Assessment of Positional Accuracy of Topographic Maps and Plans of Banja Luka (Bosnia And Herzegovina) of Different Editions

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The quality of data on topographic maps (TM) and plans is implied by the degree of thematic and geometric deviations of the presented data from their actual position. To determine the geometric (positional) accuracy is usually applied deductive method of questioning. As one of the elements of quality of the TM, positional accuracy is particularly noted in relation to other elements in both their impact on the use of the value of the finished product, and by the exactness of the determination and quantification. In classical cartography, it was almost a synonym for quality of the maps. Positional accuracy of geographic information is an important quantitative element of their quality, regardless of whether they are in digital or analog form. In the paper points is repesented the need for evaluation of positional accuracy of geographic information, describes the current standard for evaluating the accuracy and show the results of applying on the raster topographic maps and plans.

Under the positional accuracy is implied the coincidence of the position of a point in a set of geographic information, respectively in the model of geospace - maps, database, orthophoto etc, with the real position of that point in space. It can be either external (absolute) or inner (relative), depending on whether a match is determined at the position in the coordinate system (absolute accuracy) or in the other sub-set (relative accuracy).

When it comes to assessing the positional accuracy of Geographical Data, ISO family of standards defines some basic principles and general procedures. American national standard for spatial data accuracy - NSSDA applies to digital data in raster and vector form, through which they will be evaluated raster topographic maps and plans of the city of Banja Luka (Republic of Srpska, Bosnia and Herzegovina).

Development history of cartography in BiH dated back to the time of the Bosnian kingdom, where was the first mention of the name of the place of Banja Luka (1494). The paper presents an unusual approach to the assessment of cartographic publications of the Banja Luka, where through this standard shows the quality of the topographic maps and plans of the Banja Luka. It was assessed positional accuracy of geographic information on topographic maps and plans in the period of 1881, 1936, 1942, 1945, 1969, 1977. and 2011. Based on this research, it was established the quality of publications published in the geographic space of the BiH where in this time frame there was not sufficient information and evidence as opposed to the developed European countries, where it was established by official records on the basis of the similar publications.

1. INTRODUCTION

Of fundamental importance for users and publishers of geographical, topographical and similar maps is knowledge of the data and their accuracy. Primary importance in this field is the possibility of examining and quantifying in the exact way. Modern topographic mapping led to the established conventional solutions and standards in view of the content of topographic maps which raised their value in use both in our country and in the world (Radojčić, 2008). In the geographic field of the Republic of Srpska (Bosnia and Herzegovina - BiH), this type of work is neglected for years because of its complexity, as well as due to non-fulfillment of all the conditions necessary for the realization of such tasks. In the past, in the former Socialist Federal Republic of Yugoslavia, were made only by the Military Geographical Institute (MGI), in Serbia.

The main problem we encounter when assessing the accuracy of the contents of topographic maps represent a selection of the proportions of accuracy (ie, the size of which accuracy is measured and evaluated), and the corresponding set of points that represent the map list and map sheets that represent a whole. On that basis, the great importance of knowing the quality of spatial data, because if decisions are based on data whose quality is poor or unknown, the consequences can be significant (Peterca et al., 1974). In classical cartography long time, the term quality maps considers its accuracy, which is addressed through two main components: geometric (positional) accuracy and precision of general information that provides a map (Petrović, 2008). In both cases, under the accuracy, refers to the degree of compliance data downloaded from the list of maps and his reference accuracy (true value).

There are several standards for evaluating positional accuracy of cartographic products based on point-to-point analysis (NMAS-USGS, 1947; EMAS-ASCE, 1983; ASPRS, 1990; NSSD-FGDC, 1998; SDEM-USGS, 1998), where among them one of the most important is American National Standard for the accuracy of the maps (National Map Accuracy Standard - NMAS), and American national standard for spatial data accuracy - NSSD. Almost all of the methodology are based on an independent determination of the positional error on the sample points on the basis of the test, if these values agree with the standard (Ureña, 2011).

2. CARTOGRAPHIC PUBLICATIONS TOPOGRAPHIC PLANS AND MAPS OF BANJA LUKA

Significant development of cartography in this region of the Balkans begins exemplary, original and scientifically based works of Serbian scientist Jovan Cvijić. Making of topographical plans preferably binds to the Austro-Hungarians in the process of making cartographic publications for the area of the former Military Frontier. The Austro-Hungarian cartographers are almost the only and the most important factors showing this geofield in the first half of the 19th century. It is important to note that the geographic and topographic maps of the Austro-Hungarian cartographer in quality and quantity substantially exceed maps of other European cartographers. Later development is linked to the activities of Serbian Military Geographical divisions created by the decision of the Chief of Serbian General Staff in 1876. (Stefanović, 2003). Unscrewing various historical upheavals in the geographic space came to the creation of cartographic publications for this extremely important geostrategic position.

Thus, the number of publications of Austria-Hungary, the Kingdom of Yugoslavia, the Independent State of Croatian-NDH (the fascist state during World War II, under whose jurisdiction was geospace of Krajina), SFR Yugoslavia in which time has been made the first topographic maps of the area. In the last few years it was done the digitization of different proportional TM series of editions VGI's.

Cartographic publications were primarily operated to obtain a visualized display of property. They are used as an integral part of the cadastral records. *The property is inviolable and sacred right. No one shall be deprived of his rights unless requiring public purposes, but in this case only when is permitted by law* (Declaration of the Rights of Man and of the Citizen of 1789).

With the development of civilization in this region begins and the development of cartography where we have the first images of this region (in the present-day western Serbian Republic, Bosnia and Herzegovina) on maps of the Roman Empire. Further course of history, and changing rulers made new publications for the purposes of estate records. Thus, during the reign of Mehmed II, the Ottoman Empire, ordered the preparation of cadastral maps of Bosnia in 1475 within which was the territory that covers the area of Banja Luka (Begić, 1998). These publications were the basis for the functioning of the system deed records. After the annexation of Bosnia and Herzegovina by Austria-Hungary, one of the most important events in the preparation of cadastral surveying and establishing the land cadastre, is the command and guidance from 04. 07. 1880 to the Turkish translation of existing grunt books and their subsequent conduct. In the period from 1880 to 1884 the Austro-Hungarian survey carried out on the basis of which were made cadastral maps and records. As a rule it was made in the scale of 1: 6 250, where the exception plans of cities and densely populated areas have been made in the scale of 1: 3 125; 1: 781.25, and 1: 562.5. On the topographical plans of that period primarily structure consisted land, roads, water resources, forests, buildings constructed on the land and mineral fields. The first topographical plan Banja Luka, which is assessed in this survey, was recorded in 1881 (Begić, 1998).

The management of these areas after the First World War, established the Kingdom of Serbs, Croats and Slovenes, which in 1928 changed its name to the Kingdom of Yugoslavia. Then continues to work on establishing better records on the basis of the Austro-Hungarian grunt. Within the survey during the Kingdom of Yugoslavia it was created a new topographic plan Banja Luka in 1936.

In 1942, during World War II, on these area was established Independent State of Croatia. Hence arise and new needs for establishing records and needs new survey. These were carried out to manufacture a new Topographic plan of Banja Luka, whose amendment made in 1945 and it is a real detailed topographic representation which is made to present a lot better quality compared to the previous published editions.

After the Second World War, SFR Yugoslavia through activities MGI give a special attention to the establishment of a new system of records. MGI has since 1953 implemented a complete survey of the territory of SFR Yugoslavia, within which is the first in 1969 and then in 1977 was made Topographic map of Banja Luka in the scale of 1:25 000. In Bosnia and Herzegovina in 2002, was launched the project of Digital topographic maps of the scale 1:25 000, with financial and technical assistance of the Japan International Cooperation Agency (JICA). Within this project the first time in this area is done evaluating of the quality of the topographic maps (Ključanin et al., 2011). Digital topographic map of Banja Luka was made in 2011 which is the last official publication of this geo-up for which will be made an assessment of the quality of positional accuracy. Test teritory would include the territory of the 17 ° 7'30 " - 17 ° 15 ' E.G.L. and 44 ° 45' - 44 ° 52'30 " N.G.L. for various editions from 1881 to 2011.

3. STANDARDS FOR ASSESMENT OF POSITIONAL ACCURACY

When it comes to rating the positional accuracy of geographic information, ISO standards define only the basic principles and general procedures. Users of the ISO standards define specific measures of accuracy and statistics that are used for evaluating and reporting on the quality and prescribe the minimum methodology to be applied for obtaining quality assessment. Unlike of global "industrial" or "de facto" standards only at the national level appear closer to certain standards that govern this issue. The powerful influence on standardization in this field have two American standards: National standard of accuracy maps (United States National Map Accuracy Standards - NMAS) of 1947 and the National Standard for the accuracy of the data space (National Standard for Spatial Data Accuracy-NSSD) of 1998.

Standards in the field of geographic information at the global level, most have been developed by the International Organization for Standardization ISO (International Organisation for Standardisation) - or its Technical Committee 211 TS (Technical Committee), the Open GIS Consortium OGC (Open GIS Consortium) and to a lesser extent, World Wide Web Consortium W3C. In the field of geographic information, only ISO standards are an official at the global level.

Beside them were developed also the military standards including the most important whose were issued by NATO. Working Group for geographic information in digital form DGIWG (Digital Geographic Information Working Group) and the US Department of Defense, created the standards that are used not only as a starting point for the development of appropriate NATO standards, but also in the armies that are politically and ideologically close to the US military.

To define the quality of geographic data is applied ISO9000 approach that quality defines as a set of characteristics of a product or service that reflect the ability of that product or service that meets certain requirements formulated in advance. This approach is further developed as standard ISO 19113, ISO19114 and ISO 19115.

Model data quality should be designed and formulated before the actual production of spatial data, in order to take into account user requirements and objectives for achieving quality. In short, the model formulates the quality requirements of quality specifications at the entity level, revealing the sources of possible errors that affect the quality of data and precise measurements needed to ensure the quality of operations (Jakobsson et al., 2011). In order to achieve this are used for defining quality standards. In BiH, there are no approved national standards on quality cards, so they used the following international standards:

1. ISO 19113: 2003 - Quality Principles prescribe principles for quality description of geoinformation, as well as concepts for dealing with information about the quality of geospatial information. It defines two components that are used to describe the quality of the data set, namely:
   a) Elements with a sub-element of data quality (data quality elements and data quality

subelements), which describes how well a set of data meet predefined criteria in product specification and provide quantitative information on the quality and

b) The overall data quality elements (data quality overview elements), which provide general, descriptive information about data quality.

2. Standard ISO 19114: 2003 - Quality evaluation procedures, establishing a system of evaluation and reporting quality results. Quality assessment procedure consists of applying procedures for evaluating the quality of certain operations related data, and carried out by producers and data users.
3. The ISO / TS 19138 - Data quality measures standardize the components and data structures for reasons of shaping their homogeneity and quality.

Information obtained by processing spatial data are used in the decision making process, and their quality has an impact on the reliability of the final solution. Winning the characteristics of reliability data can be used for command and control system (Talhofer et al., 2011).

4. AMERICAN NATIONAL STANDARD FOR SPATIAL DATA ACCURACY

The national standard for spatial data accuracy (NSSD) conducts statistical and methodological assessment tests for assessing the accuracy of the spatial position of points on the maps and digital geospatial data compared with georeferenced position of certain points with greater accuracy (Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy 1998).

Points whose coordinates are compared should be chosen so that they can be easily identified and unambiguous, and in the event, which is evaluated in the reference set. Usually these are average points of line facilities (roads, railways, canals, etc.) that intersect at an angle of about 90°, lonely trees, monuments, etc. Standard prescribes that selected points must be evenly distributed in the data set and define the criteria for the timetable for the collection of data about the area which covers an area of a rectangle shape (like a list of maps), assuming that the positional accuracy of the observed area is uniform.

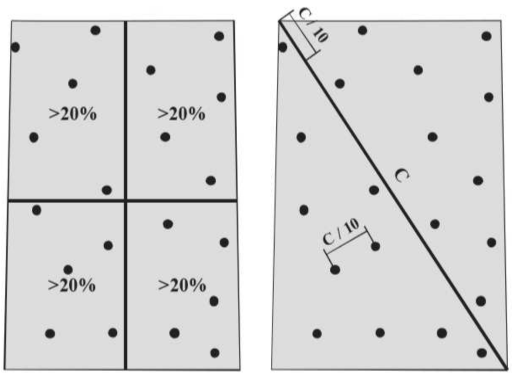

Figure 1. Criteria of point distribution for testing using standard NSSDA

According to this criterion, in each quadrant of the studied area must be at least 20% of the total number of points, where they are located at the distance that is at least 10% of the length of the diagonal (Figure 1).

Positional accuracy of the data sets that are georeferenced is determined by combining the results of tests called. horizontal accuracy (the accuracy of position with respect to a horizontal date, i.e., the two-dimensional coordinates). Standard NSSDA for assessment of positional accuracy as the starting point used root mean square error, which is referred to as RMSE (Root Mean Squared Error). Error RMSE is the square root of the mean of the sum of squares of differences of measured coordinates of points in the set whose accuracy is assessed and the appropriate reference ("true") coordinates. Accuracy is communicated in units in which the coordinates are expressed in nature (meter or feet), which enables a direct comparison of different products, regardless of the difference in scale or resolution. For a confidence level of accuracy was used 95%. Using this standard will be executed rating accuracy position of points on topographic maps and plans in the realization of this work.

5. ASSESMENT HORIZONTAL ACCURACY USING NSSDA

Horizontal accuracy will be tested by comparing the positional coordinates of well-defined points in the database with three coordinates of the same points from an independent source of higher accuracy. The errors in the recording of data or processing, such as feedback or inconsistency between the data and independent source of higher accuracy in the definition of the coordinate reference system, must be corrected before processing accuracy assessment. At least 20 control points must be tested and distributed to reflect the geographic area of interest and the distribution of errors in the database. When the 20 point are tested, 95% confidence level gives possibility to a point to exceeds the threshold of trust given to the product specifications. For their needs it is determined by the mean squared error of the position by the coordinate axes:

$$RMSE_y = \sqrt{\frac{1}{n}\sum_1^n dy^2} \quad \text{и} \quad RMSE_x = \sqrt{\frac{1}{n}\sum_1^n dx^2} \tag{1}$$

where are d_y and d_x the difference between the measured and reference coordinate in the direction of the coordinate axes x and y. Horizontal error in point i is:

$$RMSE_i = \sqrt{dy_i^2 + dx_i^2} \tag{2}$$

So the horizontal *RMSE* of the whole pattern is:

$$RMSE_r = \sqrt{\frac{1}{n}\sum_1^n dy^2 + \frac{1}{n}\sum_1^n dx^2} = \sqrt{RMSE_y^2 + RMSE_x^2} \tag{3}$$

If the $RMSE_y = RMSE_x$ it is:

$$RMSE_r = \sqrt{2RMSE_y^2} = \sqrt{2RMSE_x^2} = 1{,}4142RMSE_y = 1{,}4142RMSE_x \tag{4}$$

If the errors are independent and have a normal distribution, the horizontal accuracy with a level of confidence of 95% is calculated according to the formula:

$$Accuracy_r = 1{,}7308 \cdot RMSE_r \tag{5}$$

In the other side, if the $RMSE_y \neq RMSE_x$ then is:

$$Accuracy_r = 1{,}4477 \cdot 0{,}5 \cdot (RMSE_y + RMSE_x) \tag{6}$$

This information may include descriptions of the source material from which the data is collected, the accuracy of measurement associated with the compilation, the procedure of digitization, equipment and quality control procedures used in manufacturing.

No matter which method is used, it is necessary to explain the accuracy of the coordinates and describe the testing of digital geospatial metadata for this case (Federal Geographic Data

Committee, 1998, Section 2) which should satisfy the base characteristics of spatial data.

6. ACCURACY ASSESMENT OF SPATIAL DATA ON DIGITAZED TOPOGRAPHIC PLANS AND MAPS OF BANJA LUKA

The survey was completely based on a comparative study of distances and angles defined by network of control points, elected in places that can be identified within the topographic maps of the city of Banja Luka, created from the 19th century to the present. For easier identification, is determined by the twenty control points selected on the leaves of maps from 1881, 1936, 1942, 1969, 1979, 1984 and 2011, where the plans and maps in this paper are shown in a slightly lower resolution because of the size of the joint sheets for each of the edition. The criteria used to define the points are easy to identification on:

- topographic map;
- field and determination of coordinates;
- historical maps, which are analyzed.

Twenty points do not appear necessary at all analyzed maps, but minimal set of mandatory fifteen points is the basis of all the maps, which comprise the core of the city of Banja Luka. Identified on a topographic map, points have their coordinates obtained through global positioning campaign. It was provided approximately equal accuracy of ± 2 cm at each given point. Points are defined in the coordinate system of the Gauss Kruger projection for compatibility purposes of topographic maps. The need to apply scale factor (the average calculated value of 1.00053) to the obtained distances is checked and it was found that there is no significant impact on its implementation. The distances are calculated between every two points, placing the actual distance matrix. To analyze charts were used the following criteria:

- Maps covering the period between the 19th century and the 21st century, in conformal projection;
- It is taken as the maximum possible number of control points, some of which less uncertainty;
- Presence of graphic extent or the possibility of its determination;
- Scanning resolution is compatible with the research, more than 300 dpi.

7. RESULTS AND DISCUSION

Positional accuracy of graphical data on analogue topographic Maps of larger scale shows that the geometric accuracy of analogue topographic maps almost proportional reduction in area, due to the increased surface print and line width, which is a decrease in geometric precision analogue topographic maps, on a certain level, as a result of cartographic - reproduction process. Therefore, the mean squared error position of geodetic control points used to map sheets ranges from ± 3.8 m to ± 39.5 m. This confirms that the leaves of TM have the correct absolute position within the projections used and no significant increase or decrease, rotation, translation, or cutting down on surface mapping.

Errors contained in data obtainined by digitizing existing maps contain errors, the original data collection and processing (as surveying and mapping errors), and also errors transformation (scanning, georeferencing, vectorization). Data quality of digital TM depends on the graphics (map) sources, numerical sources (catalogs of geodetic points), the process of analogue-to-digital conversion, as well as methods of modeling and data processing.

After scanning and vectorization of topographic maps (analog maps and reproductive originals) in digital form, additional activity was the control and data modeling. To control is used to check the reference data (geodetic points) according to the available resources. The accuracy of the original maps (reproduction originals) that are used as input data is defined by the Gaussian mean square error and the maximum permissible error. The original script that was done using classical survey is calculated as:

$$M_1 = \pm\sqrt{mk^2 + am^2} \tag{7}$$

The mean square error definitely plotted topographic original and previous assessment accuracy are shown in Table 1:

Table 1. Mean squared error definitely plotted topographic original and previous assessment of accuracy

Year built TM	Mean square error definitely plotted topographic original [mm]	The previous assessment of accuracy [m]
1881.	180	45
1936.	180	45
1942.	120	30
1969.	60	15

For TK, whose original was made by photogrammetric method has a mean squared error, including an error of photogrammetric original $m_f = \pm 0{,}15mm$, which is calculated as:

$$M_2 = \pm\sqrt{mf^2 + am^2} = \pm 30mm \tag{8}$$

With regard to the manner of making, the accuracy of such developed original (TM25 Banja Luka in 1979 and digitized TM25 from 2011) has a prior assessment of the accuracy of ± 7.5, while the 1984 has a prior assessment of the accuracy of ± 15m. The analysis was performed only on the exterior accuracy by comparing the linear measure between each point, and the value of the angle, by checking the difference between the basic and historical maps. Network reconstruction is accomplished by completing the following conditions:

- identification of control points and determining their position on maps, and
- materialization points and grid lines for the calculation of distances, transformed in comparison to the same unit of measure (meter).

Detection of surface deformations that occur over time, is necessary to point on the map graphically compared with known reference coordinates. This is particularly important in cases of local character, where it is necessary that there is a greater amount of points with relatively uniform density distribution at the surface of the useful maps. The internal accuracy of the maps is verified by comparison with the scale of the graphics shown on the map. Comparing the values were determined mean and standard deviation, which is calculated as the difference between linear and angular measurements of specific comparison.

Rating positional accuracy of geographic information on topographic maps and plans in the period 1881, 1936, 1942, 1969, 1979, 1984 and 2011 was performed by the sequence of statements and so will be presented research results.

Topographic map of Banja Luka from 1881 is the first reproduced original of the Banja Luka made on the basis of the Austro-Hungarian classical survey. For assessing the accuracy of TM Banja Luka from 1881 (Figure 2) was performed digitizing TM Banja Luka in 1881, and the results obtained (Table 2) show that the rendering of the original given a very unreliable value, but that is in accordance with the then existing conditions fulfilled the requirement of the previous accuracy.

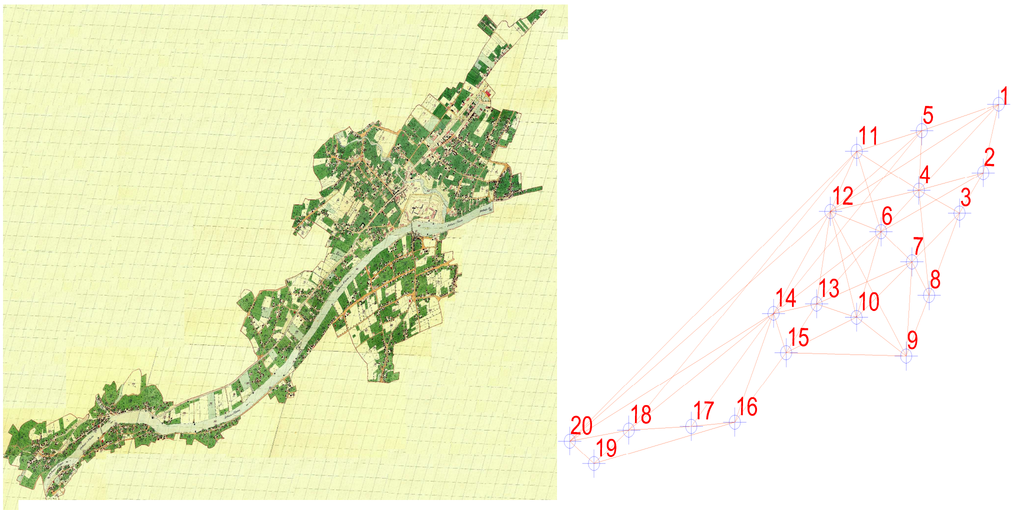

Figure 2. TM of the Banja Luka from 1881 (left) and network on the basis of which was made assessment of the accuracy (right)

Table 2. Parameters of accuracy TM Banja Luka release 1881

Mean squared error by coordinate axis [m]	35.202	37.678
Maximal deviation by coordinate axis [m]	82.872	67.022
Mean square position error [m]	89.195	
Maximal deviation by position [m]	87.585	
Standard deviation of position [m]	24.612	

Topographic map of Banja Luka in 1936 was made on the basis of the first, classic survey of the Kingdom of Yugoslavia. For assessing the accuracy of TM Banja Luka in 1936 (Figure 3) was performed digitization and the obtained results (Table 3) show that the rendering of the original yielded very unreliable values, which did not meet the requirement of the previous accuracy.

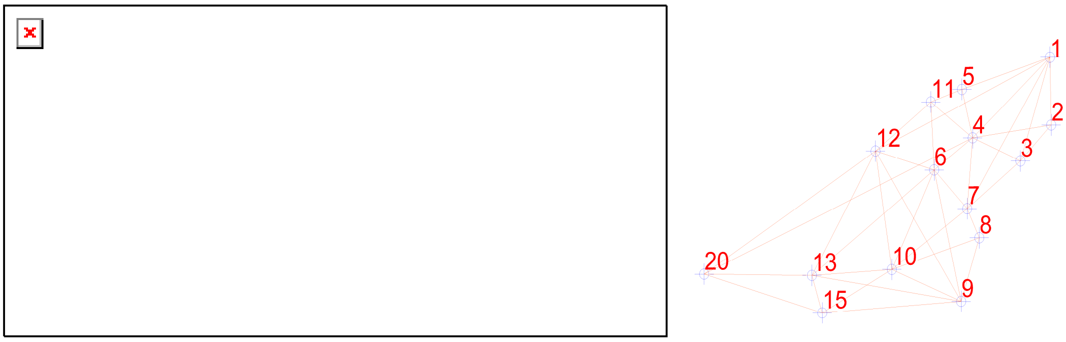

Figure 3. TM of the Banja Luka from 1836 (left) and network on the basis of which was made assessment of the accuracy (right)

Table 3. Parameters of accuracy TM Banja Luka release 1836

Mean squared error by coordinate axis [m]	44.686	42.747
Maximal deviation by coordinate axis [m]	89.549	88.568
Mean square position error [m]	107.005	
Maximal deviation by position [m]	97.096	
Standard deviation of position [m]	37.677	

Topographic map of Banja Luka in 1942 was made on the basis of the classic survey of the Independent Croatian state. For assessing the accuracy of TM Banja Luka from 1942 (Figure 4) was performed digitization and obtained results (Table 4) show that the rendering of the original yielded highly reliable value, which met the requirements of the previous accuracy.

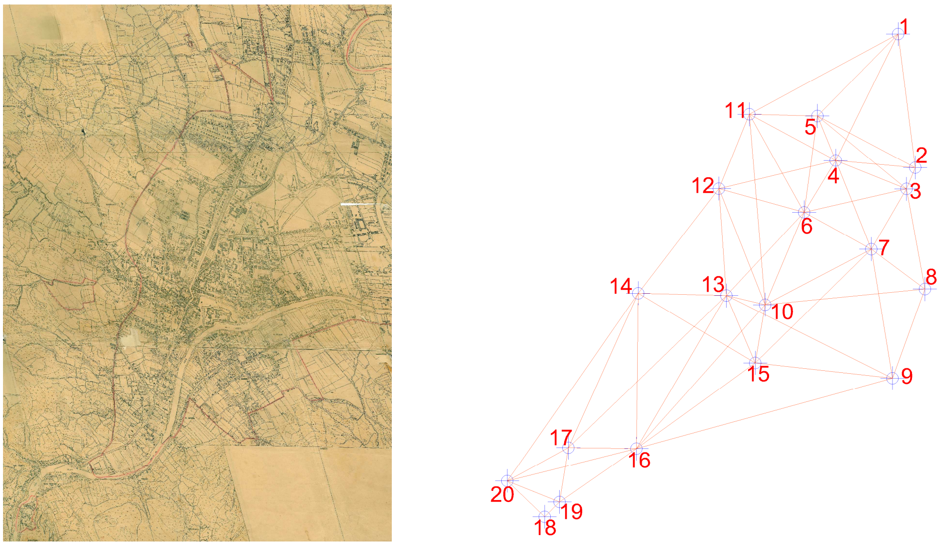

Figure 4. TM of the Banja Luka from 1942 (left) and network on the basis of which was made assessment of the accuracy (right)

Table 4. Parameters of accuracy TM Banja Luka release 1936

Mean squared error by coordinate axis [m]	33.708	17.430
Maximal deviation by coordinate axis [m]	72.964	46.846
Mean square position error [m]	62.585	
Maximal deviation by position [m]	73.426	
Standard deviation of position [m]	21.993	

Topographic map of Banja Luka from 1969 was made on the basis of the classic survey of Socialist Federative Republic of Yugoslavia, held by the Military Geographical Institute (MGI). For assessing the accuracy of TM Banja Luka from 1969 (Figure 5) was performed digitization and the results obtained (Table 5) show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

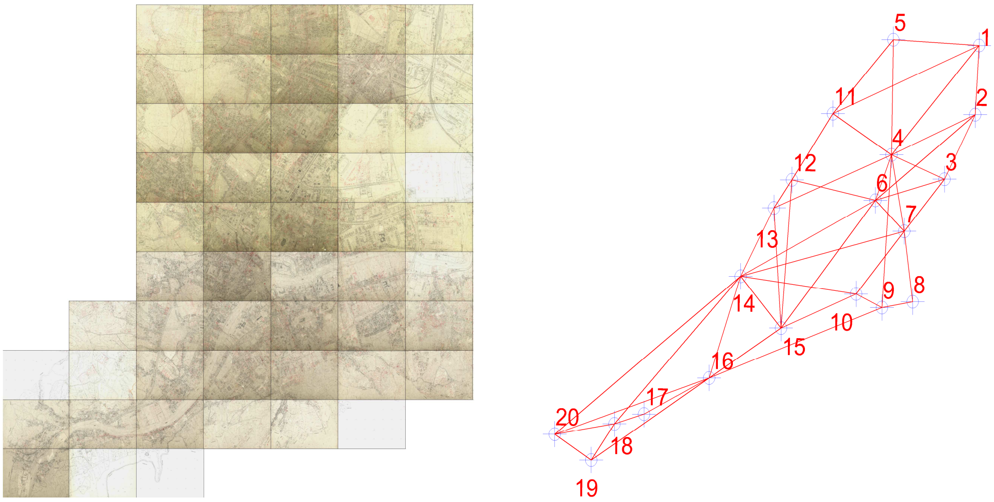

Figure 5. TM of the Banja Luka from 1969 (left) and network on the basis of which was made assessment of the accuracy (right)

Table 5. Parameters of accuracy TM Banja Luka release 1969

Mean squared error by coordinate axis [m]	14.034	8.418
Maximal deviation by coordinate axis [m]	29.808	17.636
Mean square position error [m]	27.478	
Maximal deviation by position [m]	30.590	
Standard deviation of position [m]	8.294	

Topographic map of Banja Luka in 1979 was made on the basis of photogrammetric survey of SFR Yugoslavia, held by MGI. For assessing the accuracy of TM Banja Luka in 1979 (Figure 6) was performed digitization and the results obtained (Table 6) show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

Table 6. Parameters of accuracy TM Banja Luka release 1979

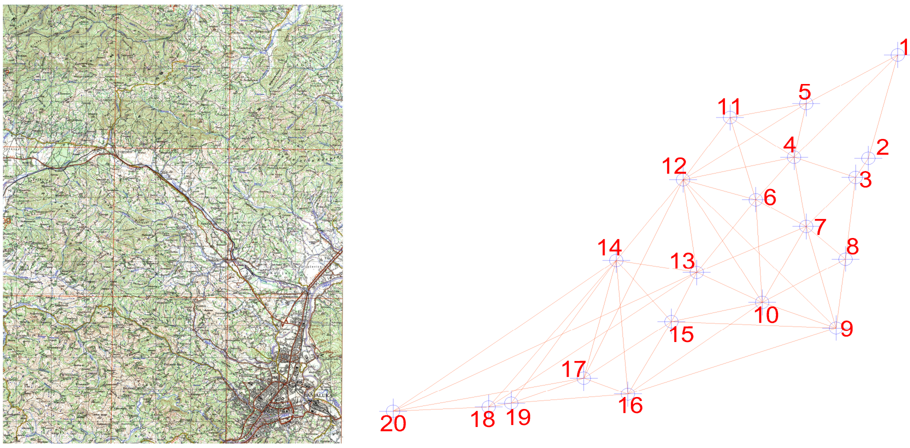

Figure 6. TM of the Banja Luka from 1979 (left) and network on the basis of which was made assessment of the accuracy (right)

Mean squared error by coordinate axis [m]	8.909	8.669
Maximal deviation by coordinate axis [m]	19.856	27.802
Mean square position error [m]	21.512	
Maximal deviation by position [m]	27.896	
Standard deviation of position [m]	6.896	

Topographic map of Banja Luka in 1984 was made on the basis of photogrammetric survey of the SFR Yugoslavia, held by MGI. For assessing the accuracy of TM Banja Luka in 1984 (Figure 7) was performed digitization and the results obtained (Table 7) show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

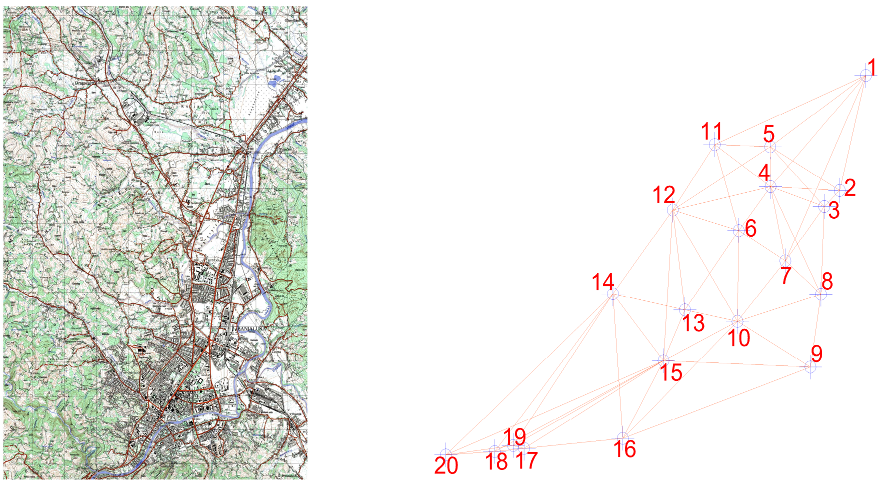

Figure 7. TM of the Banja Luka from 1984 (left) and network on the basis of which was made assessment of the accuracy (right)

Table 7. Parameters of accuracy TM Banja Luka release 1984

Mean squared error by coordinate axis [m]	4.007	3.071
Maximal deviation by coordinate axis [m]	9.297	8.180
Mean square position error [m]	8.662	
Maximal deviation by position [m]	12.383	
Standard deviation of position [m]	3.178	

Digital Topographic map of Banja Luka from 2011 was made by the digitization of analogue original from 1984 (Figure 8) and on this occasion was presented an assessment of the digitized TM Banja Luka, which was conducted by the Department of Geodetic and Property Affairs of the Republic of Srpska. It was carried out digitization and obtained results (Table 8) show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

Table 8. Parameters of accuracy TM Banja Luka release 2011

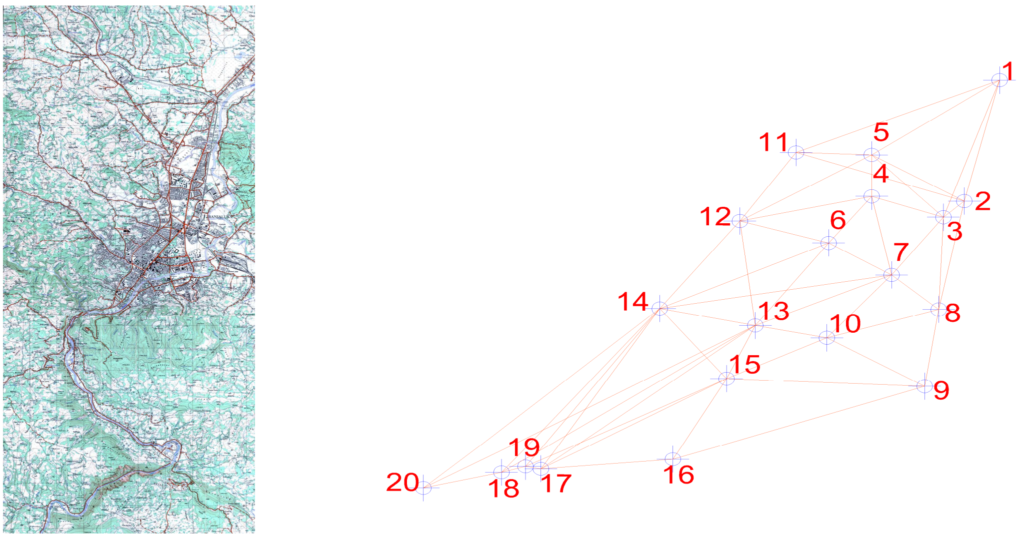

Figure 8. TM of the Banja Luka from 2011 (left) and network on the basis of which was made assessment of the accuracy (right)

Mean squared error by coordinate axis [m]	4.481	3.344
Maximal deviation by coordinate axis [m]	8.416	7.310
Mean square position error [m]	9.576	
Maximal deviation by position [m]	8.536	
Standard deviation of position [m]	2.023	

The results showed that all except the the 1936 meet the requirements of the positional accuracy compared to the pre-defined a'prior values, regardless whether they are determined on the basis of classical or the photogrammetric survey.

8. CONCLUSION

The development of digital technology created the need for formulating new definitions, as well as the basis for expansion and processing of existing and adoption of new standards not only for the quality of maps but also in quality datasets of area (geographic information systems, topographic databases, etc.). Practical evaluation of the accuracy of the position of topographic maps of the city of Banja Luka, in this study included: (1) analyzing the contents of topographic maps, (2) the selection of appropriate control points, (3) modeling the network on the basis of landmarks, (4) statistical evaluation of mathematical models assess accuracy of the position, and (6) a brief interpretation of the results of mathematical modeling accuracy assessment of seven time epochs.

Also, the main objectives of the research include the applicability of the results of mathematical modeling positional accuracy assessment: a) in the geometrical model, b) in the preparation of base additions and updates of the existing content of the topographic maps and the like.

To achieve the set of the objectives, it is necessary to fulfill additional prerequisites and/or conduct research:

- social, economic and legislative support at national and international level (eg. Use of appropriate data neighboring countries, the adoption of appropriate laws, regulations, rules and guidelines);
- inclusion of newer and improved results of geodetic measurements (eg, thickening and maintenance of the geodetic reference basis, the inclusion of the results of the geometric and precise leveling, etc.);
- an aerial survey of the national territory on the basis of which will be made new edition with better accuracy (eg, higher resolution aerial photographs, equal time periods between refills content topographic maps, etc.);
- more frequent analyzes, not only the positional accuracy of topographic maps, but also its other characteristics (eg, semantic, attribute, all for the purpose of obtaining better geospatial data).

With this is achieved that will be made available up to date basis for further work and design in various fields of business activities that require the assessment of the quality of distributed geographical data.

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