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DEVELOPMENT OF PASSENGER TRAIN TRANSPORT IN THE BRNO URBAN REGION BETWEEN 1980 AND 2010

Rozwój pasażerskiego transportu kolejowego w rejonie miejskim Brna w latach 1980-2010

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Abstract: The lengthy timespan of thirty years shall be a playground of many changes and variations in all spheres of social life and technical world. Public transportation is an integral part of both mentioned fields and co-operates with their changes. The urban region of Brno, the second largest city in the Czech Republic, is the region with a strong core (city of Brno) and thus it is a rail hub as well. Since 1980, the whole urban region underwent several changes in an industrial structure (from industrialization and preference of heavy industries to de-industrialization and dominance of services), a social organization (transition from industrial to post-industrial patterns of life, from urbanization to suburbanization and subruralization), an arrangement of the settlement system (from densely-populated estates on the edges of the city to suburbanization) and transportation patterns (moving from public transportation to individual road transportation). The aim of this paper is to provide an overview of changes in train public transportation in Brno urban region between 1980 and 2010. As a basis of the analysis, timetables of 1980, 1990, 2000 and 2010 were taken. There have been analysed all stations with commuting time of passenger trains during the day less or equal 60 minutes. Results of timetable analysis are put into the context of other socio-economic terms. The main outcomes show little changes in the length of transport time, in the distribution of trains during the day, in differences between weekday (in this paper Wednesday) and weekend, in the usage of express trains and in train lines. The paper also compares conditions before and after establishing the Integrated Transport System in South Moravia Region in 2004.

Key words: passenger train transport, passenger trains, Brno urban region, Czech Republic, timetable, South Moravian Region, Integrated public transport system.

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1. Introduction

Passenger train transport is an important part of transport systems. It has a long development during its existence. It was formerly considered as an addition of freight transportation. According to its spatial and technical attributes (fully separated body of railway, stable speed, large number of passengers transport facility), rail transportation nowadays is one of the fastest kinds of transportation in cities and urban areas. This phenomenon emerges in the Czech Republic since 2000, mostly in Prague and Brno, because of highly-developed railway network.

The aim of this paper is to outline the development of basic transport paradigms and railway network quality in Brno urban region during last thirty years. Analysis of timetables was chosen as a key method. Data were taken from the years 1980, 1990, 2000 and 2010. Thus, the research question of this paper is: „What are the changes in time-space patterns of commuter trains in Brno urban region between years 1980, 1990, 2000 and 2010?" The paper contains four parts. The first part introduces the issues, theoretical approaches and terms and conditions of the Czech Republic and Brno urban region. The second part contains a methodology for research, the results of which are analysed later in the third part. The fourth part of paper provides discussion of the results.

1.1. Theoretical approaches

Phenomenon of work commuting has begun its importance during the industrial revolution. Since that, work commuting is an integral part of euro Atlantic way of living (Dickinson, 1957; Tonev, 2013). Commuting from economically less exposed regions to economically important ones is motivated mostly by higher vague and wider offer of workplaces (Harvey, 1996; Šerý, 2010; Votrubec, 1980). As soon as workplaces in agriculture in rural places decreased, work commuting became a great advantage. This disparity led also to migration from rural to urban areas. Growing railway network made commuting to work possible, together with net of suburban tram (streetcar) and trolleybus networks (Dujka, 2012). Strong development of bus transportation, in the Czech Republic since 1950s, made everyday migration even easier (Ryba, 2004).

Passenger rail transportation in the Czechoslovakia belongs to key and subsidized parts of economy and transportation (Toušek et al., 2008). Its relative importance decreases, however it is considered to be an environmental alternative of individual car transport (Hoyle, Knowles, 1998; Rodrigue et al., 2010; Seidenglanz, 2007). This is also the reason of its preference in urban regions and agglomerations, namely in the western Europe (Newman, Kenworthy, 1999c; Seidenglanz et al., 2014). Exploration of public rail transportation phenomenon in the Czech Republic increases after 1990 with the beginning of suburbanization. This led to spatial deconcentrating of residential and industrial activities out of traditional urban cores (Hnilička, 2005; Horská et al., 2002; Marada, 2010).

1.2. Brno urban region

Brno urban region can be roughly defined as the City of Brno itself and the administrative districts of municipalities with extended powers (AD MEP) Kuřim, Šlapanice, Rosice, Židlochovice, Blansko, Tišnov, Slavkov u Brna and Ivančice. In total, this area is home to over 670,000 inhabitants which is approximately 57% of the population of the South Moravian Region.[1] The significance of the Brno urban region is not negligible in the settlement structure of the Region and the entire Czech Republic. The Brno urban region is not defined in a uniform manner or administrative delimitation; however, a number of research works have attempted to define it, among others *Atelier Era* 2008, Hampl (1996, 2005), Mulíček et al. (2006), Mulíček and Szczyrba (2004), Seidenglanz et al. (2014), Seidenglanz et al. (2015).

By population, Brno is the second largest city in the Czech Republic (377,973 inhabitants as at 1st January 2017). It is also an important cultural, industrial and university centre. In modern history, the city experienced the greatest boom during the Industrial Revolution when it became the centre of textile, chemical and engineering industries. These days, Brno is primarily focused on subjects doing business in the field of tertiary and quaternary; moreover, the existence of six state universities and of many research institutes has a significant share in research orientation. Due to the economic superiority of Brno, no other similar centres were created in the immediate background. The municipalities in the neighbourhood of Brno mostly keep a sub-rural character in the composite landscape. Industry in these municipalities had only partial importance. The most significant areas were Rosicko and Oslavansko (west of Brno) where the mining and processing of black coal took place in a relatively small area until 1992. This coal was mainly used in the Brno industry (Plchová, 1999). After the World War I, there was a more significant development of engineering companies north of Brno (Kuřim, Adamov, Blansko). These companies

[1] Data on 1st January 2017. Source: Czech Statistical Office.

were based mainly on strategic reasons in the narrow valleys in connection with previous smaller iron works.

After World War II, the population of the cities strengthened the most (mainly the population of Brno, Blansko, Adamov and Kuřim). This was mainly due to the construction of large districts of housing estates. Most of the non-urban settlement had a rural character with an emphasis on agricultural primal production. Although the suburbanization process started in the first half of the 1990s, the municipalities in the closer neighbourhood of Brno remained less significant. As in the past, the development of larger centres was hindered also by natural conditions: the northern and western parts of the region have the character of forested highlands. Moreover, with the exception of the north-west and south-west quadrant, there are municipalities with a large population (around 500 to 1,000 inhabitants). This was one of the other reasons for the absence of a large centre.

1.3. Railway network and the development of the area service through commuter trains

The first railway was brought to Brno in 1839; it was the leg of The Emperor Ferdinand Northern Railway (KFNB) from Břeclav. By 1870, the basic framework of the railways in Brno was completed – the railways were to Česká Třebová (1849), Rosice u Brna (1856), Přerov (1869) and to Vienna via Hrušovany nad Jevišovkou (1870). By the year 1900, the railways to Havlíčkův (Německý) Brod and Kolín via Tišnov (1885), to Jihlava via Třebíč (1886) and to Veselí nad Moravou via Kyjov (1887) were added. At the end of the 1930s, the construction of a new arterial railway Brno – Havlíčkův Brod via Tišnov and Křižanov began (Sekera, 2011). This railway was fully finished in the 1960s. On the contrary, before the WW II, the significance of the railway to Vienna via Hrušovany decreased. As a result of the post-war order, the railway was interrupted in the border section, and it was degraded to a local railway. By the end of the 1950s, the railway network in the Brno urban region was given the current form.

Due to the activity of several different railway companies, there was the intricate network of railways and railway stations in the cramped wider city centre. After the expropriation of the railways, the upper station was transformed into the main station while the so-called lower station south of the city remained only for freight transportation. Approximately from the beginning of the 20th century, there has been a debate about the location of the main station, and about the unification of the railway network. An agreement has not yet been reached. The current main station with its directional and spatial parameters does not correspond to the current requirements for the volume of traffic, and for the combination of commuter and long-distanced passenger transportation; however, due to the unresolved situation regarding the location of the main station, a great rebuilding or extension of the existing station is impossible (Dukát, 2005; Kučera, 2010; Seidenglanz et al., 2014; Seidenglanz et al., 2015).

The railway network in the Brno urban region is currently created by two spinal arterial corridors and two intrastate-important railways. The so-called Southern long-distanced corridor Prague – Česká Třebová – Brno – Břeclav – Bratislava – Štúrovo passes through Brno. This corridor was headed in the section Prague – Kolín – Havlíčkův Brod – Brno until the reconstruction of the railway Brno – Česká Třebová in the 90s of the 20th century. The so-called Vlára railway Brno – Veselí nad Moravou – Nové Město nad Váhom/Trenčianská Teplá (today in Slovakia) was connected to this corridor. Vlára railway ensured the connection of the Czech part of the former Czechoslovakia with Central Slovakia; however, its international significance after the division of the state in 1993 markedly declined to a regional level. On the contrary, the importance of the railway Brno – Přerov has increased and serves as a connection of Brno, Ostrava region and the Polish part of Silesia; nevertheless, this railway is in an unsatisfactory state. The network of intrastate-important railways is completed by the railway Brno – Třebíč – Jihlava which connects southern Moravia with southern Bohemia. From the infrastructure point of view, the largest changes in the railway network after 1980 were only the reconstruction and the increase of speed (railways to Břeclav and to Česká Třebová) and the electrification (railways to Česká Třebová and to Přerov). A number of tracks, as well as speed conditions, remained without great changes on all railways throughout the reporting period.

The overview of railways passing through the Brno urban region is shown in Tab. 1 and in Fig. 1. The table shows basic information about the railways, a number of tracks, traction (I – independent, E – electric) and maximal speeds according to current data from The Railway Infrastructure Administration (RIA). The numbers of the railways are taken from the timetable 2010, the number of the railway Vranovice – Pohořelice is taken from the timetable 2000/2001. In Traction column, the years in the brackets indicate when the electrical operation started on the appropriate railway. The scope of the article does not allow more detailed information about the infrastructure and its development, but this is partly indicated in chapter 3.

Tab. 1. Overview of the railways passing through the Brno urban region. The numbering of the railways corresponds to the situation in the year 2000

Railway No.	Section	No. of tracks	Traction	Max. speed
240	Brno – Třebíč – Jihlava –Havlíčkův Brod	1	I	60 – 85
244	Brno – Hrušovany nad Jevišovkou Moravské Bránice - Oslavany	1	I	70 – 80 45 – 50
250	(Prague –) Havlíčkův Brod – Žďár nad Sázavou – Křižanov – Tišnov – Brno – Břeclav – Kúty ŽSR	2	E (1967)	North: 85 – 120 South:160
251	Žďár nad Sázavou – Nové Město na Moravě – Tišnov	1	I	55 – 60
253	Vranovice – Pohořelice	1	I	non-provided
254	Šakvice – Hustopeče u Brna	1	I	55 – 60
255	Zaječí – Čejč – Hodonín	1	I	45 – 50
260	(Prague –) Česká Třebová – Svitavy - Brno	2	E (1999)	105 – 140
262	Česká Třebová – Chornice – Skalice nad Svitavou	1	I	45 – 50
300	Brno – Přerov (– Bohumín)	1	E (1994)	85 – 100
340	Brno – Kyjov – Veselí nad Moravou	2	I	85 - 100

Source: Timetable 2000/2001, Timetable 2009/2010, RIA.

The arrangement of the Brno railway hub is strictly nodal. In the area of Brno, there is an intersection of radials while within tens of kilometres from Brno, the railway tangents were not created even at the local railways level. The radials do not have almost any branches in the close neighbourhood of Brno. Due to the tracing of the main railway Břeclav – Brno leaving micro-regional centres, several short dead-end railways were built: Hrušovany u Brna – Židlochovice, Vranovice – Pohořelice and Šakvice – Hustopeče u Brna. Similarly, on the railway Brno – Hrušovany nad Jevišovkou – Vienna, there was built a branch Moravské Bránice – Ivančice – Oslavany. These branches were built to connect micro-regional centres to the railway network. Later, it turned out that the service of these towns and villages by bus is cheaper and with advancing road infrastructure even more advantageous.

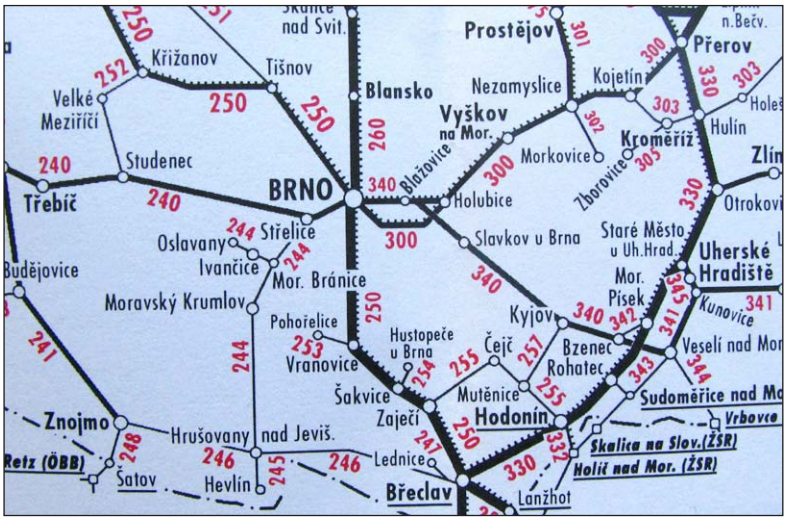

Fig. 1. Railway map of the Brno urban region and its wider neighbourhood

Source: Timetable 2000/2001.

Passenger railway transportation in the Czech Republic consists of several train categories. These categories are mainly divided according to the primary purpose of service: beginning with passenger trains with frequent stops to expresses connecting the more distant towns and agglomerations. The following paragraph provides an overview of the train categories occurring in the investigated area according to the timetable 2010. Due to the scope of the article, it is impossible to describe the development of passenger-train categories in more detail; however, the mentioned categorization is sufficient for the following text.

- ***Ordinary passenger train (Os)*** – Trains usually stop at all stations and stops on the track and serve primarily for the transport of persons at the micro-regional to the regional level. In timetable, ordinary passenger trains are usually unlabelled.
- ***Through train (Sp)*** – Trains stop at selected stations and stops on the track, and serve mainly for fast regional transport. Through trains are complementary to express trains (R-trains, see below), with which they share a number of characteristics and complement in many ways. In 1980 and in 1990, they were in the form of some "second-category expresses" and they were burdened by a special supplement.
- ***Express train (R)*** –Trains stop at selected stations and stops on the track and serve mainly for fast regional transport. In 1980 and in 1990, they were burdened by a special supplement.
- ***EuroCity (EC)*** – European railways' trains with a guaranteed international standard consisting of modernised coaches and a restaurant car. Supplement for a higher quality train was required only in 2000. This train category, existing since the early 1990s, is not intended for the basic operation of the territory at a regional level.
- ***EuroNight (EN)*** – Night train of a higher quality consisting mostly of accommodation coaches. This train category is not intended for the basic operation of the territory at a regional level.
- ***SuperCity (SC)*** – Trains with speed and transport quality above standard which stop in county towns only, possibly in border stations. They consist of modernised coaches or electric motor unit, within a refreshment possibility during transport. This train category is not intended for the basic operation of the territory at a regional level.

The primary purpose of Os-trains was the transport of persons at a regional to micro-regional level. Due to the strict tariff separation (supplements for a higher quality train) of Os-trains from other long-distance trains (beginning with Sp-trains), these trains were used for longer journeys until the supplements were cancelled at least for Sp-trains and R-trains. Os-trains were generally operated on routes up to 100 km long. The journey by these trains was lengthy due to long waiting in stations or due to delays caused by preferences of other trains including freight.

After 1989, there has been a gradual change in train driving policy. In the 1990s, the supplements for Sp-trains and R-trains were already abolished. In 2000, only journeys by trains of the highest categories (see above) were burdened by a special supplement. In 2010, the supplements were cancelled altogether. Routes of Os-trains were reduced and scheduled waiting was ceased. The decline in freight transportation and the unlocking of the capacity of railways also had a role in acceleration. In 2004, Integrated Transport System of South Moravian Region (ITS SMR) was established in the closest neighbourhood of Brno. By 2010, it was extended to almost the entire territory of the South Moravian Region (Čuma, 2014). The railways form a spinal system of public transportation in ITS SMR; Os-trains also gradually switched to the tact timetable and became an important component of regional transportation, particularly in suburban area. With the gradual expansion of ITS SMR, the importance of passenger-rail transportation in certain segments (Brno – Blansko, Brno – Sokolnice – Telnice, Brno – Tišnov) was increased. Along with it, the tariff and traffic integration of this transportation with buses was realised. On the contrary, passenger services were cancelled on the end sections or on railways with a low demand (Vranovice – Pohořelice, Ivančice – Oslavany) (*Plán dopravní obslužnosti Jihomoravského kraje*, 2016). Sp-trains and R-trains also became a part of ITS. The ability to use these trains for daily commuting shortens travel time and changes the isochrons of the daily commute's time distance.

2. Methodology

The key method for this work was the analysis of train timetables in selected years. All passenger trains on the railways in the Brno urban region were analysed. The outputs of the analyses based on the following methods were maps showing the number of trains in individual stations and their time distance from the centre, as well as comparisons of changes through development indexes.

The area of research is focused on the Brno urban region. There are many ways in which urban areas can be defined. The most commonly used methods are number of inhabitants, density of connections with centre, intensity of commuting, or time distance (e.g. Blažek, Uhlíř, 2011). For the purposes of this research, time distance of train travel from the selected point in the centre was selected as the most appropri-

ate. Similarly, the region was delineated by Seidenglanz et al. (2014), and Seidenglanz et al. (2015). J. Dujka (2014) uses the same procedure in a modified form. The Brno urban region is defined by 60-minute isochron of train travel time from Brno. 60-minute isochrone has been set as a limit value based on the assumption that a person is willing to spend for transportation to/from work or school 120 minutes a day maximally (Votrubec, 1980). Due to the economic importance of Brno and due to the absence of such a significant centre at the corresponding distance, the time of 60 minutes seemed to be optimal although D. Seidenglanz et al. (2014) have worked with the time of 45 minutes. The time distance of the relevant station was created as the average value of the travel times of all trains for the direction to Brno and from Brno, always according to the timetable of the relevant year. As reference points, the stations Brno main station (for tracks No. 240, 244, southern part of the track No. 250 and the following tracks, 260 and the following tracks, 300 and 340) a Brno-Královo Pole (for the northern part of the track 250 and track No. 251).[2]

The research is defined in the years 1980, 1990, 2000 and 2010. The year 1980 is completely classified into the period of the industrial era. Emphasis is placed on settlement and labour spatial concentration, and on the use of kinds of public transportation. Individual car transport is less important in terms of the modal split. It is due to socio-economic conditions and due to state policy in the area of auto mobilisation (Seidenglanz, 2007; Kraft, 2011; Dujka, 2014). The year 1990 can be marked as the peak of the industrial period. As a result of social changes at the end of 1989, smaller private enterprises were emerging besides traditional great employers. This is related to the erosion of spatial rhyming according to work shifts in great factories. The expansion of a car as a normal mean of transport begins at the expense of public transportation (e.g. Ryba, 2004; Seidenglanz, 2007). The year 2000 already fully reflects processes typical for the post-industrial era. Over the past decade, there have been significant changes in housing, economy and transport. The processes of settlement, commercial and industrial suburbanization gradually cross the border of the city of Brno and extend to neighbourhood municipalities. In the economy, the significance of the primer and the secondary is decreasing and the number of persons employed in the tertiary increases (Šerý, 2010). From the spatial point of view, there has been diffusion of job opportunities beyond traditional industrial areas. The year 2010 can be described as the peak of the processes taking place in full in 2000. All types of suburbanization reach a mature phase of development. Public city transport sometimes plays a significant role (especially in commuter transport) due to a change in the policy of timetable construction. There are attempts to prefer non-engined means of transport (Hoyle, Knowles, 1998; Rodrigue, 2010; in the neighbourhood of Brno, this is mentioned by Čuma, 2014).

For the purposes of the research, it was drawn from the timetable 1980/1981 for the year 1980, from the timetable 1990/1991 for the year 1990, from the timetable 2000/2001 for the year 2000 and from the timetable 2009/2010 for the year 2010. All Os-trains[3] passing through the relevant transport hub in 24 hours were counted, both in the direction to Brno and in the direction from Brno. In order to avoid distortion in the number of strengthened connections (Sunday and Monday strengthening towards agglomerations, Friday strengthening in reverse direction) or weakened traffic (Saturday, most of Sunday, holidays), Wednesday in mid-October was selected as the reference day for each of the reviewed years. Wednesday's offer is a representative sample of the offer of connections during the working week. Connections with no more than one transfer were also counted as one connection if the transfer time was 10 minutes or less.

3. Analysis and results

At the beginning in 1980, the main purpose of Os-trains was to transport people to work, to school and to the places of leisure-time spending. The timetable was not constructed in tact and train distribution during the day was not uniform. The workday routine was determined by start and end of work shifts in factories. In the most common eight-hour-shift regime were the breaks at 6:00, 14:00 and 22:00 (see also Mulíček et al., 2010). The most of the trains were operating in the morning (between 4:00 and 8:00). On

[2] The time distance between Brno-Královo Pole station and Brno Main station is approximately 15 minutes (see fig. 7). The centre of the city and a number of districts in the north and in the west of the city is more readily available by using public transport from Královo Pole station, near Královo Pole railway station. The assumption was that the most of the passengers in the direction from Tišnov ended their train travel in Brno-Královo Pole station.

[3] Sp-trains and R-trains also became a part of the ITS. Due to the absence of special supplement, these trains were used for daily commuting in 2000. Their inclusion in the calculations will change the isochrones of time distance of daily commute. In the next phase of data processing, the trains of these categories will be included in the result; however, their inclusion is not currently possible due to the absence of appropriate data model.

the one hand, it was necessary to transport workers to their workplaces, on the other hand, it was dispensable to get pupils and students to the beginning of school. The first lessons have usually begun between 7:00 and 8:00. Until noon, between 8:00 and 12:00, there was a usual gap in Os-trains operating, around 180 minutes (in some cases even 300 minutes). Train operating in the afternoon was quite similar to the morning regime. The span between trains was longer than in the morning, while the spans were getting longer towards the evening. The last trains left centre after 22:00 (the end of a works shift), in the opposite direction the last train rode after 21:00 yet. It was common the last trains finished its ride several minutes after the midnight (24:00). Transfers in junctions were not guaranteed and the length of transfer time during the day varied in tenths of minutes.

The extent of region delimitated by 60-minutes isochrone was greatest in connection with the arterial route No. 250 – see Fig. 2. It was the only railway with

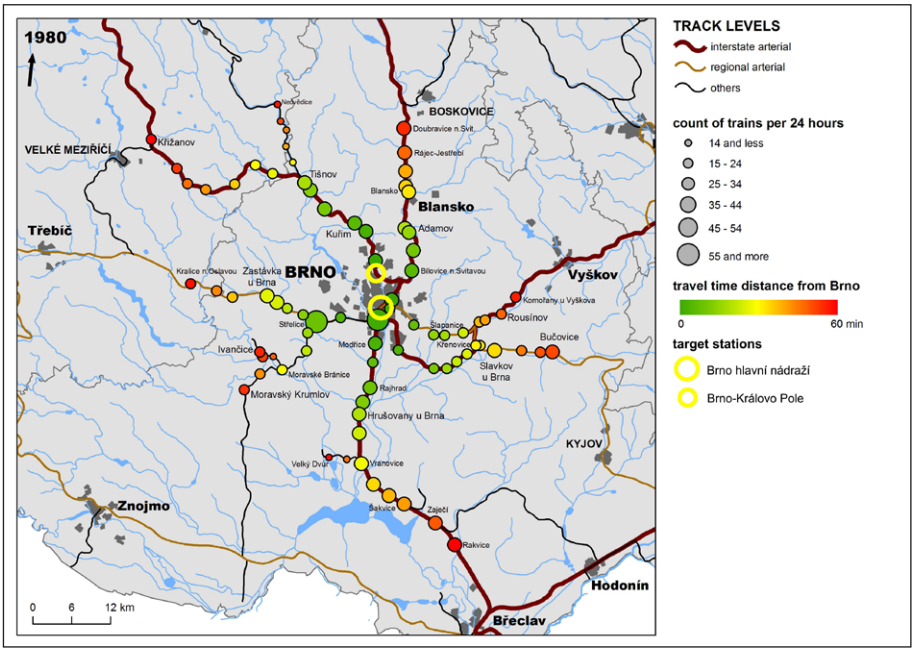

Fig. 2. Stations within 60-minutes isochrone from Brno in 1980

Source: Timetable 1980/1981, own calculations.

electric operation at this time, Os-trains were mostly operated by electric motor units. The railway was double-tracked in its full length, which increased the capacity. The most distant points were Křižanov (at 52 km4 from Brno-Královo Pole) and Rakvice (44 km). In the 1980 region delimitation were included micro-regional centres (21 km), Adamov (15 km), Rousínov (30 km), Slavkov u Brna (27 km), Bučovice (37 km), Moravský Krumlov (33 km), Ivančice (29 km) and conurbation Rosice u Brna – Zastávka u Brna (21, event. 23 km). The only other regional-levelled centre in this region was Blansko (23 km). Due to longer travel time, micro-regional centres Oslavany (34 km), Náměšť nad Oslavou (43 km), Pohořelice (33 km) and Hustopeče u Brna (41 km) were to be excluded. In the case of last two towns, poor connections in junction stations on Brno – Břeclav route were the reason of exclusion. However, these connections were constructed in the opposite direction, i.e. towards Břeclav. The region has been delimitated in the shortest way in case of Hrušovany nad Jevišovkou route (Moravský Krumlov) and Česká Třebová route (Doubravice nad Svitavou), both 33 km from Brno. Os-trains on single-track railways were slowed by the great amount of freight trains, especially on single-track railways due to a crossing.

In 1990, the situation was similar to 1980. Changes in society and politics have happened at a relatively recent time (November 1989). Changes in socio-economic sphere were not established yet. In opposite to 1980, the number of connections on all of the routes increased. Connections in junction stations were partially improved as well (for example in Vranovice towards Pohořelice, in Tišnov towards Nedvědice). In suburban parts of routes (i.e. in parts with the higher number of passengers), there are first signs of connection increase – for example Brno – Zastávka u Brna (track No. 240) and Brno – Tišnov (track No. 250). There were only little changes in 60-minutes isochrone.

[4] Distances are based on entries from timetable (tariff kilometers).

Due to the shortage in travelling times, it was possible to include station Rakšice (37 km) on track No. 244. Improved trasnfers in Vranovice enabled the including of Pohořelice – see Fig. 3.

ter the reconstruction, route Brno – Česká Třebová became the main route between Prague and Brno, instead of the former route via Havlíčkův Brod and Tišnov. Route No. 300 towards Vyškov and Přerov

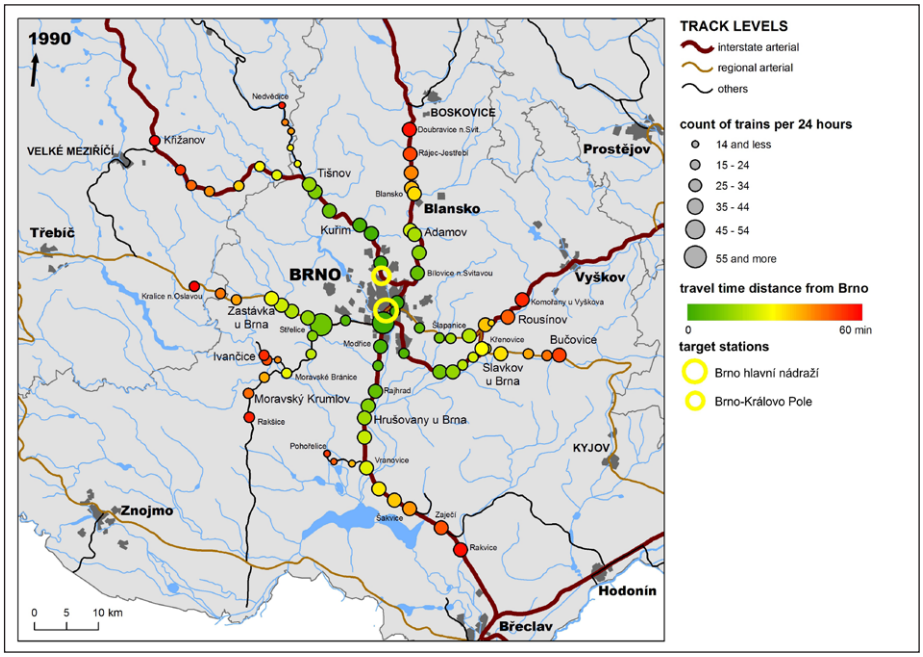

Fig. 3. Stations within 60-minutes isochrone from Brno in 1990

Source: Timetable 1990/1991, own calculations.

In 2000, fundamental changes in the number of connections are notable. The number of Os-trains increased on all of the tracks. The number of freight trains has decreased, which opened capacity for passenger transportation. Most of Os-trains have operated on track No. 250, both towards Křižanov and Břeclav and on track No. 260 towards Česká Třebová. Both of tracks are double-track railways with the electric operation and the largest amount of capacity. The increase has been similar also at the suburban route Brno – Zastávka u Brna (track No. 240). There was a significant difference between a number of connections on the track further towards Třebíč. Also, transfers with short trasfer time were to become usual, which is mostly notable on connection increase to Nedvědice (track No. 251).

The size of time-delimited region underwent great changes. In the northern direction, the extension was to the other micro-regional centre Letovice (45 km) and got close to the similarly important town of Boskovice (43 km). Boskovice could not be included due to missing connections in Skalice nad Svitavou (connections co-operated with Sp-trains and R-trains). The reason of shortage the travelling times was the general reconstruction and electrification of railway Brno – Česká Třebová (finished 1999). Af-

also underwent several reconstructions and electrification, which led to a shortage of travelling times. The shortage has been caused also by timetable changes and abolishing waiting times. It enabled region expansion in eastern direction to Vyškov (45 km). Following the corridor improving route Brno – Břeclav, it was possible to extend region in the southern direction as well, up to Podivín (48 km). It also enables including Velké Pavlovice (44 m) on branch track No. 255, also due to better connections in Zaječí – see Fig. 4.

Passenger transportation in Brno urban region underwent great changes in 2000-2010. It was due to Integrated transport system of South Moravian Region (ITS SMR) establish and slow expansion (since 2004). Rail transportation is a spine of the system, which was reflected in basic operating characteristics. Where it was spatially possible, the concourses of buses and trains were cancelled and trains were strengthened. Tact timetable has been established, based on regular intervals 30, 60 and 120 minutes (in the close neighbourhood of Brno sometimes even 15 minutes in peaks). The offer of connections went regular and the number of connections increased on all the routes. Also, guaranteed connections were created in all junction stations.

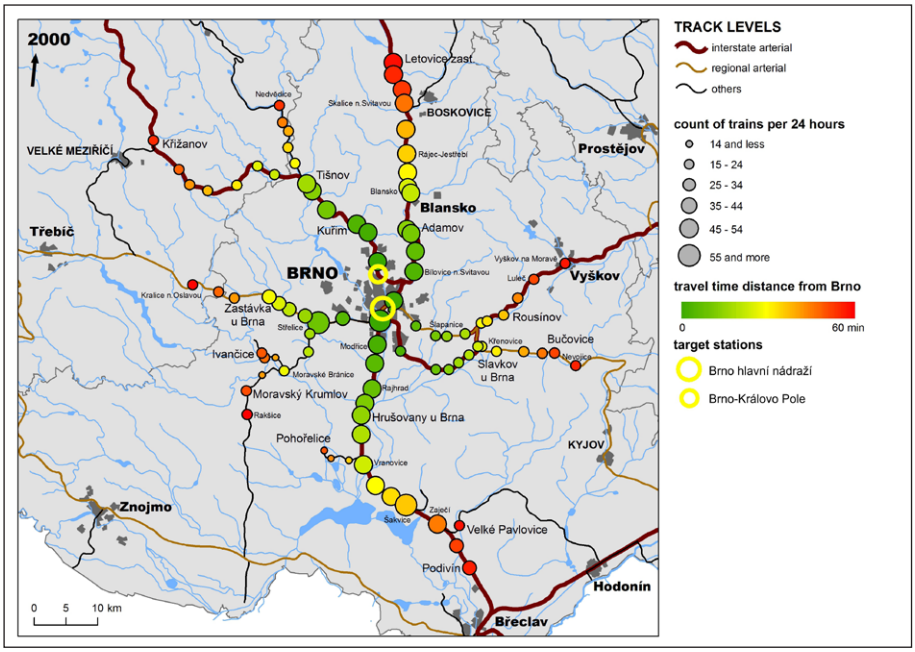

Fig. 4. Stations within 60-minutes isochrone from Brno in 2000

Source: Timetable 2000/2001, own calculations.

Sp-trains and R-trains became a part of ITS JMR. Due to the methodology used, it is impossible to consider the delimitation of the Brno urban region as complete according to the criteria established in 2010. Connections are linked to these trains at stations Šakvice (from Hustopeče u Brna), Zaječí (from Velké Pavlovice) and Skalice nad Svitavou (from Boskovice). The link to passenger trains is secondary which means only a limited number of included connections. However, the newly introduced system means the maximal use of transport infrastructure capacity. In addition to the Brno main railway station, the largest limits are the monorails and sections Střelice – Zastávka u Brna – Třebíč (railway No. 240) and Brno – Přerov (railway No. 300). On the railway No. 300, the model of full preference of R-trains Brno – Přerov – Bohumín (interval 60 minutes in the morning saddle and 120 minutes in the evening hours) and Brno – Prostějov – Olomouc – Šumperk/Jeseník (interval 120 minutes all day) was created. This led to the forced shortening of travel of passenger trains only to the station Křenovice horní nádraží. Some of the top trains must end (again for capacity reasons) at Sokolnice-Telnice station, just 24 km from the main railway station. Local transportation to Vyškov is replaced by buses.[5] On the spinal double-track railways, capacity is also exhausted due to the simultaneous operation of several layers (express international layer in 60-minute interval, express intrastate layer in the 60-minute interval just in peaks, freight transport).

The region defined by the 60-minute isochrone has changed only slightly since 2000 – see Fig. 5. On railway No. 244, Bohutice station (40 km) was included in the region. This station is the place of the natural division of the commuter frequency in the direction to Brno. On the railway to Veselí nad Moravou, there was an extension to Nesovice (60 km). Nesovice became an important hub in the ITS JMR and it is the final station of extra trains from Brno in the direction to Veselí nad Moravou. After 2005, in the closer neighbourhood of Brno, passenger transport stopped on the railway Vranovice – Pohořelice u Brna; however, the bus transport strengthened between Pohořelice and Brno. Nevertheless, Vranovice became a final stop for embedded extra trains from Brno to the south. Transportation in the terminal section Ivančice – Oslavany was also limited because of the poor location of Oslavany station in relation to settlement.

[5] Nowadays, rail transportation on route Brno – Vyškov – Přerov is not able to compete, mainly due to not-fitting infrastricture (single-track route, average speed 80 km. h^{-1}). Travelling time of R-train between Brno and Vyškov na Moravě in 2010 is 39 minutes, while travelling time by bus or car is about 10 minutes shorter. Partly it is because of highway D1 in concourse.
According to plans, the route Brno – Přerov is going to be fundamentally reconstructed, some parts are going to be new-built. The railway is going to be double-track in its full length, with maximum speed 200 $km.h^{-1}$. The beginning of the first part of project is meant to be until 2020 (Harák, 2016).

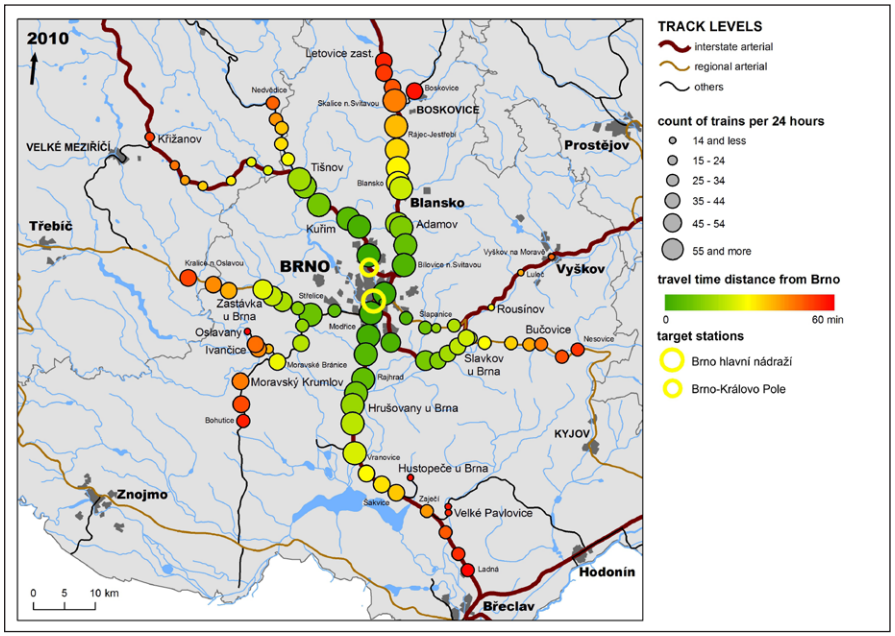

Fig. 5. Stations within 60-minutes isochrone from Brno in 2010

Source: Timetable 2009/2010, own calculations.

The aforementioned claims can also be confirmed by overview tables – Tab. 2 and Tab. 3. Tab. 2 shows changes in terms of travel time. The development of the number of trains is shown in Tab. 3. For comparison, stations about 30-minute distanced from Brno were selected (according to the data from 1980) – see Fig. 6. Stations at this time distance were selected for good ability to illustrate changes regardless of other

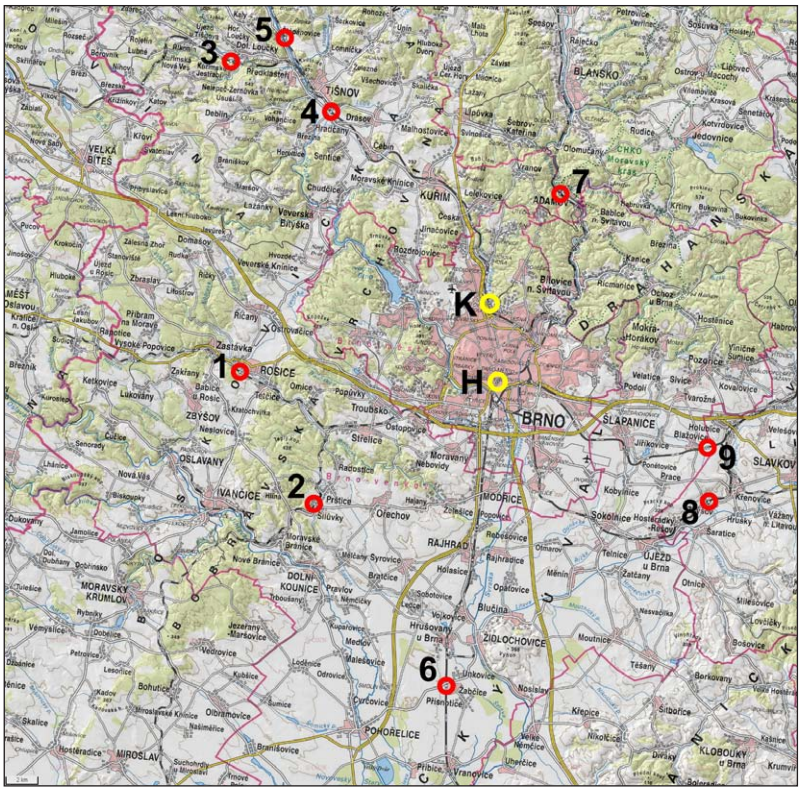

Fig. 6. Selected stations about 30-minute distanced from Brno

Source: Timetable 1980/1981, own calculations. Base map: Base map CR 1:200,000.

possible influences. On the northern branch of railway No. 250, there were analysed stations Dolní Loučky, Hradčany and Štěpánovice. Hradčany station is located in front of Tišnov and it is possible to capture the changes in suburban transportation Brno – Tišnov. At Štěpánovice station located on junction railway No. 251, there are improvements in connections at Tišnov station. The values of the station on the northern section of railways No. 250 and No. 251 were surveyed with respect to the Brno-Královo Pole station. These stations are marked with an asterisk (*) in Tab. 2 and 3.

stávka). The smallest improvement was made on railways No. 240 and No. 244. It is a limitation by infrastructure. The example of Štěpánovice shows a relatively stable travel time. Despite the improvement in the number of connections (Tab. 3), there was no acceleration in terms of shortening of transfer times in Tišnov.

The largest increase in the number of connections occurred at the southern branch of railway No. 250 – see Tab. 3. The Žabčice stop is also served by top extra trains in the section Brno – Vranovice. Although these trains were introduced after the establishment

Tab. 2. Selected stations in the neighbourhood of Brno according to the development of average travel time in minutes in the years 1980, 1990, 2000 and 2010

Stations		Railway No. (Timetable 2010)	Year				Index of change 2010/1980
			1980	1990	2000	2010	
Rosice u Brna	1	240	30.03	30.23	32.36	28.00	0.9324
Silůvky	2	244	28.32	27.18	27.83	26.26	0.9272
Dolní Loučky*	3	250	33.95	32.06	29.99	30.00	0.8837
*Hradčany**	*4*	*250*	*21.69*	*20.18*	*20.12*	*20.01*	*0.9225*
*Štěpánovice**	*5*	*251*	*36.80*	*34.67*	*34.00*	*33.50*	*0.9103*
Žabčice	6	250	29.25	27.52	26.85	26.23	0.8968
Adamov zastávka	7	260	25.96	30.27	22.18	22.44	0.8644
Zbýšov	8	300	32.44	31.50	27.23	26.50	0.8169
Blažovice	9	340	29.67	26.77	26.68	24.78	0.8352

Source: Timetables 1980/1981, 1990/1991, 2000/2001, 2009/2010, own calculations.

According to Tab. 2, the fastest acceleration occurred on railway 300 – approximately 6 minutes. The reason is probably the release of the capacity of the railway and the redirection of part of the traffic to Přerov. This is realised on the double-track No. 340 via Blažovice where there was a similar acceleration. Reconstruction of the corridor railways also led to an acceleration of more than 10% (Žabčice, Adamov za-

of ITS JMR, some increase was evident already in 2000. Other significant improvements were made also on other two-track electrified railways – on the northern branch of railway No. 250 in the section to Tišnov and on railway No. 260. On the contrary, the smallest changes occurred on railway No. 250 north of Tišnov and on railway No. 340. The offer on the northern part of railway No. 250 is relatively stable,

Tab. 3. Selected stations in the neighbourhood of Brno according to the development of numbers of connections in 1980, 1990, 2000 and 2010.

Stations		Railway No. (Timetable 2010)	Year				Index of change 2010/1980
			1980	1990	2000	2010	
Rosice u Brna	1	240	25	25	27	46	1.84
Silůvky	2	244	22	23	23	38	1.73
Dolní Loučky*	3	250	17	18	21	21	1.24
*Hradčany**	*4*	*250*	*28*	*29*	*42*	*68*	*2.43*
*Štěpánovice**	*5*	*251*	*11*	*12*	*19*	*27*	*2.46*
Žabčice	6	250	28	29	42	72	2.57
Adamov zastávka	7	260	29	30	40	70	2.41
Zbýšov	8	300	22	24	22	37	1.68
Blažovice	9	340	23	26	21	33	1.43

Source: Timetables 1980/1981, 1990/1991, 2000/2001, 2009/2010, own calculations.

as the range of the service corresponds to the settlement structure of the area (small towns, the considerable distance from the station). In the case of railway No. 340, the capacity of the Brno railway hub is the limiting factor. The railway itself is two-track and almost freight-free from the border of Brno. Due to the mentioned improvement of the transfer links in Tišnov, a significant increase is also recorded in the case of Štěpánovice station. In 2010, every train on railway No. 251 in Tišnov had a transfer link to a passenger train in railway No. 250.

4. Discussion

The selected timespan of thirty years was capable enough to illustrate the development of passenger transportation in connection with the changes of society and socio-economic sphere in the Czech Republic. The most important findings are summed up in the following points.

- The changes of timetable structure and train frequency. The former system of train operating was based on random times of departures and arrivals during the whole day. Temporal timetable has tact base and the offer of connections is more stable. On the one hand, the tact timetable provides steady intervals (with extra trains in peak hours), on the other hand, the travelling time between stations is equal in the whole day.
- The count of connections increased almost on all of the routes – see Tab. 3 and Fig. 7. The greatest growth was on suburban routes with the highest frequency of passengers, as well as on the double -track railways with electric operation. On the one hand, the growth was related with the freight transportation decrease, on the other hand the number of passengers increased due to suburbanisation after the 1990.
- The growth of capacity and railway reconstruction (mainly the arterials No. 250 – southern part – and No. 260) led to speed up the passenger trains. As noticed in many cases, the change of travelling time was reached only by the timetable adjusting. This was namely the case of single-track routes in the western and eastern direction.
- Nevertheless, the limitation of operation and the quality of connections is the infrastructure. While in 1980 and 1990 it was not possible to increase the number of Os-trains or the travelling speed due to freight trains preference, the capacity problems in 2010 are consequent upon several speed and quality levels of passenger transportation. As could be seen on track No. 300 towards Vyškov and Přerov, the Os-trains were cancelled due to favour R-trains Brno – Přerov – Bohumín. However, the problems with capacity appear also on spinal double-track railways. As a result, both in 1980 and 2010 the capacity is made almost full, but the roots are differend.
- The railways in region have not been restored yet, except of the spinal corridor Česká Třebová – Brno – Břeclav. In many other cases, the restoration is

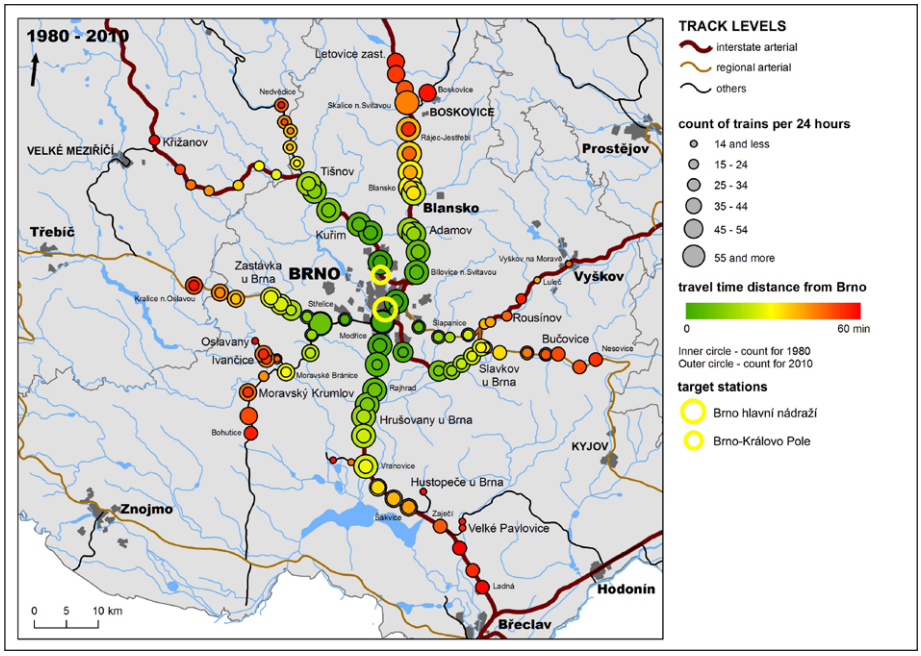

Fig. 7. Stations within 60-minutes isochrone from Brno in 1980 and 2010

Source: Timetables 1980/1981, 2009/2010, own calculations.

based on partial speed increasing or timetable adjusting. That is the reason of stable size of 60-minute isochrones delimitated region. The examples are in directions towards Třebíč (the last point Kralice nad Oslavou), Bystřice nad Pernštejnem (the last point Nedvědice) or Žďár nad Sázavou (the last point Křižanov).

5. Conclusions

The aim of this paper was to describe the development of commuter trains in Brno urban region. The passenger transportation in Brno urban region underwent a significant change: from the contribution to freight transport in the industrial era to the modern commuter trains in the post-industrial era. The most notable change was integrated public transport system establishing in 2004. This led to innovation in range of timetable making approaches. The quality of travelling increased mainly in the sphere of connection offer (the infrastructure and the vehicle fleet are restored more slowly). The key question is the sustainability of the transport organization patterns of 2010. According to the railway transportation in whole, the commuter trains preference has an impact to other levels of transportation, mainly on the express and freight trains. As far as the regional rail passenger transportation is necessary in Brno urban region, it is non-essential to find the balanced model of operating.

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