Exploring the daily mobility rhythms in an urban environment: using the data from intelligent transport systems

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ABSTRACT The recent development of modern intelligent transport systems has caused a major innovation in the organization and management of traffic and enabled a pronounced integration of new data on the transport phenomena and processes. The goal of the study is to analyse the daily mobility rhythms in an urban environment through data from intelligent transport systems. To study daily mobility rhythms, we make use of hitherto unutilized data from inductive loops and strategic traffic detectors (parts of the ITS) within the urban area of České Budějovice, Czechia. We particularly focus on the assessment of overall daily mobility rhythms and the daily rhythms of individual locations within the urban area with a goal to reveal the main conformities and differences. The research has attained two key results. It was discovered that daily mobility rhythms differ especially in individual types of vehicles (cars, medium vehicles, and long vehicles). In the assessment of spatial differences in the daily rhythms of individual locations significant differences were revealed in the courses of daily mobility rhythms in the city centre, residential areas, and shopping areas.

KEY WORDS daily mobility rhythm – intelligent transport systems – space-time mobility – inductive loops – travel behaviour

KRAFT, S., BLAŽEK, V., MARADA, M. (2022): Exploring the daily mobility rhythms in an urban environment: using the data from intelligent transport systems. Geografie, 127, 2, 127–144.
https://doi.org/10.37040/geografie.2022.004
Received November 2021, accepted February 2022.

1. Introduction

The recent rapid development and spread out of intelligent transport systems (ITS) has brought substantial changes in the organization and management of all kinds of transport over the world (e.g. Zhang et al. 2011, Zhu et al. 2018). Intelligent transport systems belong to the modern information and communication technologies designed for monitoring, analysing, and management of traffic. Due to the implementation of ITS transport is safer, more effective, and more environment-friendly. The main advantage of ITS is their integration of a number of real-time data on the character of traffic, and enabling transport planning and urban management (Qureshi, Abdullah 2013). The secondary benefit of ITS implementation is a continuous detection of a vast volume of traffic data that have not been available at all not too long ago. In relation to the gradual ITS implementation researchers are receiving important information on a multitude of transport phenomena and processes, additionally in a great detail, and from various regions of the world. Specifically, this applies to cities, where ITS often function in interconnected systems. Showing a high dynamics of transport phenomena, particularly due to the concentration of urban functions (housing, trade, work, free time, and other activities), urban space is utilised for many reasons and by various groups of inhabitants. It is also crucial that the utilisation of urban space has its distinct temporal component, since various activities are pursued at different parts of day, week, or an entire year. On that basis, we can refer to the movements of people within the urban space as showing various spatial and temporal patterns, generally designated as daily mobility rhythms (Schönfelder, Axhausen 2016). Many scientific disciplines deal with the study of daily mobility rhythms. The knowledge of differences of daily rhythms is important especially in the sphere of research but also in practice (particularly urban or transport planning). Therefore, knowledge of space-time routines of urban mobility is the key aspect in comprehension of the quality of urban life (Weber, Kwan 2002; Ahas et al. 2010), its structure as a whole, and the individual locations.

However, until recently the study of urban rhythms has been limited to small population samples or small areas within cities (see e.g., Axhausen et al. 2002 or Roy, Tubbs, Burton 2005). It was traditional to utilise travel diaries as a main research method. Over time, however, researchers started to use more extensive data files on the daily mobility rhythms. For example, Mulíček, Osman, Seidenglanz (2016) or Osman, Ira, Trojan (2020) studied transformations of daily mobility rhythms in industrial and post-industrial city through the changing public transport timetables. A great challenge for the study of daily mobility rhythms are location data of mobile phones (e.g., Krygsman, De Jong 2007; Ahas et al. 2010 or Ouředníček et al. 2018). It was precisely due to the use of mobile positioning data that the knowledge of daily mobility rhythms became markedly enhanced. The advantage is the opportunity to acquire data for vast territories or large population samples. Nevertheless, these data exhibit some limitations caused, for instance, by their complicated accessibility, higher costs, or ethical issues concerning the protection of privacy of individual respondents (see discussion in Steenbruggen, Tranos, Nijkamp 2015). A new direction in the research of daily mobility rhythms is also their study through the data from ITS. Among other things, implementation of ITS in urban regions brought availability of a large quantity of continuously recorded data on the movement of people and vehicles in cities and utilisation of urban space. At the same time, their indisputable advantage is availability of the data since these are of a non-commercial character. Ironically, the data from ITS have been used truly little for the study of daily mobility rhythms as yet, especially in geographical research. ITS data are quite commonly used, especially in transport planning, as they provide essential information on the spatial mobility of the population, its variability and differentiation (see e.g. Thomas, Weijermars, Van Berkum 2008; Kaparias et al. 2012).

The purpose of this article is to introduce ITS data into geographical research on urban rhythms. Therefore, the aim of this paper is to study the differences of urban rhythms through ITS data. Our research relies mainly on information from two data sources – the primary source of information are the data from strategic traffic detectors that are complemented by a secondary source in the form of inductive loops. The paper has the character of a causal study on the example of studying urban rhythms at selected intersections in the city of České Budějovice. The city is the regional capital of South Bohemia and has nearly 100 thousand inhabitants. University students, tourists, and other groups of inhabitants form an integral part of the city's population. In general terms, each individual and every group of inhabitants show different demands for and possibilities to use the urban space, and this is manifested in different daily rhythms of the individual locations (see e.g., Kraft et al. 2020). Although we are aware that data on traffic volumes at individual intersections reflect urban rhythms rather indirectly, we consider this data source interesting and useful for geographical analysis. It is the concept of rhythmicity of place that we consider important, as crossroads can be seen as key points enabling the spatial mobility of the urban population.

The paper is structured as follows. The introductory part is followed by the theoretical embedding of the issue of intelligent transport systems, including the description of their working and the use of the system, and a broadly conceived concept of daily mobility rhythms that belong to significant topics of contemporary urban studies. The main attention is focused on analyses of daily mobility rhythms through the data from ITS. The final summary contains the conceptualisation of the entire subject matter, inclusive of further perspectives of the research.

2. Theoretical background

Mobility rhythms are an essential part of the geographical space. Rhythms are typical for individuals, groups of inhabitants, or citizens of entire states (Novák, Sýkora 2007; González, Hidalgo, Barabási 2008; Taylor, Józefowicz 2012; Schneider et al. 2013). An inspirational platform for the research of daily mobility rhythms are primarily the approaches of time geography, which are directed towards the research into time-space mobility and geography of everyday life (Ellegard, Vilhelmson 2004; Paiva, Cachinho, Bararta-Salgueiro 2017). Especially the geographic study of human activities in time facilitated the development of the study of time-space rhythms. The crucial concepts (path, project, station, bundle etc.) associated with time-space rhythms emerged within the time geography. An example can be primarily stations, which can be perceived as the crossroads of the daily trajectories of individuals and whole groups (Edensor 2011; Smith, Hetherington 2013). It relates to space, time, and energy. He says that through the rhythms we can investigate partial places in cities. Through daily mobility rhythms, we can explore particular locations within space, and thereby understand the differences of individual locations (Lefevbre 2004). They allow us to understand differences, dynamics, and organization of cities and their parts.

An essential innovation in the study of daily mobility rhythms has been primarily the development of modern geoinformation technologies. They enabled the researchers to process larger population samples within a relatively short time and visualize these samples by time-space aquariums (Kwan, Schwanen 2016). The development of GIS and GPS facilities has contributed to a major enhancing of the knowledge on time-space rhythms of our society because it enabled ascertaining of the movement trajectories of a great quantity of people in real time. Especially the studies based on analyses of mobile positioning data proved most useful in the study of mobility rhythms (e.g., Fekih et al. 2020 or Šveda et al. 2020). Despite that, some limitations ensuing from the financial demand of the research (high acquisition costs), the localization precision of recorded data (depending on the quality of signal and density of stations) or limited possibilities to acquire the structure of individual users (e.g., age, sex, income etc.) can be perceived. For many scientific disciplines (including geography, sociology, economy, etc.) big data present several challenges but also risks. We can see a great benefit of big data primarily in a detailed capturing of mobility of persons, both from the viewpoint of time and that of space, and also the analysis at linking with other data, e.g., on demographic characteristics of the respondent sample or accompanying phenomena relating to the time-space mobility of persons, like the traffic situation at a given time or weather conditions (Kwan, Schwanen 2016). Currently, we may consider e.g. the context of Covid-19 epidemic situation at various levels of lock-down (see e.g. Arimura et al. 2020).

Without a doubt, intelligent transport systems belong to the rapidly evolving spheres of transport planning and management in many states. In the context of the growing problems relating to transport, especially in urban regions (rush hours connected with congestions, planning, and organization of transport terminals, optimization in the use of transport infrastructure, car parking, etc.) ITS represent a suitable solution to mitigate the negative environmental impacts of high-intensity traffic. In general, implementation of ITS is linked with an effort to achieve higher coordination of transport, better comfort for travellers and drivers, higher safety and awareness of the travellers, and other aspects (Zhang et al. 2011). Therefore, during the last three decades, new technologies have seen a rapid expansion, and they facilitate transport processes of all transport modes. However, the fullest use of ITS is made especially in car transport (e.g., Ambak, Atiq, Ismail 2009), which is most burdened by the negative consequences of high-intensity traffic. As a rule, data collection from intelligent transport systems is carried out automatically. Autonomous devices mostly communicate by means of a satellite signal, sending important information on the status and position of a certain vehicle or equipment into a control unit, or to an operator. By means of aggregation of individual items of information data from traffic flows are collected, and the traffic flows feed information back into traffic control devices (e.g. telematics, traffic lights etc.). Navigation systems working with information from real traffic (e.g. Google Maps) or systems of public transport priority in cities operate on a similar principle (Gentile, Noekel 2016; Nuzzolo, Comi 2016). As their distinct advantage, ITS gather large amount of information in real time, with a great geographical precision, and store such information for an extended period of time giving rise to entire terabytes of traffic data, thereby enabling a construction of long and exceptionally precise time series of traffic data. Through these data, it is possible to analyse and comprehend a multitude of hitherto little explored aspects of human mobility. Due to the vast scope of the data, their topicality, and an option of linking to the other types of localization data, we can consider the data from ITS to be the so-called big data (a more general discussion e.g. in Kitchin 2013).

The data originating from ITS have a large number of practical use. Additionally, to direct use of the ITS geolocation data for planning and management of traffic it is possible to mention for instance a wide usage for the study of time accessibility in cities in various parts of the day (Juan, Wu, McDonald 2006), estimates of an average speed of public transport (Vanajakshi, Subramanian, Sivanandan 2009; Oskarbski et al. 2015), or a prediction of transport intensities for the purposes of land-use planning and transportation engineering (e.g. Meiying, Hainana, Led 2015). Because of the rapid spreading of these systems, we can assume growth in ubiquitously ascertained information about traffic. A great challenge is also the possibility of integrating transport data with other indicators.

3. Data and methods

For the analysis of daily mobility rhythms in the city we use data on the intensity of road transport. The data come from inductive loops and strategic traffic detectors. Both of these devices are part of urban ITS and serve primarily as instruments for information gathering and traffic management. The data from inductive loops record mainly information on the number of passing vehicles in individual traffic lanes (Mazaré et al. 2012; Cohen, Christoforou 2015). Based on this, it is possible to study the daily mobility rhythms at the individual crossroads. Strategic traffic detectors provide more complex data (Li et al. 2019), recording not only the data on traffic intensity, but additionally many other important indicators of the character of traffic (vehicle speed, occupancy of lanes, vehicle length or an average time gap between vehicles etc.). Strategic traffic detectors are usually placed at the individual road sections in the vicinity of individual crossroads.

However, data on the number of vehicles passing at individual intersections does not necessarily reflect local mobility rhythms. In many cases, they may be the result of various pacemakers arising in more distant areas within and outside the city (e.g. traffic volume in the central part of the city is influenced by various factors). This limitation should therefore be taken into account. On the other hand, the traffic volume at each intersection is a reflection of the rhythmicity of the place (intersection) in which the temporal and spatial aspects of traffic are accumulated. We study the daily mobility rhythms within the city of České Budějovice in the southern part of the Czechia. It is the regional capital of South Bohemia with a population over 94 thousand inhabitants; however, the built-up area including the large suburban settlements has more than 120 thousand inhabitants (see e.g. Sýkora, Mulíček 2009). Especially those living in the suburban areas form a significant part of daily city users with specific daily rhythms of various activities (ensuring the transport of children into schools and kindergartens in the morning hours, commuting to work, picking up children and their transport to places of after-school activities, and other afternoon activities etc.).

The data from inductive loops and strategic traffic detectors evenly cover the entire city area. The mentioned items of information (the number and types of vehicles, temporal distribution of traffic etc.) are provided by altogether 114 strategic traffic detectors at 44 profiles. These profiles cover the entire city area in an even manner. We have data from the period of November 4th to 17th, 2019 available. This is a period covering the days of usual traffic (standard weekdays, standard days of weekend). Additionally, this is a period prior to the onset of the worldwide Covid-19 pandemic that has had a marked impact on an overall decrease in population mobility.

For our study of the daily mobility rhythms, we mainly focus on the differences in daily mobility rhythms in the individual parts of the city. The data are analysed by the basic statistic methods (average, mean, standard deviation etc.), and by visualisation of the overall course of the daily mobility rhythms. The main purpose of this approach is the detection of differences in the mobility rhythms at individual crossroads. For the ease of interpretation, we aggregate the data for individual transport modes. In search of spatial differences in the mobility rhythms we make use of a relativised value suitable for comparing various crossroads and their values. Due to the fact that the induction loop data are affected by some degree of error in data collection (e.g., imperfect detection of the number of passing vehicles on rainy days), we used the Grubbs test to eliminate extreme values in each data set. The resulting typology of daily urban rhythms is analysed by means of the statistical instruments of skewness and kurtosis, which accentuate the more significant differences of the individual rhythms.

4. Results

4.1. Overall daily rhythms

Daily mobility rhythms are significantly influenced by a number of factors of a general and specific nature. General factors include the opening hours of shops, schools and nurseries, banks and offices. Specific factors include, for example, the location of employers, the function of different parts of the city or the specifics of the urban road network. The basic results of the dataset correspond to this. During the reference period 1,484,815 cars, 214,048 medium-sized vehicles, and 79,226 long vehicles (of which 12,592 vehicles with a length in excess of 21 metres) were recorded in all profiles. Temporal and spatial distribution of the vehicles is crucial for us from the viewpoint of an overall comparison. Out of the overall traffic flows cars account for nearly 84 percent of all vehicles; conversely, the share of large vehicles is around 4.5%. While the dominant representation of cars is apparent at all of the analysed crossroads, large vehicles show an increased concentration at the busiest crossroads in the city, through which especially the transit transport passes through the city (see Fig. 1). This is due to the fact that the city of České Budějovice has not yet built a bypass road, so all transit traffic passes through the city. This naturally affects mobility rhythms in the city, especially at key transit crossroads in the city.

The overall course of the mobility rhythms in the city corresponds to a normal course of transport in the city (see Thomas et al. 2008). During weekdays, the rhythm shows identical characteristics with the existence of two maximums (the morning and the afternoon rush hours). While the morning rush hour is usually concentrated between 6 a.m. and 9 a.m., the afternoon peak extends from 2 p.m. to 6 p.m. We can also confirm that at some crossroads both rush hours are equal, but

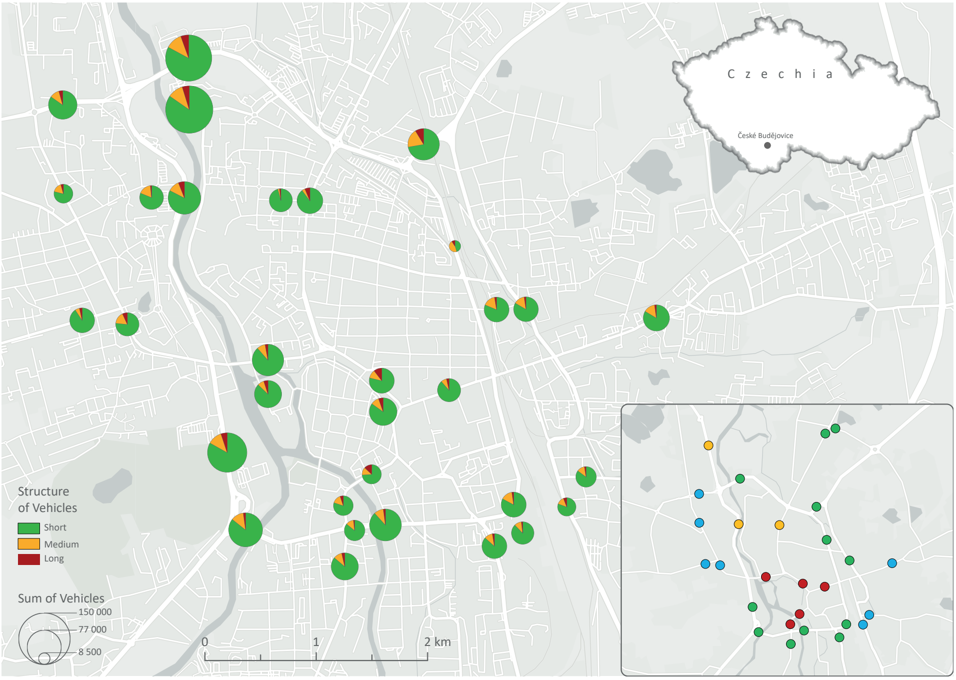

Fig. 1 – Locations of inductive loops and strategic traffic detectors and the structure of transport volumes

at some crossroads the intensity of traffic during the afternoon rush hour is markedly higher (see below). This confirms, among other things, that the rush hour with maximum traffic is shifting from the morning to the afternoon. Such changes are particularly typical of post-industrial mobility rhythms (see Oakil, Nijland, Dijst 2016). During weekend days the traffic decreases roughly by one third and its structuring in the form of peaks and troughs is less conspicuous. Interestingly, at the individual crossroads the scatter of relativised values of traffic intensity is higher during weekends than on weekdays. This indicates that on weekdays at the reference crossroads the mobility rhythms are relatively homogenous, whereas especially on Saturdays the differentiation of the mobility rhythms is obviously higher (Fig. 2).

The obvious differentiation of the mobility rhythms in the city is typical for individual types of vehicles. At all crossroads cars show a distinct temporal variability of traffic in correspondence to the course of normal weekdays. These can be characterized by a period of minimum traffic intensity from midnight till 5 a.m. followed by a steep increase in traffic till the morning rush hour with its maximum value between 7:00 and 7:59. On weekdays in the hours that follow the character of traffic shows a decrease to the local minimum in the form of a mid-morning trough

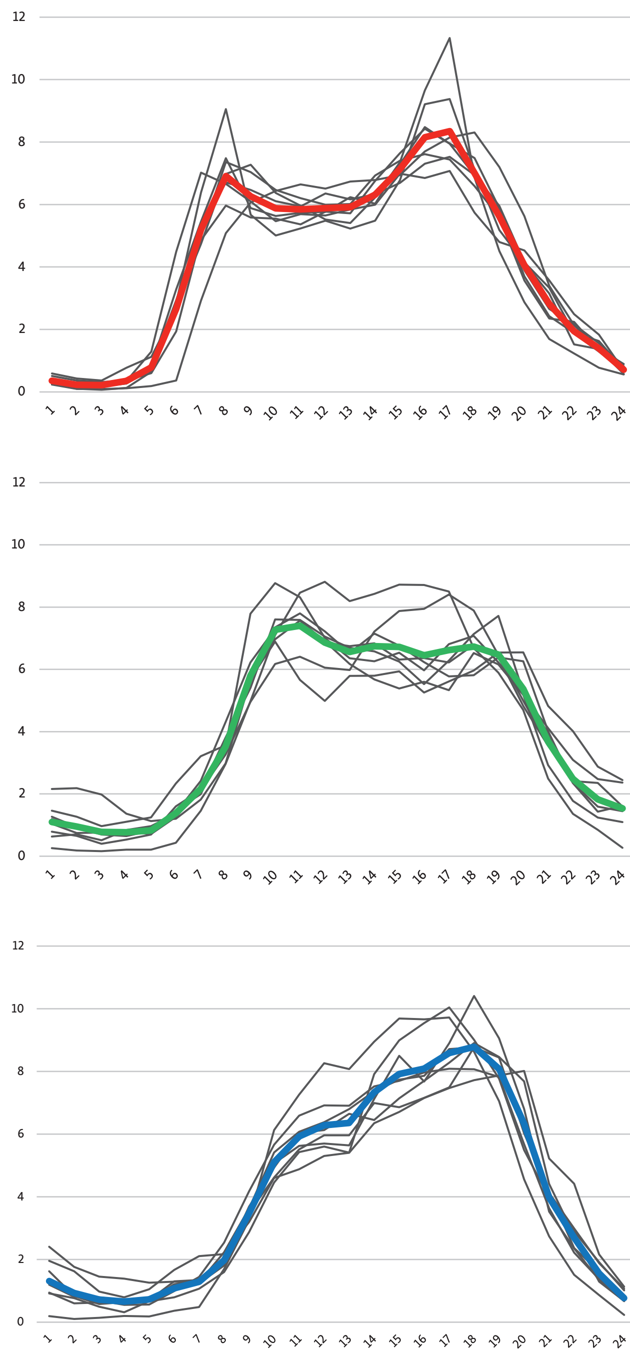

Fig. 2 – Relativised daily mobility rhythms during weekdays (red), Saturdays (green), and Sundays (blue), the bold line shows the average value

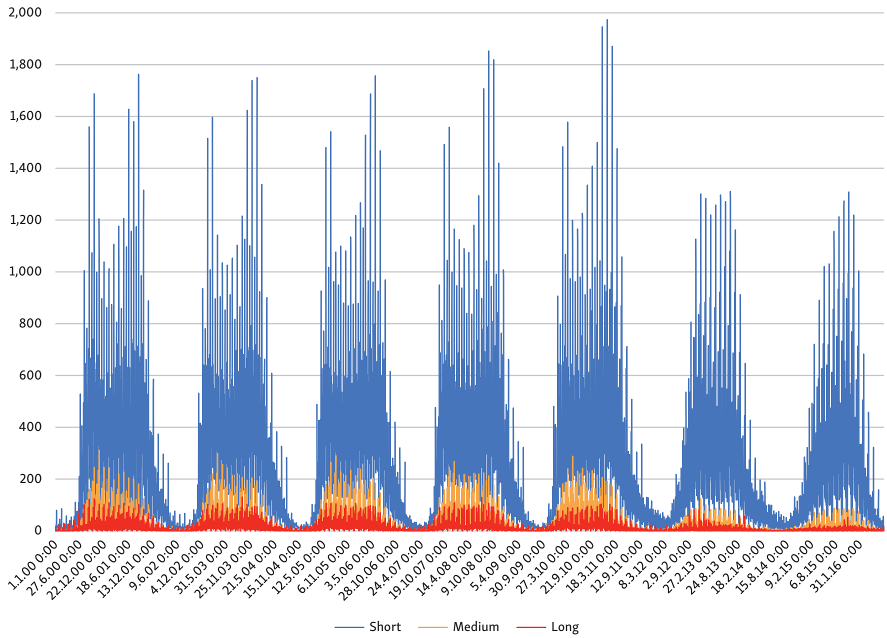

Fig. 3 – Daily mobility rhythms during one week according to types of vehicles

between 11 a.m. and noon. The maximum traffic value is usually reached during the afternoon rush hour between 3 p.m. and 5 p.m. This maximum demonstrates itself most markedly on Fridays. After this the traffic intensity diminishes again to finally reach the minimum values at night (after 10 p.m.). During weekend days the traffic peaks are not so marked, and the temporal scatter of the traffic is higher (similarly e.g. Borowska-Stefańska, Kowalski, Wisniewski 2020). Other transport modes (medium and large vehicles) exhibit a lesser temporal variability of traffic within the city's transport system. The highest values of traffic during morning hours (with a maximum between 8 a.m. and 9 a.m.) are typical for medium vehicles. This is probably related to meeting the customer-supplier relationships within the city organism (Furmankiewicz, Burylo, Dolzblasz 2020). Especially in medium vehicles the mobility rhythms are likely to be influenced by the early opening hours of shops and other services (Kärrholm 2009). During weekend the traffic of long vehicles is minimal (Fig. 3).

4.2. Spatial differences

It is evident from the above overview that the time-space mobility rhythms of the individual crossroads are more or less similar; however, in some cases great

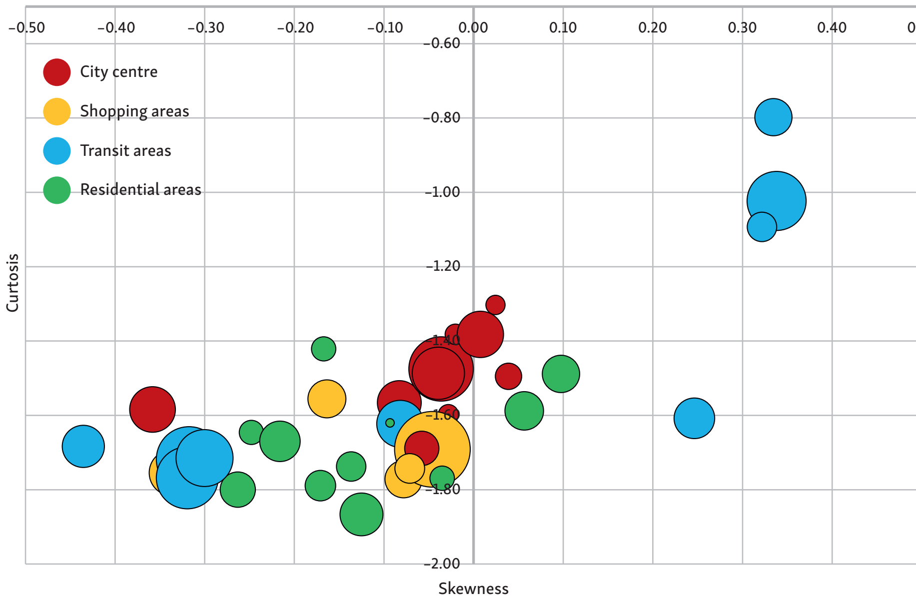

Fig. 4 – Skewness and kurtosis of the mobility rhythms at particular crossroads. (Number of passing vehicles; red – city centre, blue – transit areas, green – residential areas, yellow – shopping areas.)

differences occur, nonetheless. These are mainly subject to the function of the individual crossroads within the city's transport system, or their location within the city's structure. Therefore, in the next phase we observe the spatial differences in the individual mobility rhythms of the city because it can be assumed that various types of urban structures (residential areas, commercial districts, city centre etc.) will show different daily mobility rhythms. With regard to the different transport intensity values at various crossroads we study the mobility rhythms through relativised values. For these purposes, the city has been divided into the following structures (city centre, residential areas, shopping areas, other areas), to which individual crossroads were assigned.

Figure 4 illustrates the differentiation of skewness and kurtosis of the transport intensity values between the individual crossroads. It is apparent that within similar urban structures some crossroads show similar characteristics of the traffic. For example, the crossroads in the city centre show specific features displaying (with one exception) identical characteristics of skewness and kurtosis. Therefore, we can confirm these crossroads have an identical character of traffic ensuing from the existence of smaller differences between maximum and minimum values during the day. On the contrary, the skewness around zero values suggests that the traffic is not markedly concentrated either in the morning or in the afternoon hours (Mareggi 2013), so we find a relatively stable utilisation of the crossroads

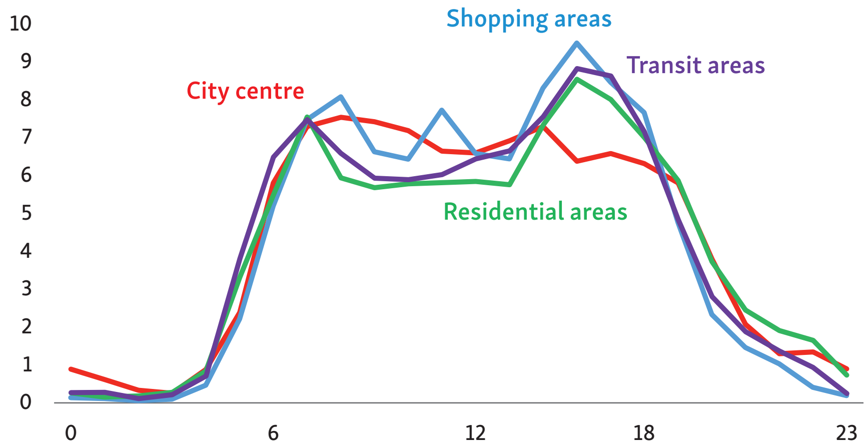

Fig. 5 – Typical daily mobility rhythms during weekdays at particular urban structures

throughout the day. The group of crossroads near the shopping areas again shows relatively similar values characterized by somewhat more marked fluctuations between maximum and minimum values. A great increase in traffic intensity in the afternoon hours of Thursdays and Fridays is of interest as well; the assumption is that a distinct rhythmisation factor will be exactly the daily and weekly rhythms in shopping and the opening hours of individual services (see e.g. Sun et al. 2017 or Mulíček, Osman 2018) traditionally located in shopping centres (shops, restaurants, multiscreen cinemas etc.). Negative values of skewness are also in correspondence with the more marked afternoon load. Crossroads in the residential areas form a relatively heterogeneous group. These are characterised by a generally lower traffic intensity, a more distinct polarisation between maximum and minimum values, which is in conformity with the normal daily rhythms of urban population (compare with Kang et al. 2012; Noulas at al. 2012; Nemeškal, Ouředníček, Pospíšilová 2020). Because of the prevailing negative values of skewness, the afternoon rush hour is more conspicuous than the morning one in most crossroads. The crossroads situated on other areas (mainly on the transit routes within the city) present the most heterogeneous group, which usually contains remarkably busy crossroads, where the normal inner-city traffic becomes saturated exactly by transit transport. While the crossroads at the city entries are primarily concentrated in the right part of the plot (a more marked morning rush hour than the afternoon one), the crossroads on the intra-urban circle are concentrated in the left part of the plot (a more marked afternoon rush hour). This is in conformity with the fact that the intra-urban circle transfers also the transport links of shopping centres located on the outskirts as well as the relations within the city and its suburban hinterland.

On the grounds of the previous analysis, it is possible to render a model of the typical course of daily rhythms at the crossroads in particular urban structures. Figure 5 illustrates the relativized values of transport intensity during weekdays as averages for the whole monitored period. Certain differences existing between crossroads within specific urban structures are obvious. Typically, this relates to the crossroads situated within the city centre, which are characterized especially by a relatively homogenous distribution of traffic intensity during the day (from 7 a.m. till 7 p.m.). Of all assessed categories, these crossroads also show the highest intensity of traffic during night hours, which corresponds to the concentration of services and entertainment in the city centre. The crossroads at shopping areas show somewhat more polarised rhythms with morning and afternoon rush hours. In these places also an increased intensity of traffic becomes distinctive around noon and in the afternoon (typical mainly for Thursdays and Fridays); during night hours the traffic is negligible. The crossroads in residential areas show more irregular rhythms (cf. e.g., Edensor 2011) with a typically high intensity of traffic in the morning and afternoon (return) peak hour traffic (7 a.m. to 9 a.m.; 3 p.m. to 6 p.m.) and a marked mid-morning trough (10 a.m. – 2 p.m.). On the contrary, the crossroads at transit roads (other areas) display the most heterogeneous rhythms. Apparently, the considerable mix of various transport rhythms at these crossroads ensues from their situation and the function of the individual crossroads in the city transport system. This is where intra-city and suburban transport typically blend with the transit transport. Therefore, a certain kind of rhythm created by the mix of various kinds of traffic (morning and afternoon rush hours, less conspicuous morning trough etc.) manifests itself at these crossroads as well.

5. Discussion and conclusion

Utilisation of the data from intelligent transport systems is an emerging field. In the last decade, great possibilities to analyse transport data of a large scope, for long periods of time, and in a great spatial detail open up for researchers. One of the options in the new approaches to the assessment is the study of daily mobility rhythms through the data from intelligent transport systems. These systems provide interesting and hitherto little used data on a multitude of traffic phenomena and processes.

The results obtained in the study illustrate the differentiation of the daily mobility rhythms studied through the data from inductive loops and strategic traffic detectors. These instruments are located close to the important crossroads to serve especially for the coordination of traffic. On comparing absolute and relative values of traffic intensity and the applied statistic indicators we concluded that the overall mobility rhythms are relatively similar with some exceptions. Out of the most significant results we must mention the findings of considerable differences in the overall daily rhythms expressed through individual kinds of vehicles. While passenger cars tend to create clear rhythms corresponding to the normal needs of the inhabitants, lorries show a more marked concentration especially in morning hours of weekdays. From the spatial point of view association of the crossroads' rhythms with the situation of the crossroad within the city transport system and in various types of urban organism from the point of view of their prevailing function is of interest. It is apparent that the crossroads' rhythm becomes saturated by the position of the crossroad within the hierarchy of transport networks (transit roads against local ones) on one hand, and the rhythm ensuing from the function of the given urban structure (residential areas against shopping zones etc.) on the other hand. The final rhythm of a crossroad it the outcome of synchronization of both partial rhythms.

The ascertained results are of importance both for research and practice. In the first place, it is necessary to point out the findings of differences in the daily rhythms between the individual urban structures (city centre, shopping areas, residential areas, and others). Apparently, there are certain differences in the mobility rhythms of these urban structures; however, in comparison to other studies (e.g. Calabrese et al. 2013; Smith, Hetherington 2013; Paiva, Cachinho, Bararta-Salgueiro 2017; Kraft et al. 2020) these differences are not so marked. This is caused primarily by the specific approach to the study of the daily rhythms, namely by means of the data from strategic traffic detectors. It is obvious that the crossroads within the transport organism of the city cater for a wide spectrum of transport needs, and this causes a partial equalizing of the individual transport rhythms without giving rise to markedly different mobility rhythms.

Despite the mentioned limitations we consider the approaches to the study of daily city rhythms based on the data from intelligent transport systems to be very valuable. Their indisputable advantage is the fact that these systems continuously record a large amount of information in a great territorial detail, and – in contrast to the data of mobile phone operators – with a great precision. This enables a long-term study of a number of transport phenomena and processes (including the study of daily city rhythms), which is of a great relevance for a multitude of disciplines (economy, transport sciences, geography, sociology etc.). A great advantage is the application of these data in transport planning (for example planning the city transport etc.). In our opinion, the future research into these phenomena should also focus on the integration of the data from ITS with other socioeconomic indicators.

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ACKNOWLEDGEMENTS

This article results from the project: "New Mobility – High-Speed Transport Systems and Transport-Related Human Behaviour"; Reg. No. CZ.02.1.01/0.0/0.0/16_026/0008430, co-financed by the Operational Programme Research, Development and Education and Ministry of Education, Youth and Sports of the Czech Republic.

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