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THE BASIS FOR THE ESTABLISHMENT OF A DATABASE OF UTILITY LINES CADASTRE - REALISTIC APPROACH

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SUMMARY

In this study, for the purpose of determining the quality of a digital cadastral plan lines, we made production of digital lines plan, vectoring, and the diameter of the original data and maintaining the diameter of the five types of lines. Since digital utility cadastre plan is the basis for making part of the database of the cadastre lines, but that lately often resorted vectorization of analogue lines plans, or "digitization on the screen" in this study we analyzed the accuracy and reliability of digital geodetic plan lines created vectoring analogue plan. There we also made individual and comparative analysis of digitized content, according to the type of lines, on the basis of which it was concluded that the overall quality of the digital plan lines obtained vectoring pretty good that can meet the needs of most users of the cadastre lines. The conclusions drawn in this article can serve amendments and harmonization of existing geodetic and cadastral regulations with the regulations related to the business owners lines, regulations governing zoning and help define the strategy and development directions records of public infrastructure.

Key words: *digitization, digital lines, land lines*

INTRODUCTION

The level of development of one country and its individual regions is measured, among other things, through the level of development of infrastructure which allows supply of the population, economic and other entities with water, electricity, gas and other energy products, communication services, as well as concerns about wastewater. Concerning the importance of this infrastructure for the smooth functioning of all parts of the state and local communities, individuals and legal entities, as well as to protect the public interest the construction and infrastructure development, developed countries pay special attention to the legal regulation of infrastructure planning in space, its construction and development. The major part of this infrastructure to technical standards falls inside the so-called linear infrastructure, i.e. a building located in the area, so there are a large number of parcels that as a rule, are not owned by the owner of the building infrastructure.

Cadastral lines are the special state records run by the official surveying authorities and containing information on the area necessary for the operation of utility systems populated areas, especially in large cities.

At the same time, many municipal institutions take their own records on infrastructure resources, which contain the necessary location information. There was a lack of cooperation between cadastre and utility systems, and the lack of application of modern technologies in the collection, updating and distribution of data in geodetic and municipal records. The existence of this cadastre in analog form without using a computer significantly hinders its use. This problem also applies to other segments of the surveying work. Thus, for example, processing survey data, before the beginning of modern computers, represented significant activity organized by surveying work related to the monitoring of large dams [1].

It is necessary to identify solutions and to propose the necessary steps that will contribute to the cadastre lines which are directly involved in the development of the information system of municipal infrastructure. Defining based on existing up to date graphic and alphanumeric data that is translated into digital form will effectively and efficiently be exchanged with users [2].

In accordance with user requirements it is necessary to determine what additional information is required, as well as the ways in which they should be collected, with consideration of the major problems that it is encountering. It is especially important to propose future tasks demarcation line cadastre, on the one hand, and municipal institutions and all interested parties on the other.

The subject of the research in this paper is a way to register public, municipal and other infrastructure in Serbia. Besides this the study included the creation of digital cadastral plan lines. The main focus of research has been put on the quality of the digitized cadastral maps lines and underground installations, and included plans scale 1: 500 in the CCI Kragujevac, Serbia.

The basic and primary goal of the research, in this paper, is that according to a comparative analysis of plans digitized lines, obtained by digitizing, and vectorization of analogue geodetic plans and from the original field measurements, evaluate the accuracy and reliability of cadastral maps obtained with scanning lines, which represent the basis for the formation of pipeline cadastre.

MATERIAL AND METHODS

The digitalization of geodetic plans

Digital surveying plan is defined as an information system on space and consists of four components: data, software, hardware and users, supporting primary processes: data collection, processing, maintenance and distribution of digital databases plan [3]. Thus, it can be concluded that the digital surveying plan is an information system, subsystem or digital geodetic information system (Article 3 of the Regulation on the DGP-in). The promptness and accuracy, as well as the general existence of digital plans, greatly facilitates the operation of various private and public organizations and the implementation of a number of projects in various fields. The existence of digital plans, or their timeliness and accuracy, significantly affect the realization of land reclamation projects through land consolidation projects [4].

Digitization of cadastral today one of the "most pressing" issues, which is not surprising because the digital cadastral plans necessary prerequisite for the reform of the cadastre, efficient spatial data management and change ways of thinking, a link to the e-Society [5].

Problem digitizing cadastral lines is not easy, especially if you add to the current state of the cadastre, which can not in favor of it. Former collection of spatial data for plans is very different from the present proceedings, but it can be assumed that such plans do not meet the needs of today's society [5]. It should also be taken into account that through the years in different ways analogous plans accumulated errors that are difficult or almost impossible to establish.

Digital utility cadastre plan must contain all the information that is contained and analog cadastral plan. The purpose of conversion of cadastral maps from analog into digital vector form, inter alia, to enable the removal of all errors that have accumulated for many years, because they could not be detected on the analogue Plan, to enable faster and easier maintenance of the land cadastre and power lines, access to spatial cadastral information, facilitated by drawing and processing of graphic elements [6].

Forming a digital plan lines is a priority task (FIG According to the resolution, all analog plans were to be withdrawn from use until 2014). First you need to determine the appropriate standards. It can be said that the standard of everything has to be brought to the system function. This applies to hardware, software, implementation, training, and in a way the price can be one of the important factors to affect the selection and adoption of standards [2].

Output format digital plan should be one of those that support the world's leading GIS tools (DXF, DGN, DWG), even though the software for a digital plan is part of GIS software in order to exchange data with all other users of the digital plan in the first and second phase [3].

Digital plan lines can be made from the data obtained by:
- Digitalization, or vectorization of analogue geodetic plans (secondary methods).
- The original field geodetic measurements (primary methods).

Digitization involves converting different analog sources (content of plans and maps, text, sketches) into digital values. There are two methods of digitizing analog lines plans [3]:
- Digitization using the digitizer, and
- Scan while digitizing, and vectorization, using a computer.

The first method was initially dominant, but later increasingly abandoned as irrational because it is significantly more expensive (high cost digitizer), more difficult for operators and unsuitable for large scale works. Today it serves as an additional tool in the plans that are damaged; their scanning is not possible [3].

Another method is now almost exclusively used. Its advantage is that the operator can increase the desired detail directly on your computer monitor and guide the cursor far more precisely to the desired point. The speed and convenience of operation is significantly higher than in the first method. Digitization process should be accompanied by an interactive software that will react in certain cases (re-digitize the same points, lines, etc.). Also, when creating software translating the elements of the plan analog to digital form, special attention should be focused on eliminating deformation, correction, or calibration that selected software solution performs, with the task to preserve the printing accuracy analogue plan. When we talk about accuracy, i.e., measurement uncertainty digitization, there are numerous written works, and it was the subject of many analyzes, so that there will be no special consideration [2]. Some data that were used for the experiment was obtained by this method.

Digital plan can be obtained on the basis of the data of geodetic measurements, i.e. the diameter and the diameter of maintenance. The second part of the data that were used for the experiment was obtained by this method. When making digital plan in this way, the data contained in the records need to be entered into the computer. Software is required for entry and processing of measurement data, which calculates the coordinates and angles detailed points, or direct entry of coordinates and the angle, if they are pre-calculated. These data (point number and coordinates) are stored in a separate file and should be ready for mapping and further processing with the help of graphics software for surveying [2]. Software to create digital plan should, inter alia, that contains tools for constructing points that were taken some of the envisaged additional method (curved cross-section, measurement, etc.) [3].

Data collection for the experiment

With a view to determining the quality of digital plans obtained by classic digitization, vectorization or using a computer, implemented an experimental part of the work, which included:

1. Scan however, digitization and vectorization of cadastral plan list of analogue lines 7F25-H9-71, scale 1: 500 (CCI Kragujevac, Serbia), using a computer.

2. Digitization same newspaper analogue plan cadastre lines 7F25-H9-71 scale of 1: 500, from the original measurement data.
3. Statistical analysis of the data.

Working original of cadastral plan 7F25-H9-71, which was chosen for the experiment, has emerged reproduction of the original cadastral plan (created in the process of the initial diameter of more than 50 years). Before scanning and geo-referencing was performed a visual inspection of the contents list and was observed that the digital display emerged after scanning visible and geometrically suitable for geo-referencing. Scans analog lines cadastre plan is geo-referenced with the help of the software package "D_map_geosoft_2008" (Figure 1) and based on it made digitalization.

For a detailed list of this cadastre number 7F25-H9-71 is performed vectorization, or "digitizing from the screen":

- Power lines and it was digitized 186 points,
- Gas pipeline network, and it was digitized 632 points,
- Sewage network and it was digitized 207 points,
- Telecommunications network and it was digitized 114 points, and
- Water supply network and it was digitized 189 points.

Picture 1. Scanned and geo-referenced list 7F25-H9-71

To create a digital plan cadastre lines 7F25-H9-71 is made on the basis of original sketches and speedometer of the minutes of the original diameter and the diameter of maintenance. Sketches and records are in excellent condition, which significantly facilitate the process of formation of the digital plan. Based on the minutes of the speedometer calculate the coordinates of detailed points for all lines. Based on the sketch details and the calculated coordinates of the detailed points on account of the formation blade 7F25 content-H9-71, this refers to:

- Electricity lines and it was charts the 174 points,
- Gas network and on that occasion he charts the 619 points,
- Sewage network and on that occasion he charts the 196 points,
- Telecommunications network and on that occasion he charts the 109-point and
- Water supply and it was charts the 185 points.

Individual analysis of the results was performed according to the types of digitized lines. With a view to determining the quality of digital plans formed vectorization, certain differences of coordinates of detailed points of vectorization obtained from the original data survey and maintenance diameter. According to the differences of coordinates, we determine wrong position of digitized points. The lack of regulations governing accuracy in this area is not an isolated case.

So in some areas of construction there are no universal criteria and strict standard benchmarks, such as the case of the optimal design of steel structures [7]. Since there are no regulations that strictly govern the accuracy of the digitized points (regulations relating to the surface), but from the aspect of practical use content cadastre and mapping accuracy of the details on analogue plans, as well as a certain confidence interval (based on probable errors E95), the authors this study classified the mistakes into four groups:

- Minor - accuracy $0 < \sigma p < 0.15$ [m];
- Significant - accuracy $0.15 < \sigma p < 0.35$ [m];
- Critical - accuracy $0.35 < \sigma p < 0.55$ [m] and
- Rough- accuracy $0.55 < \sigma p$ [m].

RESULTS

According to data obtained through the experiment, we determined the difference between the coordinates of points, obtained by vectorization from the original data survey and comparison of the classification given in the previous chapter.

In Table 1. we gave an exhaustive overview of the number of errors, the average error percentage share in the total number of errors, according to the type of water and the established classification.

Table 1. The number of errors, the average error percentage share in the total number of errors for the treatment lines

Type of line	Error	Minor	Significant	Critical	Rough	Without Rough
Electrical lines	Number	56	81	30	7	167
	%	32.18	46.55	17.24	4.02	95.98
	The Average Error [m]	0.09	0.23	0.42	0.71	0.22
Pipeline	Number	354	197	32	36	583
	%	57.19	31.83	5.17	5.82	94.18
	The Average Error [m]	0.08	0.22	0.44	0.68	0.15
Sewerage	Number	105	71	15	5	191
	%	53.57	36.22	7.65	2.55	97.45
	The Average Error [m]	0.09	0.21	0.44	0.86	0.16
Telecommunications	Number	72	31	5	2	108
	%	65.45	28.18	4.55	1.82	98.18
	The Average Error [m]	0.08	0.22	0.40	0.60	0.14
Plumbing	Number	108	58	14	5	180
	%	58.38	31.35	7.57	2.70	97.30
	The Average Error [m]	0.09	0.21	0.41	0.67	0.15

After individual analysis of the observed lines, there was also a comparative analysis. The comparative analysis included the results obtained by analysis of individual types of lines. The analysis included the following parameters:

- The number of errors according to the type of lines,
- Percentage share of certain errors in the total number of faults per type of lines, and
- Average error position detail points according to the type of lines.

Table 2 presents a comparative analysis of the number of defects by type of lines and the proposed classification.

Table 2. Comparative analysis of errors by type lines

Error / Type of line	Minor	Significant	Critical	Rough	Total	Without Rough
Electrical lines	56	81	30	7	174	167
Pipelines	354	197	32	36	619	583
Sewerage	105	71	15	5	196	191
Telecommunications	72	31	5	2	110	108
Plumbing	108	58	14	5	185	180
Total	695	438	96	55	1284	1229

Table 3 presents a comparative analysis of the percentage share of certain errors in the total number of errors, according to the type of lines and the proposed classification.

Table 3. Comparative analysis of the percentage share of certain errors in the total number of errors by type lines

Error / Type of line	Minor [%]	Significant [%]	Critical [%]	Rough [%]	Total [%]	Without Rough [%]
Electrical lines	32.18	46.55	17.24	4.02	100.00	95.98
Pipelines	57.19	31.83	5.17	5.82	100.00	94.18
Sewerage	53.57	36.22	7.65	2.55	100.00	97.45
Telecommunications	65.45	28.18	4.55	1.82	100.00	98.18
Plumbing	58.38	31.35	7.57	2.70	100.00	97.30
Total	54.13	34.11	7.48	4.28	100.00	95.72

Table 4 presents a comparative analysis of the average position error detailed points, according to the type of lines and the proposed classification.

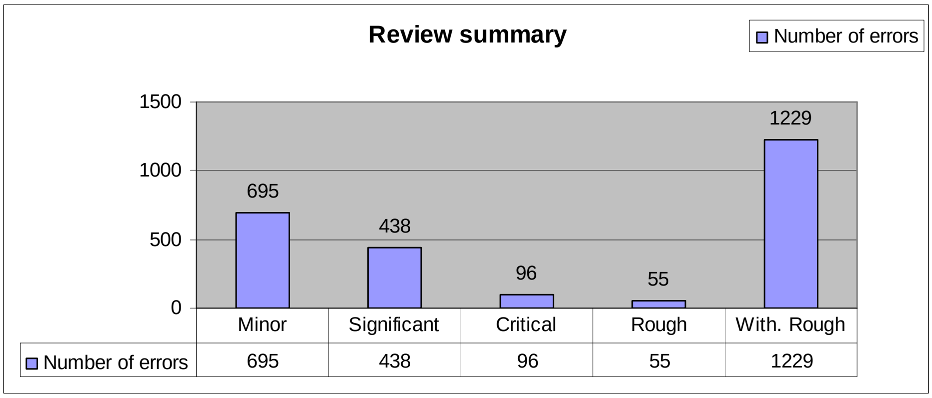
Table 4. A comparative analysis of the average position error detailed points according to the type of lines

Error / Type of line	Minor [m]	Significant [m]	Critical [m]	Rough [m]	Without Rough [m]
Electrical lines	0.09	0.23	0.42	0.71	0.22
Pipelines	0.08	0.22	0.44	0.68	0.15
Sewerage	0.09	0.21	0.44	0.86	0.16
Telecommunications	0.08	0.22	0.40	0.60	0.14
Plumbing	0.09	0.21	0.41	0.67	0.15
Total Average	0.08	0.22	0.43	0.70	0.16

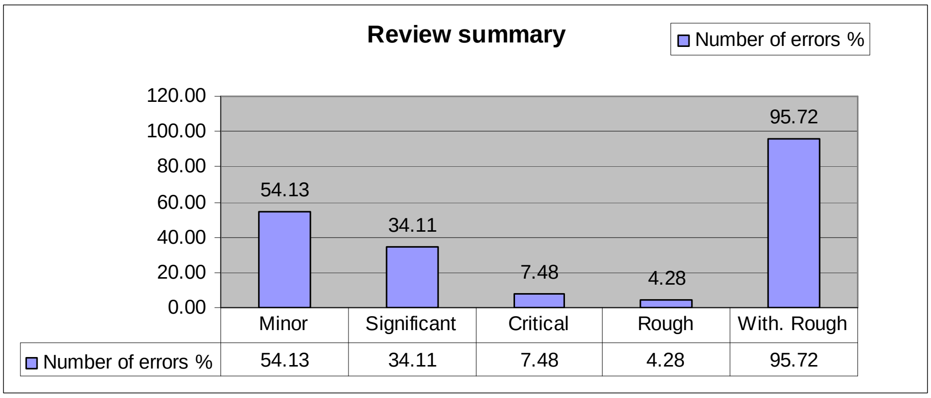
In Table 5 we present a summary statement of all observed lines, obtained by comparative analysis of the number of errors, mistakes and the average percentage of the total number of errors, according to the established classification, while the graphical representation presented in Figures 2, 3 and 4th.

Table 5. Summary overview of errors, mistakes and the average percentage share in the total number of errors for all the observed lines

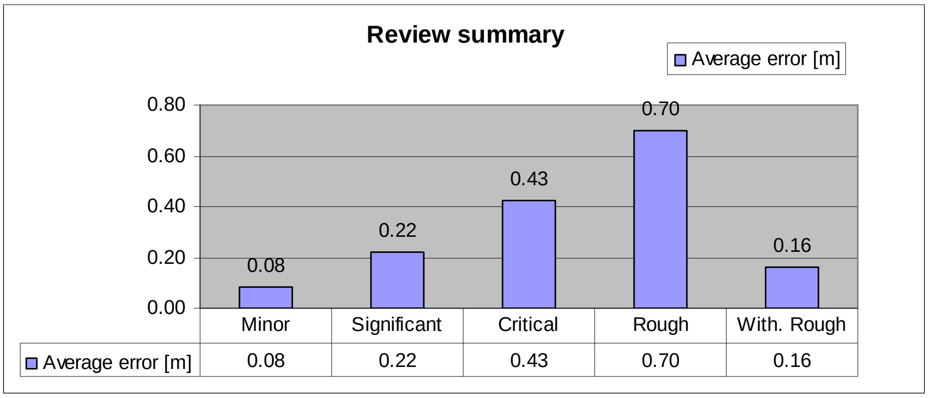
Error	Minor	Significant	Critical	Rough	Without Rough
Number	695	438	96	55	1229
%	54.13	34.11	7.48	4.28	95.72
The Average Error [m]	0.08	0.22	0.43	0.70	0.16



Picture 2. Summary overview of identified errors for all lines



Picture 3. Cumulative overview of percentage share in the total number of errors for all lines



Picture 4. The overall average for all lines errors summary

DISCUSSION

Based on the analysis of the results presented in this paper, which relate to digitalization of electricity network, it can be concluded that the most significant errors are identified (81 or 46.55 %), followed by minor (56 or 32.18 %) and finally critical (30 or 17.24 %). The total number of points, which errors are not classified as rough, is 167, or 95.98 % of the total number of digitized points of the electricity network. Looking in terms of accuracy of survey and production of digital surveying, it can be concluded that only 32.18 % of the points meets the quality criteria. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 78.73 % of digitized points of electricity network, has accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 4.02 % points, which are classified as gross errors. The resulting average positional error detailed points of the electricity network is 0.09 m points to 32.18 %, 0.23 m of 46.55 % points and 0.42 m points for 17.24 %. Based on the above, should be treated just the results obtained for the power grid, it can be concluded that the process of digitizing successfully implemented or that are digitized substrates can be treated as "good" because it is 78.73 % detailed points usable in terms of the majority of users of this cadastre.

Based on the analysis results, which relate to digitations gas pipeline network, it can be concluded that identified the most minor errors (354 or 57.19 %), followed by significant (197 or 31.83 %), and finally critical (32 or 5.17 %). The total number of points, which errors are not classified as rough, is 583, or 94.18 % of the total number of digitized points of the pipeline network. Looking in terms of accuracy of survey and production of digital surveying, it can be stated that 57.19 % of the points meets the quality criteria, which is a very good result. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 89.02 % of digitized points of gas pipeline network has accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 5.82 % points, which are classified as gross errors. The resulting average positional error of detailed points of the pipeline network is 0.08 m points to 57.19 %, 0.22 m of 31.83 % points and 0.44 m to 5.17 % points. Based on the above, should be treated just the results obtained for the gas pipeline network, it can be concluded that the process of digitizing successfully implemented or that are digitized substrates can be treated as "good" because it is 89.02 % detailed points usable in terms of the majority of users of this cadastre.

Based on the analysis results, which relate to digitization sewage network, it can be concluded that identified the most minor errors (105 or 53.57 %), and significant (71 or 36.22 %), and finally critical (15 or 7.65 %). The total number of points, which errors are not classified as rough, is 191, or 97.45 % of the total number of digitized points of sewerage network. Looking in terms of accuracy of survey and production of digital surveying, it can be stated that 53.57 % of the points meets the quality criteria, which is a very good result. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 89.79 % of digitized points of sewerage network has accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 2.55 % points, which are classified as gross errors. The resulting average positional error detailed points sewerage network is 0.09 m points to 53.57 %, 0.21 m to 36.22 % points and 0.44 m to 7.65 % points. Based on the above, should be treated just the results obtained for the sewage network, it can be concluded that the process of digitizing successfully implemented or that are digitized substrates can be treated as "good" because it is 89.79 % detailed points usable in terms of the majority of users of this cadastre.

Based on the analysis results, which relate to digitization of telecommunications networks, it can be concluded that identified the most minor of errors (72 or 65.45 %), and significant (31 or 28.18 %), and finally critical (5 or 4.55 %). The total number of points, which errors are not classified as rough, is 108, or 98.18 % of the total number of points digitized telecommunications network. Looking in terms of accuracy of survey and production of digital surveying, it can be stated that 65.45 % of the points meets the quality criteria, which is a very good result. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 93.63 % of digitized points of telecommunications networks, has accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 1.82 % points, which are classified as gross errors. The resulting average positional error detailed points telecommunication network is 0.08 m points to 65.45 %, 0.22 m to 28.18 % points and 0.40 m of 4.55 % points. Based on the above, should be treated just the results obtained for the telecommunications network, it can be concluded that the process of digitizing successfully implemented or that are digitized substrates can be treated as "good" because it is 93.63 % detailed points usable in terms of the majority of users of this cadastre.

Based on the analysis results, which relate to digitization of water supply network, it can be concluded that identified the most minor errors (108 or 58.38 %), and significant (58 or 31.35 %), and finally critical (14% or 7.57 %). The total number of points, which errors are not classified as rough, is 180, or 97.30 % of the total number of digitized points of the water supply network. Looking in terms of accuracy of survey and production of digital surveying, it can be stated that 58.38 % of the points meets the quality criteria, which is a very good result. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 89.73 % of digitized points of water supply network has accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 2.70 % points, which are classified as gross errors. The resulting average positional error detailed points of the water supply network is 0.09 m points to 58.38 %, 0.21 m to 31.35 % points and 0.41 m to 7.57 % points. Based on the above, should be treated just the results obtained for water supply, it can be concluded that the process of digitizing successfully implemented or that are digitized substrates can be treated as "good" because it is 89.73 % detailed points usable in terms of the majority of users of this cadastre.

Based on the analysis of the results obtained by comparative analysis, relating to digitization of all lines treated in this paper, it can be concluded that we identified the most minor errors (695 or 54.13 %), followed by significant (438 or 34.11 %), and finally critical (96 or 7.48 %). The total number of points, which errors are not classified as rough, are 1229, or 95.72 % of the total number of digitized points all treatment lines. Looking in terms of accuracy of survey and production of digital surveying, it can be stated that 54.13 % of the points meets the quality criteria, which is a very good result. If we take into account that the upper limit misstatement 0.35 m, it can be concluded that 88.24 % of all digitized points treated lines, has the accuracy that could meet the needs of users of the cadastre lines. In relation to the total number of digitized points, we identified only 4.28 % of the points, which are classified as gross errors. The resulting average positional error detailed points of the treated lines is 0.08 m points to 54.13 %, 0.22 m of 34.11 % points and 0.43 m of 7.48 % other. Based on the above, if we treat all the results obtained in this study, it can be concluded that the process of digitizing is successfully implemented or that are digitized substrates can be treated as "good" because it is 88.24 % detailed points usable in terms of the majority of users of this cadastre.

Based on the study of numerous studio and professional literature and individual and comparative analysis of digitized lines that have been conducted and presented in this paper, it can be concluded that the quality of digitized plans cadastre lines affected by the following factors [8,9]:

- Fault mapping and development of analogue cadastral maps,
- Pitfalls of translating analog to digital plans.

Mistakes in detailed mapping points and formation of content in the drafting process have a great impact on the quality of analogue cadastral maps lines. If in the process of analogue surveying taken into account only obtained a graphical representation on the cadastral lines, but not executed, and control on the basis of tacheometrics measurements, or numerical data, survey and control measurements (second orientation, the list of errors diameter, length fronts, etc.), then, among other things, lead to differences between the content of the analog lines of the plan and the actual situation on the ground and the states in the accompanying elaborate diameter.

Maintenance and restoration of cadastral maps lines have changed throughout history, depending on changes in the legal system and the available technology. All the weather data in diameter are set into the existing cadastral lines or the limits of existing cadastral parcels and already mapped lines lower accuracy. As the technology of data collection progressed, so has increasingly come to the switching of "accurate" data "incorrect" content of cadastral maps lines. Translation Errors of analogue to digital lines plans, in the drafting process have a great impact on the quality of digital cadastral maps lines, because it was made obsolete and digitizing cadastral maps virtually unusable. In addition, if you are in the process of digitizing takes into account only the graphical representation of the analog cadastral map, not the original data in diameter, and numerical data, this can lead to differences between digital and vectorization of the plan obtained from the original data diameter.

Although the "digitization of the screen" proved to be a cost-effective method, preference should be given to the development of digital cadastral plan data from the original diameter, because this approach provides maximum reliability in the quality and accuracy of data, and reduces the risk of new errors, as well as the elimination of existing incurred during the mapping details. This should be given serious consideration, since the quality and accuracy of the data the greatest value of this cadastre.

CONCLUSION

Tardiness and poor quality of cadastral records of lines in Serbia puts the process of design and construction of various facilities and new power lines before great challenges. In the future, we should make great efforts to establish an up to date and quality of this cadastre, which would certainly affect the faster and better development of the country.

In the experimental part of the work, for the purposes of determining the quality of executed plan is the creation of digital lines vectorization from the original data survey and maintenance in diameter, five kinds of lines. They also made individual and comparative analysis of digitized content, according to the type of lines and implemented through discussion concrete conclusions.

The results obtained in this study indicate that the quality of digitized content telecommunications network the best, the worst and the electricity network. The reasons for this, among others, should be sought in the fact that telecommunication lines recorded and mapped in the last twenty years, and electricity during the fifties and sixties.

The results obtained in this study also indicate that the overall quality of the digital plan lines obtained vectoring pretty good, which can meet the needs of most users of the cadastre lines.

Looking in terms of speed of development of the digital lines of the plan, it is clear that the vectorization is faster and more economical methods. However, from the aspect of quality and accuracy, digitalization of the original data and maintaining diameter has a huge advantage, because such an approach provides maximum reliability in the quality and accuracy of data and reduces the risk of new errors, as well as the elimination of existing incurred in the mapping details. In this study we gave only plans in scale 1: 500, which are the "most accurate”, but it opens a question for future research: "What is the situation with regard to the cadastral lines of other dimensions, especially the scale of 1: 2500 which are the reproduction of plans 1: 5000, as well as to improve the quality of digitized cadastral maps lines and bring them into the state of accuracy, so that they can be a good basis for the development of projects of various facilities and the construction of new power lines?!" We should conduct a further analysis in causes, and the result of the quality and accuracy of digital cadastral maps lines and find a model for their improvement.

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