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THE INCREASE OF THE GEOGRAPHICAL ACCESSIBILITY OF THE TERRITORY – A DECISION-MAKING FACTOR FOR THE DEVELOPMENT OF THE NATIONAL ROAD NETWORK AND THE ADMINISTRATIVE REORGANIZATION OF ROMANIA

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Abstract: *An adequate management of the territory requires the latter's high accessibility, and this depends to a large extent on the configuration and capacity of the national road network. In order to assess the current accessibility of the Romanian territory by road, a national road network was formalized with the 41 county seats as nodes and the simple geographical accessibility was calculated based on the minimum distance between the nodes and the associated travel time, while the complex geographical accessibility was calculated taking into account the travel time and the population of the travel home node. The results reached support the need to develop the national road network in the immediate future by creating a network of highways which should exceed the current level, when the index node is minimal - there is one single node, the capital city, Bucharest - and by implementing the existing proposal - road crossing of the Danube by building a bridge (or a tunnel) in the Galati area. A second line of analysis is aimed at the future regionalization of Romania; a study was made on the accessibility of the county seats within the current RO 03 development region and revealed that it is possible to configure the new regions in such a way as to include the county of Arges in a region where the municipality of Pitesti could provide the best accessibility, an important argument for it to be designated the seat of the region.*

Keywords: geographical accessibility, road network, road infrastructure capacity, transport pole, administrative region.

INTRODUCTION

The fact that the administration of the territory requires an adequate accessibility is a thing that enjoys absolute acknowledgment. In this sense, of illustrative value is the administrative system of the Persian Empire, which encompassed 20 satraps whose imperial capitals were connected by roads. Similarly, the expansion and consolidation of the Roman Empire would not have been possible without simultaneously building a lasting network of roads that connected the newly conquered provinces to the capital ("All roads lead to Rome!").
According to a general definition, geographical accessibility represents the ease of approach to one location from other locations. This may be measured in terms of the distance travelled, the cost of travel, or the time taken [14].
The concept of accessibility is based on the relative spatial position and is assessed through the position of an area in relation to the transport infrastructure, this being considered a travelling support [21]. As a result, the configuration and capacity of the transport infrastructure is a key element in determining accessibility.
Considering the transport network as a graph (with nodes and arcs), the geographical accessibility of a node is the sum of all minimum distances (or times or costs) of transportation that separates it from other nodes [22]. The smaller the value, the bigger the accessibility of the node.

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$$A_i = \sum_{j=1}^{n} d_{ij} \qquad (1)$$

where:

- A_i = the geographical accessibility of the node *i;*
- d_{ij} – the distance between the nodes *i* and *j*, following the shortest way;
- n – number of nodes.

If one is also considering the node characteristics that are conducive to mobility (opportunities for travel – the number of inhabitants determines emissivity and the number of activities determines the node attractiveness), one uses the potential accessibility [23], which is a more complex expression than the simple geographical accessibility.

So, a measure that is often used is to measure accessibility in a transportation analysis for the *i* zone is [24]:

$$A_i = \sum_{j=1}^{n} O_j \cdot f(C_{ij}) \qquad (2)$$

where:

- O_j = number of opportunities in *i* zone;
- $f(C_{ij})$ = function of the generalized travel cost (or transport time, according to the formula "time is money").

ANALYSIS OF THE NATIONAL ROAD NETWORK

Using the existing data on the national road network [28] and statistically processing the data, the following observations arise:

• The national road network (highways, European roads, main and secondary roads) has a length of 16.500 km (of which 632.8 km are represented by highways)

• Density of the national transport network: 16500 km / 238391 km^2 = 69.2 km / 1000 km^2 (the value is rather high, consistent with the fact that virtually the entire Romanian territory is populated).

• Density of the highway network: 632.8 km / 238391 km^2 = 69.2 km/ 1000 km^2 = 2.65 km / 1000 km^2 (one of the lowest in Europe, although the density of the Romanian population is among the highest!)

Using the data provided by various dedicated computer programs [30], the national road network was formalized as a graph with the 41 county seats as nodes (Figure 1) and the associated matrix was achieved, stating the distances between nodes and the time of travel between the respective distances, as well as the expression [Population x Time] calculated for potential accessibility – of which an excerpt is presented in Table 1.

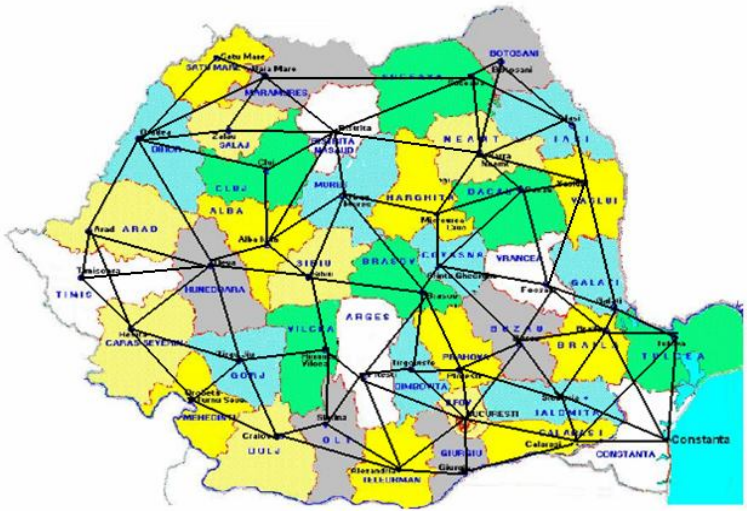


Figure 1. Formalizing the national road network as a graph.

Table 1. Excerpt from the matrix with the distances and transport times between the county seats.

County seat		Bucharest			…	Constanta			…	Tulcea			…
	P_j [loc]	**D_i**	**P_i*T**	**T_i**	…	**D_i**	**P_i*T**	**T_i**	…	**D_i**	**P_i*T**	**T_i**	…
Bucharest	1883425	0	0	0		223	235428125	125		281	378568425	201	
Alba Iulia	63536	351	17154720	270		583	24651968	388		641	29544240	465	
Alexandria	45434	89	4316230	95		313	9223102	203		371	12676086	279	
Arad	159074	556	69197190	435		787	87967922	553		845	100216620	630	
Bacau	144307	290	33912145	235		391	41849030	290		266	36653978	254	
Baia Mare	123738	596	57538170	465		773	72015516	582		686	73500372	594	
Bistrita	75076	434	29279640	390		659	36411860	485		576	38739216	516	
Botosani	106847	446	38999155	365		547	44875740	420		421	41029248	384	
Braila	180302	217	27405904	152		199	25783186	143		100	21636240	120	
Brasov	253200	169	38739600	153		394	63300000	250		452	82796400	327	
Buzau	115494	109	10740942	93		229	18017064	156		205	23907258	207	
Calarasi	65181	130	9386064	144		142	5410023	83		199	10233417	157	
Cluj - Nap	324576		112627872	347		682	153199872	472		616	178841376	551	
Constanta	283872	223	36051744	127		0	0	0		125	28671072	101	
Craiova	269506	228	46624538	173		460	78426246	291		517	99178208	368	
Deva	61123	398	18948130	310		629	26160644	428		687	30867115	505	
Drobet-TS	92617	341	23895186	258		572	34916609	377		630	41955501	453	
Focsani	79315	185	12135195	153		287	16656150	210		167	13959440	176	
Galati	249432	238	43650600	175		181	44648328	179		82	25442064	102	
Giurgiu	61353	64	3803886	62		280	10368657	169		338	15031485	245	
Iasi	290422	417	98743480	340		429	111812470	385		320	89159554	307	
Mierc Ciuc	38966	264	9507704	244		489	12975678	333		373	14222590	365	
Oradea	196367	596	88561517	451		827	111929190	570		885	126853082	646	
Piatra N	85055	349	25431445	299		450	30194525	355		325	27047490	318	
Pitesti	155383	118	11653725	75		349	29988919	193		407	41953410	270	
Ploiesti	209945	61	12596700	60		288	33381255	159		284	49127130	234	
Ramnicu V	98776	177	12643328	128		408	24298896	246		466	31904648	323	
Resita	73282	504	28433416	388		736	37080692	506		793	42723406	583	
Satu Mare	102411	638	50386212	492		869	62470710	610		722	66362328	648	
Sfantu Gh	56006	197	9969068	178		422	15401650	275		352	19546094	349	
Sibiu	147245	275	31804920	216		507	49179830	334		564	60517695	411	
Slatina	70293	178	8856918	126		410	17151492	244		468	22493760	320	
Slobozia	48241	126	4052244	84		137	3955762	82		159	6271330	130	
Suceava	92121	437	33163560	360		538	38230215	415		412	34821738	378	
Targoviste	79610	80	6368800	80		308	15444340	194		366	21494700	270	
Targu Jiu	82504	291	19800960	240		522	29536432	358		580	35806736	434	
Tg Mures	134290	343	38004070	283		569	65936390	491		521	63250590	471	
Timisoara	319279	563	135055017	423		794	172729939	541		852	197314422	618	
Tulcea	73707	280	14962521	203		131	7370700	100		0	0	0	
Vaslui	55407	325	15901809	287		349	18062682	326		240	12134133	219	
Zalau	56202	548	23211426	413		780	29899464	532		678	34451826	613	
TOTAL		**11831**	**1313515751**	**9772**		**18643**	**1946341273**	**13053**		**17972**	**2280904423**	**14542**	
			Obs: The data highlighted in yellow in the T column include an additional 30 minutes for ferry crossing from Galati.										

When calculating the average speed on the important European road link from Pitesti to Sibiu, an important observation arises:

• The current road link between Pitesti and Sibiu allows an average speed of only **62 km/h** - one of the lowest in the country, which is a strong argument for a more rapid implementation of the Pitesti – Sibiu highway project, which will lead to an increase in accessibility not only for the localities in the vicinity, but for the entire territory of the country through connections with the A3 Bucharest – Oradea highway in the Fagaras and Turda nodes, provided that it maintains, however, the development plan of the highway network for the 2020 time horizon (Figure 2).

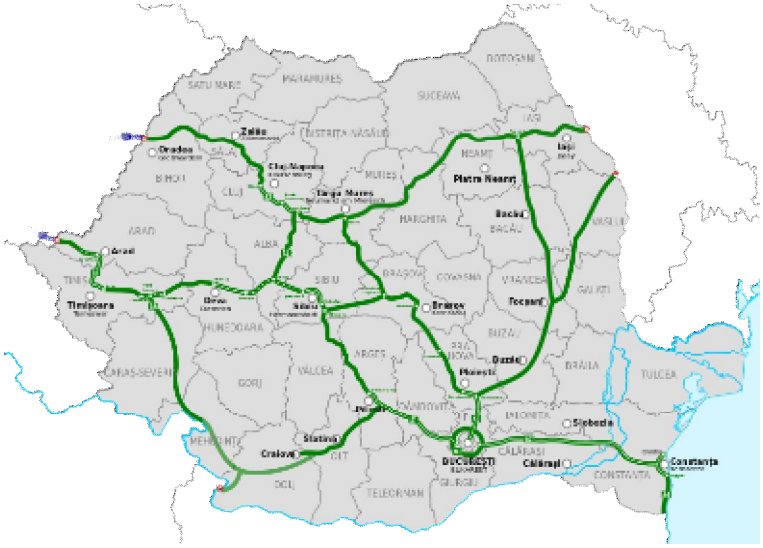


Figure 2. The 2020 Strategic Plan for the highway network.

Using the equation [29]:

$$V_m = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} V_{ij}}{C_n^2} \tag{3}$$

where:

- d_{ij} = distance between the nodes *i* and *j*;
- t_{ij} = time of travel between the nodes *i* and *j*;
- n = 41, representing the number of road nodes (there are 41 county seats and Ilfov is incorporated in the municipality of Bucharest),

another interesting observation arises:

•The average speed on the national road network linking the 41 county seats [8] is only **72.5 km/h**, far too small compared to the possible value of 100 ... 110 km/h in case of a developed network of highways!

To highlight the accessibility that the current national road network provides, the data presented in Table 1 have been processed as follows:

- the simple geographical accessibility was calculated in relation to the distance between localities and in relation to the transport time between localities (for the road connections that require ferry crossing at Galati, another 30 minutes were added), in accordance with equation (1); the initiative to calculate the simple geographical accessibility in relation to the fuel consumption on the route was dropped because it was observed that on all the dedicated sites the fuel consumption is calculated simplistically, solely for an average consumption of 7.5 l/100 km (basically, we obtain values similar to those calculated based on distances), useful for the reimbursement of transport expenditure, but far from reality – this observation will turn into a proposal to improve these dedicated programs!

- the potential geographical accessibility was calculated in relation to the product between the population of the county seat and the time it takes to arrive at the destination (it is found that the time has become a priority, given the intensification of the pace of life), in accordance with equation (2).
- the data obtained were ranked downward and were presented in Table 2;
- the accessibilities obtained for the 41 county seats were represented by ordered bar graphs (Figure 3), based on three criteria.

Table 2. Excerpt from the matrix with distances and transport times between the county seats.

County seat	D_i Sum
Brasov	10786
Sfantu Gheorghe	11037
Ploiesti	11359
Miercurea Ciuc	11663
Sibiu	11753
Bucuresti	11831
Targoviste	11928
Targu Mures	12037
Buzau	12169
Ramnicu Valcea	12235
Pitesti	12270
Focsani	12366
Alba Iulia	12591
Piatra Neamt	13170
Bacau	13191
Slatina	13559
Deva	13936
Bistrita	13963
Cluj - Napoca	13966
Alexandria	14075
Giurgiu	14120
Slobozia	14430
Craiova	14504
Targu Jiu	14565
Vaslui	14918
Braila	15064
Galati	15555
Calarasi	15559
Suceava	15787
Iasi	16082
Drobeta-TS	16488
Zalau	16526
Botosani	16689
Baia Mare	17117
Resita	17763
Tulcea	17972
Oradea	18185
Arad	18395
Satu Mare	18433
Constanta	18643
Timisoara	18674
TOTAL	**595354**

County seat	T_i Sum
Brasov	9458
Ploiesti	9590
Sfantu Gheorghe	9629
Bucuresti	9772
Pitesti	9782
Ramnicu Valcea	9810
Sibiu	9901
Targoviste	9923
Buzau	10257
Targu Mures	10323
Miercurea Ciuc	10496
Alba Iulia	10599
Slatina	10727
Focsani	10732
Slobozia	10937
Giurgiu	11159
Bacau	11284
Calarasi	11348
Alexandria	11429
Piatra Neamt	11609
Deva	11668
Craiova	11760
Cluj - Napoca	11782
Braila	12165
Targu Jiu	12240
Galati	12503
Bistrita	12545
Vaslui	13024
Drobeta-TS	13047
Constanta	13053
Suceava	13596
Zalau	13679
Iasi	13906
Baia Mare	14420
Botosani	14489
Tulcea	14542
Resita	14645
Timisoara	14797
Oradea	14817
Arad	15051
Satu Mare	15771
TOTAL	**492265**

County seat	P_i*T_i Sum
Bucharest	1313515751
Ploiesti	1396709557
Pitesti	1450261869
Targoviste	1482172592
Brasov	1519440478
Ramnicu Valcea	1542240890
Buzau	1547233962
Sfantu Gheorghe	1590877325
Slobozia	1611178321
Giurgiu	1614007188
Slatina	1645025915
Calarasi	1653216497
Sibiu	1688134549
Alexandria	1693951650
Focsani	1727038637
Miercurea Ciuc	1820827908
Craiova	1848830150
Braila	1870480957
Alba Iulia	1878004996
Targu Mures	1891728071
Bacau	1918229337
Constanta	1946341273
Galati	1972576257
Targu Jiu	2030834284
Piatra Neamt	2066484624
Deva	2072171400
Drobeta-Ts	2158113892
Cluj - Napoca	2164463790
Vaslui	2238413262
Tulcea	2280904423
Bistrita	2341979800
Iasi	2420952080
Suceava	2440983795
Zalau	2520049129
Botosani	2556568552
Resita	2577979046
Timisoara	2647930810
Oradea	2689289059
Arad	2702671197
Baia Mare	2738817158
Satu Mare	2925308732
TOTAL	**82195939163**

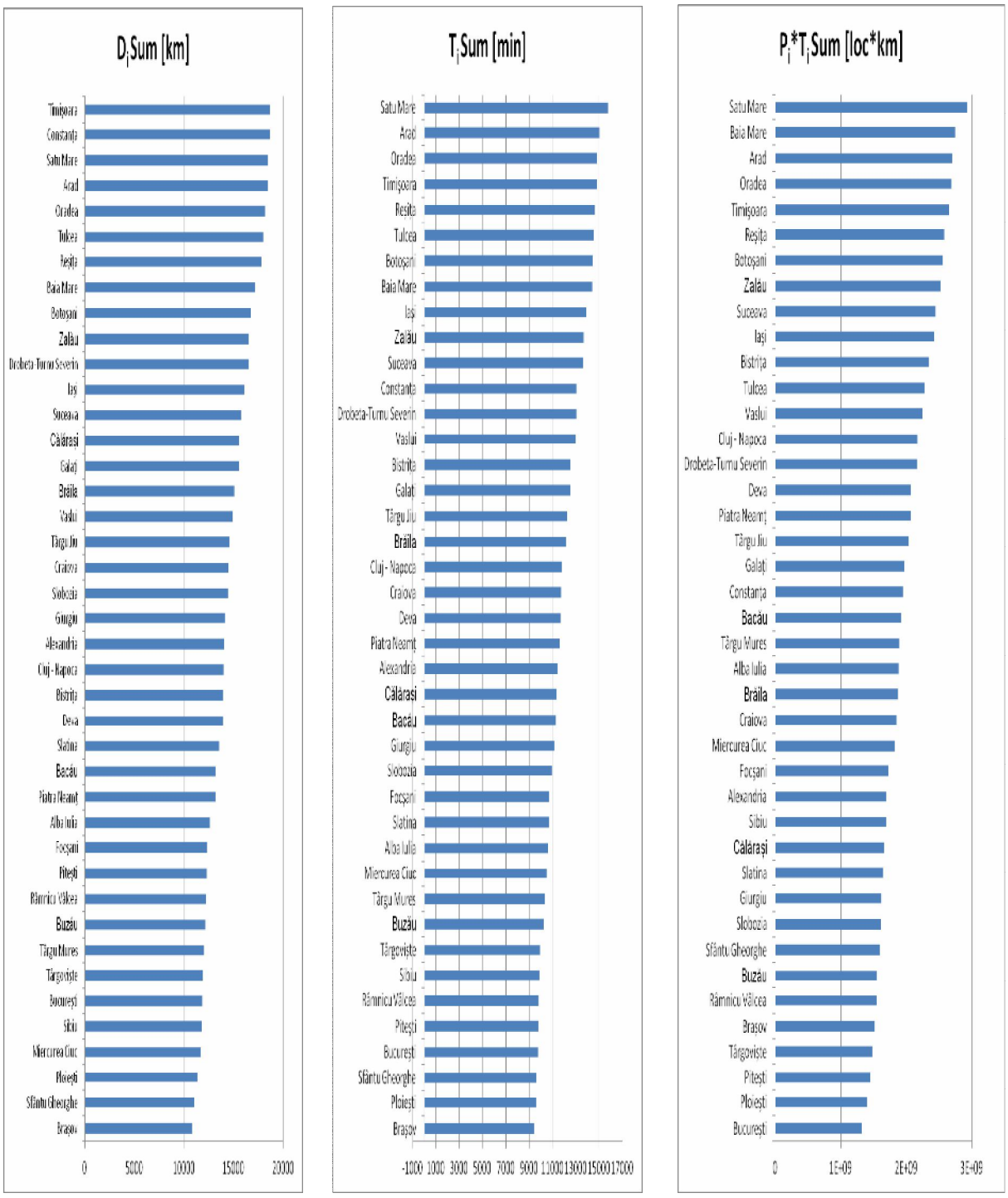


Figure 3. County seat accessibility on the national road network by Distance, Time and Population x Time.

From the data processed it is to be noted that the Bucharest - Ploiesti - Brasov road axis has the best simple geographical accessibility (keeping in mind solely the characteristics of the transport network - distance or transport time), but if one is considering the opportunities of the county seats (considered proportional to population size), it is noted that the best (complex) accessibility is attributed to the capital of the country, which is a strength for managing the national territory.

Even more, since works are currently being performed only on the highways that will have a single node - the capital of the country, the municipality of Bucharest - the position of the capital as a transport pole in Romania will be strengthened (Figure 4).

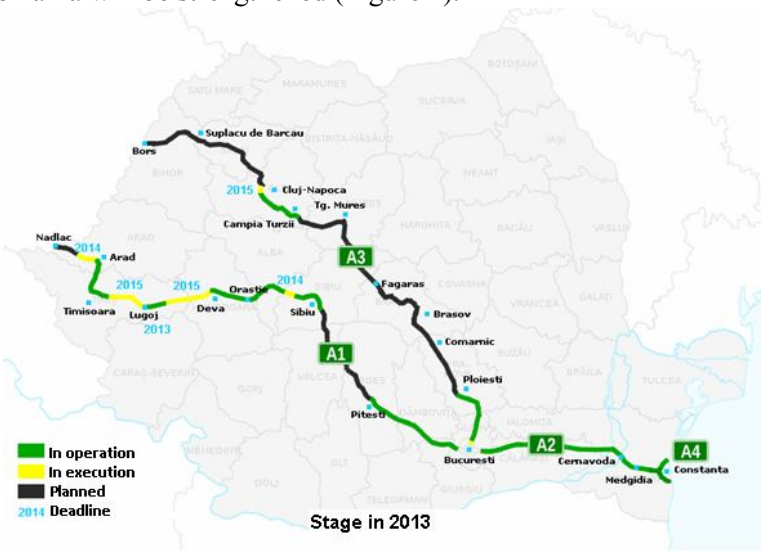
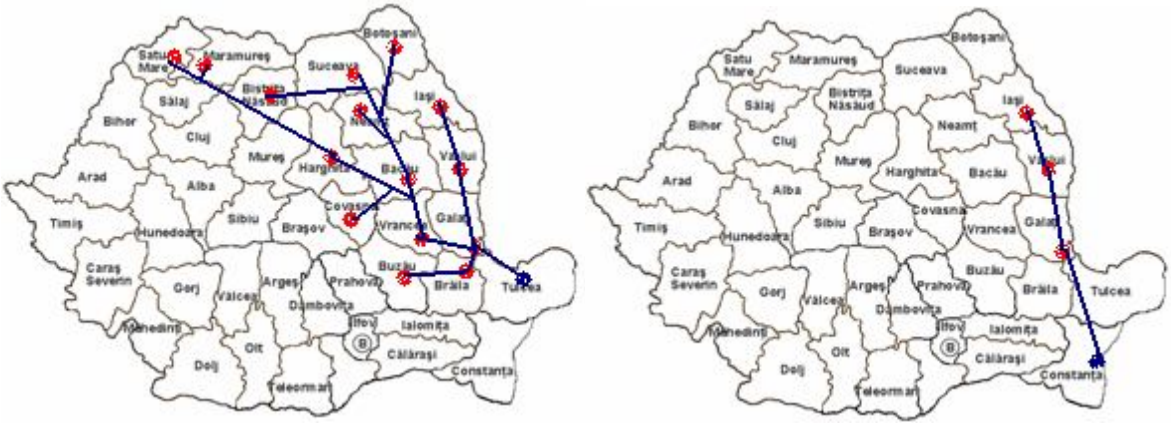


Figure 4. The situation of the highway network in 2013 in Romania.

Another observation resulting from the analysis of the data collected from the sites devoted to the description of road routes [7] is that it is necessary to build a bridge (or tunnel) to cross the Danube at Galati (now the ferry is being used – which is time-consuming, has a high cost and generates a lot of discomfort for the drivers), leading to a better global accessibility and, in particular, to better links between the counties in northern and north-eastern Romania and the Danube Delta and the Romanian seashore (Figure 5).



a) *b)*

Figure 5. Road links by ferry across the Danube at Galati, to Tulcea (a) and Constanta (b)

GEOGRAPHICAL ACCESSIBILITY – AN ARGUMENT FOR THE FUTURE ADMINISTRATIVE ORGANIZATION OF ROMANIA

One of the disputes of great interest nowadays is the future regionalization of Romania: how many regions will there be, how will they be and which will be the seats of the region?
It is accepted that the best location for the seat of a development region is the seat that leads to a minimal demand for transport: a full satisfaction of the demand for transport is desired, but it would be

ideal for the transport demand to be confined to the socio-cultural needs - only deliberate travels, not necessary travels.
The criterion that is most relevant to regionalization is given by the objective function: population mobility (number of travels, number of kilometres travelled or time, or cost ...), aiming at its minimization.
But even more relevant is a mobility indicator that should take into account the activities performed in the respective location, these being appreciated in best terms as proportional to the population of the locality, which is the reason why other parameters, containing the product between population and distance, time or cumulative cost, are highlighted.
The municipality of Pitesti is currently part of the RO 03 development region, whose seat is the municipality of Calarasi (Figure 6).

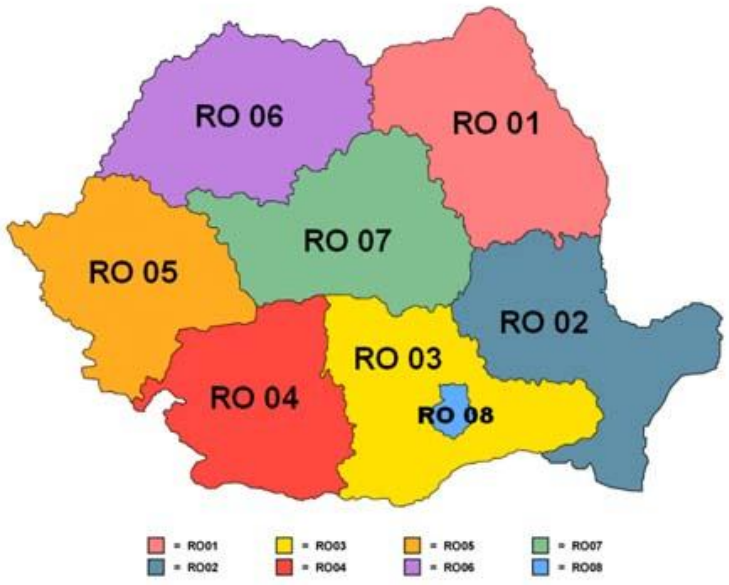


Figure 6. The current 8 regions of development in Romania.

A mere visualization of the map reveals that the municipality of Calarasi does not justify its status as the capital city of the RO 03 region of development, being placed absolutely eccentrically and entailing long trips from more populated county seats, such as the municipalities of Ploiesti and Pitesti. But this can actually be revealed through the determination (Table 3) and the graphical representation of the simple geographical accessibility in relation to travel times, as well as of the complex geographical accessibility weighted against the population of the original places of travelling (Figure 7).

Table 3. The accessibilities calculated for the seven county seats in the RO 03 region.

County Seat	P_j [place]	Sum T_i [min]	Sum P_i*T_i [place*min]
Alexandria	42129	758	72373229
Calarasi	57118	743	71932330
Giurgiu	54655	653	62622870
Pitesti	148264	714	53946136
Ploiesti	197542	644	43784533
Slobozia	43061	723	69706981
Targoviste	73964	664	47053094

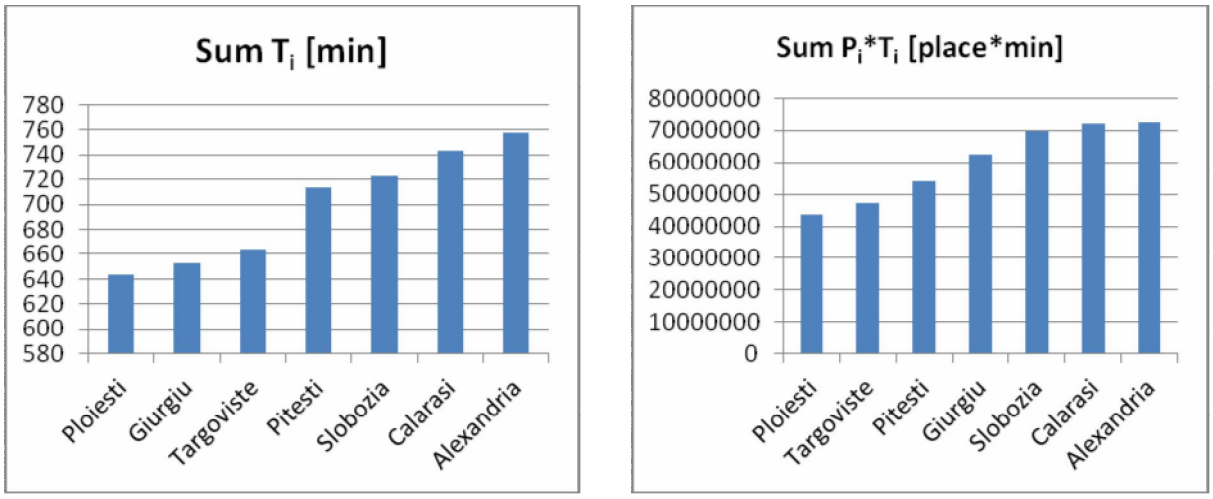


Figure 7. The geographical accessibility of the county seats in the RO 03 Region.

It is noted that in the current context of the regionalization, making Calarasi the seat of the region is absolutely disadvantageous as the best geographical accessibility is attributed to the municipality of Ploiesti, which makes it eligible for being the regional seat.
Although the municipality of Pitesti is geographically positioned at the edge of the region, given the fact that it has a relatively large population (being surpassed only by the municipality of Ploiesti), in terms of complex accessibility it ranks the 3rd – however, insufficient to lay claims to be the regional centre.
But in a new regionalization scenario (with 10 or 12 regions), the municipality of Pitesti is likely to become the seat of a region. If the 12-region version is agreed on, a possible division into regions comprising 3-4 counties (there are algorithms for this division as well, specific to the geography of transportation – but they are not the subject of this paper) could allow Pitesti to be the seat of the region.
For this, the most advantageous solution would be a region that encompasses the counties of Arges, Valcea, Dambovita and Olt (justified by the structure of the national road network as well), in which context, reprising the above calculations, the undeniable position of the city of Pitesti as the pole of transport is revealed.
The calculations made for the accessibility of the county seats of this hypothetical region (that largely overlaps with the previous Arges region, which existed before 1968) are summarized in Table 4.

Table 4. The accessibilities calculated for the four county seats in the hypothetical region.

Potential regional seat	**P_j [place]**	**Sum T_i [min]**	**Sum P_i*T_i [place*min]**
Pitesti	155383	194	16102627
Ramnicu Valcea	98776	274	25616634
Slatina	70293	273	28233951
Targoviste	79610	278	27638287

The graphical representations for the values determined reveal the incontestable leading position of Pitesti as a regional seat option in this case (Figure 8).

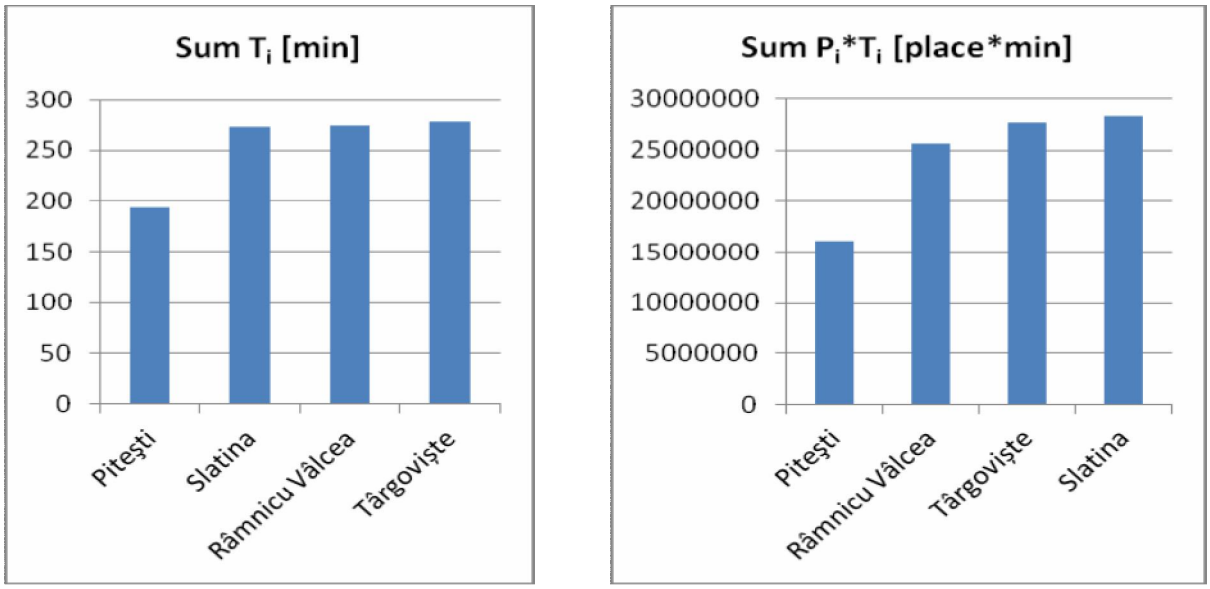


Figure 8. The geographical accessibility of the county seats in the proposed region.

One can note that it is possible to promote regionalization projects that bring the municipality of Pitesti and the county of Arges in a favourable position, but the strongest arguments are in favour of the version with 12 regions.

CONCLUSION

The results reached support the need to develop the national road network in the immediate future by creating a network of highways which should exceed the current level, when the index node is minimal - there is a single node, the capital city, Bucharest - and by implementing the existing proposal - road crossing of the Danube by building a bridge (or a tunnel) in the Galati area.
It was noted that on all the sites dedicated to road routes which also present fuel consumption on the route, this is calculated in a simplistic manner, solely for an average consumption of 7.5 l/100 km (basically, we obtain similar values to those calculated based on distances). This value is useful for the reimbursement of the transport expenditure, but it is far from reality as fuel consumption on the route depends on many factors: the vehicle type (technical factor), the driving style (human factor) and the characteristics of the route - traffic capacity, degree of tortuosity and degree of declivity (road factor), so the need to improve these sites in what concerns the fuel consumption on the route was identified.
The analysis undertaken in view of the forthcoming regionalization of Romania reveals that the current seat of the RO 03 development region is not justified in terms of geographical accessibility and demonstrates that it is possible to configure the new regions so as to include the county of Arges in a region where the municipality of Pitesti could provide the best accessibility, an important argument to be designated the seat of the region.

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