ASSESMENT OF POSITIONAL ACCURACY ON HISTORICAL REVIEW OF TOPOGRAPHIC MAPS AND PLANS OF BANJALUKA REGION (BOSNIA AND HERZEGOVINA) OF DIFFERENT EDITIONS

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

Under the positional accuracy it implies the coincidence of the position of a point in a set of geographic information, ie. the model of geospace - map, database, orthophoto and the like, with the actual position of that point in surface. It can be 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 geographic Data, family ISO standard defines only the basic principles and general procedures. American National Standard for the accuracy of spatial data - NSSD refers to digital data both raster and vector graphics

through which will be evaluated raster topographic maps and plans of the city of Banja Luka (Republic of Srpska, Bosnia and Herzegovina).

History of the development of cartography in BiH dates back to the time of the Bosnian kingdom, when the first mention of the name of the place called Banja Luka (1494). The paper presents an unusual approach to the assessment of cartographic publications of Banja Luka, where through this standard was shown the quality of topographic maps of Banja Luka. It was assessed positional accuracy of geographic information on topographic maps and plans in the period of 1881, 1936, 1942, 1969, 1979, 1984 and 2011. On the basis of these studies have established a quality publication in the geographic space where BiH in this time frame has insufficient data and records in contrast to developed European countries, where it was established on the basis of official records of similar publications.

Key words: *Cartography, Standars, NSSDA*

1. INTRODUCTION

For users and publishers of geographical, topographical (TM) and thematic maps of fundamental importance is the knowledge of the data or their accuracy. The possibility of examining and quantifying in the exact way represents a fundamental importance in this field. 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 (Petrović, 2006; Radojčić, 2008; Puceković, 2014). In the geographic space of the Republic of Srpska (Bosnia and Herzegovina-BiH), this type of work is not done for years because of its complexity and non-fulfillment of all the conditions necessary for the realization of such tasks.

When assessing the accuracy of the content of TM, main problem we face is a election of representation 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 represents in a whole. From the foregoing, it can be seen the importance of knowing the quality of geospatial data, because if decisions are based on data whose quality is uncertain or unknown, the consequences can be significant (Peterca et al., 1974). In classical cartography, the notion of quality maps for a long time was considered its accuracy, which is addressed through two main components: geometric (positional) accuracy and precision of general information that provides a map (Petrovic, 2008). Both cases of accuracy is defined as the degree of compliance data downloaded from the list of maps and its 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 the most important are: American The national standard for accuracy maps (National Map Accuracy Standard - NMAS) and American national standard for spatial data accuracy - NSSD. Almost all of the methodology 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 (Siva Kumar, 2000; Ureña, 2011).

2. CARTOGRAPHIC PUBLICATIONS TOPOGRAPHIC PLANS AND MAPS OF BANJALUKA

On the territory of western Republic of Srpska (BiH) first cartographic representations appear with the development of modern civilization, ie. the Roman Empire. Further course of history with changing of rulers on theese territory was made a new publications for the purposes of estate records. Thus, during the reign of Mehmed II, the Ottoman Empire, ordered the creation of cadastral maps of Bosnia in 1475 within which was the area that covers the territory of Banja Luka (Begic, 1998). Development of topographic maps, better quality, in this region of the Balkan Peninsula, is primarily bound in the government-vine Austro-Hungarian Empire with creations of the cartographic publications for the area of the former Military Frontier. The Austro-Hungarian cartographers are one of the most important in presenting this area in the first half of the 19th century. In the period from 1880 to 1884. the Austro-Hungarian survey carried out on the basis of which they made cadastral maps and records. They are made in the scale of 1: 6 250, where the exception was plans of cities and densely populated areas in the scale of 1: 3 125; 1: 781.25, and 1: 562.5. Later development is linked to the cartographic activities of the Serbian military departments of Geography created by the decision of the Chief of Serbian Military Staff in 1876. (Stefanovic, 2003). Unscrewing various historical events in this geographic space came to the creation of cartographic publications for this extremely important geostrategic position.

After the First World War on this region - was established the Kingdom of Serbs, Croats and Slovenes, which in 1928 changed its name to the Kingdom of Yugoslavia. Then was continued work on establishing better records on the basis of the Austro-Hungarian grunt. During the Kingdom of Yugoslavia, within the survey in 1936, was created a new topographic plan of Banja Luka. In 1942, during World War II, was established Independent State of Croatia. They carried out to manufacture a new Topographic plan of Banja Luka, whose amendment was made in 1945. After the Second World War and the creation of the Socialist Federal Republic of Yugoslavia (SFRY), MGI – through their activities special attention is given to the establishment of a new system of records. Since 1953, MGI has conducted a complete survey of the territory of Yugoslavia in the framework of which the first was in 1969 and then in 1977 was made TM of Banja Luka in the scale of 1:25 000. In 2002, BiH has launched the Project Digital topographic maps (DTM) in the scale of 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 TM (Ključanin et al., 2011). DTM of Banja Luka was made in 2011 which is the last official publication of this geospace of which was carried out quality assessments positional accuracy in this work. Test was made on the territory of 17 ° 7'30 '' - 17 ° 15 ' E.G.D. and 44 ° 45'-44 ° 52'30 '' N. G.W. of various editions from 1881 to 2011.

3. STANDARDS FOR ASSESSMENT OF POSITIONAL ACCURACY

In assessing the positional accuracy of geographic information, ISO standards define only the basic principles and general procedures. Users, ISO standards define throught 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.

To define the quality of geographic data is applied ISO 9000 approach where quality is defined 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 standard ISO 19113, ISO 19114 and ISO 19115.

Model data quality should be designed and formulated before 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, it was used for defining quality standards. In BiH, are no approved national standards on quality cards, so they used the following international standards:

1. ISO 19113: 2003 - Quality Principles prescribe principles for describing the quality of geospatial information, as well as concepts for dealing with information about the quality of geospatial information.
2. Standard ISO 19114: 2003 - Quality evaluation procedures, establish a system of evaluation and reporting quality results.
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 applied to system management (Talhofer et al., 2011). In this area, a strong influence on standardization 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) from 1998.

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 unambiguous in the event, which is evaluated in the reference set. Usually these are average point of line facilities (roads, railways, canals, etc.) that intersect at an angle of about 90° such as monuments, religious buildings, lonely trees, 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 leaf TM), assuming that the positional accuracy of the observed area is uniform. According to the criteria 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).

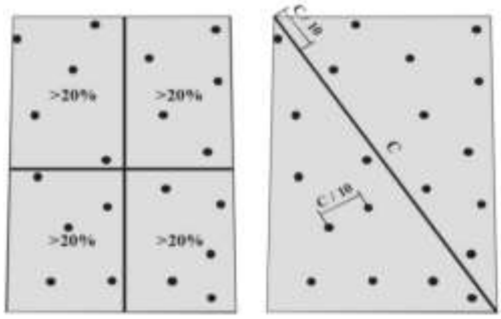

Figure 1. Criteria of point distribution for testing using standard NSSD

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 datum, i.e., the two-dimensional coordinates). Standard NSSD as a starting point uses the 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 communicated accuracy is used 95% confidence level.

Horizontal accuracy by using this standard were tested by comparing the positional coordinates of well-defined points 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 tested, 95% confidence level to a point, exceeds the threshold of given trust to the product specifications. For their needs was determined by the mean squared error position by the coordinate axes:

$$RMSE_y = \sqrt{\frac{1}{n}\sum_1^n dy^2} \qquad and \qquad RMSE_x = \sqrt{\frac{1}{n}\sum_1^n dx^2} \tag{1}$$

where dy and dx are differences between the measured and reference coordinate in the direction of the coordinate axes x and y. Horizontal error in point i is:

$$RMSE_i = \sqrt{dy_i^2 + dx_i^2} \quad (2)$$

Then *RMSE* of the whole sample:

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

If the $RMSEy = RMSEx$ then:

$$RMSE_r = \sqrt{2RMSE_y^2} = \sqrt{2RMSE_x^2} = 1{,}4142RMSE_y = 1{,}4142RMSE_x \quad (4)$$

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:

$$Accuracy_r = 1{,}7308 \cdot RMSE_r \quad (5)$$

In the other side, if the RMSEy ≠ RMSEx then:

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

The obtained information may include: descriptions of the source material from which the data is collected; accuracy of measurement associated with the compilation; procedure of digitization; control equipment and procedures used in the production of quality.

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

4. RESULTS AND DISCUSSION

The survey was completely based on a comparative study of distances and angles of the defined network of control points, elected in places that can be identified within the topographical plans and maps of Banja Luka, made from the 19th century to the present. For easier identification, is determined 20 control points selected on the leaves of TM and plans from 1881, 1936, 1942, 1969, 1979, 1984 and 2011, where the plans and maps are presented in a somewhat poorer spatial resolution due to the size of geospace marked on these issues of TM and plans. The criteria used to define the points are easy to identify:

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

Twenty control points do not appear necessary at all analyzed maps that comparise the core of the city of Banja Luka. The following points on TM have their coordinates obtained through global positioning campaign. They provided approximately equal accuracy of ± 2 cm at each given point. Points are defined in the coordinate system of Gauss-Krüger projection for compatibility purposes of topographic maps. The need to apply scale factor (the average calculated value of 1.00053) of 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 the 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.

Positional accuracy of graphical data on analog TM of larger scale shows that the geometric accuracy of analog topographic maps is almost proportional to reduction area, due to the increased surface print and line width which is a decrease in geometric precision analog TM, at a certain level, as a result of cartographic - reproduction process. Therefore, the mean squared error of the position of geodetic control points used sheets of TM in range from ± 3.8 m to ± 39.5 m. This confirms that the leaves of TM have the correct absolute position within the used projections and no significant increase or decrease, rotation, translation, or cutting down in the surface mapping. Errors contained in data were obtained by digitizing existing maps that contain errors of the original data collection and processing (as surveying and mapping errors), and also transformation errors (scanning, georeferencing, vectorization). Data quality on digital TM depends of the graphics (map) sources, numerical sources (catalogs of geodetic points), the process of analog-to-digital conversion, as well as methods of modeling and data processing.

After scanning and vectorization of TM (analog maps and reproductive originals) in digital form, additional activity was the control and data modeling. For control was used the check of the reference data (geodetic points) according to the available resources. The accuracy of the original source (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:

$$M_1 = \pm\sqrt{mk^2 + am^2} \quad (7)$$

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 of production TM	Mean squared error definitely plotted topographic original [mm]	Previous assessment of accuracy [m]
1881.	180	45
1936.	180	45
1942.	120	30
1969.	60	15

For TM, whose original was made by photogrammetric method has a mean squared error, including an error of photogrammetric original mf = ± 0.15mm, which is calculated as:

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

With regard to the manner of making, the accuracy of such a developed original (TM25 Banja Luka in 1979 and DTM in 2011) has a prior assessment of the accuracy of ± 7.5 m, while the 1984 has a prior assessment of the accuracy of ± 15 m. The analysis was performed only on the exterior accuracy by comparing the linear measure between each point, the value of the angle, 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 of the 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 TM was 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.

Topographic map of Banja Luka edition 1881 (Figure 2a) is the first reproductive original of Banja Luka made on the basis of the Austro-Hungarian geodetic survey. When assessing the accuracy of these

Figure 2. Topographic map of Banja Luka edition 1881 (a), Topographic map of Banja Luka edition 1936 (b)

maps first was performed digitization and reobtained results show that the rendering of the original given a very unreliable value, but which is in accordance with the existing conditions fulfilled the requirements of the previous accuracy.

Topographic map of Banja Luka edition 1936 (Figure 2b) is made on the basis of the first, classic survey of the Kingdom of Yugoslavia. When assessing the accuracy of TM Banja Luka in 1936 first was made the digitization and the results show that the rendering of the original provided very unreliable values, which did not meet the requirement of the previous accuracy.

Topographic map of Banja Luka edition 1942 (Figure 3a) was developed based on the classic survey of the Independent Croatian state. When assessing the accuracy of TM Banja Luka in 1942 first was made the digitization and the results show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

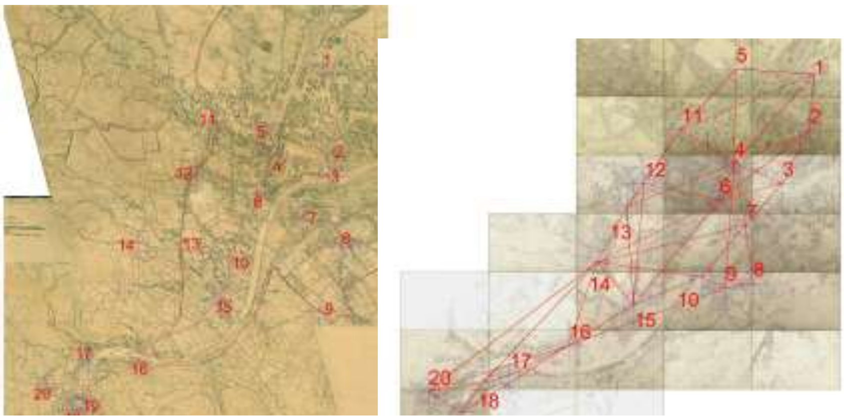

Figure 2. Topographic map of Banja Luka edition 1942 (a), Topographic map of Banja Luka edition 1969 (b)

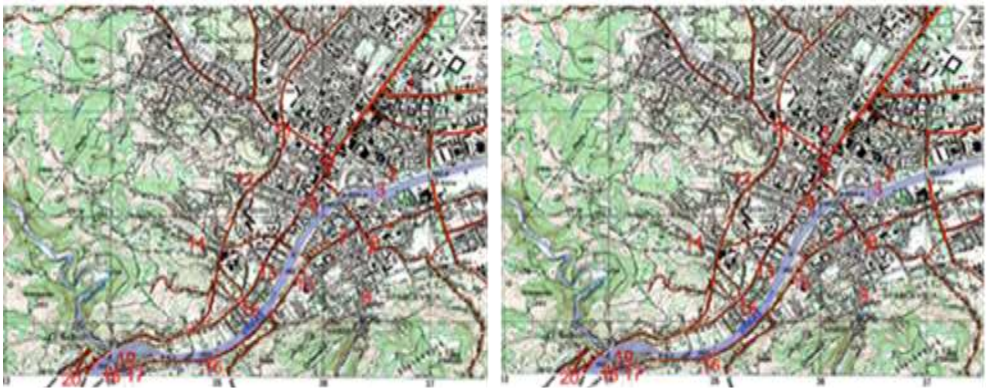

Figure 2. Topographic map of Banja Luka edition 1979 (a), Topographic map of Banja Luka edition 1984 (b)

Topographic map of Banja Luka edition 1969 (Figure 3b) was made on the basis of the classical survey SFR Yugoslavia, which was held by the Military Geographical Institute (Belgrade). When assessing the accuracy of TM Banja Luka from 1969 first was made the digitization and the results show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

Topographic map of Banja Luka edition 1979 (Figure 4a) is made on the basis of photogrammetric survey SFR Yugoslavia, held by MGI. When assessing the accuracy of TM Banja Luka in 1979 first was made the digitization and the results show that the rendering of the original yielded highly reliable value, which met the requirements of the previous accuracy.

Topographic map of Banja Luka edition 1984 (Figure 4b) is made on the basis of photogrammetric survey SFR Yugoslavia, held by MGI. When assessing the accuracy of TM Banja Luka in 1984 first was made

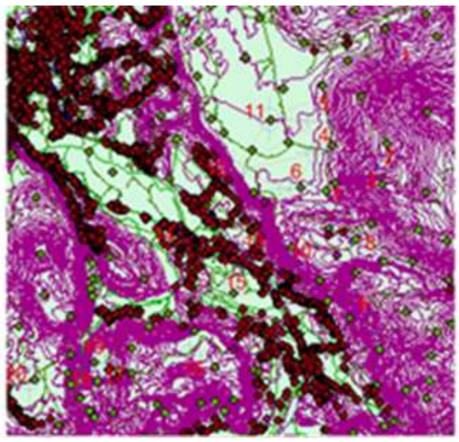

Figure 4. TM Banja Luka edition 2011

the digitization and the results show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy.

Digital Topographic map of Banja Luka edition 2011 was made by the digitization of analog originals from 1984 (Figure 5), and on this occasion was presented an assessment of the digitized TM Banja Luka performed by the Republican administration of Geodetic and Property Affairs of the Republic of Serpska. The results show that the rendering of the original provided very reliable value, which met the requirements of the previous accuracy. Table 2 presents the results of evaluation Topographic maps of Banja Luka different editions of the same proportional series.

Table 1. Results of accuracy of TM Banja Luka of different editions

EPOCH	Mean square error by the coordinate axes [m]		Maximal deviation by coordinate axis [m]		Mean square error of the position [m]	Maximal deviation by position [m]	Standard deviation of position [m]
1881	35.202	37.678	82.872	67.022	89.195	87.585	24.612
1936	44.686	42.747	89.549	88.568	107.005	97.096	37.678
1942	33.708	17.430	72.964	46.846	62.585	73.426	21.993
1969	14.034	8.418	29.808	17.636	27.478	30.590	8.294
1979	8.909	8.669	19.856	27.802	21.512	27.896	6.896
1984	4.007	3.071	9.297	8.180	8.662	12.383	3.178
2011	4.481	3.344	8.416	7.310	9.576	8.536	2.023

5. 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 in the field of quality chart production but also in the field of quality sets of spatial data (GIS, topographic databases, etc.). Practical evaluation of the accuracy of the position of topographical plans and TM 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) a 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 epochs of time (period).

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 existing content TM and the like.

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

- social, economic and legislative support at national, regional 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 and satellite imagery, equal time periods between refills content TM, etc.);
- more frequent analyzes not only the positional accuracy of TM but also its other characteristics (eg, semantic, attribute, all for the purpose of obtaining better geospatial data).

This results in a timely, accessible, up to date basis for further work and design in various areas of economic activity that is required and assessed the quality of distributed geoporostornih data.

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