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ORGANIZATION AND ESTABLISHMENT OF A GEOGRAPHIC INFORMATION SYSTEM OF THE PRODUCTION AND HIGH VOLTAGE ELECTRICAL DISTRIBUTION NETWORK IN THE REPUBLIC OF MACEDONIA

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ABSTRACT

A geographic information system (GIS) is a computer software system that allows acquisition, entering, storage, processing, updating, searching, interpretation, understanding and displaying of various geographic data and other supporting, non-geographic data. It is a technology and methodology that is on the rise, especially in the last decade of the XX century (Markoski, 1995; 2011). This work explains the practical work and the establishment of GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia, with a special emphasis on the working methods and procedures, which are necessity for getting a complete and functional GIS.

Key words: GIS, electrical distribution network, Republic of Macedonia.

SUBJECT AND PROBLEM AT WORK

The subject of this work is the production and high-voltage electrical distribution network in the Republic of Macedonia, i.e. all production and electrical distribution facilities that comprise it.

The goal of this GIS-application is:

- Defining the research area;
- The process of creating a cartographic drawing for the purposes of the specific GIS (In this case, for the production and high-voltage electrical distribution network in the Republic of Macedonia);
- Defining of relational databases for this issue;
- Defining and acquisition of data ;
- Establishment of interactive relationships between the cartographic drawing and the databases;

- Defining the functionally most appropriate requirements of the GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia.

OBJECTIVE STUDY OF THE DETERMINED ISSUE

The main goal is the development of GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia, review of the arrangement and the extension of the facilities, upgrading them with the necessary attribute data and in the continuation providing an automated search of the objects, management of the system and upgrading it with data following the principle from bigger to smaller. It means that, the GIS needs to be upgraded until the phase of the last consumer. In that way there will be opportunity for functional records, more efficient organization and management of the electrical system in the Republic of Macedonia.

METHODS

During the research and the practical work for preparing the GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia, geographic, cartographic, informatics and statistical methods were used.

The cartographic methods were used in the process of preparing the cartographic base maps in electronic form based on topographic maps of the Republic of Macedonia in a scale of 1:25000,(VGI 1970-75; AKN, 2008-12; N. Gapkovski & M. Jovanovski, 2007). The geographic methods were used for identifying the production and electrical distribution objects on the topographic maps.Its application also have had the statistical methods, especially in the statistical treatment of the data.

Besides the aforementioned methods, in this GIS project, the informatics methods were also used. They were used in the process of the cartographic preparation, the computer organization of the databases and in the process of establishing the interactive relationships in the system.

WORKING PROCEDURES

The making of a GIS system means performing series of interconnected and mutually conditioned working procedures (Markoski, 2011) which are essential for its functioning. These working procedures include:

- Cartographic preparation
- Creating the databases
- Establishment of interactive relationships
- Functionality of the geographic information system

CARTOGRAPHIC PREPARATION

The cartographic preparation is a bigger unity that encompasses several related procedures in sequence, which means that one operation inevitably leads to the next. This whole is the basis for the preparation of a GIS (Markoski, 1997; 2002; 2003; 2011) and includes:

- Selection of cartographic sources;
- Scanning the cartographic sources (analogue maps) and converting them to a digital raster form;
- Importing the raster base maps into the GIS software;
- Orientation of the cartographic base maps;
- Putting the cartographic picture in the appropriate scale,
- Georeferencing;
- Making a manual for cartographic processing;
- Digitizing;
- Creation of a digital cartographic vector data for the purposes of GIS
- Encryption of the data in GIS;
- Removing of the errors from the drawing;

The implementing of the aforementioned procedures leads to creating a cartographic drawing which is the basis and inevitable part of the Geographic Information System to follow.

Selection of the cartographic sources. For the purposes of the GIS-application for the production and high-voltage electrical distribution network in the Republic of Macedonia, in accordance with the scale, the projection, the content of the maps and other criteria, as most appropriate, topographic maps in the Gaus-Kruger projection with a scale of 1:25000 (VGI 1970-75; AKN, 2008-12) were chosen as the base maps.

Scanning the analogue maps. All selected topographic sections (about 220 sections) were scanned, so that the analogue maps were converted into a digital cartographic raster form with a compatible extension (TIF and JPG), in colour and in higher resolution.

Inserting the raster images into Autodesk Map. The inserting of the raster base maps for the purposes of this GIS-application was made in the Autodesk Map software, as basis for the digitizing to follow. After the completion of this procedure, the raster images appear onto the software data frame and are ready for georeferencing.

Georeferencing. The georeferencing is a procedure in which the raster image is associated with a state coordinate system (SCS) in accordance with the used cartographic projection. With this procedure the location of the raster data is defined by using coordinates from the frame of the maps or other four points in the software package whose coordinates are read from the topographic maps. This procedure is fundamental for the further work (because it enables data which has real coordinates and dimensions corresponding to those in the nature) and making of this GIS-application. This action was repeated on all topographic maps individually.

Creating a manual for cartographic processing. The process of digitizing the maps was based on a special manual for cartographic processing in which the digitizing of the following elements was defined: the hydro power plants, the thermal power plants, the 400 kV, 110 kV and 35 kV transmission lines, the power transformers, the cities and the larger, more central villages as geographic elements, the geographic and rectangular network as mathematical elements as well as the names of the places and sites. In this phase, the principles of vectorization were set, so that a systematization and classification was performed for the contents to be vectorised. In that context, the following layers were created: Znak_HE (Sign HE), Znak_TE (Sign TE), Znak_400 kV (Sign_400 kV), Znak_110 kV (Sign_110 kV), Znak 35 kV (Sign 35 kV), Znak_Stolbovi (Sign Pillars), Znak_naseleno mesto (SignSettlements), Elektrovodi_400 kV (Power Lines_400 kV), Elektrovodi_110 kV (Power Lines_110 kV), Elektrovodi_35 kV (Power Lines_35 kV), Geografska mreza (Geographic Network), Pravoagolna mreza (Rectangular Network), Ime_naseleno mesto (Name_Settlement) and Ime_lokalitet_trf (Name_Locality_trf), which further served for the storage of the vector data. For all the elements to be vectorised an appropriate point, line and polygon objects were defined. The designed objects have different shape i.e. the point objects are represented as so-called blocks, which means marking the object into one fundamental point regardless of its complexity. In accordance with the manual it was to draw the polygons as closed lines, by using the polyline tool. In this context, the centroids should be mentioned. They represent a central point, as the only one within a polygon.

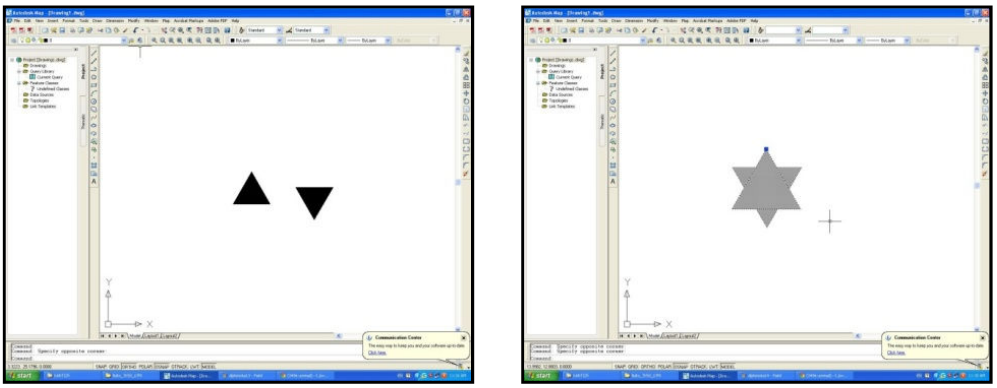

Figure 1: Creation of a block and its marking in one fundamental point.

Digital cartographic processing. The digital cartographic processing means converting the inserted raster data into digital vector form. In the process of vectorization point, line and polygon objects were digitized. The cities, the villages, the hydro-power plants and thermal power plants were represented as points. The dimensions of the point objects were defined according to the scale of the maps. As line objects were represented the transmission lines. During the digitalization of the line objects (the transmission lines), they are recorded as electronic records of lined up and vector interconnected points. Each of these points is defined by X and Y coordinates. The transmission lines are vectorised segment by segment i.e. the digitizing is made from one pillarto another, part by part, so that all segments can be identified as separate in the later stages. The larger power transformers were represented as polygon features. During the vectorization it is also paid attention to the topologic relationships among the elements of the map.

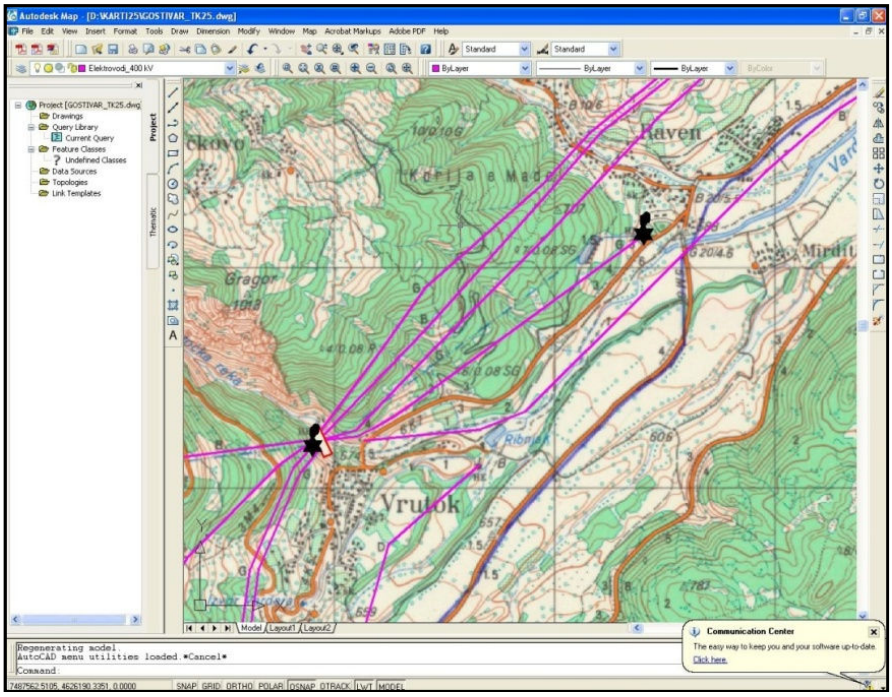

Figure 2: An example for digitizing of point and line objects for a wider region, surrounding the area of Vrutok.

After the completion of the digitizing of the maps, a procedure of joining the vector data from the different sections of topographic maps into one common database followed, with the goal of creating a complete cartographic drawing for the needs of the GIS of the production and high-voltage electrical distribution grid in the Republic of Macedonia.

This operation was enabled by the previously performed procedure of georeferencing of the topographic maps in a digital raster form. This procedure was performed with opening a new Autodesk Map document in which all the digital data from the different sections was copied, so in that way a complete cartographic drawing for the purposes of the aforementioned GIS was created.

Creating a cartographic drawing for the purposes of GIS. After the completion of the digitizing in accordance with the conditions determined in previously created manual for cartographic processing and the joining of the vector data, in fact a cartographic drawing in a vector form for the purposes of the GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia was made. With this vector drawing there are already some possibilities for certain analysis and extracting some information, for example the coordinates of the point objects, the length of the line objects i.e. the transmission lines, or the surface of the polygon objects, such as the power transformers and the production facilities and so on. In the further stages, the databases were attached to the vector data. It is important to mention that the emphasis was not put on the design and the appearance of the vector data as it is the case when preparing cartographic drawing for the purposes of printing a map, because when working on a GIS the primary goal is its functionality.

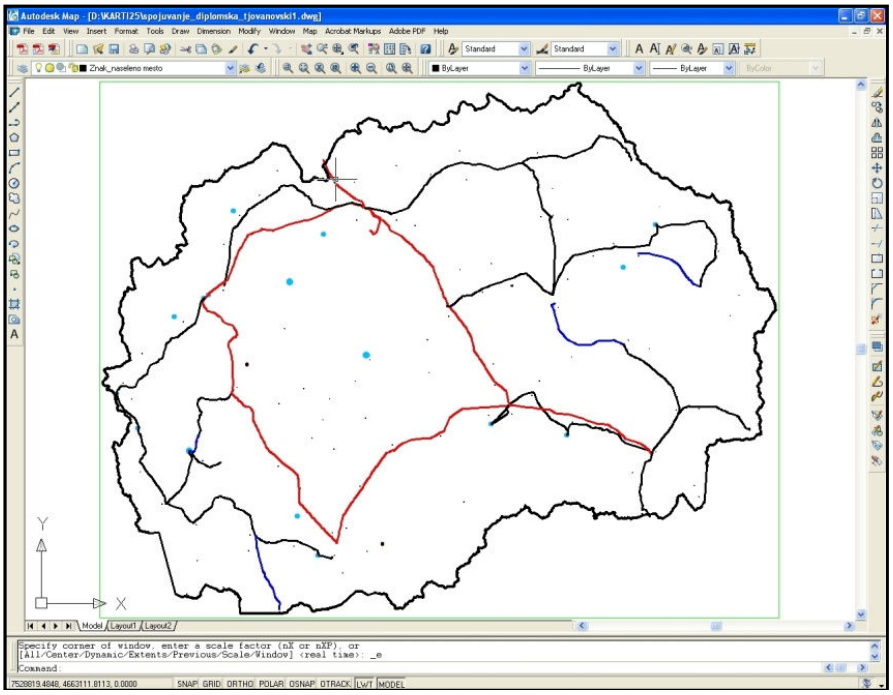

Figure 3: Cartographic drawing for the purposes of the GIS application.

Detection and correction of errors. During the process of digitizing of the raster data there is always the possibility of making certain errors, so it is inevitable to detect them and correct them. The most common errors that can happen during the digitizing are for example, improperly merged lines, errors in the merging of the lines and polygons, errors in the joining the vector data from the different sections etc. The correction is made manually or automatically within the software package. The joining of the vector data from the different cartographic sections is made to ensure that there is cartographic continuity of the digital map.

The correction of the errors is an important procedure for every GIS-application because the errors in the digital data can lead to attribute and topological errors in the further stages.

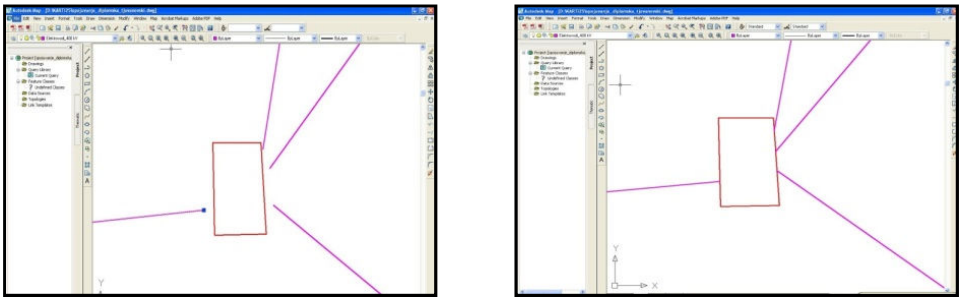

Figure 4: Improperly connected line object with polygon object
and correction of the errors.

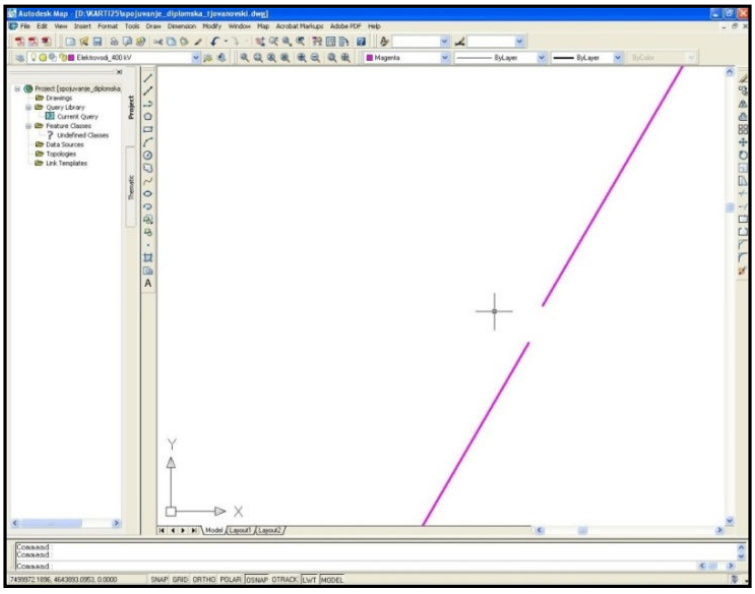

Figure 5: Error as result of the joining of the contents of two adjacent topographic maps.

Orientation of the cartographic picture. The cartographic editions basically have their orientation (direction towards north) according to the applied cartographic projection. However, in the process of scanning (converting the analogue data to a digital raster form) the disorders to the north direction of the raster images is very common. Therefore, during the cartographic preparation an orientation of the geographic picture is made according to the north direction followed by the digitizing of the cartographic contents.

In the cases when georeferencing of the cartographic digital raster forms is made they automatically orientate in the north direction. In the case of the actual application of GIS of the production and high-voltage electrical distribution grid in the Republic of Macedonia the cartographic base maps were georeferenced, therefore the classical orientation by rotating the base maps was unnecessary.

Applying the appropriate scale to the cartographic image. Applying the appropriate scale to the cartographic base maps for the purposes of the GIS application was basically unnecessary because the base maps were previously georeferenced. However, the applying of the scale has its importance because it is important to know in which scale the GIS application has been made. It allows us to have an idea of the dimensions of different elements on the maps. It is also an important component of the cartographic preparation because it enables us to determine the sizes of the formats of the papers on which we want to print contents of the cartographic base maps and of the new cartographic products which are based on analysis and searches from the databases.

Coding data for the needs of GIS. For the needs of a GIS, a codification of the elements within the framework of the cartographic picture is necessary (point, line, polygon objects and text).

For codification of point and line objects there are two possible approaches. The first approach is codification at the stage before or after digitizing the location of a specific object, and

the second approach is codification of the elements separately, after the exact locations of the objects have been entered.

The process of codification of polygons is more complicated compared to the codification of point and line objects due to the fact that every part of the line or clutch which connects different polygon will belong only to one polygon. If every polygon needs to be coded as completely separate graphic unit, then there will be double digitalization of individual line segments.

There are several methods for avoiding the double digitalization of the line segments. One method is to connect each segment of the line with a pair of codes of characteristics which describe the identity of the polygons from the "left and "right: side of the line. The terms "left" and "right" are indicated by the direction in which the line is digitized. Encoding the connected segments that way, further the software can create every polygon by searching those clutches that characterize it. The segments will be sorted automatically by matching the equivalent start and end points. Until the clutches belong to more polygons, double storage will not be required. If every clutch is provided with a unique identifier, further a list of identifiers is created, which will force the necessary geometric data.

Codification of text elements during the digitalization of cartographic products means determining the identity of the objects of the map, according to their shape and characteristics or with textual notificationof the map. Often when digitizing the maps the text can be saved as separate graphic object. This is acceptable if the purpose of the digitalization is providing an accurate computer graphic representation of the source document, but if it comes to analysis of geographic information or creating maps with different scale than the original, the text which within the framework of the original map is constant and not linked to the spatial elements will be limited. Therefore, it is recommended that the text is linked with the spatial object, so when a database is created it will serve as a feature for that object in it. In that way we can use the name to determine the geometry and vice versa.

ORGANIZATION AND ESTABLISHMENT OF DATABASES

After the cartographic preparation, the second major and fundamental whole for establishing a GIS application is the organization and establishment of the databases. The databases are defined as information for the objects of the geographic space and all their characteristics, needed for GIS purposes. In fact, the databases enable the strong possibilities of GIS for analysis and generation of new data based on the already existing database. By linking the databases with the digital cartographic data we get a complete GIS application, which is a powerful tool for search, analysis and interpretation of geographic data.

It should be noted that, within the frameworks of GIS internal and external databases can be distinguished. The internal databases are those which are established within the individual GIS software packages, while very often because of their size a specifically designed software for databases is used. In that case we speak of external databases.

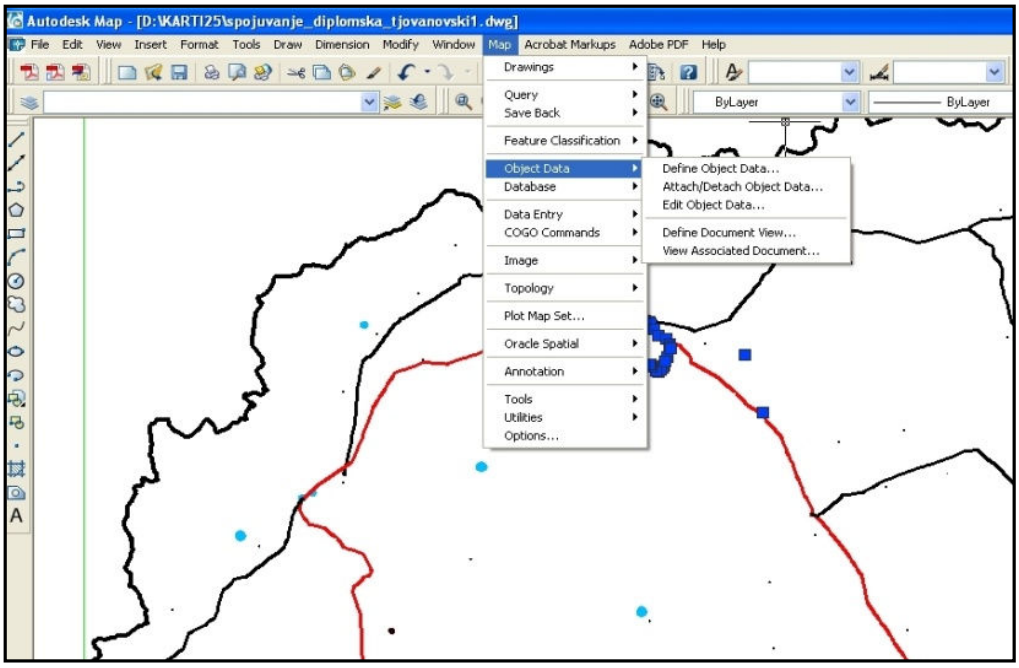

Figure 6: The database menu in Autodesk Map.

For the purposes of the GIS of the production and high voltage electrical distribution network in the Republic of Macedonia, according to the size of the databases, for their establishment, the capabilities of the Autodesk Map software were sufficient, which means that they are internal databases established within the framework of the software intended for creating a GIS, in which the process of digitalization was also implemented.

Identification of the facilities of the production and high-voltage electrical distribution grid

The objects that make up the production and high-voltage electrical distribution grid in the Republic of Macedonia can be divided into three categories:

- Production facilities
- Electrical distribution facilities and
- Power transformer stations.

In that context, for the needs of this GIS application, entities for all the aforementioned categories were defined, and then appropriate attributes for all of them were entered.

Identification of production facilities. The production of electricity in the Republic of Macedonia takes place in hydro and thermal power plants. In that context, these elements are included in the databases for the GIS of the production and high voltage electrical distribution gird in the Republic of Macedonia i.e. for all of them an appropriate entities were established and consequently the appropriate attributes for those entities were entered.

For the hydro power plants the following entities were defined: ID, Ime (Name), X, Y, Lokacija (Location), Proizvodstvo (Production), Mokjnost (Power), Godina (Year).

In the continuation, a tabular display is presented, excerpt from the databases, with the aforementioned entities and attributes relevant to them related to the hydro power plants in the Republic of Macedonia.

Table 1. Review of the database for the hydro power plants as production facilities.

ID	Name	X	Y	Location	Power (MW)	Year	Produc.
001	HE Pena	7496349	4652956	Tetovo	2.56	1927	/
002	HE Raven	7488393	4626099	Raven	19.2	1959	/
003	HE Vrutok	7486893	4625140	Vrutok	150	1957	/
004	HE Vrben	7477318	4619108	Vrben	12.8	1959	/
005	HE Shpilje	7458977	4594482	Debar	84	1969	300
006	HE Globochitsa	7465813	4583501	Globochitsa	42	1965	191
007	HE Pesochani	7481924	4576198	Pesochani	2.9	1952	/
008	HE Strezhevo	7516603	4555366	Strezhevo	2.4	1993	/
009	HE Sapunchitsa	7523316	4542979	Bitola	2.9	1952	/
010	HE Kozjak	7514095	4630233	Poreche	80	2004	150
011	HE Matka	7525138	4645438	Skopje	9.6	1938	/
012	HE Bogomila	7538557	4606922	Veles	0.9	/	/
013	HE Tikvesh	7578731	4584916	Kavadartsi	116	1966	184
014	HE Doshnitsa	7602788	4581369	Demir Kapija	5.1	1953	/
015	HE Zrnovtsi	7620747	4634890	Kochani	1.6	1950	/
016	HE Kalimantsi	7631235	4648600	Kalimantsi	13.8	1970	/

Sources:
http://www.elem.com.mk/index.php?option=com_content&view=article&id=64&Itemid=149&lang=mk
http://www.elem.com.mk/index.php?option=com_content&view=article&id=103&Itemid=208&lang=mk

As it can be seen, the data is an excerpt of the database of the GIS of the production and high voltage electrical distribution grid in the Republic of Macedonia, where a total of 16 hydro power plants are included.

When it comes to the thermal power plants, on the territory of the Republic of Macedonia the production takes place in three capacities: REK Oslomej, REK Bitola and TE Negotino. They are included within this GIS application, therefore for all of them the following entities were defined: ID, Ime (Name), X, Y, Lokacija (Location), Pogon (Plant), Godina (Year) и Proizvodstvo (Production).

Table 2. Review of the database for the thermal power plants.

ID	Name	X	Y	Location	Plant	Year	Production (MW)
081	REK Oslomej	7543707	4546738	Oslomej	Jaglen	1989	125
082	REK Bitola	7500422	4604085	Novaci	Jaglen	1982	675

The largest producer of electricity from the thermal power plants, but also the largest producer on the territory of the Republic of Macedonia overall is REK Bitola, with more than 70% share in the total production of electricity.

Identification of distribution facilities. In this category the 400 kV, 110 kV and 35 kV transmission lines are included, therefore they are treated within this GIS application and for all of them appropriate databases are created. In that context, for the transmission lines the fol-

lowing entities are taken into account: ID, Relacija_od (Relation-of), Relacija_do (Relation-to), Jachina (Strength) и Tip_na_stolb (Pillar Type). Below the database which refers to the transmission lines included in this GIS application is presented.

Table 3. Review of the database for the transmission lines.

ID	Relation-of	Relation-to	Strength	Pillar Type
017	7564478, 4622680	7538030, 4653950	400	B
018	7539771, 4646770	7538039, 4653950	400	B
019	7537828, 4654197	7524776, 4669356	400	B
020	7486948, 4625221	7537663, 4654188	400	B
021	7486903, 4625202	7529151, 4547144	400	B
022	7529200, 4547131	7545166, 4575833	400	Z
023	7584236, 4590870	7545177, 4575842	400	Z
024	7629733, 4575124	7584385, 4590963	400	Z
025	7564502, 4622656	7584281, 4590943	400	B
026	7645205, 4628897	7625468, 4639540	35	Z
027	7598805, 4623418	7620744, 4610363	35	Z
028	7503029, 4549460	7510678, 4525771	35	Z
029	7481992, 4576240	7485178, 4581488	35	Z
030	7499189, 4650841	7537789, 4654214	110	B
031	7493215, 4629216	7499199, 4650821	110	B
032	7486899, 4625213	7458944, 4594526	110	B
033	7458944, 4594526	7465812, 4583600	110	Z
034	7465807, 4583512	7474460, 4559496	110	Z
035	7474483, 4559485	7483403, 4553401	110	B
036	7474483, 4559485	7481922, 4576240	110	B
037	7496006, 4595981	7492105, 4572644	110	Z
038	7483403, 4553401	7503031, 4549483	110	B
039	7503037, 4549464	7523363, 4543035	110	B
040	7626681, 4557565	7629184, 4555429	110	Z
041	7629732, 4575108	7626675, 4557570	110	Z
042	7638284, 4588147	7629734, 4575124	110	Z
043	7602787, 4581468	7629734, 4575124	110	Z
044	7584385, 4590963	7602802, 4581444	110	B
045	7578761, 4584926	7584284, 4590850	110	B
046	7578760, 4584928	7584236, 4590870	110	Z
047	7638283, 4588195	7661004, 4582969	110	B
048	7638283, 4588195	7620802, 4610284	110	B
049	7645263, 4628919	7631264, 4648649	110	Z
050	7617725, 4641479	7631201, 4648642	110	B
051	7598165, 4626304	7617665, 4641442	110	Z
052	7588492, 4668352	7598122, 4626324	110	B
053	7564494, 4622664	7598078, 4626314	110	Z
054	7523363, 4543035	7527635, 4542306	110	Z
055	7588491, 4668363	7623334, 4669037	110	Z
056	7538045, 4653989	7588461, 4668345	110	B

Sources:
http://www.elem.com.mk/index.php?option=com_content&view=article&id=64&Itemid=149&lang=mk
http://www.elem.com.mk/index.php?option=com_content&view=article&id=103&Itemid=208&lang=mk

Identification of the power transformers. For the power transformers the following entities were defined:: ID, X, Y, Jachina (Strength) и Povrshina (Area). They are shown in Table 4.

Table 4. Review of the database for the power transformers.

ID	X	Y	Strength	Area
057	7537845	4654065	400	93279
058	7539752	4646770	400	1276
059	7564441	4622664	400	7591
060	7584313	4590912	400	13021
061	7545168	4575844	400	386
062	7529138	4547079	400	26698
063	7486926	4625212	400	6363
064	7499199	4650831	110	385
065	7493202	4629187	110	4093
066	7496004	4596014	110	4880
067	7460383	4597042	110	415
068	7474473	4559486	110	494
069	7483378	4553392	110	1452
070	7503027	4549471	110	375
071	7626672	4557561	110	298
072	7629736	4575117	110	251
073	7638273	4588167	110	2308
074	7645234	4628893	110	3817
075	7617691	4641484	110	5600
076	7588476	4668357	110	1610
077	7620794	4610336	110	7161
078	7598126	4626283	110	7863
079	7585129	4629190	110	194
080	7578739	4584923	110	797

ESTABLISHMENT OF INTERACTIVE LINKS

The establishment of the interactive links means linking the elements of the cartographic drawing (point, line and polygon features) with the corresponding data in the database. For accomplishing that goal, firstly each of the cartographic elements gets its identification number as unique to each object, and in the further stages it serves for establishing the links between the cartographic elements and the databases (Delaney & Van Niel, 2007; Gjorgjiev, 2004; Manasov, 1995; Markoski, 2011). This procedure is carried out in cases when we work with external databases, so the ID numbers from the cartographic drawing are linked with the corresponding ID numbers into the databases. The identification numbers within the databases are usually found in the first column of the table and in the following columns the other entities with their attribute data are lined up For the needs of this GIS application, this procedure was not necessary because the databases were created within the Autodesk Map software i.e. they are internal databases. Still, because of the possibilities for upgrading the GIS application in the future, all the cartographic elements are assigned unique identification numbers, which means that space is left for linking with larger size external databases

FUNCTIONING OF THE GIS APPLICATION

With the creation of the cartographic drawing in digital vector form and the establishment of the databases and their linking, we get a complete GIS application for the production and high voltage electrical distribution network in the Republic of Macedonia. Thus the user is enabled countless searches, analysis and setting numerous requests to the system. They vary from simple to very complex. Therefore (Markoski, 2011) the realization of such requests enables:

- cartographic review after the forming of the digital raster and vector forms,
- maps in digital form based on the data from the database,
- various reports after various requests from the database and
- possibilities for creating and designing new maps for different purposes and with different scale

The maps in digital form can be created directly over the cartographic drawing with its developingand design and as output result with searching and analytic operations from the databases. These maps are generated very quickly (in just few seconds and minutes) and can be used directly/on the screen. But if they need to be printed, they should be completed and designed according to the cartographic principles and standards.

CONCLUSION

A geographic information system (GIS) is a computer software system that allows acquisition, entering, storage, processing, updating, searching, interpretation, understanding and displaying of various geographic data and other supporting, non-geographic data. Both technology and methodology that integrates multiple components into one interconnected system: hardware, software, data and people (Markoski, 1995) and as such it is of a great help to us in making rational decisions, easier and more efficient planning, organization, operation etc. The beginnings of GIS date from the 70s of the XX century, but their massive application is noticed in the last decade of the previous century. For the purposes of this GIS application cartographic, geographic, statistical and mathematical methods were used. For the establishment of GIS of the production and high-voltage electro distribution network in the Republic of Macedonia an implementation of a range of related and mutually conditioned working procedures which were fundamental for its functioning was needed. In the process of creating this GIS, digital cartographic vector data was created in scale of 1:25000 and for every object specific databases are presented for the production (hydroelectric power stations and thermal power stations) and electrical distribution network (transmission lines and power transformers) in the Republic of Macedonia. These working procedures can be divided into several major parts: cartographic preparation, creation of databases, establishment of interactive relationships and functioning of GIS.

The cartographic preparation is the first major and fundamental part needed for each GIS. It consists of multiple interconnected processes, the implementation of which leads to creating a digital cartographic vector drawing for the purposes of GIS. In this case, based on topographic maps with a scale of 1:25000 (about 220 sections), a cartographic drawing for all the production and power distribution objects was made, as basis on which further the databases were added.

The creation of the databases is the second major part. They can be defined as attributes for all the necessary and selected objects organized into one or more independent or interrelated spreadsheets. They are associated with the corresponding elements of the cartographic drawing with the ultimate goal of completion of the GIS of the production and high-voltage electrical distribution network in the Republic of Macedonia. In this case, 16 hydroelectric power stations, 2 thermal power stations, 39 transmission lines and 23 power transformers are included.

Appropriate databases were designed for all the elements and they were interactively connected to the corresponding digital cartographic elements of the map.

The linking of the cartographic drawing with the databases is possible by establishing interactive links. They represent a special technical and technological procedure that connects the cartographic elements with the corresponding data/entities in the database. All cartographic elements are assigned an unique identification number, and then the interactive links with the database are established. That is how the GIS application is completed.

After the establishing of the GIS of the production and high-voltage electro-distribution network, as the last part of the process. the functioning of the GIS can be mentioned. The functioning includes implementation of a variety of applications, queries and analysis and getting new output products in a cartographic, alpha, numeric, alphanumeric, spreadsheet, photographic or other form, based on the already existing digital map and databases.

At the end, it can be added that there are always possibilities for this GIS application to be further updated and upgraded until the last phase were the consumers will be included, so that will enable functional records, more efficient organization and management of the electrical network in the Republic of Macedonia.

REFERENCES

VGI, Topografski karti, razmer 1:25000, teritorija na Republika Makedonija, Belgrad, (1970-75) (in Serbian)

AKN, Topografski karti, razmer 1:25000, teritorija na Republika Makedonija , Skopje (2008-12), (in Macedonian)

N. Gapkovski, M. Jovanovski, *Opshta Geologija*, Skopje (2007), (in Macedonian)

J. Delaney& K. Van Niel, *Geographical Information Systems.* (2007).

V. Gjorgjiev, *Geo informacioni sistemi*, Skopje (2004). (in Macedonian)

S. Manasov, *Geoinformacioni sistemi, kompjutersko procesiranje na informacii za prostorot,* Skopje (1995). (in Macedonian)

B. Markoski, Geografski informaciski sistemi, Univerzitet "Sv. Kiril i Metodj" Skopje (2011), (in macedonian)

B. Markoski, *Kartografija*, Geomap, Skopje (2003). (in Macedonian)

B. Markoski, Kartografskite i alfanumerichkite izvori kako osnova za geografski informaciski sistem na Skopje, *Zbornik na trudovi od nauchen sobir "Mozhnosti za vospostavuvanje geografski informaciski sistem na grad Skopje",* Skopje (2002). (in Macedonian)

B. Markoski, Geografijata i tehnologiite na Geografskite informativni sistemi "*Zbornik na trudovi od Simpoziumot Perspektivi i pravci razvoja geografija*, Brezovica (1997).

B. Markoski, Geografijata i tehnologiite na Geografskite Informaciski Sistemi, *Geografski razgledi* 34, Skopje (1999). (in Macedonian)

B. Markoski, Geografsko informativni sistemi, *Primatko*, Skopje, (1995) pp. 30-33 (in Macedonian)

http://www.igeografija.mk/Portal/?p=782
http://www.elem.com.mk/index.php?option=com_content&view=article&id=64&Itemid=149&lang=mk
http://www.elem.com.mk/index.php?option=com_content&view=article&id=103&Itemid=208&lang=mk

ОРГАНИЗАЦИЈА И ВОСПОСТАВУВАЊЕ ГЕОГРАФСКО ИНФОРМАЦИСКИ СИСТЕМ НА ПРОИЗВОДНАТА И ВИСОКОНАПОНСКАТА ЕЛЕКТРО-ДИСТРИБУТИВНА МРЕЖА ВО РЕПУБЛИКА МАКЕДОНИЈА

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И З В О Д

Географските информациски системи претставуваат компјутерски софтверски системи што овозможуваат аквизиција, внесување, меморирање, обработување, ажурирање, пребарување, интерпретирање, разбирање и прикажување на разни географски и други придружни, негеографски податоци. Тие претставуваат технологија и методологија која интегрира во една меѓусебно поврзана целина повеќе компоненти: хардвер, софтвер, податоци и луѓе, а како такви се од голема помош при донесувањето на порационални одлуки, полесно и поефикасно планирање, организирање и работење. Почетоците на ГИС датираат од 70-тите години на XX век, но нивна масовна примена се забележува во последната декада на минатиот век.

За потребите на оваа ГИС-апликација се користени картографски, географски, статистички и математички методи.

Воспоставувањето на ГИС на производната и високонапонската електро-дистрибутивна мрежа подразбираше спроведување на низа поврзани и меѓусебно условени работни постапки, фундаментални за неговата функционалност. Во процесот на креирањето на конкретниот ГИС се изработени наменски картографски електронски векторски цртежи во размер 1:25000 и за секој објект се презентирани конкретни бази на податоци за производната (хидроцентрали, термоцентрали) и електро дистрибутивната мрежа (електроводови и трансформаторски станици) во Република Македонија.

Ваквите работни постапки можат да се поделат на неколку поголеми целини: картографска подготовка, формирање на бази на податоци, воспоставување на интеракциски врски и функционирање на ГИС-апликацијата.

Картографската подготовка претставува првата голема и фундаментална целина за потребите на секој ГИС систем. Оваа целина се состои од поголем број меѓусебно поврзани постапки, чие реализирање доведува до формирање на наменски картографски цртеж со предзнак ГИС. Во случајов врз база на топографски карти со размер 1:25000 (на околлу 220 секции) е изработен картографски цртеж за сите производни и електродистрибутивни објекти во Република Македонија, како основа врз која понатаму се надоврзуваат базите на податоци.

Формирањето на базите на податоци е втората голема целина. Тие се дефинираат како непосредни атрибути за сите потребни и избрани ентитети организирани во една или повеќе

независни или меѓусебно поврзани табеларни прикази. Истите се поврзуваат со соодветните на нив елементи на картографскиот цртеж со крајна цел комплетирање на ГИС на производната и високонапонска електро-дистрибутивна мрежа во Република Македонија. Во случајот се опфатени 16 хидроцентрали, 2 термоцентрали, 39 електроводови и 23 трансформаторски станици.

За сите објекти се оформени соодветни бази на податоци и истите интеракциски се поврзани со соодветните картографско графички објекти на наменската карта.

Поврзувањето на картографскиот цртеж со базите на податоци е овозможено преку воспоставување на интеракциски врски. Тие претставуваат посебна техничко-технолошка постапка со која се поврзуваат картографските елементи со соодветните податоци/ ентитети во базата на податоци. На сите картографски објекти се доделени единсвени идентификациски броеви, а потоа се воспоставени интеракциските врски со базите на податоци. Така е комплетирана конкретната ГИС-апликација.

По воспоставувањето на ГИС на производната и високонапонска електро-дистрибутивна мрежа, како последна целина се издвојува функционирањето на истиот. Функционирањето подразбира реализирање на разновидни барања, пребарувања и анализи и добивање на нови излезни производи во картографска, алфа, нумеричка, алфанумеричка, табеларна, фотографска или друга форма врз основа на постоечкиот дигитален цртеж и бази на податоци.

На сето тоа, може да се додаде дека, постојат можности оваа ГИС-апликација постојано да се ажурира и надградува сé до фаза на последниот потрошувач, така што се овозможува функционална евиденција, поефикасна организација и управување со електросистемот во Република Македонија.