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## System of Suburban Bus Service in Central Croatia

Milan Ilić\*

This article deals with the suburban bus transport in Central Croatia. The density and structural characteristics of the bus transport network have been analysed. The centres of the bus transport were analysed according to several aspects: the number of the outgoing lines, the number of destinations, the length and structure of the bus lines, the frequencies and number of the bus departures. The transport flows were measured by the number of the buses passing through particular parts of the network. According to the conducted analyses, the centres of the bus transport were classified into four hierarchical categories.

**Key Words:** suburban transport, bus service, Central Croatia

### Sustav prigradskog autobusnog prometa u Središnjoj Hrvatskoj

U radu se proučava prigradski autobusni promet u Središnjoj Hrvatskoj. Razmatrani su gustoća i strukturalna obilježja mreže autobusnog prometa. Centri autobusnog prometa analizirani su kroz nekoliko aspekata: broj polaznih linija, broj odredišta, duljinu i strukturu linija, frekvencije i broj polazaka autobusa. Prometni tokovi mjereni su brojem autobusnih veza u pojedinim dijelovima mreže. Utvrđeno je da prevladavaju linije na kratke udaljenosti. S obzirom na promatrane parametre, centri autobusnog prometa klasificirani su u četiri hijerarhijske kategorije.

**Ključne riječi:** prigradski promet, autobusni promet, Središnja Hrvatska

### INTRODUCTION

Apart from the fact that in the majority of the Croatian towns it makes a dominant form of public transport (more precisely, the only one in all towns except Zagreb and Osijek), bus transport plays an important role in connecting a town with its closer and remoter surroundings. The past research in Croatia has shown that bus transport is the principal element of the suburban transport systems of particular towns, and that it has played an important role in organisation of the area around them (Sić, 1987 a). Owing to its technological and organisational advantages, it enabled a better supply level of communications than railway, covering the area dispersively. In the conditions of a relatively low automobilisation level (as well as of the rare use of automobiles, particularly because of economic reasons) it is obvious why bus has taken over the principal role in commuting among towns and their surroundings.

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This work analyses the bus transport in the area of Central Croatia. Its purpose is, on the basis of the available data, to state which towns are the principal centres of bus transport, and to single out several hierarchical categories based on the network development and some other characteristics.

The research area is Central Croatia, the region which, in functional sense, could be defined as the Zagreb macroregion. It represents a demographic, economic and traffic focus of Croatia, not only because of Zagreb - the capital of the country, but also because of a series of the lower centrality level towns, to which a special attention will be paid in this work. Consequently, this work will not analyse the urban and suburban transport of Zagreb and the towns included in it. Zagreb, as the largest city in the country, has often been the subject of geographical research, and what is more, we can say that it was the centre of interest of the geographers preoccupied with cities and their influence on the surroundings by traffic, labour commuting etc., which is quite understandable. There is no doubt that Zagreb deserves it by its largeness and significance, by its gravitational power and largeness of its gravitational area, by its influence on the closer and remoter surroundings, by development of its transport system and influence surpassing not only Central Croatia, but also the whole country. However, the centres of the regional and smaller significance in the area of the Zagreb macroregional influence have frequently been overshadowed by its largeness and importance and so pushed into the back seat. Therefore, in this work, the emphasis will be laid on the analyses of certain spatial phenomena and processes in the area of Central Croatia "out of the metropolis". One of the footholds of such an approach is the fact that several works dealing with Zagreb as a work centre and the urban region centre, Zagreb suburbanisation, Zagreb public transport, etc. were published in some last ten years (Vresk, 1992, Vresk, 1994, Vresk, 1997, Sić, 1994, Opačić, 1999 etc.).

## WORK METHODS AND DATA SOURCES

Geographical analysis of transport system is most often carried out from two aspects. The first one relates to the transport network analysis: the number of bus lines, their length and spatial distribution and characteristics of the nodes. The second one relates to the transport flow analysis, that is to the network use: drive frequency, number of the transported passengers and similar. Besides, it is possible to analyse the number of the included transportation means and their effect (capacity, passed kilometres, fuel consumption, profit and sim.) which are the data of technical-exploitation and economic character, but they can indirectly point to the transport system features.

The choice of the indicators which will be used in analyses is most often limited by the available data. That's why the bus transport analysis in this work is based on the timetables of the bus companies doing their job on the territory of Central Croatia. The data about the bus lines have been used: their number, length, destinations and routes as well as their drive frequencies.

With regard to the observed area, a large number of the bus lines and network complexity, it was required to establish certain methodological principles. First it was necessary to determine which lines and towns would be included into consideration.

As to the bus lines, all those in regular workweek transport, without regard to distance and destination features, are included. Namely, because of more complex urbani-

sation processes and migration flows in larger urban settlements, we can distinguish the urban lines in a limited sense and the lines which end in suburban areas (Sić, 1987 a). In organisation system and statistical sources they are all included into urban transport. On the other hand, all bus lines organised on the regional basis are defined as the inter-place transport, although, functionally, we can distinguish the lines designed for the closer surroundings and those for the remoter destinations (Sić, 1987 a). In a limited sense, the first ones can be defined as the suburban lines (suburban transport), and the second ones as the interurban or intercity lines. Having examined the timetables, we can note that, as a rule, they also serve in the suburban transport of both terminal towns, because the buses stop on the same stations where do the buses of the suburban lines leading to a smaller neighbouring destination. Therefore, those lines have also been included into the analysis. Particular lines without the status of urban transport, although similar to the urban lines according to certain features (departure frequencies, transport organisation and the type of the transportation means), were also taken into consideration. In the first place we think of the lines Karlovac-Duga Resa and Sisak-Petrinja. Nevertheless, they were excluded of some analyses because they distorted a general picture by their ponder. First of all it relates to the analysis of frequencies. 787 lines have been singled out in Central Croatia by this approach.

As to the centres, all former municipal centres (because of the labour function and central functions) and all settlements whose departure lines lead towards five or more destinations were considered. Namely, some former research (Ilić, Njegač, 1992) showed that it was an approximately minimal number of lines that we could talk about a network, i. e. about a bus transport centre. In that way, 37 centres were singled out. They were mostly the former municipal centres with only several exceptions.

One of them is Klanjec, the only municipal centre with no departure lines. The other is Donja Stubica which, although a municipal centre, has played the secondary role in its municipality, while the leading role was left to Oroslavje concerning many indicators (number of inhabitants, number of work places in the settlement, number of commuters, urbanisation level etc.), and bus transport as well. Donja Stubica has a departure line towards only one destination, and Oroslavje towards seven ones. The relation between Zlatar and Zlatar-Bistrica, which was the centre of the municipality in 1991, is quite similar. In this case Zlatar has been taken into consideration.

## BUS TRANSPORT NETWORK

**Structural characteristics.** The first structural characteristic which will be considered here is the length of the bus lines. The results of that analysis are presented on the table 1.

The listed data show that the lines shorter than 30 km prevail while the number of the longer ones decreases relatively regularly. Classified into the classes of 5 km, the most represented class is that ranging from 21 to 25 km, than those from 26 to 30 km and from 16 to 20 km. These three classes cover nearly a half of all lines on the territory of Central Croatia. The lines up to 30 km account for 66 percent of all lines. The average length of the considered lines is 29.4 km, and even 63 percent of the lines are shorter! At the same time the lines longer than 90 km claim only 1 percent of all lines concerned. The longest line is Varaždin-Virovitica, and it is 129 km long. In this con-

Tab. 1 Structure of the bus lines in Central Croatia and departure frequencies according to the line length (in km)

length	number of lines	% of lines	number of departures	% of departures	average frequency
-5	6	0,76	27	1,26	4,50
6-10	48	6,10	181	8,43	3,77
11-15	102	12,96	394	18,36	3,86
16-20	116	14,74	292	13,61	2,52
21-25	130	16,52	404	18,83	3,11
26-30	118	14,99	292	13,61	2,47
31-35	61	7,75	152	7,08	2,49
36-40	56	7,12	98	4,57	1,75
41-45	27	3,43	51	2,38	1,89
46-50	32	4,07	76	3,54	2,38
51-55	27	3,43	56	2,61	2,07
56-60	17	2,16	36	1,68	2,12
61-65	10	1,27	16	0,75	1,60
66-70	10	1,27	14	0,65	1,40
71-80	11	1,40	26	1,21	2,36
81-90	8	1,02	18	0,84	2,25
91-100	2	0,25	3	0,14	1,50
100-	6	0,76	10	0,47	1,67
total	787	100,00	2146	100,00	2,73

Source: Autobusni vozni red 1990./91., Transportkomerc, Zagreb 1990

nection one should bear in mind that, as a rule, the centres and destinations of a bus line are not connected in the shortest way (as many settlements as possible are usually connected out of economic reasons), and can conclude that the short distance lines prevail, or that they are primarily used for the local transportation needs. The obtained results are in concordance with the research in the Danube-basin countries (Jordan, 1984), in Croatia (Sić, 1987 a) and in the former Yugoslavia (Sić, 1987 b). To make conclusions more easily, the distribution is presented in the figure 1.

Although the frequencies of particular lines will be more discussed later, the relation between the line length and frequencies will be briefly considered here. 2146 departures from the bus transport centres are realised on 787 singled out lines, which means that the average frequency per line is 2.73 drives (in one direction). However, on the lines up to 30 km (520 of them), 1590 departures are realised (74.1 percent of all departures), and the average frequency is 3.06 drives per line. 25.9 percent of all departures are realised on the lines longer than 30 km, and the average frequency is 2.08 departures per line. A more detailed distribution of the quoted relation is presented in the table 1. It is noticeable that the greatest frequencies are realised on the shortest lines, even if we exclude the lines up to 5 km which are not representative because they



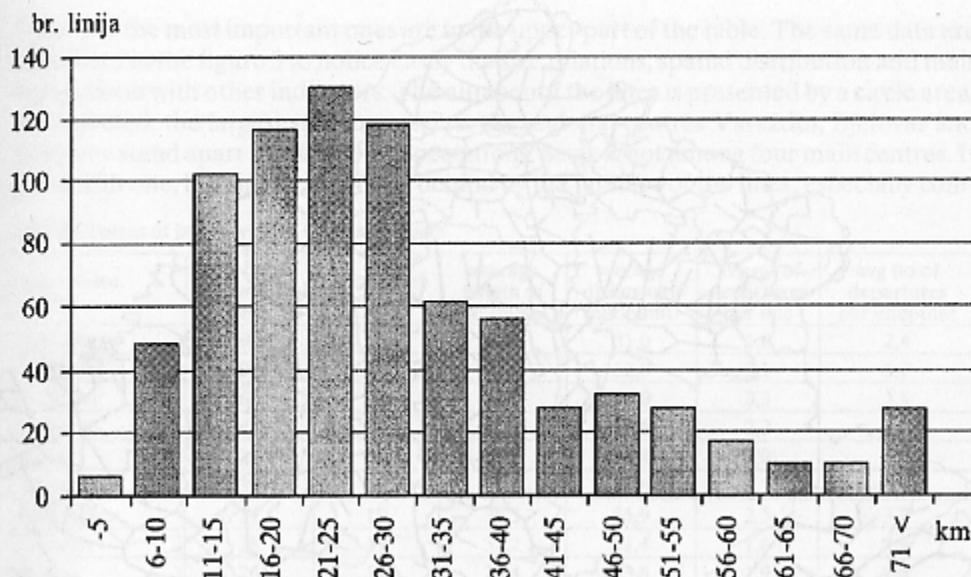


Fig. 1 Bus lines in Central Croatia according to length (in km)

Sl. 1. Autobusne linije u Središnjoj Hrvatskoj prema duljini (u km)

are few. All lines shorter than 30 km have a frequency greater than 2.5. As to the absolute values, the largest number of departures is also realised on the shortest lines, specifically in the group of the lines from 21 to 25 km long, then follow the lines from 11 to 15 km long. These two groups of lines realise more than 1/3 of all departures. These data also prove that the majority of transport takes place on the short lines.

The other element of the bus transport structure is the network spatial development. Since it is not possible to carry out the quantitative analyses (e. g. density and sim.) because there are no statistical indicators, the graphical presentation of the schematic network of the bus lines (fig. 2) will be considered. In order to enable an easier orientation the borders of the former municipalities have been plotted on.

Generally several conclusions can be reached:

- the southern part of Central Croatia (the regions of Karlovac and Sisak) are characterised by a lower network development and density
- a lower network density and a simpler structure appear in the transport corridor of Posavina and Podravina
- the endpoints of the "blind" lines correspond most often with the municipality borders
- there is a correlation of the network expansion with the population density, but also with the population structure, in which connection the settlement number and largeness are considered. A denser and more complex network can be found in the areas of greater population density, especially if it is accompanied by dispersed population (Hrvatsko zagorje, Međimurje, the territory of the former municipality Bjelovar).

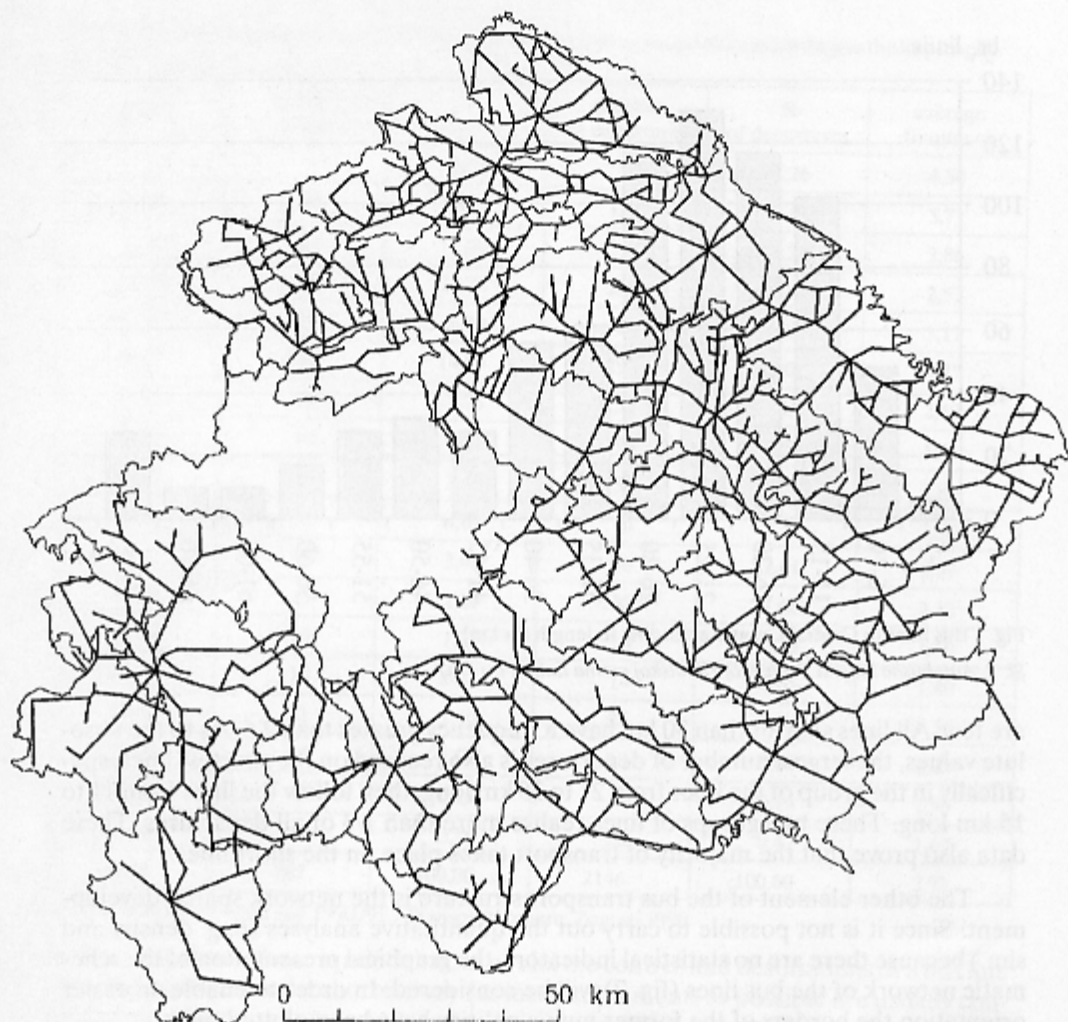


Fig. 2 Public bus transport network in Central Croatia in 1991.

Sl. 2. Mreža autobusnih linija u Središnjoj Hrvatskoj 1991. g.

### BUS TRANSPORT CENTRES

As already mentioned, 37 bus transport centres have been singled out on the territory of Central Croatia. Their largeness and significance will be considered here according to the number of the departure lines and to the number of the destinations connected with them. The spatial distribution and the reach of the mentioned connections as a gravitational area indicator will be considered too, as well as some other features of particular centres. The majority of the relevant data is given in the table. 2.

**Number of lines.** The number of the outgoing lines is a most often used significance indicator and the criterion of the centre hierarchy in the bus transport analysis. The bus transport centres in the table 2 are sorted according to the number of the departure

lines, and the most important ones are in the upper part of the table. The same data are presented in the figure 3 to notice easily the size relations, spatial distribution and their comparison with other indicators. The number of the lines is presented by a circle area. As expected, the largest settlements, i. e. the regional centres Varaždin, Bjelovar and Karlovac stand apart. Against the expectations, Sisak is not among four main centres. It is the fifth one, but significantly lags behind by the number of the lines, especially com-

Tab. 2 Centres of bus service in Central Croatia

bus service centre	number of departure lines	number of endpoints	average length of line (in km)	average distance of endpoint	avg no of departures per line	avg no of departures per endpoint
Bjelovar	92	63	32,2	31,0	1,6	2,4
Varaždin	91	50	33,2	32,0	3,1	5,7
Karlovac	66	63	31,0	30,0	3,3	3,5
Čakovec	47	19	26,1	25,6	2,2	5,4
Sisak	34	30	38,8	34,4	5,0	5,7
Virovitica	32	18	34,2	31,6	1,7	2,9
Koprivnica	31	19	36,3	35,9	2,3	3,7
Daruvar	28	19	32,2	31,4	1,6	2,4
Kutina	26	19	30,4	33,6	1,9	2,6
Križevci	23	20	22,6	21,6	2,5	2,9
Krapina	23	19	17,0	16,7	5,1	6,2
Garešnica	23	14	33,5	28,1	2,8	4,6
Glina	21	20	25,7	24,3	2,2	2,4
Novska	20	17	27,5	28,2	1,9	2,2
Petrinja	19	18	24,2	24,9	5,8	6,2
Dvor	16	13	39,1	33,5	2,7	3,3
Pakrac	15	14	26,8	26,0	3,9	4,1
Hrv. Kostajnica	14	13	25,4	24,0	4,0	4,3
Sv. Ivan Zelina	14	12	22,1	23,4	1,2	1,4
Čazma	14	12	22,9	23,4	1,6	1,8
Zabok	12	12	25,7	25,7	2,9	2,9
Ivanec	12	8	21,6	19,1	2,8	4,3
Ivanić-Grad	12	8	38,3	39,8	1,7	2,5
Ludbreg	12	7	27,8	22,9	3,4	5,9
Novi Marof	11	8	22,4	20,4	2,4	3,3
Zlatar	10	10	21,2	21,2	3,1	3,1
Đurđevac	10	5	24,0	24,0	2,7	5,4
Jastrebarsko	8	8	22,4	22,4	3,3	3,3
Duga Resa	8	8	21,0	21,0	4,3	4,3
Grubišno Polje	8	4	24,5	21,5	1,8	3,5
Oroslavje	7	7	21,7	21,7	2,6	2,6
Slunj	6	6	27,7	27,7	2,8	2,8
Pregrada	6	5	14,0	12,6	3,7	4,4
Vrbovec	5	3	45,4	46,3	1,6	2,7
Ozalj	4	3	15,8	14,7	1,5	2,0
Gvozd	4	2	20,3	20,0	2,3	4,5
Vojnić	3	3	23,7	23,7	1,3	1,3
total	787	579	-	-	-	-

Source: Autobusni vozni red 1990./91., Transportkomerc, Zagreb 1990

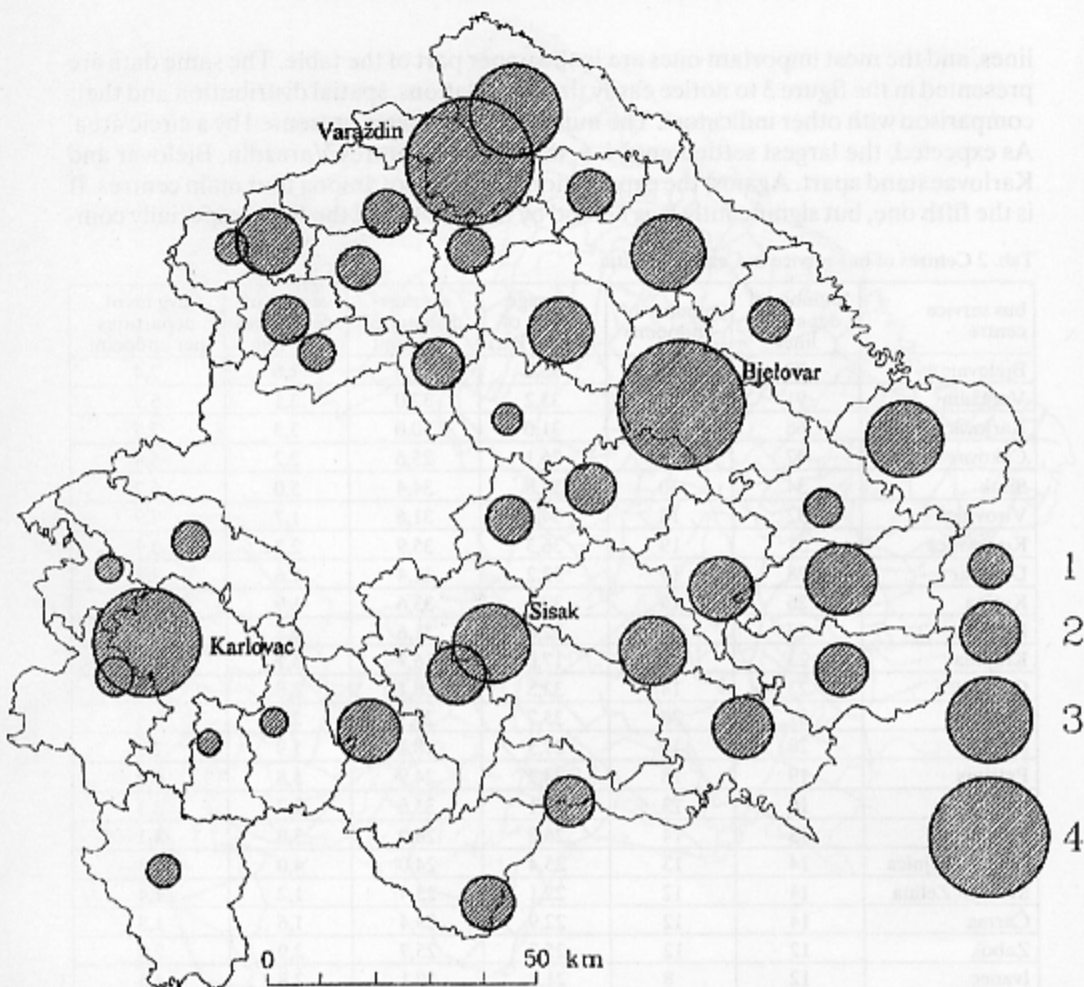


Fig. 3 Bus transport centres in Central Croatia according to the number of departure lines in 1991; number of lines: 1) 10; 2) 20; 3) 40; 4) 80

Sl. 3. Centri autobusnog prometa u Središnjoj Hrvatskoj prema broju polaznih linija 1991. g.; broj linija: 1) 10; 2) 20; 3) 40; 4) 80

pared to Varaždin and Bjelovar. On the other hand, the high position of Čakovec with even 47 departure lines, is beyond expectations.

The number of the departure lines from particular centres has been put into correlation with several factors which are supposed to influence it: the settlement size (number of inhabitants), the number of work places in a settlement, the number of daily commuters to the settlement, the share of daily commuters in the employed in the settlement, the population density, the road network density, the municipality area, the number of the settlements in the municipality, etc. However, a strong (statistically significant) bimodal correlation was not proved for any of the mentioned factors. That means that none of them has a prevailing significance, but their influence is the result of their compound correlations. In this matter, neither the ponder of every single factor is

equal in all centres, nor all factors included into the system are quoted here. Moreover, some of them are hardly quantifiable. One of them is, for example, the influence of the spatial organisation and index of primacy in the hierarchial structure of particular nodal regions. Specifically, in the region of Karlovac the eye is caught by a prominent difference between the largest centre, Karlovac, which holds the third place by its 66 lines, and the other centres in its gravitational area (the former community of municipalities) of which none has more than 10 lines (Vojnić 3, Gvozd and Ozalj 4 each, etc.). On the other hand, Sisak is less dominant in its gravitational area: the second centre according to the number of lines (Kutina) has only a few lines less than Sisak, and the proportion between the strongest and the weakest centre in the region is 2.4:1. As to Karlovac, this proportion is 22:1! Such proportions are largely the consequence of the relations in the central place systems of particular regions. So the relation between the population of Karlovac and Ozalj is 51:1, and between Sisak and Dvor is 19:1. As to the number of work places, the relation between Karlovac and Ozalj is 37:1, and that between Sisak and Dvor is 21:1. Similar differences can be noticed if we consider the relations of the first and the second centre in the region.

Regardless of the mentioned differences, some conclusions can be made. First of all, a marked asymmetry of the series which is not very disperse. This statement can be proved by several facts: first seven centres (19 percent) account for a half of all departure lines; nevertheless, even 19 centres (51 percent) vary from the average value less than  $\pm 0.5$  standard deviations, and 33 centres less than  $\pm 1$  standard deviation. On the other hand, two centres vary over +3 standard deviations, one centre +2.2, and one +1.2 standard deviations. It can be said that four centres (Bjelovar, Varaždin, Karlovac and Čakovec) belong to the first category of the bus transport centres according to the criterion of the departure lines number. 5 centres with 25-35 departure lines would belong to the second category, and the centres with 18-24 lines, i. e. those with the values around the average (21.2) belong to the third one. The following group is that with 10-17 departure lines, and, finally, the last group includes 10 centres with less than 10 departure lines each.

Comparison with other indicators considered so far suggests that the principal bus transport centres are large work centres. Furthermore, the centres whose gravitation areas are characterised by a greater population density have a larger number of departure lines. The exceptions are the centres of smaller municipalities, especially if they are close to larger towns (municipalities in Hrvatsko zagorje, Ludbreg, Sv. Ivan Zelina). As expected, a larger number of lines correspond with the areas of greater bus lines network density.

**Number of destinations.** The second criterion for consideration of particular bus transport centres is the number of destinations towards which the bus lines lead. The data about that feature are given in the second column of the table 2, and the values are graphically presented in the figure 4. Generally taken, the differences according to the previous indicator are not great, but in some individual cases they are very significant. Namely, it has turned out that particular centres have approximately or completely the same number of lines and destinations (that means that the connection with every destination is being realised by only one line), some have the number of lines essentially larger than the number of destinations, consequently, the connections between the centres and destinations can be multiple. The greater the difference between the

number of lines and destinations is, the more complex the network is, and it enables a better connection of settlements, that is, a larger number of alternative connections. These differences will be analysed a little later, the number of destinations will be considered first.

Regarding the considered centres, the average number of destinations is 15.7, and 33 centres deviate from that number for less than one standard deviation. That means that the series is very compact (or poorly disperse), and only three bus transport centres deviate more significantly: Karlovac and Bjelovar stand out markedly, Varaždin a bit less markedly, while Sisak lags behind a little. Glina and Križevci follow with 20 destinations each (deviation from the average is more than 0.25 standard deviation). The centres of medium size are those with 13-19 destinations, consequently the centres around the average values. Such centres prevail, there are eleven of them. The centres with a little number of destinations can be found in the Karlovac region again, but Vrbovec, Grubišno Polje, Pregrada, Đurđevac, etc. also belong to that group of centres.

It has already been mentioned that, regarding particular centres, the number of lines and destinations differ significantly. If we compare figures 3 and 4, the largeness of the circles and their spatial distribution, two regularities (with some exceptions, of course) can be noticed:

- the difference between the number of lines and destinations is more frequent and prominent in the northern part of Central Croatia
- these differences are more marked concerning larger centres

The greatest difference has been determined in Čakovec: 47 bus lines are directed towards only 19 destinations (40.4% of the total bus lines), which means that Čakovec is connected with every destination by 2.5 bus lines on average. In reality, Čakovec and Mursko Središće are connected by even 7 lines of different routes, Čakovec and Štrigova by 5 lines, as well as Čakovec and Podturen, Čakovec and Varaždin by four bus lines, etc. To be fair, in these examples only one line stands out by high frequencies. Knowing the characteristics of Međimurje, these results can be connected with population density (166 inh./km<sup>2</sup>), with the road network density (613 m/km<sup>2</sup>) and complexity, with a great labour force mobility (70% of the employed in Čakovec are commuters), as well as with the fact that it is a question of a large area where there was "place" for development of a complex network. These could be the main factors which, on the one hand call for, and on the other give a possibility for development of such a complex network.

Let us observe the other centres being remarkable for a great difference between the number of the bus lines and destinations (the number of destinations does not surpass 75% of the bus lines number), the smallest centres excluded (with less than 10 outgoing bus lines), because the relations applying to them can be the result of pure coincidence, not of certain regularities. Besides Čakovec, the following towns belong to the mentioned group: Đurđevac, Varaždin, Virovitica, Ludbreg, Garešnica, Koprivnica, Ivanec, Ivanić-Grad, Daruvar, Bjelovar, Novi Marof i Kutina. If we compare the values of the quoted parameters, we can conclude:

- in all towns except Bjelovar more than 40 percent of the employed are commuters (in Novi Marof even 82%)

- the majority of the municipalities is populated with more than 75 inh./km<sup>2</sup>, and some even surpass 100 inh./km<sup>2</sup> (Novi Marof 103 inh./km<sup>2</sup>, Ivanec 121 inh./km<sup>2</sup>, Varaždin 252 inh./km<sup>2</sup>)
- except Daruvar and Virovitica, all municipalities are prominent for a great density of modern road network (more than 400 m/km<sup>2</sup>).
- dispersed population prevails in all municipalities: the number of settlements on a square kilometre is larger ( in some municipalities even several times) than the value average for the whole researched area.

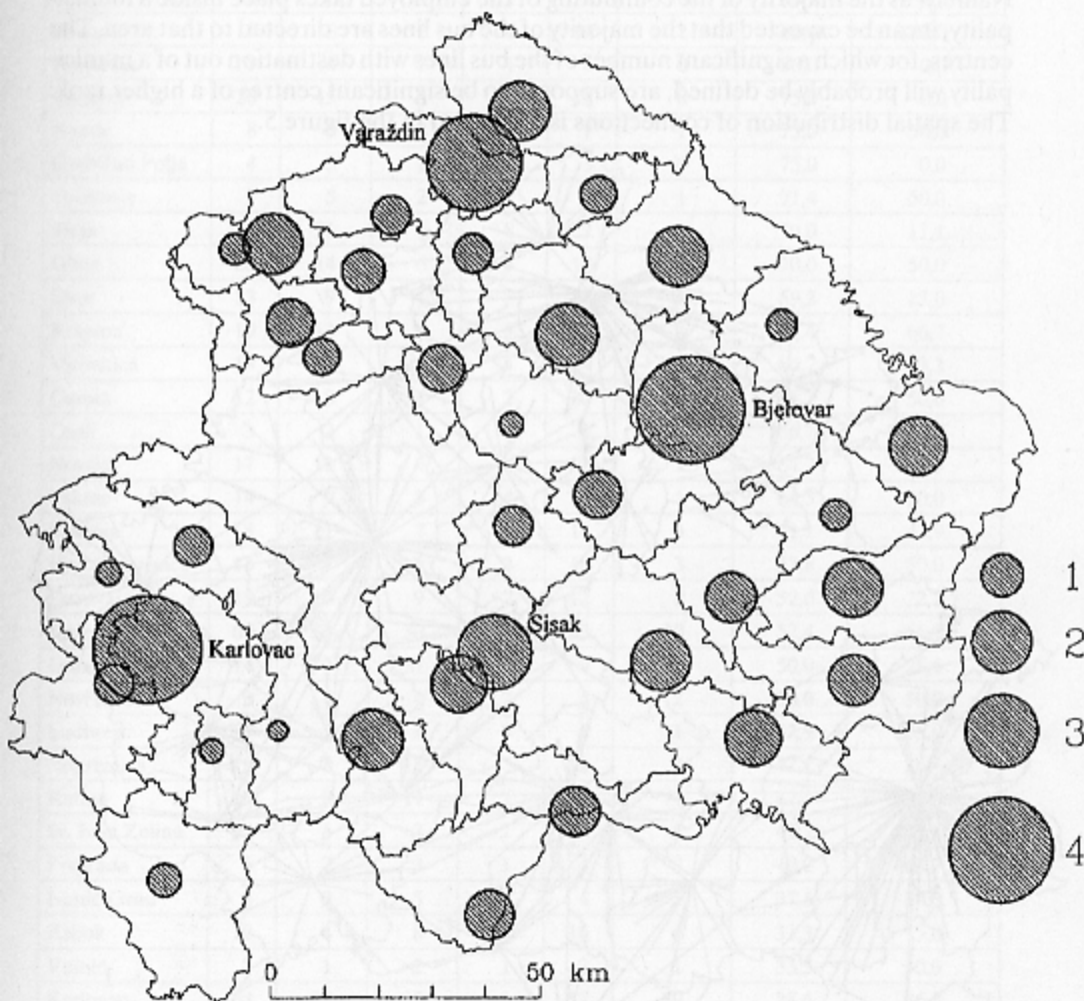


Fig. 4 Bus transport centres in Central Croatia according to the number of endpoints; number endpoints; 1) 10; 2) 20; 3) 30; 4) 60

Sl. 4. Centri autobusnog prometa u Središnjoj Hrvatskoj prema broju odredišta 1991. g.: broj odredišta: 1) 10; 2) 20; 3) 30; 4) 60

On the other hand, in the regions of Sisak and Karlovac a simpler bus transport structure prevails. In that structure the number of destinations surpasses the number of the bus lines for 85 percent (Novska, Sisak, Petrinja), and even for 95 percent (Glina, Karlovac). At the same time these are the centres standing out for a small share of commuters in the total number of the employed: Sisak and Glina 37 percent each, Petrinja 33 percent, and Karlovac only 22 percent - least in all Central Croatia.

**Structure and length of the bus lines.** Here, we shall consider the characteristics of particular centres regarding the length of the outgoing bus lines, destination distance, and the bus lines structure according to the area's political-territorial organisation. Namely, as the majority of the commuting of the employed takes place inside a municipality, it can be expected that the majority of the bus lines are directed to that area. The centres, for which a significant number of the bus lines with destination out of a municipality will probably be defined, are supposed to be significant centres of a higher rank. The spatial distribution of connections is presented in the figure 5.



Fig. 5 Graph of connections in the bus transport network in Central Croatia in 1991: 1) endpoints; 2) municipality centres in 1991; 3) endpoints of periurban and intercity bus transport in Zagreb

Sl. 5. Grafveza centara autobusnog prometa Središnje Hrvatske 1991. g.: 1) odredišta; 2) općinski centri 1991.; 3) odredišta prigradskog i međugradskog prometa Zagrebu



Tab. 3 Centres of bus service in Central Croatia according to location and endpoint function

bus service centre	number of endpoints			endpoint function			share (%)	
	total	in municipality	out of municipality	municipality centre	settlement		endpoints in municipality	settlement in endpoints out of municipality
					total	out of municipality		
Gvozd	2	2	0	0	2	0	100,0	0,0
Čakovec	19	18	1	1	18	0	94,7	0,0
Jastrebarsko	8	7	1	1	7	0	87,5	0,0
Duga Resa	8	7	1	1	7	0	87,5	0,0
Slunj	6	5	1	1	5	0	83,3	0,0
Zlatar	10	8	2	0	10	2	80,0	100,0
Đurđevac	5	4	1	1	4	0	80,0	0,0
Križevci	20	15	5	5	15	0	75,0	0,0
Ivanec	8	6	2	1	7	1	75,0	50,0
Grubišno Polje	4	3	1	1	3	0	75,0	0,0
Oroslavje	7	5	2	1	6	1	71,4	50,0
Sisak	30	21	9	8	22	1	70,0	11,1
Glina	20	14	6	3	17	3	70,0	50,0
Dvor	13	9	4	3	10	1	69,2	25,0
Krapina	19	13	6	2	17	4	68,4	66,7
Virovitica	18	12	6	4	14	2	66,7	33,3
Čazma	12	8	4	2	10	2	66,7	50,0
Ozalj	3	2	1	1	2	0	66,7	0,0
Novska	17	11	6	4	13	2	64,7	33,3
Pakrac	14	9	5	4	10	1	64,3	20,0
Petrinja	18	11	7	4	14	3	61,1	42,9
Hrv. Kostajnica	13	7	6	3	10	3	53,8	50,0
Daruvar	19	10	9	7	12	2	52,6	22,2
Bjelovar	63	33	30	10	53	20	52,4	66,7
Garešnica	14	7	7	5	9	2	50,0	28,6
Novi Marof	8	4	4	2	6	2	50,0	50,0
Ludbreg	7	3	4	3	4	1	42,9	25,0
Koprivnica	19	8	11	7	12	4	42,1	36,4
Kutina	19	8	11	7	12	4	42,1	36,4
Sv. Ivan Zelina	12	5	7	2	10	5	41,7	71,4
Pregrada	5	2	3	1	4	2	40,0	66,7
Ivanić-Grad	8	3	5	4	4	1	37,5	20,0
Zabok	12	4	8	2	10	6	33,3	75,0
Vojnić	3	1	2	1	2	1	33,3	50,0
Karlovac	63	18	45	6	57	39	28,6	86,7
Varaždin	50	13	37	6	44	31	26,0	83,8
Vrbovec	3	0	3	3	0	0	0,0	0,0
ukupno	579	316	263	117	462	146	54,6	55,5

Source: Autobusni vozni red 1990./91., Transportkomerc, Zagreb 1990

The majority of the data relevant for these analyses are given in the table 3. The bus transport centres are sorted according to the share of destinations in the municipality. In the upper part of the table there are the centres with a large share of destinations inside the same municipality, and in the lower one, those where that share is little. However, it is obvious that this is not a sufficient criterion, because, in the neighbouring positions in the table there are centres of essentially different characteristics; e. g. Gvozd and Čakovec at the top, and Varaždin and Vrbovec at the bottom of the table. Therefore, this characteristic is to be considered complexly with the whole number of destinations and their functions. Namely, a large share of destinations out of a municipality, accompanied by a larger total number of destinations, among which settlements prevail (e. g. Varaždin), points to a strong centre with a large gravitational area. Conversely, the centres with a small number of destinations inside the same municipality (e. g. Vrbovec with no destinations), and with the majority of municipal centres as other destinations (in the case of Vrbovec 100%) can be characterised as the centres with an underdeveloped network and poor gravitational impact. Moreover, among the centres with a large share of destinations in the area of the same municipality we should distinguish those with a large number of bus lines (Čakovec), i. e. which have developed dense networks in their areas, and those where a large share of destinations is accompanied by a small total number of bus lines (Gvozd), which points to underdeveloped transport (and other) functions.

On the basis of the correlation among these indicators, the considered centres can be classified into several groups.

Varaždin, Karlovac and Bjelovar stand out as the most important centres. They stand apart among other centres by the number of destinations out of their own municipalities (30-45, the first next one only 11), out of which a large number and share (66.7-86.7%) are not other municipal centres. If we want to define differences between them, we can state that Bjelovar stands out for a large number of connections with other municipal centres (even 10), and Karlovac and Varaždin are prominent for a markedly large share of destinations out of municipality borders, which points to a very large reach of gravitational impact.

Sisak, Daruvar, Koprivnica and Kutina can be classified into the second group. They are the centres with 9-11 destinations out of their own municipalities, but the municipal centres prevail. Consequently, the connections with the settlements out of the proper municipality mainly refer to the intercity bus lines. A more detailed analysis can prove that in the region of Sisak there are mainly smaller settlements, so we can conclude that the gravitational influence of Sisak is being realised indirectly, through these centres. This conclusion is in concordance with the facts established in the analysis of the bus transport network complexity. On the other hand, Daruvar is connected with the municipal centres of the same size or with the larger ones.

The third group consists of a larger number of the centres with 5-8 destinations out of their own municipalities, but with very different values of the features being considered here. So, according to the total number of destinations, we distinguish the centres with the values of 17-20, and those with the values of 8-14 (the average value for all centres is 15.6). In this matter, all centres with a larger total number of destinations account for more than 60 percent of destinations in their own municipalities, but they differ significantly regarding the character of destinations out of them. For example, all destina-

tions out of municipalities connected with Križevci are former municipal centres, and, as to Krapina, 1/3 of them. Zabok and Sv. Ivan Zelina stand apart among the centres with 14 or less destinations which are largely settlements. As a half of them are out of municipal borders, we can conclude that such is the reach of their central functions (some of them, at least).

The centres with 2-4 destinations out of municipalities belong to the fourth group. According to the number of destinations Dvor and Čazma lead, and Zlatar lags behind a little. The rest are smaller centres which are "in the shadow" of the neighbouring large centres. Nevertheless, some of them have developed their own local bus transport networks. First of all we think of Ivanec, Novi Marof and Oroslavje.

Finally, the last group consists of the settlements with only one (or no) destination out of the same municipality, and towards a municipal centre of a higher rank. According to the criterion applied here, Čakovec belongs to this group, although it does not belong to the group of underdeveloped bus transport centres according to any other criterion. Čakovec is one of the most powerful bus transport centres according to the number of the outgoing bus lines, it is prominent for a large number of destinations and the bus transport network complexity. It also accounts for the largest share of destinations in the area of the same municipality. We can say that Čakovec is the only bus transport centre where there is a prominent discordance between the earlier applied criteria and this systematisation. As to the other centres of this group, five of them are located in the gravitational area of Karlovac, and two in the area of Bjelovar. Their position in the bus transport system and development of their local networks are in concordance with the earlier established facts and the consequence of the spatial organisation and system of the centres in the Bjelovar region, and especially in the Karlovac region.

The bus line length is often used as an indicator of the bus transport development, because it can point to some of its structural and functional characteristics. As it was stated in the first part of this work, in the area of Central Croatia the bus lines of smaller length (to 30 km) prevail, which means that the main function of the bus transport is the local connection. In this matter, the bus line length need not be identified with the reach of the gravitational impact of particular centres, because in the local bus connections two points most frequently are not linked by the shortest way. Having analysed the length of the bus lines going from particular centres, significant differences among them were not found. The most important factors influencing the bus line length are the size of the municipality (because the majority of the lines end within the municipal borders) and the number of the lines with destinations out of it.

**Departure frequencies.** The number of drives on particular bus lines is an indicator of the interaction power between two settlements linked by the considered lines. High frequencies on particular bus lines are the indicator of strong connections, while a small number of bus departures shows a weak connection of a centre with its destinations.

Here, we shall consider the bus line frequencies according to the initial centres. Since it has been determined that the frequencies of the shorter bus lines are usually higher than those of the longer ones, it is logical to presume that the centres with a smaller average length of the bus lines will have a higher average frequency, all the more reason that the interactions between a town and its surroundings are the strongest. Of course, some other factors have influence here, and some of the most important

Tab. 4 Departure frequencies in the bus service centres of Central Croatia

bus service centre	average frequency of departure per line	average frequency of departure per endpoint	average length of line	average distance of endpoint	number of lines	number of endpoints
Petrinja	5,8	6,2	24,2	24,9	19	18
Krapina	5,1	6,2	17,0	16,7	23	19
Ludbreg	3,4	5,9	27,8	22,9	12	7
Sisak	5,0	5,7	38,8	34,4	34	30
Varaždin	3,1	5,7	33,2	32,0	91	50
Đurđevac	2,7	5,4	24,0	24,0	10	5
Čakovec	2,2	5,4	26,1	25,6	47	19
Garešnica	2,8	4,6	33,5	28,1	23	14
Gvozd	2,3	4,5	20,3	20,0	4	2
Pregrada	3,7	4,4	14,0	12,6	6	5
Duga Resa	4,3	4,3	21,0	21,0	8	8
Hrv. Kostajnica	4,0	4,3	25,4	24,0	14	13
Ivanec	2,8	4,3	21,6	19,1	12	8
Pakrac	3,9	4,1	26,8	26,0	15	14
Koprivnica	2,3	3,7	36,3	35,9	31	19
Karlovac	3,3	3,5	31,0	30,0	66	63
Grubišno Polje	1,8	3,5	24,5	21,5	8	4
Jastrebarsko	3,3	3,3	22,4	22,4	8	8
Dvor	2,7	3,3	39,1	33,5	16	13
Novi Marof	2,4	3,3	22,4	20,4	11	8
Zlatar	3,1	3,1	21,2	21,2	10	10
Zabok	2,9	2,9	25,7	25,7	12	12
Križevci	2,5	2,9	22,6	21,6	23	20
Virovitica	1,7	2,9	34,2	31,6	32	18
Slunj	2,8	2,8	27,7	27,7	6	6
Vrbovec	1,6	2,7	45,4	46,3	5	3
Oroslavje	2,6	2,6	21,7	21,7	7	7
Kutina	1,9	2,6	30,4	33,6	26	19
Ivanić-Grad	1,7	2,5	38,3	39,8	12	8
Glina	2,2	2,4	25,7	24,3	21	20
Bjelovar	1,6	2,4	32,2	31,0	92	63
Daruvar	1,6	2,4	32,2	31,4	28	19
Novska	1,9	2,2	27,5	28,2	20	17
Ozalj	1,5	2,0	15,8	14,7	4	3
Čazma	1,6	1,8	22,9	23,4	14	12
Sv. Ivan Zelina	1,2	1,4	22,1	23,4	14	12
Vojnić	1,3	1,3	23,7	23,7	3	3

Source: Autobusni vozni red 1990./91., Transportkomerc, Zagreb 1990

ones are the transport demand which is the consequence of the population density and mobility (number of commuters), competition with other kinds of transport (railway, private transport), etc. A certain confusion can be sown by the fact that some centres are connected with a particular destination by several bus lines, so the average value of frequencies per bus line will be lower than the status quo.

Table 4 is a derivative of the table 2 in which the bus transport centres are sorted according to the average frequencies per destination. The shaded cells mark the value equal or above the average for the given feature. A presumed regularity of the relation between the bus line frequencies and line length (or destination distance) is affirmed by the fact that the centres with the frequencies above the average (in the upper part of the table) have a length of the bus lines below the average with only several expected exceptions (Sisak, Karlovac, Varaždin). If we sort the centres according to the departure frequencies per line, we get the similar results.

We must point out that Petrinja and Duga Resa stand apart according to the intensity of the observed phenomenon. This is, first of all, the consequence of very intensive connections with Sisak or Karlovac, which is reflected in very high frequencies: 55 buses depart from Petrinja to Sisak every day, and 25 ones from Duga Resa to Karlovac. We can register similar departure frequencies from Sisak (to Petrinja), or Karlovac (to Duga Resa) but, because of a larger total number of the outgoing lines, that impact is not so prominent there. If we leave out those bus lines which resemble to the urban transport according to some organisation and other features, Sisak and Karlovac remain near their previous positions, Petrinja ranks somewhat lower, but remains among the destinations of the size above the average. Duga Resa belongs to the underdeveloped centres where it has been classified according to other indicators (number of lines, line length).

**Number of bus departures.** The number of bus departures from a particular centre was the starting value for the average frequencies calculation, and the absolute value will be used here as one more indicator of power and significance of particular centres. To some extent, this is a more real indicator than frequencies which are under the influence of a larger number of factors (transport organisation, network form, geographical features of surroundings), because it shows more directly a certain centre's power which is measured by its interaction with the surroundings.

We point out that it is only a question of the bus departures on the initial bus lines, while the transit bus lines are not included. The number of the bus departures from particular centres is presented in the figure 6 by means of the circle areas.

This presentation gives a certain hierarchy of the centres because several categories with only 2-3 marginal cases can be singled out. Of course, the categorisation has not been carried out only by means of the picture, but the method of the series dispersion analysis was also applied, concretely standard deviation and standard error of the mean, which served as an exact numerical indicator while establishing borders of particular categories (tab. 5).

Four regional centres stand out as the centres of the first category, with much the largest number of departures. Varaždin and Karlovac lead. They all deviate from the average value for more than 1.5 standard deviations.

Three centres of transitive features stand apart from the following larger group: Krapina, Petrinja and Čakovec (deviation from the average 0.75-1 standard deviation).

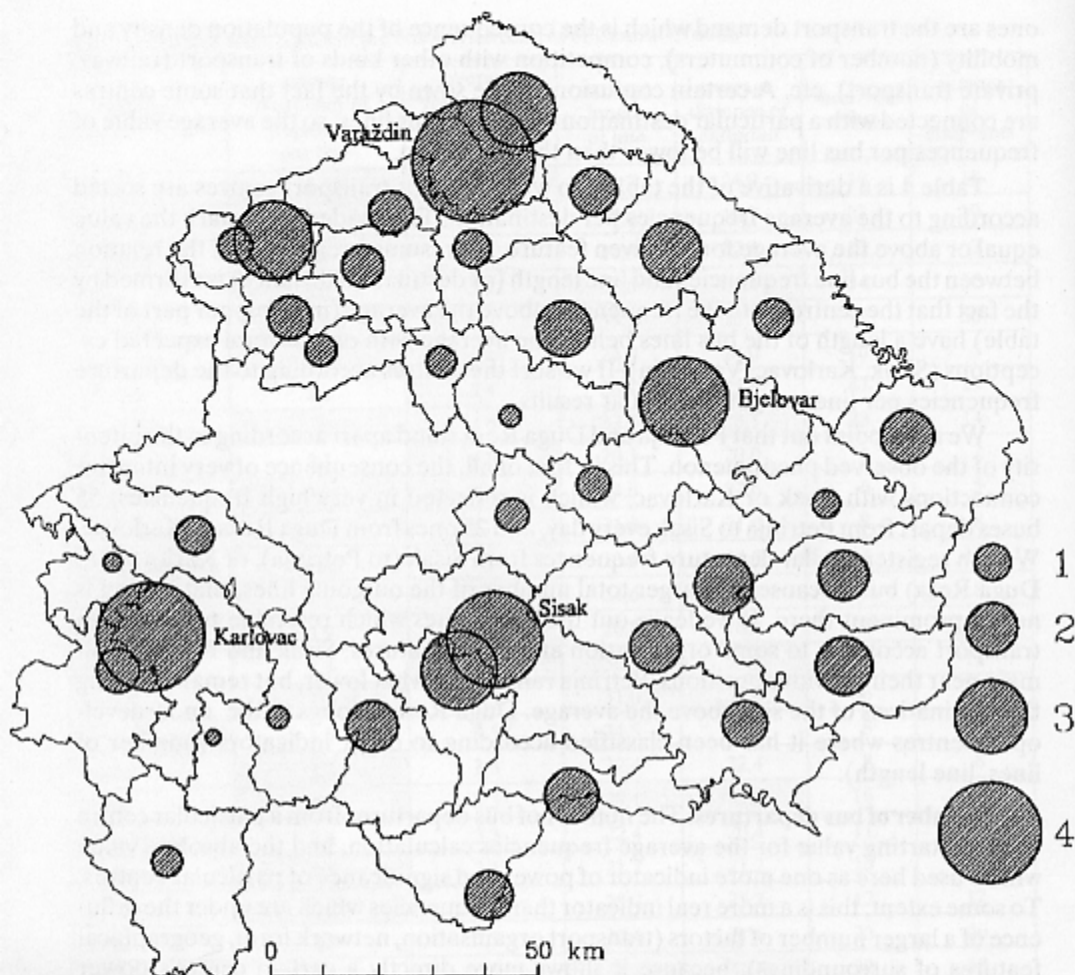


Fig. 6 Number of the bus departures from the bus transport centres in Central Croatia in 1991; number of bus departures 1) 25; 2) 50; 3) 100; 4) 200

Sl. 6. Broj polazaka autobusa iz centara autobusnog prometa Središnje Hrvatske 1991. g.; broj polazaka: 1) 25; 2) 50; 3) 100; 4) 200

They lag behind the previous centres, but markedly deviate from the first following centre. They account for over 100 bus departures on the initial bus lines, which shows their great influence on their gravitational areas. Previous analyses showed that they were mainly the areas of municipalities, which especially holds true for Čakovec. As to Petrinja, we should point out that nearly a half of the realised departures is realised on the bus line towards Sisak, which, in some elements, has an urban transport character. Without these departures Petrinja would be in the following category (a circle as large as Pakrac or Križevci).

The next category consists of the centres with the average values of the departures number 45-70 ( $\pm 0.20$  standard deviations). They are mostly the centres of extensive

Tab. 5 Bus service centres in Central Croatia according to the number of departures on outgoing lines

centre	number of departures	standard error of the mean
Varaždin	283	3,74
Karlovac	219	2,67
Sisak	170	1,86
Bjelovar	149	1,51
Krapina	117	0,98
Petrinja	112	0,90
Čakovec	103	0,75
Koprivnica	70	0,20
Garešnica	64	0,10
Križevci	58	0,00
Pakrac	58	0,00
Hrv. Kostajnica	56	-0,03
Virovitica	53	-0,08
Kutina	49	-0,15
Glina	47	-0,18
Daruvar	46	-0,20
Dvor	43	-0,25
Ludbreg	41	-0,28
Novska	38	-0,33

centre	number of departures	standard error of the mean
Zabok	35	-0,38
Duga Resa	34	-0,40
Ivanec	34	-0,40
Zlatar	31	-0,45
Đurđevac	27	-0,51
Jastrebarsko	26	-0,53
Novi Marof	26	-0,53
Čazma	22	-0,60
Pregrada	22	-0,60
Ivanić-Grad	20	-0,63
Oroslavje	18	-0,66
Slunj	17	-0,68
Sv. Ivan Zelina	17	-0,68
Grubišno Polje	14	-0,73
Gvozd	9	-0,81
Vrbovec	8	-0,83
Ozalj	6	-0,86
Vojnić	4	-0,90
total	2146	

Source: Autobusni vozni red 1990./91., Transportkomerc, Zagreb 1990

municipalities, and some of them are remarkable as large work centres. It is characteristic that all of them are situated in the area of Bjelovar or Sisak, consequently, where the regional centres, according to their characteristics, have smaller values, and, according to other considered features, they are less "dominant" in their areas as well.

The third category includes seven centres with 30-45 departures (-0.25 - -0.5 standard deviation). We are mainly talking about the centres under the influence of larger neighbouring centres, but in their gravitational areas they have developed the bus transport networks of modest dimensions. A special case in this group is Duga Resa which would be classified among the weakest centres (9 departures, a circle as large as that of Gvozd) if there were no its connection with Karlovac (a high-frequency connection - 25 departures).

The last group consists of the weakest centres with less than 30 departures on the initial bus lines daily (deviation over -0.5 standard deviation). As a rule, it deals with the centres relatively near or "in shadow" of larger centres (Đurđevac, Novi Marof, Pregrada, Garešnica, the centres in the Karlovac region) or they are to a large extent under the influence of Zagreb (e. g. Ivanić-Grad, Sv. Ivan Zelina) or both (Čazma, Jastrebarsko). In this group we also find several smallest centres with less of 10 departures (over -0.75 standard deviation) for which we can hardly say that they are the bus transport centres. We are mainly talking about the smaller settlements in the Karlovac region, and Vrbovec which realises the majority of its connections by the transit bus lines.

## TRANSPORT INTENSITY IN BUS TRANSPORT NETWORK

By the notion transport intensity we mean here the number of bus departments (daily) on particular segments of bus transport network. Consequently, it is the indicator pointing to the real supply level of bus lines in particular parts of the observed area. Although it can be expected that the greatest transport intensity will be in the surroundings of the large bus transport centres (because the majority of transport takes place on the shorter lines), certain deviations are also possible. Namely, all bus transits are included in the transport intensity analysis, so it is possible that the transit bus lines "reinforce" the transport intensity in the smaller centre surroundings. For example, the buses on the line Varaždin-Koprivnica also contribute, in fact, to the supply level of bus service on the parts of the network around Ludbreg, and to the connection of Ludbreg not only with Varaždin and Koprivnica, but also with the nearest surroundings. These bus transits are registered here and included into the data about using these network segments. The results of this analysis are presented in the figure 7. While interpreting the results we must

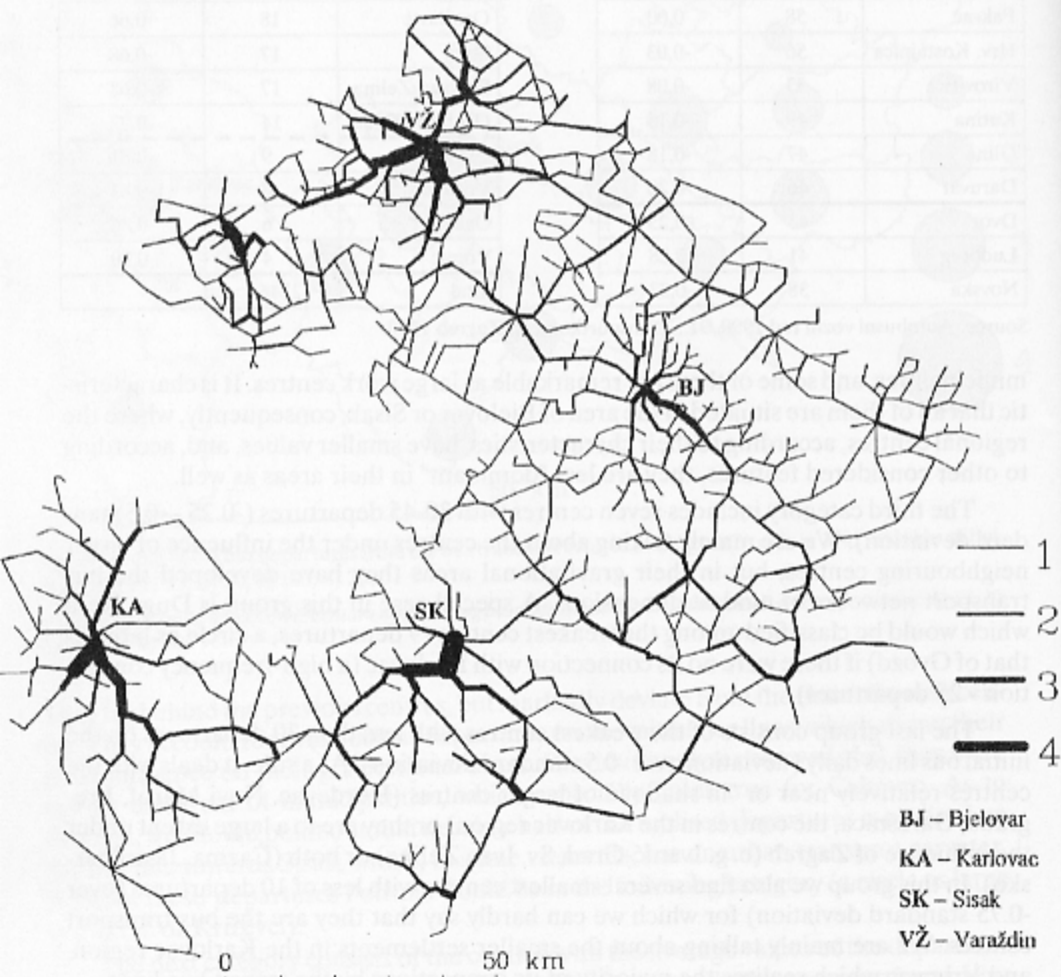


Fig. 7 Intensity of traffic in the public bus transport network in Central Croatia in 1991; number of bus passes daily by segments: 1) 10; 2) 25; 3) 50; 4) 100

Sl. 7. Intenzitet prometa u mreži javnog autobusnog prometa Središnje Hrvatske 1991. g.; broj dnevnih polazaka autobusa po odsječku: 1) 10; 2) 25; 3) 50; 4) 100



take care of the factors influencing the bus transport development. Population density, structure and mobility have turned out to be the most significant ones.

Since in the figure 7 the number of bus departures is proportionally presented by width of a line, the supply level of the connections in the surroundings of particular centres (and in this way the intensity of the centres influence on their surroundings) has reflected itself in the size of dark surfaces. As expected, four regional centres stand apart in the first category: Varaždin, Bjelovar, Sisak and Karlovac. Varaždin prominently leads among them, and Bjelovar lags most of all.

Varaždin stands out by the intensity of connections, and by their reach as well. In the spatial structure there are five main directions towards five municipal centres of the former community of municipalities. These directions correspond with the main transport directions which define the transport position of Varaždin: the central Danube basin - the northern Adriatic and the Eastern Alps - the Lower Podravina region (Sić, 1986) with the addition of strong flows from the area of Ivanec. In the nearest surroundings the most intensive direction leads southwards and grows weaker after branching out towards Novi Marof and Varaždinske Toplice and some smaller destinations. In Međimurje we can see a strong influence of Čakovec which has overtaken the leading role in that region with a developed network of local connections. The local influence of Ivanec is less prominent, and Ludbreg and Novi Marof lag even more.

Although it is remarkable for a large number of bus lines, Bjelovar does not stand out as a dominant centre in its area. The impression of transport intensity has been additionally lessened by the bus transport network form extended in the nearest surroundings, so particular transport directions are defined less markedly. However, the most important direction leads to the south-east, but it grows weaker rather quickly. It is evident that the influence of Bjelovar is confined to a relatively small area with weakly organised network of the subordinate centres. Although the bus connections of Bjelovar with all municipal centres of the former community of municipalities have been established, they did not influence the picture of the region bus connections because of low frequencies. Particular centres organised the local bus connection networks, which can be clearly seen in the figure 7, but it is also evident that it is a question of a less connected network with more weakly prominent hierarchial relations.

The facts established by the former analyses can be affirmed on the example of Sisak. Although at first sight the transport intensity surpasses the expectations resulting from knowing the power of this centre, one should bear in mind that the bus line Sisak-Petrinja, remarkable for a very high frequency (55 drives in each direction), accounts for a large share of transport, and has almost an urban character. Without this bus line the network around Sisak would look on the map more like that around Čakovec than like the networks of other regional centres. This confirms the fact that the influence of Sisak as a bus transport centre is of rather confined power and reach. In a complementary manner, several centres of middle power have developed in the area of Sisak (Petrinja, Glina, Hrvatska Kostajnica, Dvor, Kutina) and they organised their own local networks, which can be clearly seen on the map.

As to Karlovac, a frequent connection with Duga Resa leaves its mark. However, it is of smaller importance (some 50 drives in both directions) and less influences the general pattern. As it was established in earlier analyses, Karlovac is absolutely a domi-

nant centre in the whole region, where no other centre has reached the secondary importance. As expected, the main flows are being realised along the principal roads, but they are of proportionally small intensity, which corresponds to the modest power of the centres they are directed towards.

Figure 7 presents another phenomenon - an intensive transport in the region of Hrvatsko zagorje. Although no larger urban centre of a higher (regional) centrality level has developed here because of the nearness of Zagreb and Varaždin, in the previous research Krapina was marked as the most important bus transport centre in this region. Moreover, particular analysed indicators surpass the expected values, first concerning size, but also regarding the central functions. Such results are also in concordance with other research in the same field (Ilić, Njegač, 1992). The impact reach is evidently limited by municipal borders out of which the transport intensity visibly decreases.

## CONCLUSION

The bus transport analysis has been carried out from two aspects: on the one hand the bus transport network characteristics were analysed, and on the other, particular bus transport centres.

Regarding network density and structure (type) the differences of particular areas of Central Croatia were determined. The main factors influencing the mentioned features are population density, population structure (density and settlement size), road network density and population mobility measured by commuting of the employed. The politico-territorial organisation of the area also appeared to be significant, because the majority of connections, except the largest centres, was directed to the area of the same municipality. However, the acting ponder of every individual factor (and eventually some other factors) is not equal in all areas, so neither the order of their significance is constant.

In the bus lines analysis it was established that the lines up to 30 km prevailed and that they were remarkable for higher departure frequencies, so we can conclude that the main function of bus transport is connecting at a short distance. This is also confirmed by the analysis of using connections in bus transport which has shown that the transport intensity decreases with going away from the centre. Very often lines ends within the municipal borders.

The analysis of particular centres significance was carried out through several indicators. For the most part their choice was limited by the structure and quality of the available data. The number of the outgoing bus lines was considered as well as the number of destinations with which there was a direct bus connection, then the bus lines structure and length, departure frequencies per line and according to destinations, and the total number of the bus departures on the outgoing lines.

Every of the executed analyses enabled a certain classification of centres with regard to the observed phenomenon intensity. Although it is implicit that the order significantly oscillates among certain phenomena, all together it turned out that particular centres were remarkable for greater values, some most often stood at about the average values, and some lagged according to the majority of the considered indicators. On the

basis of those results a hierarchical classification was carried through and the considered centres were classified into four categories.

As expected, four regional centres of Central Croatia: Bjelovar, Karlovac, Sisak and Varaždin belong to the first category. They are remarkable for the network complexity, number of lines and/or destinations, proportionally high frequencies, a large number of bus departures and gravitation influence reach which is here reflected in the spatial distribution of destinations. They are all connected with 6-10 other municipal centres. Certain identified differences are the consequence of the spatial organisation of a certain region, and they influence the network structure. Varaždin and Karlovac realise their impact by direct connections with numerous neighbouring municipalities, while Bjelovar, and especially Sisak, accomplish that impact indirectly, through the contiguous municipal centres. Those centres are well connected with the regional centres, and have organised a well developed bus transport network in their own areas. There are no such centres in the regions of Varaždin and Karlovac, except Čakovec.

The second category consists of subregional centres. According to the features of the considered indicators, nine centres can be ranked here: Čakovec, Daruvar, Garešnica, Koprivnica, Krapina, Križevci, Kutina, Petrinja and Virovitica. Excluding Čakovec in the region of Varaždin and Krapina which is gravitationally directed to Zagreb, we are talking about the secondary centres in the regions of Bjelovar and Sisak. Although the majority of their connections end within the former municipality, except Krapina and Čakovec, they have links with 4-7 other municipal centres of different size. The centres of this group stand out for a large number of destinations (excluding Garešnica), which shows a developed bus transport network.

The third group is the most numerous and consists of microregional centres which lag a little behind the previous group according to the majority of criteria. These centres are: Čazma, Dvor, Đurđevac, Glina, Hrvatska Kostajnica, Ivanec, Ivanić-Grad, Ludbreg, Novi Marof, Novska, Pakrac, Sv. Ivan Zelina, Zabok and Zlatar. They are under an intensive impact of regional centres or directly Zagreb, and in the area of their own municipalities they have organised bus transport networks of more modest proportions, somewhere with a less transport intensity. They all dispose of the number of the outgoing lines and bus departures below the average. Excluding Zlatar, they all have connections with 2 or more other municipal centres. Regarding the group size, it is less homogenous: Glina, Dvor, Pakrac, Novska and Hrvatska Kostajnica stand apart a little by value of particular indicators.

The last group consists of ten remaining centres (Duga Resa, Grubišno Polje, Gvozd, Jastrebarsko, Oroslavje, Ozalj, Pregrada, Slunj, Vojnić i Vrbovec), which could be called local. They stand apart for a small number of lines (less than 10). A great majority of destinations are within their own municipalities, and the destinations out of them are usually other municipal centres (only per one as a rule) of a higher centrality level. The number of bus departures is also very small, somewhere even smaller than 10, and Jastrebarsko stands out to some extent, Duga Resa too because of the high frequency of its connection with Karlovac. It is characteristic that all municipal centres of the Karlovac region (except Karlovac itself) belong to this group.

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## SAŽETAK

Sustav prigradskog autobusnog prometa  
u Središnjoj Hrvatskoj

Milan Ilić

Autobusni promet ima dominantnu ulogu u javnom prijevozu putnika u Hrvatskoj, a to se posebice odnosi na prigradske prometne sustave. U ovom članku istražuju se sustavi autobusnog prometa organizirani oko glavnih centara rada u Središnjoj Hrvatskoj.

Budući da je Zagreb, kao najveći grad i najveći centar rada ne samo Središnje Hrvatske nego cijele zemlje često bio tema geografskih istraživanja, u ovom radu je izostavljen iz analiza, a u žarištu interesa bili su regionalni centri i centri nižeg stupnja centraliteta kojima do sada nije posvećena odgovarajuća pozornost.

Analiza autobusnog prometa provedena je s dva aspekta: s jedne strane razmotrene su značajke mreže autobusnog prometa, a s druge su analizirani pojedini centri autobusnog prometa.

U razmatranje je uključeno 787 linija na kojima se odvija redovan promet tijekom radnog tjedna.

Analizom strukture mreže autobusnog prometa u Središnjoj Hrvatskoj utvrđene su znatne regionalne razlike s obzirom na gustoću i strukturu (tip) mreže. Glavni faktori koji utječu na strukturu i druge značajke mreže autobusnog prometa su funkcija rada pojedinih centara i s njima povezane dnevne migracije, gustoća i prostorna struktura naseljenosti, stupanj automobilizacije i razvijenost cestovne mreže. Također se značajnom pokazala i političko-teritorijalna organizacija prostora, jer je većina veza, osim kod najvećih centara, usmjerena na područje iste općine.

Utvrđeno je da u strukturi autobusnih linija prevladavaju veze na kraće udaljenosti (najviše je linija duljine 21-25 km, a 2/3 linija kraće su od 30 km), što znači da su pretežno usmjerene na lokalni prijevoz. To je u skladu s pretpostavljenim značenjem autobusnog prometa u dnevnim migracijama radne snage i utvrđenom činjenicom da se većina tih migracija odvija unutar općinskih granica. Također, frekvencije vožnji veće su na kraćim linijama, a s duljinom linija opadaju.

Prema kriterijima broja autobusnih linija i centralnim funkcijama na istraživanom području utvrđeno je 37 centara autobusnog prometa. Njihova analiza provedena je po nekoliko kriterija. Prvi od njih je broj polaznih linija po čemu se kao vodeći izdvajaju Bjelovar i Varaždin, malo zaostaje Karlovac, a nešto više Čakovac, Sisak, Virovitica i Koprivnica. Iz navedenih centara polazi polovica linija svih razmatranih centara. S druge strane, skromnim značenjem izdvajaju se ostali centri na karlovačkom području.

Odnos broja linija i odredišta također je značajan faktor koji pokazuje razvijenost mreže. Što je razlika tih vrijednosti veća, mreža je složenija, a time su mogućnosti ostvarivanja veza veće. Glavni faktori koji utječu

na razvijenost mreže po ovom obilježju su gustoća naseljenosti, disperzna naseljenost, gustoća cestovne mreže i udio dnevnih migranata među zaposlenima u centru rada.

Analiza centara prema lokaciji i funkcijama odredišta u prvi je plan izdvojila Varaždin i Karlovac. Oni se ističu brojem (37, odnosno 45) i udjelom (preko 70 %) odredišta izvan vlastite općine, što ukazuje na gravitacijsko područje njihovih funkcija. Slijedi Bjelovar, ali među njegovim odredištima velik je udio bivših općinskih centara.

Analiza funkcija centara autobusnog prometa provedena je još po kriterijima frekvencije i ukupnog broja polazaka autobusa. Konačno, kombinacijom svih provedenih analiza napravljena je hijerarhijska klasifikacija u kojoj su centri autobusnog prometa svrstani u četiri kategorije. U prvu, kao centri regionalnog značenja svrstavaju se Varaždin, Karlovac, Bjelovar i Sisak. Drugu kategoriju čine subregionalni centri. To su Čakovec, Daruvar, Garešnica, Koprivnica, Krapina, Križevci, Kutina, Petrinja i Virovitica. Treću kategoriju centara, koja je i najbrojnija, čini 14 mikroregionalnih centara: Čazma, Dvor, Đurđevac, Glina, Hrv. Kostajnica, Ivanec, Ivanić-Grad, Ludbreg, Novi Marof, Novska, Pakrac, Sv. Ivan Zelina, Zabok i Zlatar. Četvrtu kategoriju čini 10 lokalnih centara (Duga Resa, Grubišno Polje, Gvozd, Jastrebarsko, Oroslavje, Ozalj, Pregrada, Slunj, Vojnić i Vrbovec).

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### Criticism of Theory about Geomorphological Cycles by William Morris Davis

Up to this day there has been no theory which could fully justify the fact, pointed out since the beginning of geographical development in the 19th century, of general similarity in features with 2 theories and the natural approach which represented a revolutionary progress in geomorphological ideas development, but none of them has given an appropriate answer: explanation or acceptable interpretation of our planet's relief. This regularly. The famous, so-called theory of geomorphological cycles, associated with the name of the American geomorphologist William Morris Davis, in the framework of that theory he sought to explain the existence and the wide-spreadness of the same forms in time, but that in every progressive step in the course of time during the 20th century his theory experienced an exceptionally deep criticism by his fellow geomorphologists in the world.

In this work we shall present the essence of Davis' theory and survey some essential elements of its most important theoretical approaches. Finally, we shall try to give the last status of this great geomorphological theory positive in the light of modern geomorphology and the theory of the earth's relief evolution.

**Key Words:** relief development, theory, geomorphological cycles, landscape, landscape

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