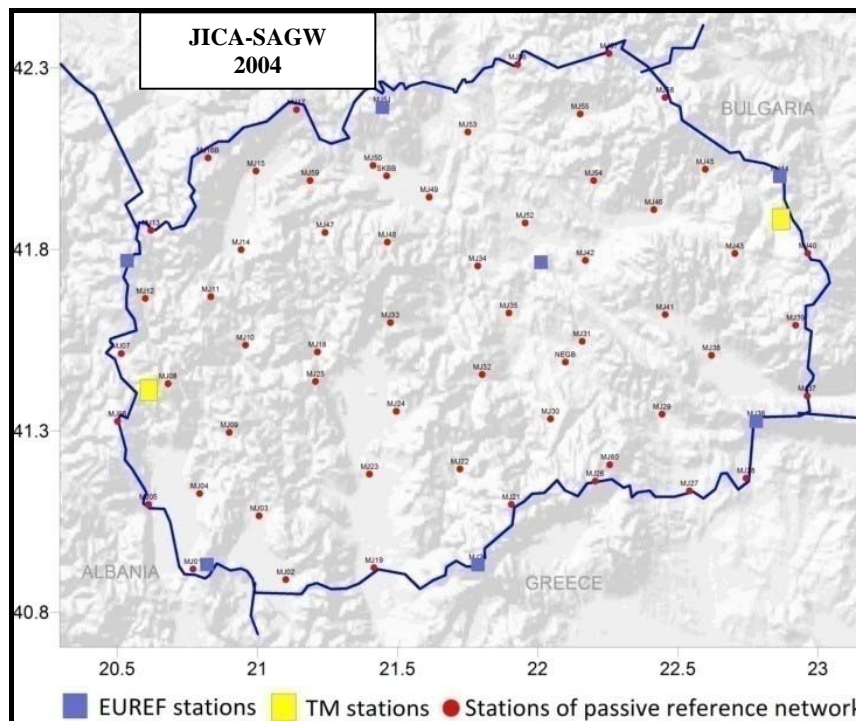


Figure 12. Passive GPS network, established in year 2004 with 50 points (Odalovic O., 2009)

As a result of the strategic business plan of the State Authority for Geodetic Works of Macedonia (SAGW, 2007b), in a period from year 2007 to 2009, the whole territory of Macedonia was covered with new GNSS network, composed by fourteen virtual referent stations (VRS), named as MAKPOS (Macedonian Positioning System). The GNSS network is established as local independent network within the Macedonian territory, without connection and adjusting with the points from the EUREF. This is the three dimensional active geodetic network of Macedonia, 24/7 operational. VRS are equally positioned on whole territory of

Macedonia, density properly, less than 50km distance between them. Thirteen of them can obtain in the same time the GPS and GLONASS signals, except one which cannot obtain the GLONASS signal, i.e. it can work only with GPS satellites (<http://makpos.katastar.gov.mk>). Their positions can be seen in the figure 13 – map with the location and type of VRS. The coverage radius of VRS is 50km, with elevation mask 0° and 1” recording rate. Utilization of the Macedonian active GNSS network makes reality the measurements with 1cm accuracy. Because of the differences between the parameters of the state coordinate system of Macedonia (table 1) and the global one (WGS84) in which the VRS works, datum transformation is the necessary procedure during usage of GPS for measurements in Macedonia. Due to non-homogenous trigonometric network, datum transformation parameters cannot be the same for whole territory of Macedonia, but they have to be calculated in local level. This problem will be solved in total after establishing the new coordinate system of Macedonia, based on datum ETRS89 and GRS80 ellipsoid. The center for managing with the MAKPOS network is located at the AREC. Data transmission from VRS to the center is done via VPN and ADSL, as well the distribution of data to users is realizing by using GPRS, GSM and internet.



Figure 13. Active GNSS network of Macedonia (<http://makpos.katastar.gov.mk>)

7. CONCLUSIONS

From the above-stated, it can be concluded that on the territory of R. Macedonia there are basic geodetic networks, developed in different periods of the past century and they represent a firm geodetic foundation for normal functioning of the geodetic occupation.

Nevertheless, it is quite worrying that after the independence of R. Macedonia as a separate political and territorial entity, the basic geodetic works were not dealt with special attention (during the continuous maintenance, densification and development/improvement).

It can be freely stated that from the basic geodetic works in Republic of Macedonia, only the development and the maintenance of the trigonometric and GNSS networks are normally and continuously performed. However, this is insufficient, particularly having in mind the expansion of the new surveying technologies, which despite the other prerequisites; require adequate conditions in the environment to be applied.

In this direction, urgent tasks of the geodetic service in R. Macedonia in the field of the basic geodetic works are: undertaking sophisticated astro-geodetic and gravimetric surveys for defining the waving of the local geoid, establishing a new starting benchmark for the basic leveling network, which presupposes performing a new high accuracy level, as well as defining the new state coordinate system based on ETRS89 datum and transforming all geodetic and spatial data from actual in to new coordinate system.

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BIOGRAPHICAL NOTES



Ass.Prof.Dr.Eng. Bashkim IDRIZI, was born on 14.07.1974 in Skopje, Macedonia. He graduated in geodesy department of the Polytechnic University of Tirana-Albania in 1999year. In 2004, he got the degree of master of sciences (MSc) in Ss.Cyril and Methodius University-Skopje. In 2005 he had a specialization for Global Mapping in Geographical-Survey Institute (GSI) of Japan in Tsukuba-Japan. On year 2007, he held the degree of Doctor of sciences (PhD) in Geodesy department of Ss.Cyril and Methodius University–Skopje. He worked in State Authority for Geodetic Works from May 1999 until January 2008. During those period, in 2004 he appointed for head of cartography department, i.e. geodetic works. From October 2003 up to January 2008, he worked as a outsourcing lecturer in State University of Tetova. From February 2008, he works as a cartography and GIS Professor at the State University of Tetova–Tetova. He continues with working as outsourcing lecturer in geodesy department of the University of Prishtina-Kosova. He is the author of three cartography university books, and more than 50 papers published and presented in national and international scientific conferences related to geodesy, cartography, GIS and remote sensing.



Prof.Dr.Eng. Risto RIBAROVSKI, was born on 09.05.1943 in Bucharest, Romania. He graduated in geodesy department of the University of Belgrade-Yugoslavia in 1967year. His first work experience was started on year 1969 as assistant for geodesy within the geodesy department at the Civil engineering faculty in Skopje. At year 1979 he got the assistant professor degree, 1984 associate professor and at year 1990 he got the professor title. He is the author of seven geodesy university books, many manuscripts for students and papers published in national/international geodesy and cartography conferences. At the moment he is professor in retiring and very active in geodetic chamber of Macedonia, scientific projects and organizing the conferences.

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