ANALIZA KAKOVOSTI PODATKOV CESTNE INFRASTRUKTURE KOT DELA CENTRALNE GEOPROSTORSKE PODATKOVNE ZBIRKE

CENTRAL GEOSPATIAL DATABASE ANALYSIS OF THE QUALITY OF ROAD INFRASTRUCTURE DATA

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IZVLEČEK

V članku je opisan osnovni logični podatkovni model centralne baze podatkov (CGB). Model je uporabljen pri podatkovni strukturi listov digitalne topografske karte največjega merila – 1 : 25.000, ki so bili izdelani v Vojaškem geografskem inštitutu v Beogradu v Srbiji. Analiza kakovosti cestne infrastrukture v CGB je bila izdelana po standardu ISO 19157, kar je vodilo do nivojskega razvrščanja elementov in podelementov kakovosti, ki so bili analizirani ločeno. Standard ISO 19157 določa postopek ocenjevanja kakovosti, ki prikazuje rezultate analize za vsak element.

ABSTRACT

This paper describes the basic logical data model from the central geospatial database (CGD) which is applicable to the structure of a digital topographic map of the largest scale – 1:25,000 made in the Military Geographical Institute (MGI), Belgrade, Serbia. CGD analysis of the road infrastructure quality, done according to the ISO 19157 standard, led to a layering of elements and sub-elements of quality which were analysed separately. ISO 19157 standard defines a procedure of quality assessment which depicts the results of the analysis for each element.

KLJUČNE BESEDE

baza prostorskih podatkov, digitalna topografska karta, cestna infrastruktura, kakovost podatkov

KEY WORDS

Geospatial database, digital topographic map, road infrastructure, data quality

1 INTRODUCTION

Spatial data represent a “reality model”, a coherent and generalized display of a complex reality. Each map or database is thus a model with a certain intent which contains a number of generalized elements which are simplified, grouped or eliminated, all for the purpose of a clearer presentation and stimulation of the communication process through information. Having an understanding of the data and its accuracy is of crucial importance both for the users and the publishers of geographic, topographic and thematic maps. Their ability to be tested and quantified precisely is of crucial importance in this field of work. Modern topographic cartography led to the established conventional solutions and standards in content display of topographic maps (TM) which raised their utility value in the country and worldwide (Petrovič, 2006; Zhang et al., 2013; Amović et al., 2015). By following the development of standards in the process of collecting, organizing, processing and presenting of spatial data in the Military Geographic Institute (MGI), spatial data are organized in the central geospatial database (CGD). The main purpose of CGD is to be the basis for generating the whole scale series of digital topographic maps which are made in the MGI. The main part of the CGD content represents spatial data that define the digital topographic map at a scale of 1:25,000. By using methods of cartographic generalization we produce whole scale series of digital topographic maps. Topographic maps have a great advantage over some other collections of spatial data because of their visual effects, conciseness and the simplicity of use and that is why the demands for a developed system of elaboration, assessment and reporting procedures of their quality are completely justified (Božić et al., 2011; Radojčić et al., 2011).

Road infrastructure represents a thematic layer of the central geospatial database. It is significant regarding the aspects of usage of different network analyses like: the establishment of the shortest route between certain locations, navigation in traffic, tracking the transport of goods, services and the population. In countries with a developed and stable economy, a clearly articulated road network data is usually established on the basis of updated topographic data and with the usage of updated and high quality spatial data and modern topographic technology. In less developed countries, there is an alternative and more financially acceptable strategy which is used for years for updating road network data by using the existing topographic maps, satellite images and other sources of spatial data which are available. (Siva Kumar, 2000; Ozah et al., 2008).

Because of all the above mentioned, the main goal of this research is to analyse the quality of this thematic layer of CGD in accordance with ISO 19157 standard and to present the results of the analysis.

The central geospatial database represents the basic topographic database in MGI. By using procedures of cartographic generalization and map design of CGD we produce whole scale series of digital topographic maps. Because of the mentioned, the main purpose of CGD is military and civilian mapping, various GIS analyses, navigation. The possibility of assessment and presentation of road infrastructure quality of CGD is in question. Due to diverse needs of users, the most frequent questions we encounter during the analysis of the road infrastructure quality are (Shekhar et al., 2002; Fisher et al., 2006, Goodchild et al., 2006):

- Does the thematic layer contain all the elements of the database defined by the physical data model?
- What is the value of road infrastructure positional accuracy for the needs of navigation?

- Are all elements of thematic layer connected well enough to enable network analyses?
- Are there any other geometries and irregular junctions?
- When were the data collected and when were they updated?

Several contributions were made for the needs of the research. An advanced conceptual frame for analysing the road infrastructure quality of CGD, which contains clear methodological and technological wholes, has been proposed. The methodological part forms an empirical frame for a selected set of limitations of a coherent evaluation of geospatial data, readability, keeping, entity level, specific/relational limitations, individual and group limitations, characteristics of classes composed of "enrichment", finding and date evaluation. In the implementation phase, the focus is on the evaluation of characteristics of classes which define the road infrastructure in CGD on the basis of this theory.

2 CENTRAL GEOSPATIAL DATABASE, DATA MODEL AND A DEPICTION OF THEMATIC LAYER OF ROAD INFRASTRUCTURE

The technological process of CGD creation is based on the mapping of the topographic map content by using methods of digital photogrammetric restoration, direct mapping from modern photogrammetric base maps such as orthophoto and its cartographic processing in CGD by using various alphanumeric data and the data acquired on the field. The process of vectorization is realized with a strict respect of a logical data model, bearing in mind possibilities and the work mode in the chosen software environment.

SQL database and the software platform of the American firm ESRI, ArcGIS, which contains an entirely new approach in the process of creation of geospatial databases are chosen for the creation of the CGD. The selection of this software platform requires a completely new technology in all phases of work, but the existing cartographic solutions remain. With the consideration of these needs, the process of CGD creation encompasses the following phases (Sekulović et al., 2011):

- Creation of a logical data model,
- Creation of a physical data model,
- Creation of a model and generalization procedures,
- Creation of symbols,
- Quality analysis.

In the process of creation of the logical data model of CGD specific geographical elements of TM are divided into thematic units. Particular cases of each of the content elements are defined by the system of layers and codes as unique indicators of belonging to the corresponding thematic unit, which is a closely defined specification of a particular class of objects. The main logical data model corresponds to the structure of a digital topographic map (DTM) of the largest scale 1:25,000 made in the Military Geographical Institute – Belgrade.

Physical data model defines the appearance of the database, i.e., „the space" for the storage of data defined by the logical data model. Types of data, the way of storing as well as all the columns in which attributes of classes and specific objects are written are also defined in the process of creation of the physical data model (Table 1).

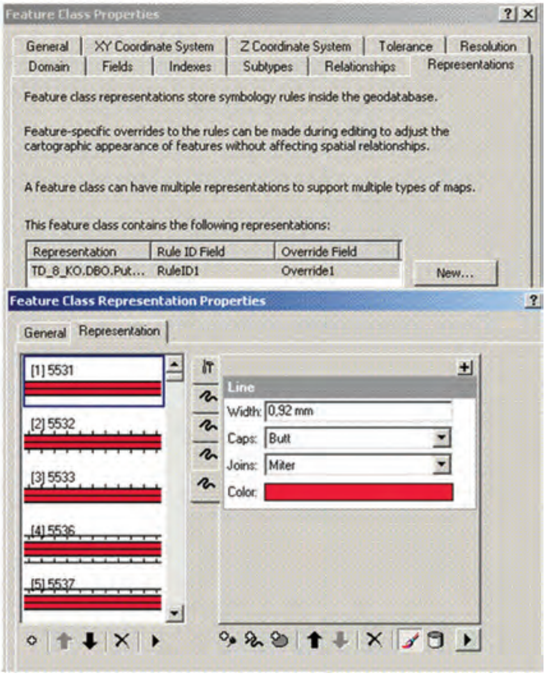
Table 1: Physical data model of the thematic layer – Roads.

DTK25.DBO.Putevi

Alias	Putevi	**Geometry:**Polyline
Dataset Type	FeatureClass	**Average Number of Points:**0
		Has M: No
FeatureType	Simple	**Has Z:**Yes
		Grid Size:-6

Field Name	**Alias Name**	**Model Name**	**Type**	**Precn.**	**Scale**	**Length**	**Null**
OBJECTID	OBJECTID	OBJECTID	OID	10	0	4	No
SIFRA_txt	SIFRA_txt	SIFRA_txt	String	0	0	4	Yes
LAYER	LAYER	LAYER	Integer	10	0	4	Yes
SIFRA	SIFRA	SIFRA	Integer	10	0	4	Yes
NAZIV	NAZIV	NAZIV	String	0	0	50	Yes
VISINA	VISINA	VISINA	Double	38	8	8	Yes
OZNAKA	OZNAKA	OZNAKA	String	0	0	10	Yes
NAPOMENA	NAPOMENA	NAPOMENA	String	0	0	255	Yes
VEZA_1	VEZA_1	VEZA_1	String	0	0	50	Yes
VEZA_2	VEZA_2	VEZA_2	Integer	10	0	4	Yes
VEZA_3	VEZA_3	VEZA_3	Double	38	8	8	Yes
VEZA_4	VEZA_4	VEZA_4	Blob	0	0	0	Yes
DATUM	DATUM	DATUM	Date	0	0	36	Yes
NAZIV_ ELEMENTA	NAZIV_ ELEMENTA	NAZIV_ ELEMENTA	String	0	0	255	Yes
VISINA_OBJEKTA	VISINA_OBJEKTA	VISINA_OBJEKTA	Double	38	8	8	Yes
ANOTACIJA_1	ANOTACIJA_1	ANOTACIJA_1	Double	38	8	8	Yes
ANOTACIJA_2	ANOTACIJA_2	ANOTACIJA_2	Double	38	8	8	Yes
ANOTACIJA	ANOTACIJA	ANOTACIJA	String	0	0	50	Yes
ZNACAJ	ZNACAJ	ZNACAJ	String	0	0	50	Yes
TIP_ZASTORA	TIP_ZASTORA	TIP_ZASTORA	String	0	0	50	Yes
GlobalID	GlobalID	GlobalID	Global ID	0	0	38	No
RuleID	RuleID	RuleID	Integer	10	0	4	Yes
Override	Override	Override	Blob	0	0	0	Yes
BSP_PUTA	BSP_PUTA	BSP_PUTA	String	0	0	10	Yes
SHAPE	SHAPE	SHAPE	Geometry	0	0	4	Yes
FOTO	FOTO	FOTO	Raster	0	0	4	Yes
SHAPE.STLength()	SHAPE.STLength()	SHAPE.STLength()	Double	0	0	0	No

Physical data model precedes the hierarchical model and in a wider sense it defines the database domain, the coordinate system, i.e. a place for storing the main graphical elements, their attributes and the default relations (relationship class) among the complex (groups of classes of objects) and simple (classes of objects) elements that are closely defined. Default relations are automatically generated in the database and as a result the obtained themes are derived from the basic classes of objects. This can be explained on the example of conversion of labels into annotations where a new class of objects is automatically created. (e.g. "*RoadsAnno*" from the class of objects "Roads"). Default relations enable changes in the basic classes of objects to be automatically carried out in the derived classes of objects as well ("*RoadsAnno*"). The derived classes are physically present only in the database because their basic, essential parameters are either obtained from the default classes of objects or predefined by the software (Figure 1).



Feature class representations store symbology rules inside the geodatabase.

Feature-specific overrides to the rules can be made during editing to adjust the cartographic appearance of features without affecting spatial relationships.

A feature class can have multiple representations to support multiple types of maps.

This feature class contains the following representations:

Representation	Rule ID Field	Override Field
TD_8_KO.DBO.Put...	RuleID1	Override1

Width: 0,92 mm
Caps: Butt
Joins: Miter
Color: 🟥

Figure 1: A picture of the representation of road infrastructure thematic layer.

The definition of the appearance of CGD is a type of a physical data modelling where in the interface of the used software the sequence of the themes display is defined, i.e., the visual display of CGD is defined on a level that cannot be achieved through symbols. This phase represents the last step in the creation of CGD concerning the practical creation.

3 THE TEST EXAMPLE AND THE USED DATA

The test area, which is analysed in this work, encompasses the road infrastructure thematic layer of a part of CGD of the Military Geographical Institute in the period of the testing shown on the Figure 2. A total number of 317,877 spatial objects analysed in the thematic layer of road infrastructure are shown in the Table 2. This includes a total of 4198 of point objects (labelled as "Objects on communication 1"), 259,991 of line objects (labelled as "Objects on communication 2"), 97 polygon objects (labelled as "Objects on communication 3") and a total of 53,591 objects with names presented in a form of annotations, geographical names related to roads. The marked rectangles on Figure 2 represent the tested sheets of digital topographic maps at scale 1:25,000, as part of CGD.

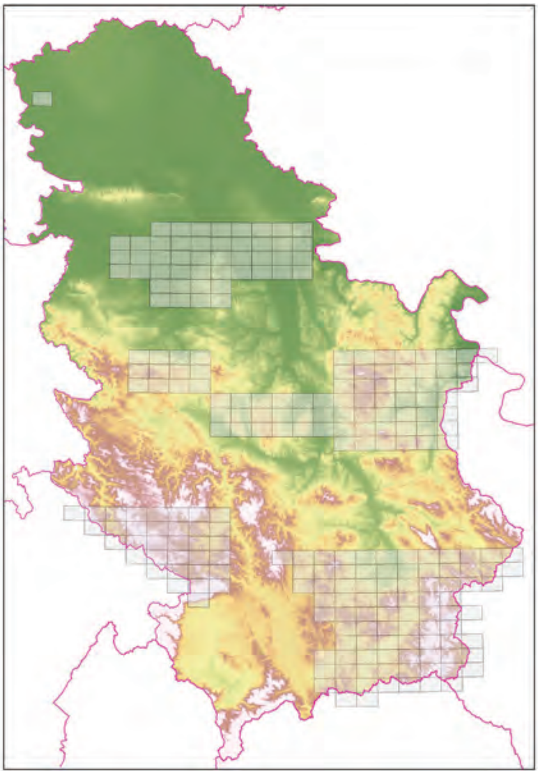


Figure 2: Test example for the evaluation of the road infrastructure quality.

Table 2: The number of analysed spatial objects.

Number	Thematic layer title	Total Number of elements	Thematic layer of corresponding annotations	Total number of annotations
1.	Objects on communication 1	4198	Objects on comm._1_Anno	1105
2.	Objects on communication 2	511	Objects on comm._2_Anno	264
3.	Roads	259,480	Roads_Anno	52,171
4.	Objects on communication 3	97	Objects on comm._3_Anno	51

4 ANALYISIS OF THE ROAD INFRASTRUCTURE QUALITY ACCORDING TO ISO QUALITY ELEMENTS

We performed the analysis of the road infrastructure by using the classification of elements and subelements of spatial data quality defined by the ISO 19157 standard for the specified test area. According to ISO 19157 standard, the quality of spatial data is defined by a quantitative model through 5 elements: completeness, logical consistency, positional accuracy, time and thematic accuracy. Each element of quality is individually analysed and assessed (Drobnjak, et al., 2014; Talhofer, et al., 2011). The assessment procedure of road infrastructure data quality is carried out in accordance with the defined ISO 19157 standard procedure with steps displayed on Figure 3. (ISO 19157, 2011).

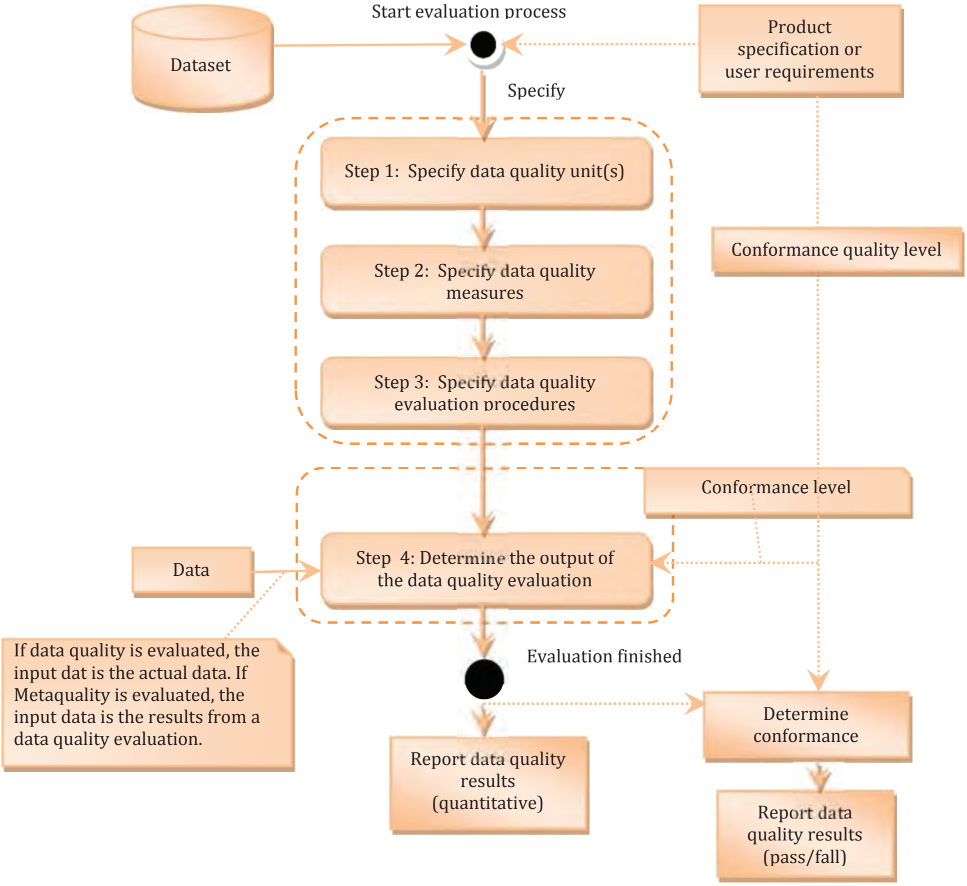


Figure 3: The procedure of quality assessment according to ISO 19157.

4.1 Completeness

Completeness is an element of quality which describes the relationship between the spatial objects present in the data collection and objects which represent the abstractions of the modern world. It is usually described as the presence or the absence of spatial data, their attributes or relations. This is why completeness contains two main sub-elements: omission and commission of data (Servigne et al., 2006; Petrovič, 2006).

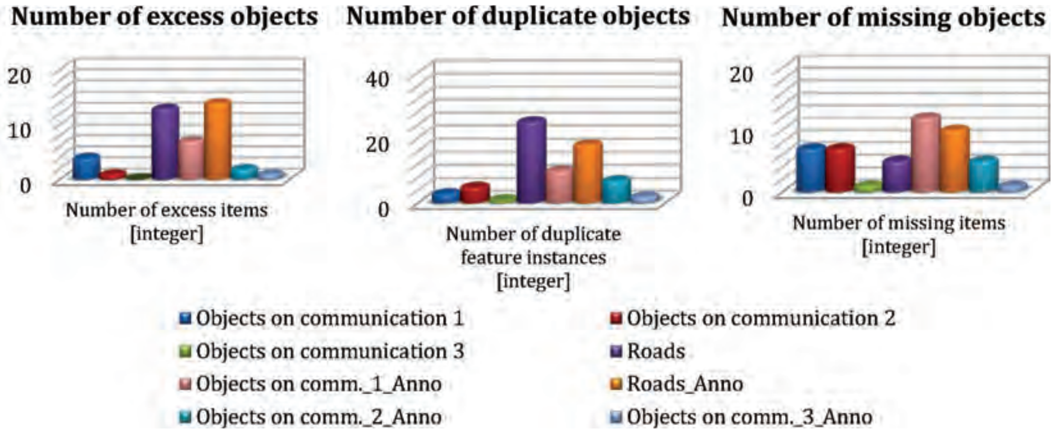
Quality measurements for completeness which were analysed in this work are: the number of objects, the number of doubled objects and the number of missing objects of the road infrastructure, their attributes and relations. Physical data model defines the direct listing of annotations of height or depth (in meters) of banks and cuts if they are encountered on the road section, the foundation width, i.e. road width, as well as the base type of the road infrastructure (Figure 4). When it comes to bridges, additional data is listed concerning the construction material of the bridge, its transport capacity (in tonnes) and width of the bridge (in meters). In the process of making of the DTM within the CGD it happens that the restorers make mistakes and accidentally erase annotations while attributes remain in the attribute field and that is how we encounter an excess of attributes with regard to their relation which represents annotation.

Figure 4: Defined annotations on the road infrastructure.

The assessment of the excess, doubled or missing objects is realized by an internal method of quality assessment of CGD spatial data, by using ArcGis Data Reviewer extension. This extension contains tools which were used for the analysis of the total number of excess, doubled and missing objects and their relations and those are: the tool for the number of excess and missing elements (Table to Table Check) and the tools for the double geometry analysis (Duplicate Geometry Check). Table 3 shows the results of the quality analysis for completeness of the road infrastructure while the diagram (Graph 1) gives a graphical depiction of the total number of excess, doubled and missing objects in relation to the number of listed annotations for the test area.

Table 3: Analysis of the road infrastructure completeness.

Dataset layer	Total number of objects in universe of discourse	Data Quality Measure (data type value)				
		Number of excess items (integer)	Rate of excess items (%)	Number of duplicate feature instances (integer)	Number of missing items (integer)	Rate of missing items (%)
COMMUNICATION						
Objects on communication 1	4198	4	0.10	3	7	0.17
Objects on communication 2	511	1	0.20	5	7	1.37
Objects on communication 3	97	0	0.00	1	1	1.03
Roads	259,480	13	0.01	25	5	0.00
Objects on comm._1_Anno	1105	7	0.63	10	12	1.09
Roads_Anno	52,171	14	0.03	18	10	0.02
Objects on comm._2_Anno	264	2	0.76	7	5	1.89
Objects on comm._3_Anno	51	1	1.96	2	1	1.96
Σ	**317,877**	**42**		**71**	**48**	



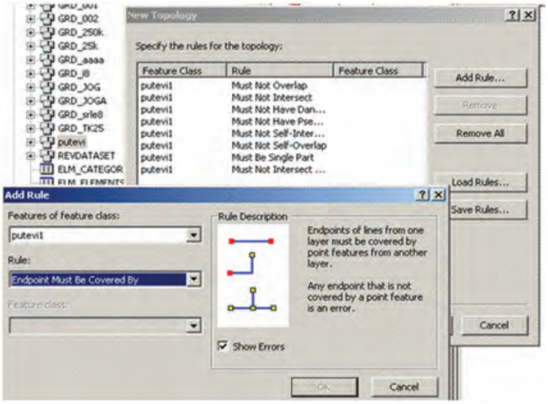
Graph 1: Analysis of the road infrastructure completeness.

4.2 Logical consistency

Logical consistency represents the degree of the data structure compatibility, its attributes and relations with logical rules. The mentioned structure can be conceptual, logical and physical. So the data collection is consistent on a logical level if it follows the structural characteristics of the selected data model and if it is consistent with the attributes and relations defined for that data (Devillers et al., 2006).

Sub-elements of logical consistency are:

- Conceptual consistency (consistency with the rules of conceptual scheme),
- Domain consistency (consistency of data values with the allowed values),
- Topological consistency (correctness of the explicitly encoded topological characteristics of a dataset),
- Format consistency (the degree of data compatibility with the physical data structure).



Specify the rules for the topology:

Feature Class	Rule	Feature Class
putevi1	Must Not Overlap	
putevi1	Must Not Intersect	
putevi1	Must Not Have Dan...	
putevi1	Must Not Have Pse...	
putevi1	Must Not Self-Inter...	
putevi1	Must Not Self-Overlap	
putevi1	Must Be Single Part	
putevi1	Must Not Intersect ...	

Features of feature class: putevi1

Rule: Endpoint Must Be Covered By

Feature class:

Endpoints of lines from one layer must be covered by point features from another layer.

Any endpoint that is not covered by a point feature is an error.

☑ Show Errors

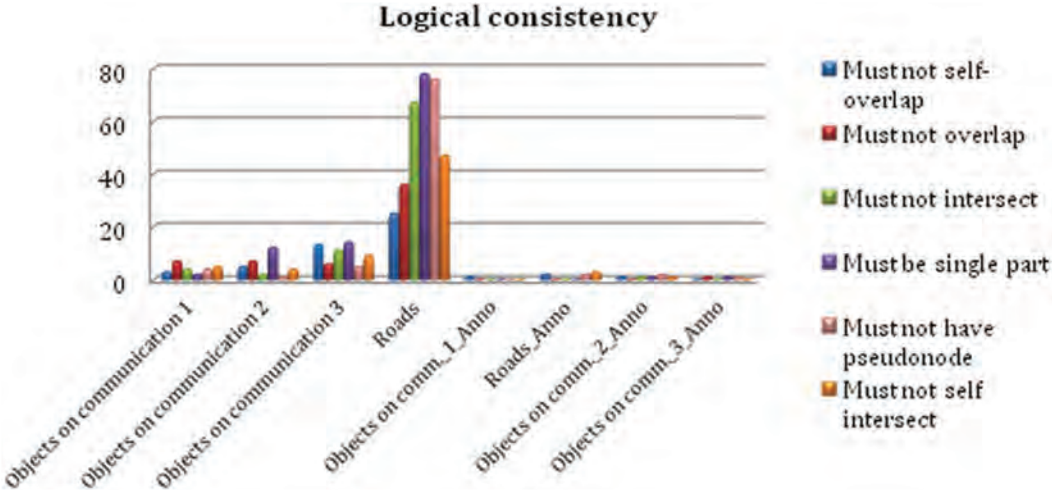
Figure 5: An example of logical consistency – verification of topological rules

Conceptual consistency, domain and format consistency are the three sub-elements of logical consistency quality which define the integrity of a spatial database. If errors occur in any of the mentioned sub-elements they have to be immediately removed because they diminish the integrity of the spatial database and can completely disable any work with spatial data from the database. Topological consistency is analysed with the usage of topological rules. Those rules are depicted in Figure 5.

An internal, direct and complete method of quality assessment, done with Topology checks tool and *ArcGis* software extension – *DataReviewer*, was used for the analysis of quality of elements concerning logical consistency. The results are depicted on Table 4 and on the diagram on graph 2.

Table 4: Analysis of the road infrastructure logical consistency.

Dataset layer	Total number of objects in universe of discourse	Data Quality Measure (data type value)					
		Must not have pseudonode (integer)	Must not selfintersect (integer)	Must not selfoverlap (integer)	Must not overlap (integer)	Must not intersect (integer)	Must be single part (integer)
COMMUNICATION							
Objects on communication 1	4,198	4	5	3	7	4	2
Objects on communication 2	511	1	4	5	7	2	12
Objects on communication 3	97	5	9	13	6	11	14
Roads	259,480	76	47	25	36	67	78
Objects on comm._1_Anno	1,105	0	0	1	0	0	0
Roads_Anno	52,171	2	3	2	0	0	0
Objects on comm._2_Anno	264	2	1	1	0	1	1
Objects on comm._3_Anno	51	1	0	0	1	0	1
Σ	**317,877**	**91**	**69**	**50**	**57**	**85**	**108**



Graph 2: Analysis of the road infrastructure logical consistency

During the analysis of road infrastructure logical consistency, a total number of 317,877 elements were analysed. By means of topological rules a total of 460 errors were found and they were automatically removed so that the thematic layer of road infrastructure could be used in other analyses. The relation between the number of analysed elements and the obtained topological errors showed a logical consistency of 99.86%.

4.3 Positional accuracy

Knowledge of positional accuracy is of fundamental value both for the user of the map and for the producer. Unlike other spatial data elements of quality, spatial accuracy consisting of a horizontal (planimetric) and height accuracy can be completely tested and accurately quantified. The testing of the spatial accuracy is done by comparing the specific points determined by reading the map with referent, far more accurate, coordinates of the same points obtained by land survey or retrieved from other accurate sources. The main problem for the process of assessing spatial accuracy is the choice of measurements (i.e. the unit for measurement and assessment of accuracy) as well as the appropriate set of points which represent a certain sheet of topographic map and sheets that represent a whole map. (Drummond et al., 1995; Ozah et al., 2008; Govedarica et al., 2011; Amović et al., 2015).

In this analysis we used *ArcGis* software tool called PAAT (Positional accuracy assessment tool). While assessing the spatial accuracy this tool uses a starting point marked as a RMSE (Root Mean Squared Error). Error in RMSE is the second root mean value of the total number of square differences between the coordinates read from the map and the appropriate referent ("*true*") coordinates. Absolute horizontal accuracy represents an uncertainty of two dimensional positions (in relations to a horizontal datum) and is expressed in error tolerance range within the 90, 95 to 99% confidence level. Accuracy is expressed in the same units as those expressing coordinates in nature (meter) thus enabling the direct comparison of different products, regardless of differences in scale or resolution. PAAT tool can analyse both horizontal and vertical components of positional accuracy. This paper only analyses the horizontal positional accuracy which is why the road infrastructure data is mapped with 2D base, digital orthophoto (ESRI, 2012). Relative horizontal accuracy represents uncertainty in difference of crossroad positions and the corresponding points collected from the referent base of digital orthophoto and it is expressed in error tolerance range within 90, 95 to 99% confidence level. The horizontal accuracy of the digital orthophoto was known and its maximum value is 0.8 m. For the tested example a total number of 6,000 characteristic points with clearly seen crossroads of different road categories was analysed and this can be seen on Figure 6.

Figure 6: An example of logical consistency – verification of topological rules.

PAAT tool requires that the mean square errors should be computed by y and x axis accordingly (1):

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

Where:

$dy_i = (y_{map} - y_{reference})_i$ is the difference of coordinates by axis y,
$dx_i = (x_{map} - x_{reference})_i$ is the difference of coordinates by axis x,
(y_{map}, x_{map}) are point coordinates measured on the map,
$(y_{reference}, x_{reference})$ are referent point coordinates ("true").

Then the equation for the root mean square error of horizontal position of point *i* is (2):

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

and the mean value of root mean square error of the horizontal position of the selected sample is (3):

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

PAAT has the ability of the automatic testing and elimination of gross errors. A testing statistic called 3σ threshold is used for this. If a specific positional error is greater than the value of 3σ, the program eliminates it, leaving the possibility to keep these points if we wish to do that (ESRI, 2012).

In the procedure of quality assessment of positional accuracy, we used PAAT tool. The type of value used is RMSE while the unit of quality value is meter (m). While analysing horizontal positional accuracy we obtained the following results:

- Absolute horizontal circular error with 90% confidence level is 4.69 m, relative horizontal circular error is 5.34 m, root mean square error in the range with 90% confidence level is 3.82 m while the standard deviation is 1.83.
- Absolute horizontal circular error in the error range with 95% confidence level is 5.02 m, relative horizontal circular error is 5.87 m, root mean square error is 3.82 m while the standard deviation is 1.83.
- Absolute horizontal circular error in the error range with 99% confidence level is 5.25 m, relative horizontal circular error is 6.71 m, root mean square error is 3.82 m while standard deviation is 1.83.

4.4 Thematic (semantic) accuracy

Thematic accuracy represents a degree of consistency between quantitative attributes and the correctness of non-quantitative attributes, classification of objects and their relations. Sub-elements of thematic accuracy are (Harding, 2006):

- Correctness of classification – comparison of classes assigned to objects or their attributes with the area of analysis;
- Correctness of qualitative attributes;
- Accuracy of quantitative attribute values.

Figure 7 shows an example of error done in thematic accuracy analysis. The shown error refers to a road being classified as a gravel road while the referent data of importance classified the road as a modern roadway (asphalt road).

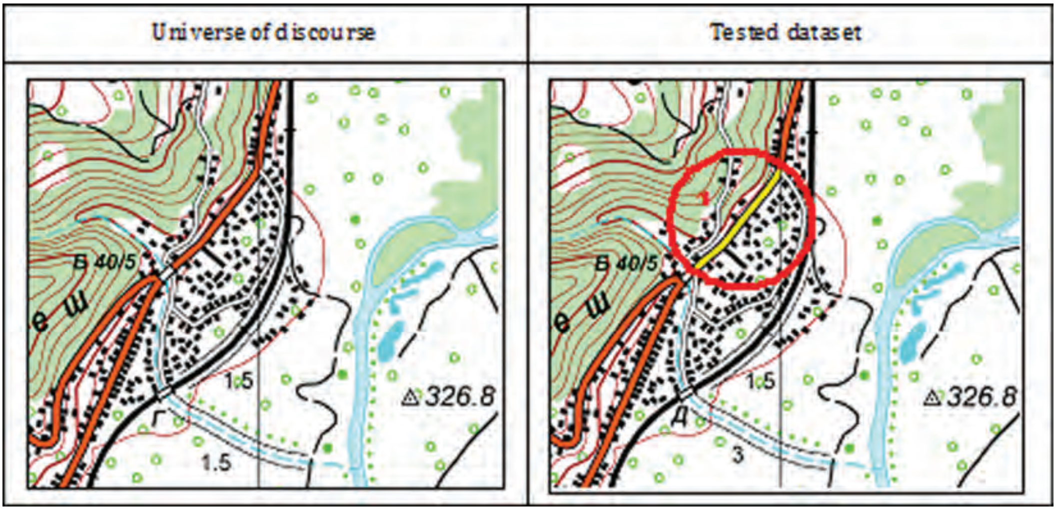


Figure 7: Analysis of thematic accuracy (asphalted – left, gravel road – right).

The process of acquisition of thematic accuracy is sometimes similar to logical consistency if we consider the difference in conceptual modelling transformed to the attribute of class and vice versa.

Similar to that, positional accuracy becomes a type of semantic accuracy when we treat the object location as a specific entity attribute.

What is identified and used in assessment of thematic accuracy is the misclassification matrix which is a quadrant matrix with *n* columns and *n* lines where *n* marks the number of classes discussed:

$$MCM\,(i,j) = (\#\ \text{class objects}\ (i)\ \text{classified as class}\ (j)) \tag{4}$$

Its diagonal elements contain wrongly classified objects in the frame of one theme while non-diagonal elements contain number of errors of wrong classification where spatial objects are wrongly classified. Misclassification matrix of spatial objects represents one of the quantitative results of DTM thematic accuracy quality assessment. It is depicted in Table 5.

With the usage of misclassification matrix, we get a coefficient of kappa statistics which is a good indicator of the choice of classification method consistency taking their randomness into account. Kappa coefficient (κ) represents a coefficient which expresses a degree of compatibility between assigned classes by removing the misclassification and it is calculated based on the following formula (ISO 19157, 2011):

$$\kappa = \frac{N\cdot\sum_{i=1}^{r} MCM(i,j) - \sum_{i=1}^{r}\left(\sum_{j=1}^{r} MCM(i,j)\cdot\sum_{j=1}^{r} MCM(j,i)\right)}{N^{2}\cdot\sum_{i=1}^{r}\left(\sum_{j=1}^{r} MCM(i,j)\cdot\sum_{j=1}^{r} MCM(j,i)\right)} \tag{5}$$

The high value of kappa coefficient ($\kappa = 0.9466$) shows that the method of classification is good and highly efficient.

Table 5: Misclassification Matrix of thematic road layer.

Universe of discourse	**Spatial Dataset**							
	Highway	**Semi-highway**	**Modern road**	**Modernized roadway**	**Gravel road**	**Better vehicular road**	**Vehicular road**	**Poorer vehicular road**
Highway	12	0	0	0	0	0	0	0
Semi-highway	0	32	2	7	0	12	0	0
Modern road	0	2	45	3	0	6	0	0
Modernized roadway	0	1	0	14	0	2	0	0
Gravel road	0	0	0	0	85	2	0	0
Better vehicular road	0	2	5	2	0	145	0	0
Vehicular road	0	0	0	0	0	0	3	0
Poorer vehicular road	0	0	0	0	0	0	3	45
Sum	**12**	**37**	**52**	**26**	**85**	**167**	**6**	**45**

4.5 Temporal accuracy

The date of data input or the date of its update is a very important factor for the user while assessing the data quality. Temporal accuracy refers to the date of acquisition, the type of change and the validity date of spatial data, i.e. temporal accuracy represents a degree of consistency between time attributes and time relations of objects.

Manipulation of time data comes down to addition of time dimension to the data model and by that to all elements of the database, for example, with the help of one or more added "attributes" for each database entity, each attribute and each relation among objects. Sub-elements of temporal accuracy are (Devillers et al., 2006):

- Accuracy of time measurement (correctness of time references – display of errors in time measurement),
- Temporal consistency (correctness of sequence of events if they exist),
- Temporal validity (expiration date).

For the assessment procedure of road infrastructure temporal accuracy, we used the creation date of the main cartographic source and that is, in this testing sample, a digital orthophoto with the date of acquisition from July 2009. Data quality value for the temporal accuracy of road infrastructure is date, while the unit of quality is year.

The temporal aspect of the CGD is realized by including tools Enable Editor Tracking for monitoring changes of resulting spatial objects. The database can then generate special four fields that define the user who first mapped the specific object, the time when the listed building was mapped, as well as the user and time of the last change to the specified spatial object. The obtained temporal validity values for all objects of road infrastructure are in the range *START_DATE* = "2012-12-02", *END_DATE* = "2015-05-15".

5 CONCLUSION

Spatial data have an increasing significance in the process of decision making, situation follow-up and planning in all segments of life and development. In these circumstances, the importance of knowledge of data quality is increasing as well as the need for quality indicators to be established and presented in a standardized way. While analysing the quality of CGD road infrastructure according to ISO standards we could conclude that it meets all international standards.

Besides spatial accuracy, the goal of this research was to analyse and present the verification of geometrical connection of elements of road infrastructure in geospatial database, so the database would gain a required utility value. This is accomplished by creation of topological rules, but the correction of the content comes down to controlling the compliance with the rules. Topological rules refer to the elimination of double lines, connectivity of lines and points, control of the connected junctions, elimination of line breaks, compatibility control of joint border lines of polygonal element contours etc. Cartographic correction of CGD road infrastructure, compared to traditional cartographic correction has an additional control function of input attributes in the associated database. This additionally complicates the process of cartographic correction so it implies the correction of visual errors created in the previous process of mapping as well as the semantic consistency in respect to following the rules of the logical data model. In this form of correction, a special attention should be paid because even though some elements have an identical visual identity, they sometimes may have a completely different structure of the attribute in the geospatial database.

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