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TRANSPORT CONCENTRATION AREAS AND THEIR RELATIONS TO THE SPATIAL ORGANIZATION OF SOCIETY: A CASE STUDY OF THE CZECH REPUBLIC

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Transport concentration areas and their relations to the spatial organization of society: A case study of the Czech Republic.

The principal objective of the study is interpretation of the relation between the spatial organization of settlement and the transport system as exemplified by the Czech Republic. In this sense, transport or transport relations are perceived as a real demonstration of the functional and spatial relations generated by the settlement system. Based on methods commonly used for identification of population concentration areas, the article discusses possible identification of transport concentration areas. The methodology of the identification of transport concentration areas is based on spatial asymmetry of transport flows distribution, or more precisely, on road transport volumes established in the Czech Republic on a regular basis every five years. The identified transport concentration areas are then compared to areas with the maximum population density and integrated systems of centres, which correspond to the methods employed to identify the metropolitan areas in the Czech Republic.

Key words: transport concentration areas, transport system, spatial organization, settlement system, Czech Republic

INTRODUCTION

Within the framework of the current trends in transport-geographical research, an increasing number of works focusing on the relation between the transport and the spatial organization of the society can be seen lately in the Czech as well as the Slovak environments and, in particular, those focusing on the dynamics of the development in the course of the transformation period of the last twenty years (see e.g. Podhorský 1996, Horňák 2004, Halás 2005, Marada 2008 or Kraft and Vančura 2009a). The reason for this interest is, above all, the fact that in many cases the transformation processes have an impact on the spatial dynamics and the importance of transport modes in the entire transport system (see discussion in Szczyrba et al. 2005). Such changes can be seen on all relevant hierarchical scales, ranging from the local to the international. We can see the main driving force of changes in the spatial organization of the transport system on the local and on the regional levels in a dramatic increase of the number of car vehicles that change human spatial behaviour in a radical manner and affect a wide range of everyday human activities (Taylor 2003, Marada 2006 or Komornicki 2008). Study of the impact of the current development of individual car transport on changes in the settlement and regional systems is among the core and today even topical research focuses in transport-geographical studies (see the discussion in Nuhn and Hesse 2006 or Keeling 2007).

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The purpose of the article is interpretation of the relationship between transport and the current spatial organization of society using the Czech Republic as an example. In this sense, it is possible to perceive transport, or more precisely transport relations, as a real demonstration of functional and spatial relations generated by the settlement system. A number of authors refer to a very close relationship between the spatial organization of transport and the settlement system (e.g. Řehák 1988, Korec 1996, Seidenglanz 2007, etc.). This fact is based on the ambivalent relationship between transport and settlement systems when a settlement system and its configuration directly influences transport relations, and on the other hand, transport relations and transport infrastructure have a direct impact on the configuration of the settlement system, and above all, on its spatial dynamics (see e.g. Knowles 2006 or Rodrigue et al. 2006).

As the discussion above shows, the most significant spatial population concentrations are expected to reach a sort of agreement with the most significant spatial concentrations. These most significant spatial concentrations of transport relations form a basis for the identification of the so-called transport concentration areas. With respect to the specifics of the Czech settlement system (see Hampl et al. 1987), in which most significant spatial concentrations of the population have ties to regional metropolises, it is also possible to expect that the identified transport concentration areas will represent a certain degree of support for metropolitan relations of the settlement system of the Czech Republic. They thus contribute in an essential manner not only to study of spatial interactions generated by the settlement system but also to the study of the core-hinterland relationship that can generally be regarded as one of the crucial human geographical phenomena. Transport concentration areas thus serve for the purpose of identification of functional relations between cities and their highly influenced hinterland. On the basis of identification of such most significant transport relations, it is also possible to opt for a "transport variant" of mutually well-interconnected centres of the settlement system to create more extensive regional complexes (first attempts by Hůrský as early as 1978 and Viturka 1981). They can serve subsequently as a sort of alternative to the identification of the metropolitan settlement systems commonly employed in the Czech Republic (Korčák 1966 or Hampl 2005, etc.).

THE ROLE OF TRANSPORT IN SPATIAL STRUCTURE

Transport can indisputably be regarded as one of the most significant everyday human activities, the importance of which consists especially in designing and implementing spatial interactions between geographical localities; transport is thus regarded as the key factor for structuring and organizing the geographical space (Seidenglanz 2008). From the geographical point of view, it is also possible to emphasize the essential role of transport for the integration of regions to make mutually cooperating functional complexes (Hoyle and Smith 1998). As early as the 1960s, American authors noticed this transport-geographical phenomenon and identified three core terms: complementarity, transferability and intervening opportunity as factors influencing origins and volume of transport interactions between geographical localities (Ullman 1973).

For example, Hanson (2004) and Muller (2004) studied the most significant transport relations to the settlement agglomerations in the United States.

An interesting parallel to the development of spatial structure of cities and transport systems (Fig. 1) is offered by Rodrigue et al. (2006). The significance of this theory consists in its high complexity as it is applied to the general stage theory based on the traditional core-hinterland polarization. The stage theory distinguishes three core developmental stages in the society and is well applicable to the development of human geographical systems although with some limitations (for details see Hampl 2005). According to this theory, the development of the society proceeds in the following stages: "pre-industrial – industrial – post-industrial", although for the purpose of geographical interpretation the following identification is more appropriate: "static – dynamic – organic". The static stage can be characterized by a low proportion of urban population, relative homogeneity of spatial structures, limited mobility and, above all, by strong determination due to natural conditions. The industrial (dynamic) stage is related to the transition to competitive relations and polarization of units, which results in differentiation given by the maturity of cities and regions. The post-industrial (organic) stage is characterized by the development of competitive-cooperative relations within the framework of the systems subject to monitoring, by hierarchization of units and above-all by integration of the system with the objective of creating a higher and a highly interlinked organic unit in particular as far as transport is concerned. Within the framework of this organic structure, more complex transport relations develop (Horňák 2006). The existing radial concentric relations are modified by new tangential relations resulting in a change of the so-called starfish-shaped structure of transport relations into the more comprehensive form of a spider's web (Nuhn and Hesse 2006).

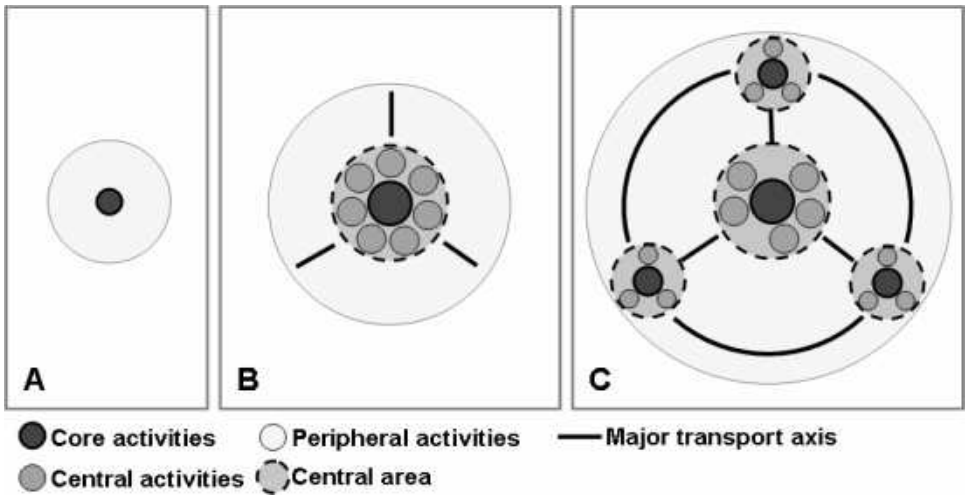

Fig. 1. Development of the spatial structure of urban regions depending on the transport axes distribution

THE PRINCIPLE OF CONCENTRATION AREAS

In general, there is an exceptional concentration of phenomena within a relatively small area on the one hand, and, exceptional intensity of interactions between units of entire systems can be regarded as core attributes of concentration areas on the other. Both attributes are logically substantiated by intensive transport relations and, in most cases, by high-quality transport infrastructure guaranteeing good transport connectivity thereof (Karvánková and Kraft 2008). Concentration areas often form a basis for identification of metropolitan areas (see below). In general, it is possible to point to the variety of methods employed to identify such (metropolitan) regions, in which it is possible to distinguish three basic approaches to definition thereof (by Hampl 2005):

1. *Identification based on the criterion of size and spatial intensity* – an example of such identification can be the Metropolitan Statistical Areas used for statistical identification of metropolitan areas in the USA (e.g. Boustedt 1960, Gibson 1987 etc.). Another example of this approach is *areas with maximum population density* identified on the basis of the population density for the settlement agglomerations in Czechoslovakia (Korčák 1966). *Areas with maximum population density* were defined as distinct spatial concentrations of the population, the area of which is minimum 50 km^2 and the population density reaches the value of 1,000 inhabitants/km^2. For the purpose of interpretation of developmental trends in areas with maximum population density, relativized criteria having the form of multiples of the average population density of the whole country were applied (Hampl et al. 1987).

2. *Identification based on the criterion of urban character of settlements* – employing social, economic or cultural aspects of the population structure in individual regions. A particularly suitable indicator is commuting from individual settlements that are linked to one or several labour centres (e.g. Best and Lanzendorf 2005, Michniak 2005, Sýkora and Mulíček 2009 or Toušek and Novák 2009).

3. *Identification based on the criterion of intensity of interactions between settlements* – this approach is based especially on two-way relational interactions between individual settlements of a metropolitan area. An example can be the so-called *integrated systems of centres* that are identified in terms of volume of mutual labour commuting between individual regional centres (Hampl et al. 1987). The value of 75 commuters per 1 km is regarded as the critical interaction level for the purpose of identification of these systems of centres. A disadvantage thereof, however, consists above all in the fact that they can be identified on the basis of data resulting from population censuses acquired once every 10 years.

METHODS

The methodology of identification of transport concentration areas is based on general principles for identification of concentration areas and is inspired, in particular, by *areas with maximum population density* (Korčák 1966, Hampl et al. 1987). With respect to the fact that the paper focuses on changes in spatial organization of road transport, data resulting from the Road Transport Survey

held in 2005 (Road and Motorway Directorate of the Czech Republic 2005), which is executed in regular five-year intervals, were used. Although this concerns only a simple registration of road transport volumes in Survey segments for a period of 24 hours along the road network of the Czech Republic without any specification of the travels points of origin and destination or the periodicity thereof, it was executed in a territorial detail sufficient for identification of concentration areas. Moreover, a certain disadvantage of the used data is the fact that the included transport volumes contain transit and irregular transport as well, which, in some cases, may overrate the actual importance of some roads. The percentage of transit transport is difficult to estimate as it relates to positional exposurability of individual road segments, etc. With respect to this fact, the empirical part takes into account only volumes of individual cars that demonstrate generally a lower percentage of transit transport than freight transport (see the discussion in Kraft and Vančura 2009b).

The methodology of interpretation is based on the concept of *areas with maximum population density*; however, it is adjusted to the employed data resulting from the Road Transport Survey. Regarding the fact that different types of roads demonstrate different volumes of road transport, and, in particular, different levels of spatial concentration of transport flows, the indicator of spatial concentration H (Tab. 1), different weights are used for the expression of spatial concentration of transport volumes (multiples of the average volumes) in individual types of roads.

Tab. 1. The level of spatial concentration H by the type of road communications

Type of road communications	Spatial concentration index H (car transport)
Highways	74.17
Expressways	73.04
1st - class roads	82.11
2nd- class road	92.96
All roads	85.80

Source: Road transport census 2005, own calculations

On the basis of these differentiations, three degrees of significance were distinguished on the level of spatial concentration (most significant, significant and less significant) for the identification of the most significant transport relations within the road network of the Czech Republic. From the point of view of transport relations, individual types of roads are assigned different multiples of the respective transport volumes. To express the transport relations with the highest volumes in the case of motorways and expressways, multiples of the average transport volumes were used, namely double, 1.5-multiple and 1.3-multiple. Triple, double and 1.5-multiple were used with the 1st- class roads and quintuple, quadruple and triple (see Tab. 2) were used with the 2nd- class roads. Thus, only values from the top quartile were counted ($Q_{0,75}$).

For the purpose of final identification of transport concentration areas, two supplementary criteria were applied: minimum scope and minimum number of centres of the entire transport area. On the basis of the empirical distribution of frequency rates, the minimum scope of transport concentration areas was deter-

mined as 0.2% of the length of all roads in the Czech Republic (in 2005). In this manner, areas with the minimum scope and rather a local operation were eliminated from the potential transport areas. From the point of view of the need for subsequent comparison, the minimum number of centres of the transport concentration areas mutually interlinked by transport was determined in the amount of at least 3 centres having minimum sub-regional significance (see Hampl 2005). In this manner again, centres with sufficient scope but without the ability to integrate several centres into a mutually interlinked unit were eliminated from the potential selection.

A proof of transport concentration centres with spatial organization of the society identified in this manner is interpreted in the following chapter using comparison with identification of the current *areas with maximum population density* (results taken from the work by Kadlec 2007) and *integrated systems of centres* identified on the basis of mutual labour commuting volume (results taken from the work by Hampl 2005).

Tab. 2. Typology of transport concentration areas

Motorways	*Average (2005) – 18,709 cars per 24-hour period*	
	most significant	double
	significant	1.5-multiple
	less significant	1.3-multiple
Expressways	*Average (2005) – 15,238 cars per 24-hour period*	
	most significant	double
	significant	1.5-multiple
	less significant	1.3-multiple
1st- class roads	*Average (2005) – 6,582 cars per 24-hour period*	
	most significant	triple
	significant	double
	less significant	1.5-multiple
2nd- class roads	*Average (2005) – 2,021 cars per 24-hour period*	
	most significant	quintuple
	significant	quadruple
	less significant	triple

Source: Road transport census 2005, own calculations

RESULTS

On the basis of spatial differentiation in the distribution of the car transport flows in the territory of the Czech Republic, 11 transport concentration areas and 2 secondary transport areas that failed to fulfil just one of the supplementary criteria for minimum scope or number of integrated centres were identified using the selected methodology. To a certain extent, the prerequisite that the concentration areas will be linked to regional metropolises, or more precisely, to inter-regional centres of the Czech Republic, the number of which was 12 as fixed according to the latest population census (Hampl 2005), was fulfilled. According to another prerequisite, the identified *transport concentration areas* were structured hierarchically depending on the scope and the number of cen-

tres thereof, when the respective hierarchy corresponds to the comprehensive significance of their core centres. For this reason, areas with the most extensive space count among the most significant transport areas: Prague (2.5% of the total road network of the CR, 21 transport-integrated centres), Ostrava (1.6%, 14 centres) and Brno (1.4%, 11 centres). They concern the most significant settlement centres in the Czech Republic, which is substantiated by the scope of the transport areas and the number of integrated centres thereof. The above-mentioned areas are followed by those of Olomouc, Hradec Králové/Pardubice and Ústí nad Labem that benefit, in particular, from their advantageous position on the road network of the Czech Republic. These areas are expected to be influenced by transit transport to a certain extent. Among the transport areas spread into a less extensive space, there are areas of the rest of mezzo-regional centres (Plzeň, Liberec, Zlín, České Budějovice and Karlovy Vary). From the point of view of completion of the list of *transport concentration areas*, it is necessary to point to the secondary transport concentration areas of Jihlava and Tábor. In particular, in the case of Jihlava, which is the only regional metropolis that does not create a full-valued transport area, it is possible to expect consolidation of its position and the resulting potential for a build-up of sufficient transport infrastructure.

Tab. 3. Structural features of transport concentration areas in the Czech Republic

Core centre	Transport-integrated centres	Type of transport concentration area	Size
Prague	Benešov, Bystřice, Votice, Beroun, Králův Dvůr, Zdice, Kladno, Slaný, Louny, Unhošť, Mělník, Brandýs n. Lab., Mladá Boleslav, Mnichovo Hradiště, Úvaly, Říčany, Hostivice, Jesenice, Mníšek p. Brdy, Dobříš, Příbram	monocentric	2.50
Ostrava	Opava, Kravaře, Hranice, Nový Jičín, Příbor, Frýdek-Místek, Paskov, Dobrá, Karviná, Orlová, Horní Suchá, Havířov, Petřvald, Třinec	polycentric	1.59
Brno	Blansko, Boskovice, Tišnov, Kuřim, Šlapanice, Židlochovice, Hrušovany, Rosice, Modřice, Slavkov, Bučovice	monocentric	1.35
Olomouc	Prostějov, Přerov, Vyškov, Lutín, Velká Bystřice, Šternberk	monocentric	0.91
Hradec Králové/ Pardubice	Hořice, Jaroměř, Třebechovice, Lázně Bohdaneč, Chrudim, Holice, Vysoké Mýto, Litomyšl	polycentric	0.89
Ústí nad Labem	Děčín, Teplice, Bílina, Litvínov, Most, Chomutov	polycentric	0.80
Plzeň	Přeštice, Chlumčany, Rokycany, Třemošná	monocentric	0.58
Liberec	Jablonec, Trutnov, Chrastava	polycentric	0.34
Zlín	Otrokovice, Fryšták, Vizovice, Uherské Hradiště	polycentric	0.30
České Budějovice	Hluboká n. Vlt., Lišov	monocentric	0.22
Karlovy Vary	Sokolov, Ostrov, Nové Sedlo, Chodov, Nová Role	polycentric	0.21
Jihlava	Havlíčkův Brod	polycentric	0.16
Tábor	Planá n. Lužnici, Soběslav	polycentric	0.13

Source: Road transport census 2005, own calculations

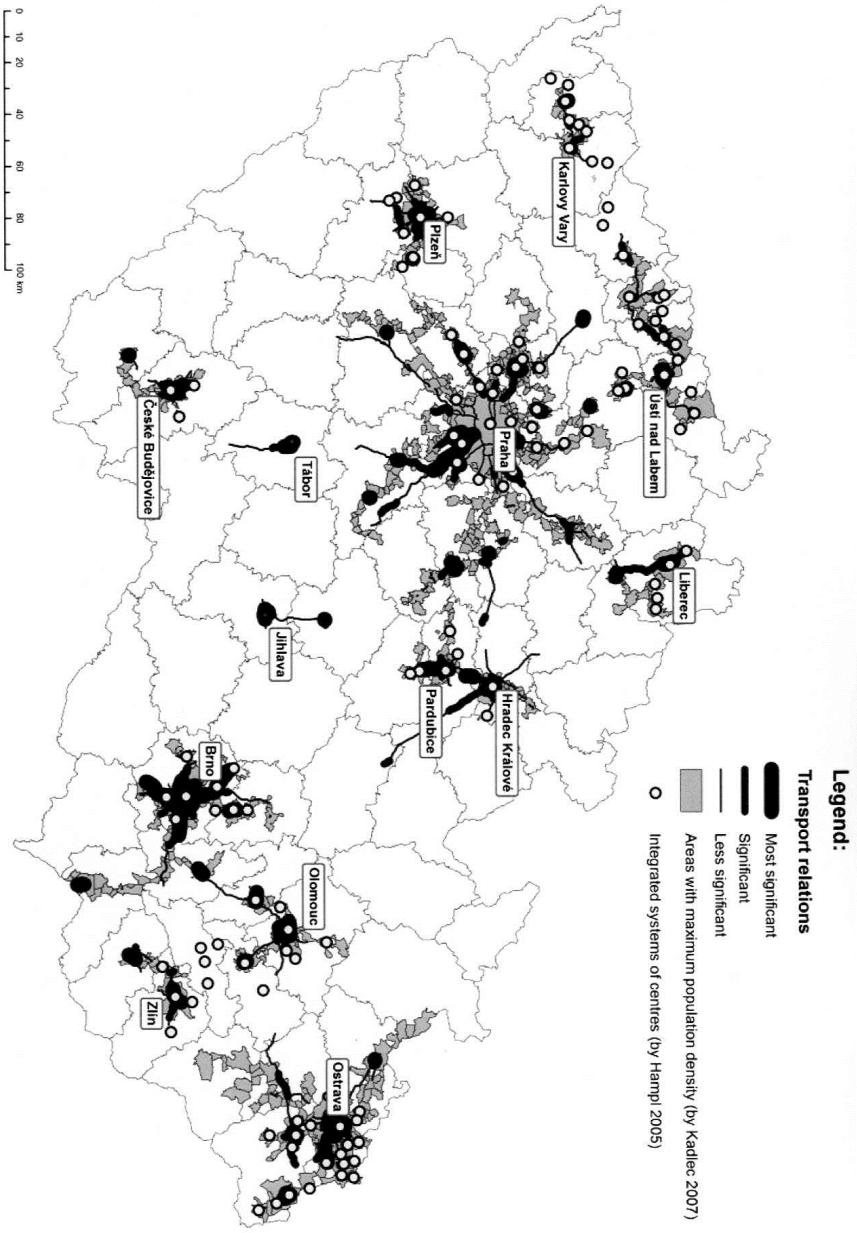

Fig. 2. Transport concentration areas in the Czech Republic (2005)

If the core centre shows a higher percentage of transport significance than the percentage corresponding to its simple share regarding all centres of the respective system, then such a core centre forms a *monocentric* type of transport area. If the respective percentage is lower, then the core centre is less dominant and consequently forms a *polycentric* system (Tab. 3). The type of concentration area is affected to a great extent, on the one hand, by the configuration of transport infrastructure, and on the other hand, by the configuration of the settlement system as such. The areas of Ostrava and Ústí nad Labem show a significant polycentricity, which is in full accord with their polycentric settlement system. On the contrary, the areas of Prague, Brno, Plzeň and Olomouc have significantly monocentric positions, which illustrate the exceptional position of these metropolises in the regional settlement system as well as the transport system.

In the last part, the identified transport concentration areas were compared to *areas with maximum population density* and the *integrated system of centres* in the Czech Republic. In both cases, a relatively high association that demonstrates an integral character of the transport concentration centres (Fig. 2.) was proven. The strong association between the most significant transport relations and the *areas with maximum population density* proved that both monitored features are in close mutual relationship.

To a certain extent, it is possible to confirm again the well-known fact that significant spatial concentrations of the population generate significant transport relations. A similar role is played by the *integrated system of centres* as the core areas of metropolitan regions of the Czech Republic as well. Among the best transport-integrated systems, there are, in particular, the areas of Prague, Brno, České Budějovice, Olomouc and Ústí nad Labem. These settlement systems exert a significant influence on the configuration of the core axis of the transport concentration areas. Relatively lower association between the transport areas and the integrated systems of centres can be seen in the areas of Karlovy Vary, Liberec and Ostrava where both the monitored features correspond to each other in some cases only. In general, however, it is possible to confirm that the transport concentration areas are closely related to both *areas with maximum population density* and the *integrated system of centres*.

CONCLUSION

The conducted empirical research concerning the possibilities of identifying transport concentration areas as exemplified by the Czech Republic proved the high complexity and integral character of transport concentration areas from the point of view of spatial aspects of the organization of the transport system of the Czech Republic and the relationship thereof to the spatial organization of society. The fact that the identified transport concentration areas were linked to the regional metropolitan cores also offers an opportunity to identify transport hinterlands of the individual settlement centres. However, methodological restriction is caused by the spatial asymmetry of transport flow distribution in the Czech Republic and the impossibility of separating transit transport, which is partially reduced regarding the examined mezzo-regional hierarchical level. The most important transport relations which form a basis for creating transport con-

centration areas also represent the most significant interactions generated by the settlement system. These interactions provide a good example of the deepening of regional distribution of labour and of the interconnecting of towns with their easily accessible environs into interlinked units which form a basis for creating of metropolitan regions. These changes are typical especially for the start of post-industrial processes as also reflected in the transport and settlement system of the Czech Republic.

Another possibility for study of transport concentration areas is probably their high complexity. Especially the relation of transport concentration areas to other forms of regionalization of the geographical space is an important question. See, for example the transport-geographical regionalization of the Czech Republic conducted by Hůrský (1978); complex socio-geographical regionalizations of the Czech Republic (see Hampl 2005 and Sýkora and Mulíček 2009) or; theoretical regionalizations based on the use of gravity model (see Halás and Klapka 2010).

An interesting question and an issue worthy of further research into transport concentration areas seems to be, in particular, the interpretation of the dynamics of development of individual transport areas in a longer run that may indicate significant changes in horizontal structure and organization of the road transport in the Czech Republic and consequently implicit changes in spatial human behaviour. Another inspiration for the follow-up study of these spatial structures of the road transport may be the expected results of the Road Transport Survey for 2010, from which more general trends in road transport development and, in particular, the current changes concerning the entire transport system of the Czech Republic can be derived.

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AREÁLY KONCENTRÁCIE DOPRAVY A ICH SÚVISLOSŤ S PRIESTOROVOU ORAGNIZÁCIOU SPOLOČNOSTI

Hlavnou témou príspevku je teoretická diskusia o súvislostiach medzi priestorovou organizáciou spoločnosti a dopravným systémom a hlavne dynamika tohto vzťahu v súčasnosti. Vzťah medzi dopravou a súčasnou organizáciou sídelného systému Českej republiky možno do istej miery považovať za obojstranný, keď sú doprava a dopravné väzby ovplyvnené konfiguráciou sídelného systému a zároveň súčasný mohutný rozvoj niektorých dopravných odvetví, predovšetkým individuálnej automobilovej dopravy, spätne ovplyvňuje organizáciu a dynamiku sídelného systému.

Na základe inšpirácie metodikou na vymedzenie areálov koncentrácie obyvateľstva v Českej republike (predovšetkým Korčák 1966 a Hampl et al. 1987) sa článok venuje empirickej verifikácii možností vymedzenia tzv. areálov koncentrácie dopravy, ktoré možno všeobecne definovať ako miesta s výnimočnou koncentráciou dopravnej intenzity a súčasne s výnimočnou dopravnou prepojenosťou jednotlivých stredísk osídlenia v Českej republike. Vymedzenie areálov koncentrácie dopravy v Českej republike vychádza z dát zo Sčítania cestnej dopravy z roku 2005, ktoré je dostatočne reprezentatívne a predovšetkým v potrebnej územnej podrobnosti. Vzhľadom na skutočnosť, že jednotlivé dopravné modusy vykazujú rozdielne charakteristiky v úrovni územnej koncentrácie (tab. 1), je príspevok zameraný len na individuálnu automobilovú dopravu, ako hlavné dopravné odvetvie ovplyvňujúce v súčasnosti rozmiestnenie viacerych sociálno-ekonomických aktivít v priestore.

Na základe diferenciácie hodnôt územnej koncentrácie je v príspevku navrhnutá metodika na určenie najvýznamnejších dopravných väzieb v troch stupňoch významu (najvýznamnejšie, významné a menej významné), ktoré slúžia ako základ na vymedzenie areálov koncentrácie dopravy. Vzhľadom na čisto asymetrické rozloženie početnosti (započítané boli len horné kvartily hodnôt $Q_{0,75}$) intenzít dopravy na cestnej sieti Českej republiky je ich odstupňovanie ďalej závislé od druhu komunikácie. Pri diaľniciach a rýchlostných cestách sú navrhnuté násobky zodpovedajúcich priemerných intenzít (2, 1,5 a 1,3), pri cestách 1. triedy analogické hodnoty 3, 2, 1,5 a cestách 2. triedy násobky 5, 4 a 3 (tab. 2). Na definitívne vymedzenie areálov koncentrácie dopravy boli prijaté kritériá minimálneho rozsahu areálov (minimálne 0,2 % z celkovej cestnej siete ČR) a minimálneho počtu dopravne integrovaných stredísk osídlenia (minimálne tri strediská mikroregionálneho významu). Na základe týchto kritérií bolo na území Českej republiky vymedzených 14 areálov koncentrácie dopravy (tab. 3) a bola stanovená ich základná typológia na báze miery dominancie hlavného strediska vo vzťahu k ostatným strediskám. V poslednej fáze boli potom vymedzené areály koncentrácie dopravy porovnávané s vymedzenými areálmi maximálneho zaľudnenia? (Korčák 1966 a Kadlec 2007) a integrovaným systémom stredísk (Hampl 2005).

V oboch sledovaných prípadoch porovnávania sa preukázala relatívne vysoká asociácia s areálmi koncentrácie dopravy, čo poukazuje na ich integrálnu povahu. Areály koncentrácie dopravy sú tak vhodnou metódou na štúdium priestorovej dynamiky dopravného systému Českej republiky. Sú zároveň námetom na ďalšie štúdium súčasnej organizácie dopravných systémov viažucich sa na regionálne metropoly Českej republiky.