INTEGRATED GEOGRAPHIC INFORMATIONAL SYSTEM, IN MONITORING THE ROADS

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Abstract: *The integrated geographic informational system is defined as a sub-system for the roads evidence and systematic inventory performance, under technical, economic and legal respect, with the compliance with the basic regulations and with the data from the Cadastral Integrated System - S.I.C. that contains two types of information: a graphical one, indicating the spatial distribution of the items studied and a textual one, for storing their associated attributes.*

Keywords: *survey, road, digital plan, data base, information, real estate, network.*

1. Introduction

The designing of data base models, that are the basis of the roads integrated geographic informational system implementation, complies with all the inter-relaltionship and constrains involved. The implementation programs utilised are: AutoCAD, ArcGIS and Microsoft Office. In order to develop the data base, the software from ESRI, ArcGIS is utilised, together with its programs, such as ArcInfo and ArcMap. Within a system, we have to identify: the set of component elements, the inner logic relationship between the system components, the inlets and outlets from the system, the variability in time of the components, the system finality and purpose.

The themes aimed in data base model assessment are: delimiting the problem area and the applicability area, the overall requirements and restrictions for project achievement: defining the outlets, functions, inlets, the entries logical structures, justifying the project achievement necessity and opportunity, the legal basis, the compatibility with the effective legislation, the expected economic effects. The schematic diagram of the Geographic Informational System is:

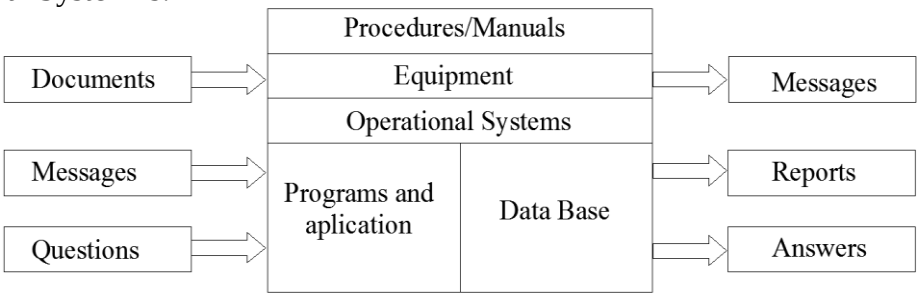


Fig.1 – Schematic diagram of a Geographic Informational System

The most important principle for planning the modern transport, is that the transport networks must be hierarchically structured, the advantages being highlighted in terms of traveling speed, capacity, savings and safety, although in certain studies is shown that, in the area with a reduced density, the hierarchic principle leads to reduced services and therefore, to

the transport costs increase. It can be noticed that the existence of a dense road network in the cities, the development of the road network within the suburban areas or in the urban centers neighbourghood, but also between the urban settlements of local or regional importance, accelerates the development and the economic growth of the areas. The establishing of routes for the roads construction is decided by political, social and economic factors, a less significant attention being frequently paid to the ballance between the transport network and the natural conditions.. There is a series of indicators that, utilising GIS technology, generate data and support information in the transport road infrastructure planning and development. Starting from the idea that transport is the main factor determining a geographic area development rate, the following three aspects are analysed: the identification of certain geographical area comprising land and soil utilisation categories with the highest economic development potential, requiring thus a transport road network development, the identification of transport road network geographic areas and the accessibility between the cities, through the transport road network.

2. The Organisation and Strategy of a GIS implementation

Regardless the magnitude and the implementation costs, the most important factor in getting an operational GIS application, cannot be financially quantified, a GIS implementation an operation success depending on the activity organising. Regardless the organisation of the structure implementing the GIS, in time, during the implementation, the performance of activities previously presented, is provided. A strategy utilised in order to comply with the most important activites requirements, for implementing a GIS, is represented by a team made of two people. This team performs the most of the management technical functions, as well as the routine operations. Thus, a member of the team performs the date base design, entering the date through the chosen methods, the basic processing and the geographical analyses provided by GIS implementation, and the second member fulfills the function of system administrator, programming the interfaces and the special macro-commands, developing GIS procedures in order to display the final results..

2.1 Providing the coordinates inter-workability between the layers

For an appropriate representation, the elements that appear in several layers will be represented by a single datum, within a special layer, a pattern. All the other layers are built starting from this pattern layer, adding specific elements.

Entering the data. A data base layer may be introduced through the conversion of certain data type CAD, existent in the format desired. The data are automatically introduced, pursuant the measurements performed by the GPS s and the local stations. There are several modalities the geographic data can be stored, namely: vectorial model, that is very closed to that utilised for maps representation, raster model, that describes the Earth surface as a matrix made of homogeneous elements, similarly to the model utilised for the images representation and the TIN (Triangular Irregular Network) model, that describes the surfaces shape under triangular forms.

Data interrogation, assumes the identification of certain elements, through indicating them on the screen, or the identification of all the elements satisfying a certain condition. Spatial interrogations are provided, in order to identify all the elements found within a rectangle of selection of a theme elements, depending on their relative position against the elements of another theme. All the localities where a road goes through, or all the cities located at less than X kilometers far from a road, etc, may thus be determined.

Geographic analysis achieved in order to comply with the objectives and with the criteria initially established for a GIS. The Geographic analysis results generate maps, report and charts. The thematic maps, the synoptic tables, as well as the comprehensive geographic representations generated pursuant the geographic analysis, prove a GIS capability of creating new information and not only of managing and extracting, in various ways, date previously acquired, being fundamentally different from a data base management GIS system. The layers overlapping achieves combinations between two layers, that represents the same land area, the objects from the first layer, point, line or polygon type, assumes the attributes corresponding to the objects over they overlap in the second layer, compulsorily of polygon type, a new layer having been obtained. Combining the spatial data and the attribute associated to each layer, new spatial relationship between the data are generated. Thus, by overlapping a layer comprising land plots, with another layer comprising soil types within an area considered, new relationships between the road areas and soil types are determined, in such a manner that the areas with damaged soil, can be identified.

Displaying of the results pursuant the geographic analysis is graphically performed on a map, accompanied by a description under a report format, comprising tabular data, including the values calculated within the analysis. In order to achieve the final map, several layers of the data base, comprising geographical objects traced in the project, are combined, a series of geographical elements are added and descriptive reports are developed. Besides the maps made available for the user, reports and charts highlighting various themes features, are generated.

2.2 Entering and operating the data implemented

After all the data have been entered in ArcMap, the user has the possibility to interrogate the information entered depending on the requirements. The software allows the project subsequent completion, with new information. A project implementing the Geographic Informational System of a road portion, must include the most important information related to the road. Thus, the data base must contain technical data about the curves length, in level and alignments, as well as the their kilometer positions, about the number of strips, slow vehicles traffic strips, verges, railway intersections, intersections with other roads. These information are centralised and entered into the data base afferent to the road portion studied. (Tables 1, 2, 3, 4, 5 and 6).

Curves and connection radius Table 1

No.	Road Type	Name	Km Positions		Direction	Length (m)
			Km	Meters		
1	DJ	156A	43	955	Right	105.51
2	DJ	156A	44	180	Left	70.31
3	DJ	156A	44	783	Left	94.33
4	DJ	156A	44	065	Right	84.79
5	DJ	156A	46	760	Left	44.81
6	DJ	156A	46	785	Right	41.4
7	DJ	156A	48	410	DR	100.44
8	DJ	156A	50	593	STG	182.55
9	DJ	156A	52	133	STG	249.68
10	DJ	156A	55	035	DR	108.27
11	DJ	156A	56	635	STG	49.63
					Total Length 1131.72m	

Traffic strips Table 2

No.	Road Type	Name	Km beginning	Meters beginning	Meters end	Strips	OBS	Length (m)
DJ	156A	43	700	56	640	2x3.00	Asphalt	12.940

Slow vehicles traffic strips Table 3

Road Type	Name	Km beginning	Meters beginning	Km end	Meters end	Side	Length (m)
DJ	156A	46	200	46	800	Right	600

Verges Table 4

Road Type	Name	Km beginning	Meters beginning	Km end	Meters end	Verges	OBS	
							Reinforced	Ballasted
DJ	156A	43	700	56	640	2x2.00	1.50	0.50

Railway intersections Table 5

Road Type	Name	Km	M	Intersection Type	Railway track	No lines	Slope	Barter	Name Line	Railway
DJ	156A	43	890	Level	NORMAL	1	Right	Without	09 Bacau-Bicaz Chei	16

Intersections with side roads - partial Table 6

No	Road Type	Name	Km	M	Road Category .	No Road int.	Side	slope	Intersection Type	Arrangement
1	DJ	156A	43	693	DN	15	Left	Left Left	Level	
2	DJ	156A	43	693	DN	15	Right	Left	Level	
3	DJ	156A	43	910	DU		Left	Left	Level	
4	DJ	156A	44	180	DU		Right	Left	Level	
9	DJ	156A	49	420			Left		Level	
10	DJ	156A	49	880	DJ	157	Left	Left	Level	
11	DJ	156A	49	880	DJ	157	Right	Left	Level	
15	DJ	156A	52	880			Left		Level	Without
16	DJ	156A	53	150			Left		Level	
17	DJ	156A	53	150			Right		Level	
18	DJ	156A	53	310			Right		Level	Without
19	DJ	156A	54	370			Right		Level	Without
20	DJ	156A	54	390			Right	Left	Level	
21	DJ	156A	55	120			Left	Right	Level	
22	DJ	156A	55	320	DU		Right	Left	Level	
23	DJ	156A	56	636	DN	15D	Left	Right	Level	
24	DJ	156A	56	636	DN	15D	Right	Right	Level	

Other information concerning the road portion considered, are the artworks found along the route. All the information related to these works are centralised, such as: concrete boxes, trenches, bridges and culverts, supporting walls, guardrails. All these information generate a good organisation of this works types (Table 7, 8, 9, 10, 11 and 12).

Concrete boxes details to culverts - transversal Table 7

No.	Road Type	Name	Km beginning	Meters beginning	Km end	Metes end	Side	Length(m)
1	DJ	156A	43	705	43	880	Left	175
2	DJ	156A	43	705	43	880	Right	175
3	DJ	156A	43	910	44	660	Left	750
5	DJ	156A	44	740	55	110	Left	10370
6	DJ	156A	44	750	56	620	Right	11870
7	DJ	156A	55	240	56	620	Left	1380
								Box Left Length – 12675m **Box Right Length – 12795 m** **Total Length – 25470 m**

Trenches - partial Table 8

No.	Road Type	Name	Km beginning	Meters beginning	Km end	Metes end	Side	Trench Type	Material	Length (m)
1	DJ	156A	44	740	45	20	Left	Trench	Concrete	280
2	DJ	156A	44	900	46	210	Right	Trench	Unpaved	1310
3	DJ	156A	45	20	45	80	Left	Trench	Unpaved	1310
4	DJ	156A	45	80	45	290	Left	Trench	Concrete	210
7	DJ	156A	46	50	46	60	Left	Trench	Unpaved	1310
8	DJ	156A	46	210	46	790	Right	Trench	Concrete	580
11	DJ	156A	49	910	51	110	Left	Trench	Unpaved	1310
15	DJ	156A	55	120	55	250	Left	Gutter	Concrete	130
16	DJ	156A	55	130	55	220	Left	Trench	Unpaved	1310
17	DJ	156A	55	250	55	540	Left	Trench	Concrete	290
										Total 13290 m

Bridge details Table 9

Road Type	Name	Km beginning	Meters beginning	Km end	Metes end	Length (m)	Locality
DJ	156A	44	660	44	710	50	ROZNOV

Lateral culverts details - partial Table 10

No.	Road Type	Name	Km	M	Side	Location	OBS
1	DJ	156A	44	740	Left	Left Side	
6	DJ	156A	48	260	Right	Right	
7	DJ	156A	49	510	Right	DJ156A	With catchment chamber
8	DJ	156A	49	560	Left	Left Side	
9	DJ	156A	51	620	Left	Left Side	
10	DJ	156A	54	440	Transversal	DJ156A	With catchment chamber
11	DJ	156A	55	120	Left	Side road Left	
13	DJ	156A	55	760	Transversal	DJ156A	
						Side culverts 9 pieces. **transversal culverts 4 pieces** **Total culverts 13 pieces**	

Supporting walls Table 11

Road Type	Name	Km beginning	Meters beginning	Km end	Meters end	Side	Work	Type	Foundation	Material	Length (m)
DJ	156A	55	120	55	240	Left			Continuous	Concrete	120
DJ	156A	54	380	54	450	Right	Excavation		Continuous	Concrete	70
DJ	156A	55	120	55	320	Right	supporting wall	embank ment	Continuous	Concrete	200
DJ	156A	55	330	55	410	Right	supporting wall	embank ment	Continuous	Concrete	80
									Total length	**470 m**	

Guardrails - partial Table 12

No	Road Type	Name	Km beginning	Meters beginning	Km end	Meters end	Side	Type	Material	Observations	Length (m)
1	DJ	156A	44	660	44	740	left	Semi heavy	METAL		80
5	DJ	156A	51	770	54	320	left	Semi heavy	METAL		2550
6	DJ	156A	54	370	54	440	right	Semi heavy	METAL	Located on the wall	70
7	DJ	156A	54	500	56	610	Left	Semi heavy	METAL		2110
8	DJ	156A	55	120	55	320	Right	Very heavy	METAL	Located on the wall	200
9	DJ	156A	55	330	55	410	Right	Semi heavy	METAL	Located on the wall	80
								LENGTH OF SEMI HEAVY GUARDRAILS			5750
								LENGTH OF VERY HEAVY GUARDRAILS			
								TOTAL LENGTH OF THE GUARDRAIL			200

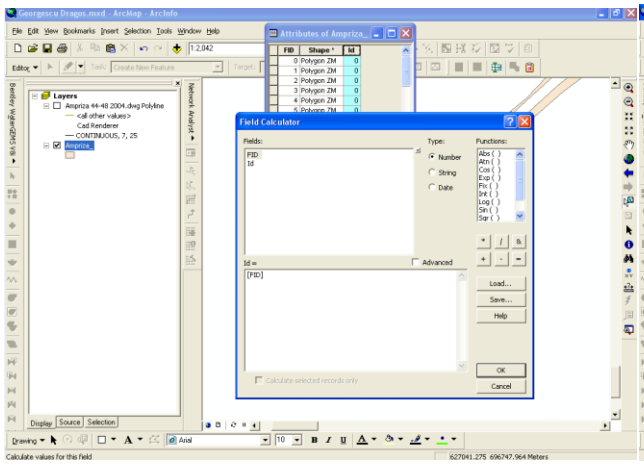
In terms of traffic safety a relational link is created between the kilometer positions of the road segment and the road signs existing in those kilometer positions, thus creating a good inventory of these signs (Table 13)

Road Signs - partial Table 13

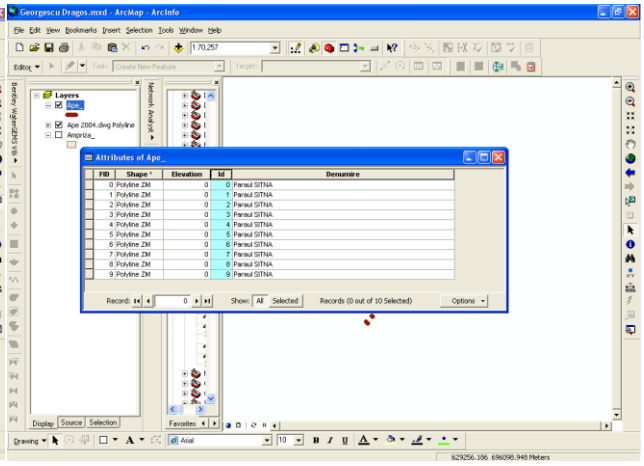
No	Road type	Name	Km	M	Part	Sign type	INSCRIPT	SUPPORT	OBS
1	DJ	156A	43	710	LEFT	REGULATION -PRIORITY	STOPPING	POLE_B	
2	DJ	156A	43	740	RIGHT	WARNING	LEVEL CROSSING WITH A RAILWAY WITHOUT BARRIERS	POLE_M	
22	DJ	156A	44	40	LEFT	WARNING	ADDITIONAL PANEL FOR LEVEL CROSSING WITH THE RAILWAY- 150 M	POLE_M	
23	DJ	156A	44	180	RIGHT	REGULATION -PRIORITY	STOPPING	POLE_M	SIDE ROAD RIGHT
24	DJ	156A	44	260	LEFT	WARNING	DOUBLE TURN OR A SERIES THAN MORE THAN TWO TURNS, FIRST ON THE RIGHT	POLE_M	
25	DJ	156A	44	600	RIGHT	REGULATION -PRIORITY	STOPPING	POLE_M	SIDE ROAD RIGHT
26	DJ	156A	44	610	RIGHT	WARNING	LEFT TURN	POLE _M	
30	DJ	156A	44	880	ST	WARNING	EXTREMELY DANGEROUS TURN TO THE RIGHT	POLE_M	
31	DJ	156A	45	140	ST	WARNING	LEFT TURN	POLE_M	
32	DJ	156A	46	120	DR	REGULATION -PRIORITY	STOPPING	POLE_M	SIDE ROAD RIGHT

2.3 Attaching of the descriptive data

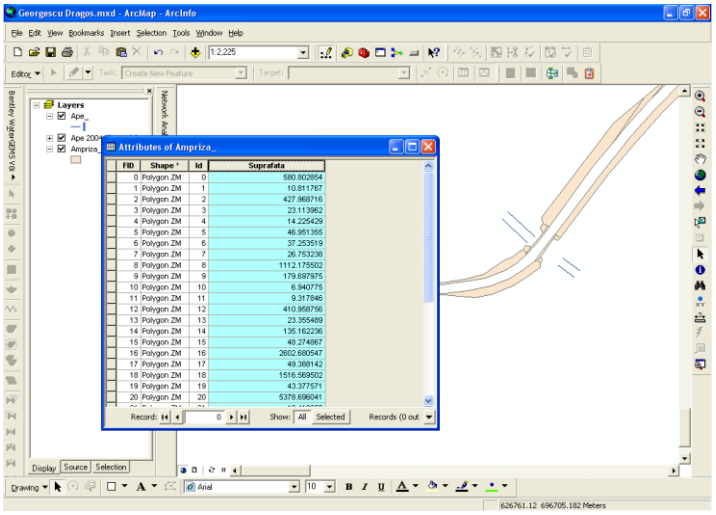
The descriptive data of the interest elements are attached on the graphical representation of the topographical survey (Fig. 2 – a,b,c).



a) Assigning the data of each polygon



b) Recording the attributes and the identification data



c) Attaching the descriptive data – Determining the area - Land surface required for built area

The road axis is the line defining the geometrical characteristics of the road direction in horizontal and vertical plane, being defined as the geometrical location of the points equally distanced of the road edges, formed of straight and curved lines, without taking into consideration the over enlargement in turns (curves) (STAS 4032/1-90).

The axis of each road shall be represented in the form of a 3D multi line described through the spatial coordinates *X, Y, Z*. The road axis is divided in homogeneous elements in terms of transversal profiles, traffic, traffic flow type, road surface, traffic speed and road gradient.

Associated to the road axis, the text information related to the road name and the location of the milestones along the sector, including the kilometer positions of the beginning and ending of the sector, shall be represented in a distinctive text type layer.

As the two alignments are connected by curves, these have to be represented through the characteristic elements (the curve radius, the input and output tangents, the bisector, etc.)

Figure 3 presents the kilometric positions and Figure 4 presents the text data of these positions.

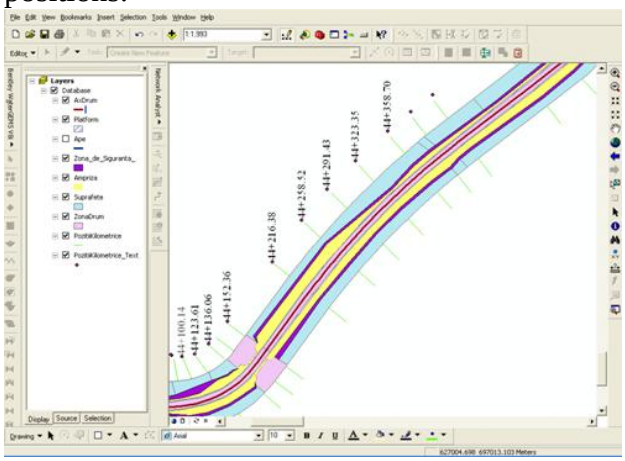


Fig.3 Data of the kilometer positions

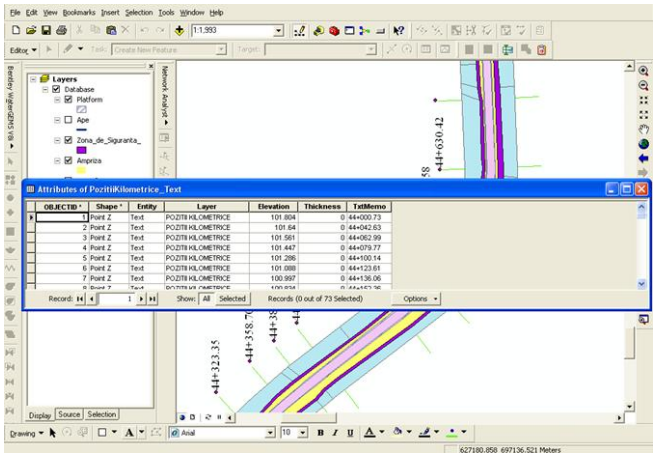


Fig.4 The textual database in kilometer positions

Outside the beginning and the end of the sector, the points which present alterations in the road gradient are recorded: road gradient larger or smaller than 2% horizontally. The data basis shall comprise the representations of the Land surface required for built area, water, safety area, road area, side roads, bridges, etc. We note that a two-way correspondence exists between each graphical element and the textual/alphanumeric database. Identifying an element by browsing the tabular database shall automatically lead the user to the corresponding element on the plan. (Fig. 5).

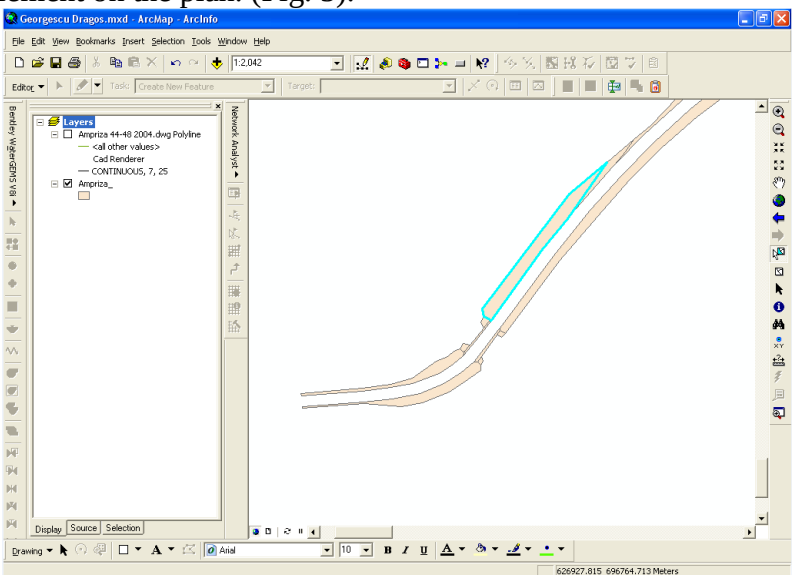


Fig. 5 browsing the database –Viewing the Land surface required for built area

2.4 Database interrogation

All program packages S.I.C. /G.I.S. include processes for database interrogation, in order to obtain a data subset. The spatial interrogations are the most important and assume the selection of the entities in terms of location or the spatial relations with the other entities. Other types of interrogations made useful are the graphical ones, attribute interrogations.

These interrogations allow **the performance of analysis and shaping of the spatial data**, which makes it distinctive of the other types of informational systems.

The interrogation of the databases represents a convenient analysis instrument, which allows the generation of tabular or graphical ratios, and in case of S.I.C./G.I.S, the correspondence graphic element- attributes in the database, which can be valued by creating a thematic map. (Fig. 6 and 7).

A more extensive interrogation at the level of the kilometer positions can be made by viewing the details concerning the width of the land surface required for built area, with the safety zones, the road axis (in alignment or in curve) as shown in Fig.3 and Fig. 4.

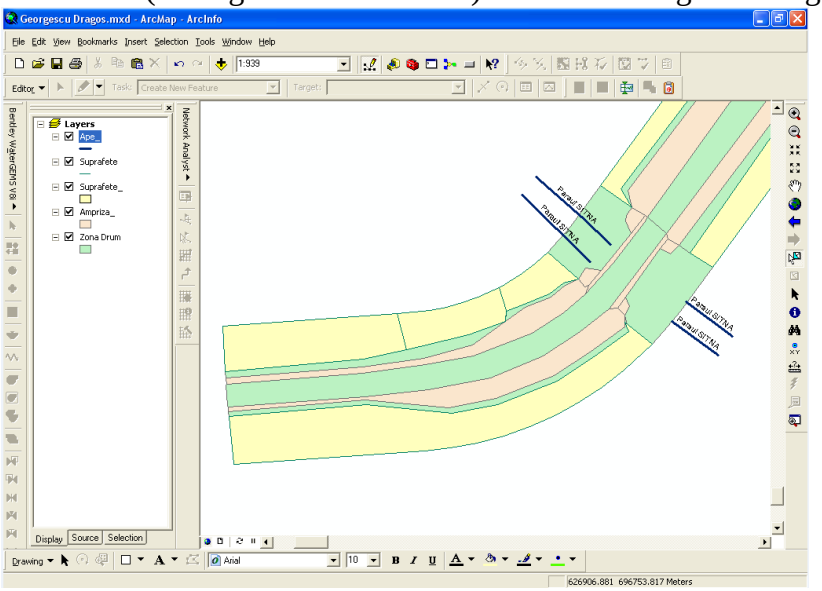


Fig. 6 Databases interrogation – Water, surfaces, land requirement, safety area

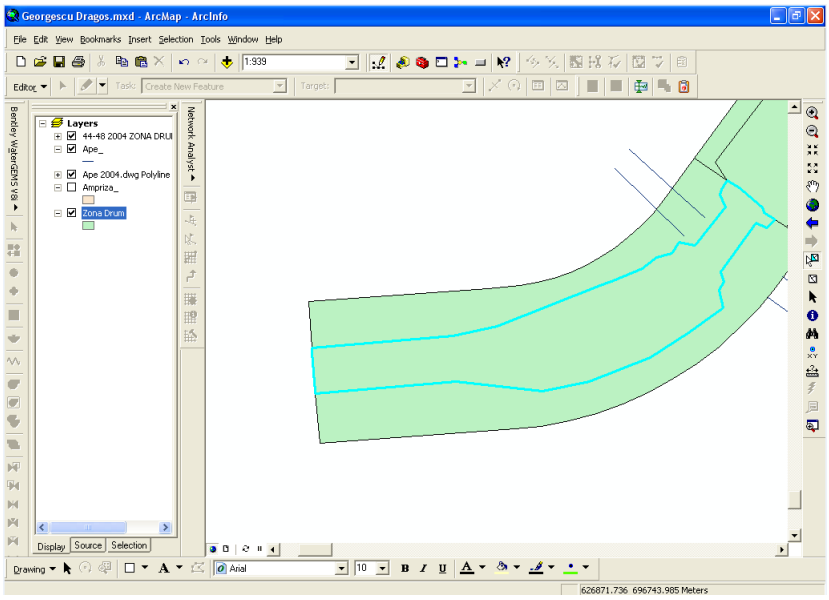


Fig. 7 Databases interrogation –Road area

An extensive interrogation of the kilometer positions of the two bridges, of the directions of the water flow, the bridges length can be made on the studied segment (Fig. 8). The side roads existing along the studied road segment can also be established and viewed using the interrogation, with details regarding the road type, the importance range, the gear of the side roads, etc. (Fig. 9)

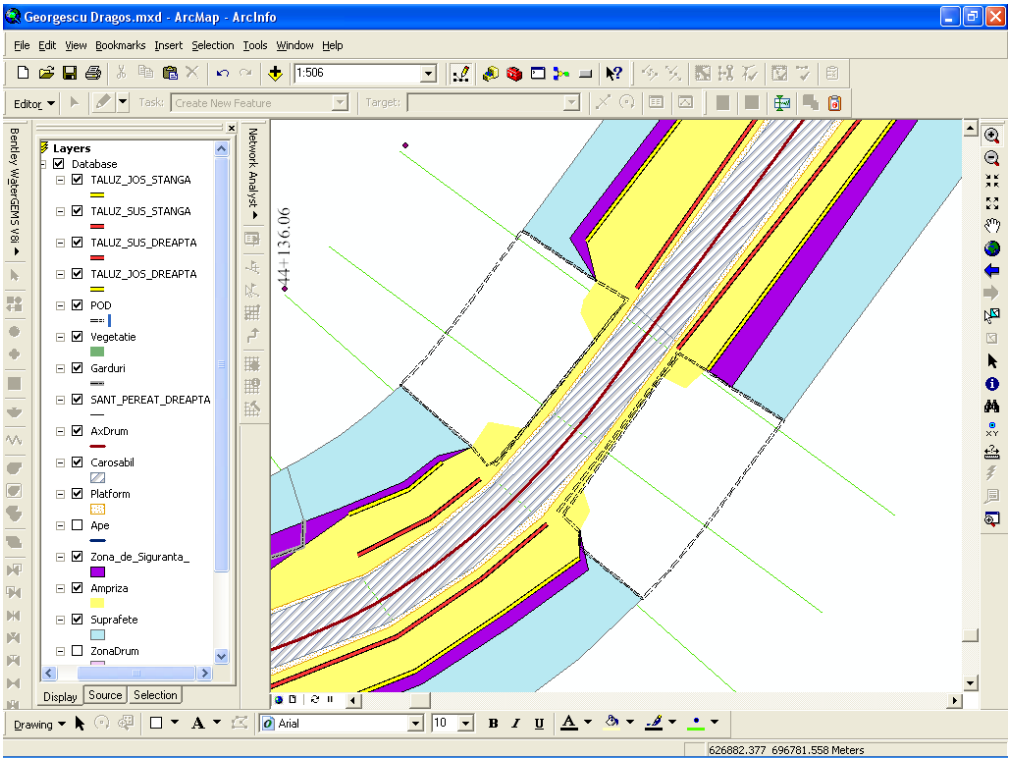


Fig. 8 Details of the bridge with clearance of 50 m

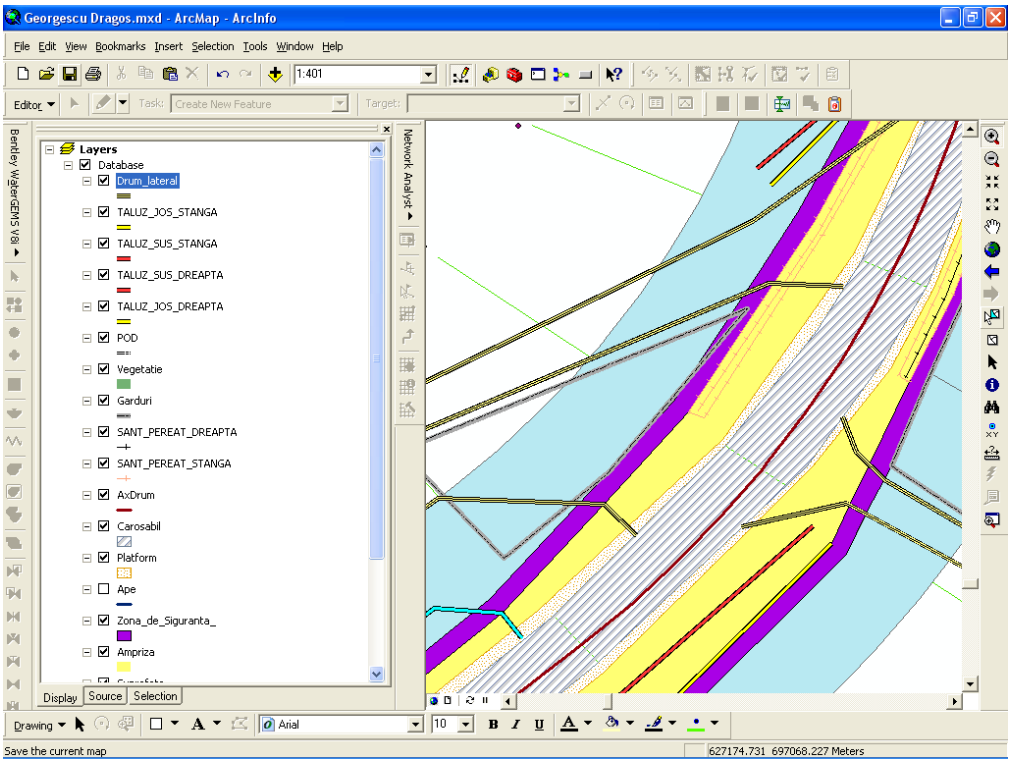


Fig. 9 Side roads

3. Conclusions

The themes pursued in the evaluation of the database model are: the demarcation of the problem range and the applicability range, the global requirements and the restrictions for the project accomplishment; the definition of outputs, functions, inputs, logical structure of

the input data, the justification of the necessity and the opportunity of the project accomplishment, the legal framework, the compatibility with the current legislation, the expected economical effects.

The availability of a dense road network in the cities, the development of roads in the suburban areas or in the vicinity of urban centers, but also in urban settlements of local or regional importance are speeding up the development of economic growth of the areas. The establishment of the routes in road construction is decided by political, social and economical factors, paying frequently a less important attention to the balance between the transport network and the natural settings.

4. BIBLIOGRAPHY

1. Connolly Th., Begg C., Stracham A., Baze de date, Ed. Teora, Bucureşti, 2001
2. Georgescu D.,Nistor Gh.,Sîmpetru A.B.,Performance of GPS suport geodetical network for digital cadastral plan of a road. Bul.Instit.Polit.Iaşi, t.LVII(LXI), f.1-4, s.Hidrotech., 2011
3. Georgescu D., Pădure D. and Cârdei M., Contributions Concerning the Tracing of the Roads Designed, Bul. Insit.Polit.Iaşi, t.LVIII(LXII), Fasc. 3-4, 2012
4. Nistor Gh., Topografie, Ed. Instit. Politehnic Iaşi, 1981
5. Nistor Gh., Georgescu D., Nica D.C., Aspects concerning the achievement of the digital cadastral plan of a road, Bul. Instit. Polit. Iaşi, t.LVII (LXII), f.1-2, s.Hidroteh., 2012
6.Nistor Gh., Georgescu D., Nica D.C. and Săndulache G., Graphical and Textual Data Base of a Road Informational System, Bul. Insit.Polit.Iaşi, t.LVIII(LXII), Fasc. 3-4, 2012