NEW LAYOUT OF THE MAIN NETWORK IN THE VYSOČINA REGION

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Abstract

The aim of this contribution is to define the backbone road network of the Vysočina Region and to introduce a system of road management to this network. The determination of the extent of the backbone road network is based on multi-criterion decision-making methods, with traffic as the basic parameter for defining the backbone road network. This is referred to as the number of vehicles passing through that section for a specified period of time. Vehicles are further divided into categories according to their size. A new backbone road network layout is designed to better reflect the current situation. In addition, a road management system is in place for the costs that need to be incurred with regard to the nature of maintenance and repairs. The article does not refer to the division of these costs; it only refers to the problem. It is precisely the efficiency of spending on the infrastructure maintenance of the means of transport that has become a frequent topic of discussion in the assessment of the management of the individual road network owners. Quality, safety, and reliability of transport infrastructure are also a limiting factor for attracting significant investment into the regions and the socio-demographic aspects of the territory. The article analyses the road network from the point of view of traffic intensity. This assessment is most used in patch planning; therefore, a major part of the article is devoted to it. Part of the contribution is also devoted to the issue of public transport on this road network. Public transport is strongly linked to transport infrastructure and is often a crucial factor in planning, especially winter maintenance on lower-class roads. The quality and efficiency of the road network must be seen as a compact unit, which directly or indirectly affects the functioning of all institutions and citizens in the territory concerned.

Keywords: backbone road network, road management system, multi-criteria decision making
JEL Classification: X12

Introduction

Increasing the efficiency of spending public budgets is a long-term and endless process. Budget appropriations are limited and it is not possible to cover the extent of a road network in the area of road infrastructure with sufficient quality. This is due to the existing internal debt, i.e. underfinancing of expenditure. It is essential to define the core backbone

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network and to continue to operate systemically in the long term with this network and to introduce a road management system. Multi-criteria decision-making methods can be used to implement the road management system. Traffic intensity is the basic parameter for defining the backbone road network.

1. Literature Review

Dvořák (2008) addresses the issues of the public budget and the deficit of public finances. Literature research and the latest findings by Kruntorádová (2015) deals with the issue of financing Czech cities, which concerns, among other items, transport and infrastructure. Abraham (2014) focuses on sustainable development with regard to environmental aspects that often limit its development and improvement. Jazcilevich et al. (2015) also analyse the economic and environmental impacts of transport and the possibilities of development. Koblížek (2016) examines the issue of passenger transport, namely the demand for bus transport in regions where, especially in those with lower population density, this mode of transport is a possible solution to the current issue. Pawlasová (2015) addresses the issue of satisfaction with public transport services provided both within basic transport services and beyond, i.e. within the commercially provided transport. Sachs (2015) deals with sustainable development in the context of technological change in the 21st Century. Solecka and Żak (2014) are focused on integrated transport systems and transport simulation. The simulation of traffic loads is an important aspect in planning the development of the communications network, which is not only about the construction but also the reconstruction of the existing roads when their units or their status often do not meet the demands of today. Sellers et al. (2017), in their most recent publication, address the problem of a new trend in public administration, which is the governance that strongly affects transport issues. The new trends deserve major attention as they have the potential to completely change the paradigms of the individual fields and to ensure greater efficiency of the expended funds. Janatka (2017) examines the issue of business in a globalised world that brings many changes compared to existing habits. It is precisely the process of globalisation that is closely related to the transport issue, which is the cornerstone of these changes along with the development of communication technologies.

In particular, articles on public-private partnerships are of particular interest to new issues published in professional journals. PPP projects are one way of helping to improve the infrastructure that is often in an unsatisfactory condition without major pressure on public budgets. These issues are addressed by Heinen et al. (2015) and Roumboutsos, Voordijk and Pantelias (2015). These authors describe the possibilities of financing large-scale construction projects using the PPP method to accelerate the construction and development of the site concerned. Besides its own principle of the functioning of this model of cooperation, the articles describe the risk for each version and other aspects of this form of cooperation between the public and private sector. The subject of the problem is also described by Roumboutsos, Voordijk and Pantelias (2015). The problems of transport and its related aspects are further solved by Dubrovsky, Yaroshevich and Kuzmin (2016), who deal with the operational efficiency of transport companies with regard to the condition of transport infrastructure and its quality and density, which have consequences

for other interested economic subjects. Newman and Kenworthy (2015) examine the possibilities of planning new transport routes and infrastructure in general with regard to its sustainability in the context of future development. The environmental impacts that transport infrastructure brings are not only positive, but also have to take into account the negative impact on the environment and other aspects, which is addressed by Matas, Raymond and Roig (2018).

From the new articles, the authors of the University of Poznań, specifically Myczko et al. (2017), focus on the negative impacts of road transport, especially mortality and other negative effects on road users and the surroundings. Behrends (2017) addresses the issue of the relationship between road and rail transport. It is the mutual interdependence of the systems that is a potential form of development in Vysočina. Simoni and Claudel (2017) deal with the possibility of simulating the traffic load, which is closely related to this paper dealing with transport in the region of Vysočina. They describe the intensity of traffic as a simulation in future years. Strategic planning in public administration, which is very closely related to the issue, is dedicated to Krbová (2016). This area has long been neglected in the Czech Republic with many of these areas now being instituted.

2. Methodological Approach

For the regional road network, it is important to know the intensity of traffic on II. and III. class roads. As part of the national census, 6,521 census points were established and 1,250 censuses were selected as part of the planned census in the Vysočina Region on II. and III. class roads. It is essential to analyse the issues both from the point of view of the total traffic intensity and its partial analysis of the individual sections of the road linking the regional seat in terms of vehicle types and the load of the road. Terrestrial communications, mainly used for economic purposes, will have a higher load on heavy goods vehicles than roads that will have a higher intensity of passenger cars and will serve primarily for social purposes or for socio-economic purposes, e.g. from the point of view of commuting. The load on the road has a major impact on the technological progress of the modernisation of the road network.

The solution to the choice of road network with regard to the introduction of a road-traffic management system will focus on two aspects. The first point solely concerns the intensity of the total of all vehicles and the intensity of trucks. The second point concerns the verification of the individual cycles of road management in terms of technological progress in the various phases of the economic cycle. Here, the key parameter is the Heavy Goods Vehicle (TNV), which is a recalculated value and, from the point of view of the technical standards, is indicative of determining, for example, the type of road surface cover. Heavy motor vehicles are the only key input parameter for determining the life of the road.

Table 1 | Abbreviations used in the census

Abbreviations used	
LN	Lightweight trucks (payload up to 3.5t) with or without trailers
SN	Medium Cargo Trucks (payload 3.5 – 10t) without trailers
SNP	Medium lorries (payload 3.5 – 10t) with trailers
TN	Heavy goods vehicles (payload over 10t) without trailers
TNP	Heavy goods vehicles (payload over 10t) with trailers
NSN	Semitrailers for trucks
A	Buses
AK	Articulated buses
TR	Tractors without trailers
TRP	Tractors with trailers
TV	Heavy motor vehicles in total
O	Passenger cars and vans with and without trailers
M	Single-track motor vehicles
SV	All motor vehicles in total (sum of vehicles)
TNV	Heavy goods vehicles (0.1.LN + 0.9.SN + 1.9.SNP + TN + 2.0.TNP + 2.3.NSN + A + AK)
PS	The ratio of the intensity of the opposite traffic flow during the Sunday (afternoon) return peak

Source: (DNRM, 2016)

The draft measures will be based on multi-criteria decision making, which takes into account the other variables that ensure the availability and interdependence of social and economic characteristics.

Table 2 shows the roads on the backbone network with the road marking and the interconnection of municipalities on the given road. The roadway designation links do not always connect to all the sites, for example, because there are two roads in front of the village, and there is only one road in the village. Nevertheless, from the point of view of the evaluation of the characteristics of the social factors in particular, the road is led by a sign between the municipalities. Furthermore, for example, by interconnecting municipalities on a given road, there is a certain short stretch following a high-order road – class I roads. In this case, there is also a road sign in one section between individual municipalities.

Table 2 | The backbone road network of the Vysočina Region

The backbone road network	
Larger settlements on the road to the backbone network	
II/128	Černovice, Pacov, Salačova Lhota, Lukavec
II/409	Černovice, Kamenice nad Lipou, Žirovnice, Počátky
II/132	Počátky, Horní Cerekev
II/112	Telč, Horní Cerekev, Pelhřimov, Červená Řečice, Košetice
II/406	Border of the region, Telč, Třešť, Kostelec
II/602	Pelhřimov, Jihlava, Velké Meziříčí, Velká Bíteš
II/130	Křelovice, Senožaty, Koberovice, Ledeč nad Sázavou, Golčův Jeníkov
II/345	Golčův Jeníkov, Chotěboř,
II/344	Chotěboř, Dolní Krupá, Havlíčkův Brod
II/150	Ledeč nad Sázavou, Světlá nad Sázavou, Havlíčkův Brod
II/347	Světlá nad Sázavou, Humpolec
II/405	Jihlava, Třebíč
II/360	Moravec, Křižanov, Velké Meziříčí, Třebíč, Jaroměřice nad Rokytnou
II/360	Nové Město na Moravě, Jimramov, border of the region
II/152	Jaroměřice nad Rokytnou, Moravské Budějovice, Jemnice
II/408	Jemnice –border of the region
II/410	Jemnice –border of the region
II/152	Jaroměřice nad Rokytnou, Hrotovice, border of the region
II/399	Třesov, Dalešice, Rouchovany, border of the region
II/399	Náměšť nad Oslavou, Jinošov, Velká Bíteš
II/379	Velká Bíteš –border of the region
II/357	Bystřice nad Pernštejnem, Dalečín, Jimramov
II/387	Štěpánov nad Svratkou, border of the region
II/345	Chotěboř, Ždírec nad Doubravou
II/352	Jihlava, Polná
II/351	Polná, Přibyslav
III/3507	Přibyslav, Havlíčková Borová, Ždírec nad Doubravou

Source: (Ksusv.cz, 2015)

Size is important in terms of the interconnection of settlements. The table below shows the population as of January 1, 2017 of larger settlements on the backbone road network. There is always a large settlement on a given road. According to the density of settlements in the Vysočina Region, which is a typical rural area, there is also the distribution

of significant settlements on the road network, which is quite different from the point of view of the mentioned settlements. It is necessary to always take the specific road into account.

Table 3 | Settlements on the backbone road network

Road	Municipalities along the route (the number of inhabitants as at January 1, 2017 are in parentheses)
II/128	Černovice (1 728), Pacov (4 871), Salačova Lhota (130), Lukavec (988)
II/409	Černovice (1 728), Kamenice nad Lipou (3 791), Žirovnice (2 915), Počátky (2 563)
II/132	Počátky (2 563), Horní Cerekev (1 840)
II/112	Telč (5 410), Horní Cerekev (1 840), Pelhřimov (16 044), Červená Řečice (1 017), Košetice (708)
II/406	Telč (5 410), Třešť (5 793), Kostelec (905)
II/602	Pelhřimov (16 044), Jihlava (50 559), Velké Meziříčí (11 593), Velká Bíteš (5 137)
II/130	Křelovice (359), Senožaty (729), Koberovice (159), Ledeč nad Sázavou (5 151), Golčův Jeníkov (2 639)
II/345	Golčův Jeníkov (2 639), Chotěboř (9 343)
II/344	Chotěboř (9 343), Dolní Krupá (420), Havlíčkův Brod (23 145)
II/150	Ledeč nad Sázavou (5 151), Světlá nad Sázavou (6 637), Havlíčkův Brod (23 145)
II/347	Světlá nad Sázavou (6 637), Humpolec (10 850)
II/405	Jihlava (50 559), Třebíč (36 330)
II/360	Moravec (623), Křižanov (1 857), Velké Meziříčí (11 593), Třebíč (36 330), Jaroměřice nad Rokytnou (4 181)
II/360	Nové Město na Moravě (10 110), Jimramov (1 186)
II/152	Jaroměřice nad Rokytnou (4 181), Moravské Budějovice (7 441), Jemnice (4 075)
II/408	Jemnice (4 075)
II/410	Jemnice (4 075)
II/152	Jaroměřice nad Rokytnou (4 181), Hrotovice (1 770)
II/399	Třesov (88), Dalešice (604), Rouchovany (1 187)
II/399	Náměšť nad Oslavou (4 871), Jinošov (226), Velká Bíteš (5 137)
II/379	Velká Bíteš (5 137)
II/357	Bystřice nad Pernštejnem (8 202), Dalečín (649), Jimramov (1 186)
II/387	Štěpánov nad Svratkou (709)
II/345	Chotěboř (9 343), Ždírec nad Doubravou (3 143)
II/352	Jihlava (50 559), Polná (5 134)
II/351	Polná (5 134), Přibyslav (4 022)
III/3507	Přibyslav (4 022), Havlíčková Borová (954), Ždírec nad Doubravou (3 143)

Source: (Černý, 2015)

Tables 4 and 5 show the characteristics of the traffic intensities of the total vehicles and heavy-duty vehicles.

Table 4 | Intensity of total SV vehicles

Frequency of traffic intensity		Variability of traffic intensity – SV
II/128	Černovice, Pacov, Salačova Lhota, Lukavěc	From I/19 Lukavec to Pacov a total of 1106 vehicles (909 heavy-duty, 192 passenger cars); in Pacov 6873 vehicles in total (859 heavy-duty, 5979 passenger cars); from Pacov to split II/124 a total of 1186 vehicles (379 heavy-duty, 1775 passenger cars), further from the division with II/124 to Čáslavsko, a total of 1154 vehicles (221 heavy-duty, 921 passenger cars).
II/409	Černovice, Kamenice nad Lipou, Žirovnice, Počátky	From the disconnection from II/398 to Rancířov no measurements were made; ranging from Rancířov to Slavonice 599 vehicles (71 heavy-duty, 508 passenger cars, from Slavonice to connection to II/153 a total of 683 vehicles (82 heavy-duty, 596 passenger cars); from Markvarec to the connection with II/408 was not a measurement section; from the connection with II/408 to I/23 a total of 897 vehicles (136 heavy-duty, 755 passenger cars).
II/132	Počátky, Horní Cerekev	From Jarošov nad Nežárkou to Žirovnice a total of 1486 vehicles (240 heavy-duty, 1232 passenger cars); in Žirovnice a total of 3310 vehicles (560 heavy-duty, 2717 passenger cars); from Žirovnice to Počátky a total of 2925 vehicles (436 heavy-duty, 2466 passenger cars); in Počátky a total of 3307 (482 heavy-duty, 2798 passenger cars); from Počátky to Horní Cerekev 1413 vehicles (172 heavy-duty, 1214 passenger cars).
II/112	Telč, Horní Cerekev, Pelhřimov, Červená Řečice, Košetice	From the beginning (from crossroad II/410) to Nová Říše the section is not measured; from Nová Říše to Telč 1145 vehicles (150 heavy-duty, 978 passenger cars); in Telč 4391 vehicles (716 heavy-duty, 3633 passenger cars); from Telč to Nová Ves a total of 1022 vehicles (269 heavy-duty, 743 passenger cars); from Nová Ves to Horní Cerekev, there is no section measured; in Horní Cerekev a total of 2497 vehicles (358 heavy-duty, 2126 passenger cars); Horní Cerekev in Nové Buky 2497 vehicles in total (358 heavy-duty, 2126 passenger cars); from Nové Buky to Pelhřimov 2645 vehicles (613 heavy-duty, 2021 passenger cars).
II/406	Border of the region, Telč, Třešť, Kostelec	From the border of Telč to Telč 2841 vehicles (372 heavy-duty, 2446 passenger cars); in Telč 4391 vehicles (716 heavy-duty, 3633 passenger cars); from Telč to Třešť 3642 vehicles (533 heavy-duty, 3094 passenger cars), 8949 in Třešť (965 heavy-duty, 7916 passenger cars); from Třešť to connection II/613 total 5517 vehicles (665 heavy-duty, 4810 passenger cars); from connection II/613 to connection in II/603 9277 vehicles (1073 heavy-duty, 8103 passenger cars).

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Frequency of traffic intensity		Variability of traffic intensity – SV
II/602	Pelhřimov, Jihlava, Velké Meziříčí, Velká Bíteš	In the city of Brno a total of 20503 vehicles (2312 heavy-duty, 18066 passenger cars); between Brno and Velká Bíteš a total of 3096 vehicles (511 heavy-duty, 2582 passenger cars); in the town of Velká Bíteš 5854 vehicles (1155 heavy-duty, 4645 passenger cars); crossing with II/390 total 3615 vehicles (703 heavy-duty, 2866 passenger cars); from crossing with II/390 to Velké Meziříčí 2931 vehicles (605 heavy-duty, 2300 passenger cars); 16401 vehicles in the town of Velké Meziříčí (2197 heavy-duty, 12305 passenger cars); from Velké Meziříčí to EXIT 141 in total 12860 vehicles (1734 heavy-duty, 10954 passenger cars); from EXIT 141 to EXIT 134 in total 4861 vehicles (1104 heavy-duty; 3726 passenger cars); from Měřín to cross with II/351 total 2911 vehicles (637 heavy-duty, 2255 passenger cars); from the intersection with II/351 after crossing with II/404 total 3921 vehicles (635 heavy-duty, 3262 passenger cars); from crossing II/404 to Velký Beranov total 5689 (1163 heavy-duty, 4585 passenger cars); from Velký Beranov to Jihlava 11987 vehicles (1376 heavy-duty, 10541 passenger cars); Jihlava 15781 vehicles (1907 heavy-duty, 13763 passenger cars); Jihlava after splitting II/406 total 13380 vehicles (1841 heavy-duty, 11466 passenger cars); after splitting with II/406 beyond Pelhřimov 3762 vehicles (685 heavy-duty, 3054 passenger cars); Pelhřimov 6362 vehicles (654 heavy-duty, 5690 passenger cars).
II/130	Křelovice, Senožonaty, Koberovice, Ledeč nad Sázavou, Golčův Jeníkov	From Křelovice to EXIT 81 a total of 1531 vehicles (303 heavy-duty, 1202 passenger cars); from EXIT 81 to the combined with II/150 total 2295 (324 heavy-duty, 1958 passenger cars); in the town of Pelhřimov 8190 vehicles (864 heavy-duty, 7283 passenger cars); Pelhřimov after crossing with III/1308 total 1674 vehicles (271 heavy-duty, 1388 passenger cars); after crossing with III/1308 outside Leština u Světlé total 928 vehicles (220 heavy-duty, 698 passenger cars); from Leština to Světlá after crossing with I/38 total 606 vehicles (75 heavy-duty, 524 passenger cars).
II/345	Golčův Jeníkov, Chotěboř,	From Ždírec nad Doubravou to Chotěboř a total of 4255 vehicles (758 heavy-duty, 3481 passenger cars); in Chotěboř a total of 5993 vehicles (1218 heavy-duty, 4756 passenger cars); from Chotěboř to Nová Ves near Chotěboř total 3069 vehicles (630 heavy-duty, 2415 passenger cars); Chotěboř next to Golčův Jeníkov total 2508 vehicles (512 heavy-duty, 1970 passenger cars).
II/344	Chotěboř, Dolní Krupá, Havlíčkův Brod	From Havlíčkův Brod to Chotěboř a total of 3256 vehicles (329 heavy-duty, 2911 passenger cars); in the town of Chotěboř a total of 6240 vehicles (852 heavy-duty, 5330 passenger cars); from Chotěboř to Jeníkovec a total of 737 vehicles (93 heavy-duty, 636 passenger cars); a road from Jeníkov to Hodonín was not measured.

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Frequency of traffic intensity		Variability of traffic intensity – SV
II/150	Ledeč nad Sázavou, Světlá nad Sázavou, Havlíčkův Brod	From Havlíčkův Brod to Světlá nad Sázavou 3427 vehicles (464 heavy-duty, 2942 passenger cars); from Světlá nad Sázavou to Ledeč nad Sázavou 2923 vehicles (329 heavy-duty, 2584 passenger cars); from Ledeč nad Sázavou to crossing II/336 total 2488 vehicles (409 heavy-duty, 2049 passenger cars); from the crossing with II/336 after EXIT 66 total of 1118 vehicles (199 heavy-duty, 917 passenger cars); from EXIT 66 to Čechtice 1724 vehicles (441 heavy-duty, 1281 passenger cars); from Čechtice to Čáslavsko total of 974 vehicles (227 heavy-duty, 734 passenger cars); from Čáslavsko to Horní Lhota there is no section of measurement; from Horní Lhota to Olešná a total of 480 vehicles (106 heavy-duty, 372 passenger cars); from Olešná to Louňovice pod Blaníkem a total of 494 vehicles (77 heavy-duty, 410 passenger cars); from Louňovice pod Blaníkem to Votice 1180 vehicles (183 heavy-duty, 987 passenger cars).
II/347	Světlá nad Sázavou, Humpolec	In the town of Humpolec 6344 vehicles (875 heavy-duty, 5389 passenger cars); from Humpolec to Světlá nad Sázavou a total of 2046 vehicles (300 heavy-duty, 1698 passenger cars); from Světlá nad Sázavou to Habra 1565 vehicles (226 heavy-duty, 1330 passenger cars).
II/405	Jihlava, Třebíč	From Jihlava to Brtnice a total of 6160 vehicles (788 heavy-duty, 5332 passenger cars); from Brtnice to connection with II/402 a total of 3111 vehicles (448 heavy-duty, 2630 passenger cars); from connection II/402 to Okříšky a total of 4346 vehicles (497 heavy-duty, 3826 passenger cars); from Okříšky to connection with I/23 total of 4963 vehicles (680 heavy-duty, 4243 passenger cars).
II/360	Moravec, Křižanov, Velké Meziříčí, Třebíč, Jaroměřice nad Rokytnou	From Jaroměřice nad Rokytnou to Výčapy a total of 5089 vehicles (709 heavy-duty, 4361 passenger cars); from Výčapy to Třebíč 6369 vehicles in total (865 heavy-duty, 5502 passenger cars); in the town Třebíč 8364 vehicles in total (1061 heavy-duty, 7248 passenger cars); from Třebíč to crossing with II/390 total of 6666 vehicles (869 heavy-duty, 5627 passenger cars); from the crossing with II/390 outside Velké Meziříčí 4445 vehicles (837 heavy-duty, 3575 passenger cars); in Velké Meziříčí 5495 vehicles in total (804 heavy-duty, 4652 passenger cars); from Velké Meziříčí to Křižanov total of 2623 vehicles (407 heavy-duty, 2193 passenger cars); from Křižanov to Moravec a total of 2811 vehicles (445 heavy-duty, 2340 passenger cars); from Moravec to Bobrová a total of 2417 vehicles (339 heavy-duty, 2063 passenger cars); from Bobrová to Nové Město na Moravě a total of 2552 vehicles (336 heavy-duty, 2184 passenger cars); from Nové Město na Moravě to Jimramov a total of 1863 vehicles (352 heavy-duty, 1481 passenger cars); from Jimramov to the border of region a total of 2031 vehicles (381 heavy-duty, 1629 passenger cars).

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Frequency of traffic intensity		Variability of traffic intensity – SV
II/360	Nové Město na Moravě, Jimramov, regional border	From Jaroměřice nad Rokytnou to Výčapy a total of 5089 vehicles (709 heavy-duty, 4361 passenger cars); from Výčapy to Třebíč 6369 vehicles in total (865 heavy-duty, 5502 passenger cars); in the town Třebíč 8364 vehicles in total (1061 heavy-duty, 7248 passenger cars); from Třebíč to crossing with II/390 total of 6666 vehicles (869 heavy-duty, 5627 passenger cars); from the crossing with II/390 to Velké Meziříčí 4445 vehicles (837 heavy-duty, 3575 passenger cars); in Velké Meziříčí 5495 vehicles (804 heavy-duty, 4652 passenger cars); from Velké Meziříčí to Křižanov total 2623 vehicles (407 heavy-duty, 2193 passenger cars); from Křižanov to Moravec a total of 2811 vehicles (445 heavy-duty, 2340 passenger cars); from Moravec to Bobrová a total of 2417 vehicles (339 heavy-duty, 2063 passenger cars); from Bobrová to Nové Město na Moravě a total of 2552 vehicles (336 heavy-duty, 2184 passenger cars); from Nové Město na Moravě to Jimramov a total of 1863 vehicles (352 heavy-duty, 1481 passenger cars); from Jimramov to the regional border a total of 2031 vehicles (381 heavy-duty, 1629 passenger cars).
II/152	Jaroměřice nad Rokytnou, Moravské Budějovice, Jemnice	In the city of Nová Bystřice a total of 2535 vehicles (257 heavy-duty, 2228 passenger cars); from Nová Bystřice to Slavonice 1005 vehicles (134 heavy-duty, 865 passenger cars); in the town Slavonice 2387 vehicles (315 heavy-duty, 2052 passenger cars); from Slavonice to Staré Hobží a total of 859 vehicles (150 heavy-duty, 695 passenger cars); from Staré Hobží to Jemnice 1405 vehicles (157 heavy-duty, 1229 passenger cars); in a town Jemnice 5606 vehicles (635 heavy-duty, 4894 passenger cars); from Jemnice to Moravské Budějovice a total of 2805 vehicles (465 heavy-duty, 2306 passenger cars); in the city of Moravské Budějovice a total of 7146 vehicles (624 heavy-duty, 6477 passenger cars); from Moravské Budějovice to Jaroměřice nad Rokytnou 4880 vehicles in total (680 heavy-duty, 4188 passenger cars); in the city of Jaroměřice nad Rokytnou a total of 3809 vehicles (554 heavy-duty, 3221 passenger cars); from Jaroměřice nad Rokytnou to the crossing with II/399 a total of 2362 vehicles (403 heavy-duty, 1931 passenger cars); from the crossing with II/399 to Slavětice a total of 4068 vehicles (760 heavy-duty, 3262 passenger cars); from Slavětice to Dukovany total of 3218 vehicles (567 heavy-duty, 2628 passenger cars).
II/408	Jemnice – regional border	From Jemnice to the border of the region 2494 vehicles in total (392 heavy-duty, 2064 passenger cars).

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Frequency of traffic intensity		Variability of traffic intensity – SV
II/410	Jemnice – regional border	From Jemnice to Želetava a total of 880 vehicles (130 heavy-duty, 740 passenger cars); in the city of Želetava 1205 vehicles in total (96 heavy-duty, 1106 passenger cars); from Želetava to Rokytnice nad Rokytnou a total of 429 vehicles (58 heavy-duty, 369 passenger cars); from Rokytnice nad Rokytnou to Stařeč total of 686 vehicles (107 heavy-duty, 555 passenger cars); from Stařeč to Třebíč a total of 4700 vehicles (440 heavy-duty, 4170 passenger cars).
II/152	Jaroměřice nad Rokytnou, Hrotovice, regional border	From the border of the region to Slavoň a total of 1005 vehicles (134 heavy-duty, 865 passenger cars); from Slavoň to Staré Hobzí 859 vehicles (150 heavy-duty, 695 passenger cars); from Staré Hobzí to Jemnice 1209 vehicles (192 heavy-duty, 998 passenger cars), in a town Jemnice a total of 5606 vehicles (635 heavy-duty, 4894 passenger cars); from Jemnice to Moravské Budějovice a total of 2805 vehicles (465 heavy-duty, 2306 passenger cars); in the city of Moravské Budějovice 7146 vehicles (624 heavy-duty, 6477 passenger cars); from Moravské Budějovice to Jaroměřice nad Rokytnou 4880 (680 heavy-duty, 4188 passenger cars); from Jaroměřice nad Rokytnou to Hrotovice a total of 2362 vehicles (403 heavy-duty, 1931 passenger cars); from Hrotovice to Slavětice a total of 4068 vehicles (760 heavy-duty, 3262 passenger cars); from Slavětice to Dukovany 4089 vehicles (916 heavy-duty, 3166 passenger cars).
II/399	Třešovice, Dalešice, Rouchovany, regional border	From the border of the region to Rouchovany a total of 560 vehicles (86 heavy-duty, 471 passenger cars); from Rouchovany to the crossing with II/152 1532 vehicles in total (266 heavy-duty, 1243 passenger cars); from the crossing with II/152 to Dalešice a total of 2320 vehicles (390 heavy-duty, 1877 passenger cars); from Dalešice to Třešovice a total of 594 vehicles (101 heavy-duty, 490 passenger cars); from Třešovice to the I/23 a total of 1091 vehicles (129 heavy-duty, 957 passenger cars); from Náměšť nad Oslavou to EXIT 162 a total of 2584 vehicles (463 heavy-duty, 2110 passenger cars).
II/399	Náměšť nad Oslavou, Jinošov, Velká Bíteš	From the border of the region to Rouchovany a total of 560 vehicles (86 heavy-duty, 471 passenger cars); from Rouchovany to the crossing with II/152 1532 vehicles in total (266 heavy-duty, 1243 passenger cars); from the crossing with II/152 to Dalešice a total of 2320 vehicles (390 heavy-duty, 1877 passenger cars); from Dalešice to Třešovice a total of 594 vehicles (101 heavy-duty, 490 passenger cars); from Třešovice to crossroad with I/23 a total of 1091 vehicles (129 heavy-duty, 957 passenger cars); from Náměšť nad Oslavou to EXIT 162 a total of 2584 vehicles (463 heavy-duty, 2110 passenger cars).
II/379	Velká Bíteš – regional border	From Velká Bíteš to the border of the region 2890 vehicles (550 heavy-duty, 2312 passenger cars).

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Frequency of traffic intensity		Variability of traffic intensity – SV
II/357	Bystřice nad Pernštejnem, Dalečín, Jimramov	In the city of Bystřice nad Pernštejnem a total of 3241 vehicles (198 heavy-duty, 3008 passenger cars); from Bystřice nad Pernštejnem to Dalečín 1741 vehicles in total (176 heavy-duty, 1554 passenger cars); from Dalečín to Jimramov a total of 816 vehicles (158 heavy-duty, 640 passenger cars).
II/387	Štěpánov nad Svratkou, regional border	From Vír to Štěpánov nad Svratkou a total of 562 vehicles (90 heavy-duty, 470 passenger cars); from Štěpánov nad Svratkou to Nedvědice a total of 2621 vehicles (299 heavy-duty, 2304 passenger cars).
II/345	Chotěboř, Ždírec nad Doubravou	From Golčův Jeníkov to Nová Ves u Chotěboře 2513 vehicles in total (456 heavy-duty, 2045 passenger cars); from Nová Ves u Chotěboře to Chotěboř a total of 3069 vehicles (630 heavy-duty, 2415 passenger cars); in the city of Chotěboř 5993 vehicles (1218 heavy-duty, 4756 passenger cars); from Chotěboř to Ždírec nad Doubravou a total of 4255 vehicles (758 heavy-duty, 3481 passenger cars).
II/352	Jihlava, Polná	From the disconnection from I/38 to Polná a total of 1753 vehicles (298 heavy-duty, 1441 passenger cars); from Polná to the connection to I/19 a total of 480 vehicles (73 heavy-duty, 403 passenger cars).
II/351	Polná, Přibyslav – end of road with this number	From Přibyslav to Polná a total of 1336 vehicles (213 heavy-duty, 1098 passenger cars); from Polná to the crossing with II/353 a total of 1336 vehicles (213 heavy-duty, 1098 passenger cars); from the crossing with II/353 to the crossing with II/602 a total of 551 vehicles (104 heavy-duty, 435 passenger cars); from the crossing with II/602 to Čechtín a total of 1695 vehicles (226 heavy-duty, 1453 passenger cars); from Čechtín to Třebíč a total of 1053 vehicles (113 heavy-duty, 32 passenger cars); in the city of Třebíč 13561 vehicles in total (2217 heavy-duty, 11201 passenger cars); from Třebíč to the crossing with II/401 a total of 5064 vehicles (689 heavy-duty, 4345 passenger cars); from the intersection with II/401 to the connection with II/399 4010 vehicles in total (576 heavy-duty, 3393 passenger cars).
III/3507	Přibyslav, Havlíčková Borová, Ždírec nad Doubravou	From the crossroad with II/350 to Havlíčková Borová a total of 1072 vehicles (232 heavy-duty, 833 passenger cars); in Havlíčková Borová a total of 1681 vehicles (318 heavy-duty, 1343 passenger cars); from Havlíčková Borová to the connection with I/34 a total of 884 vehicles (158 heavy-duty, 723 passenger cars).

Source: (Černý, 2015)

Table 5 | Intensity of TV heavy vehicles

Major settlements on the backbone road network		Variability of traffic intensity – TV
II/128	Černovice, Pacov, Salačova Lhota, Lukavec	Add from Černovice 212, 218, behind Pacov 380, 264
II/409	Černovice, Kamenice nad Lipou, Žirovnice, Počátky	From Černovice 141, 232, 157, 172
II/132	Počátky, Horní Cerekev	249
II/112	Telč, Horní Cerekev, Pelhřimov, Červená Řečice, Košetice	From Telč 144, 113, 278, 367, 360, 177
II/406	Regional border, Telč, Třešť, Kostelec	From the border of the region 385, 587, 697, 680
II/602	Pelhřimov, Jihlava, Velké Meziříčí, Velká Bíteš	From Pelhřimov 594, 602, 714, before Jihlava 1925, 1158, beyond Jihlava 1325
II/130	Křelovice, Senožonaty, Koberovice, Ledeč nad Sázavou, Golčův Jeníkov	From Křelovice 138, 185
II/345	Golčův Jeníkov, Chotěboř	From Golčův Jeníkov 474, 527
II/344	Chotěboř, Dolní Krupá, Havlíčkův Brod	From Chotěboř 474, 527
II/150	Ledeč nad Sázavou, Světlá nad Sázavou, Havlíčkův Brod	From Ledeč 357, 549
II/347	Světlá nad Sázavou, Humpolec	From Světlá nad Sázavou 145, 175
II/405	Jihlava, Třebíč	From Jihlava 725, 474, 244, 227, 314, 349
II/360	Moravec, Křižanov, Velké Meziříčí, Třebíč, Jaroměřice nad Rokytnou	From Moravec 195, 615, 817, 562
II/360	Nové Město na Moravě, Jimramov, regional border	From Nové Město 478, 219, 169
II/152	Jaroměřice nad Rokytnou, Moravské Budějovice, Jemnice	From Jaroměřice 689, 318, 284, 104
II/408	Jemnice – regional border	From Jemnice 127
II/410	Jemnice – regional border	From Jemnice 42
II/152	Jaroměřice nad Rokytnou, Hrotovice, regional border	From Jaroměřice 255, 367, 252
II/399	Třesov, Dalešice, Rouchovany, regional border	From Třesov 63, 357, 262, 85
II/399	Náměšť nad Oslavou, Jinošov, Velká Bíteš	From Náměšť nad Oslavou 580
II/379	Velká Bíteš – regional border	From Velká Bíteš 621, 359
II/357	Bystřice nad Pernštejnem, Dalečín, Jimramov	From Bystřice 152, 143, 126
II/387	Štěpánov nad Svratkou, regional border	From Štěpánov 224
II/345	Chotěboř, Ždírec nad Doubravou	From Chotěboř 974, 605
II/352	Jihlava, Polná	From Jihlava 136
II/351	Polná, Přibyslav	From Polná 189

Source: (Černý, 2015)

In order to evaluate the significance of the communication, we can compare the intensity of traffic (individual types) with the number of inhabitants living in selected major settlements on the relevant roads. From the point of view of determining the ratios, this has a considerable limitation because it is not possible to determine the relative indicators related to the average values since not all the seats on the given road are counted and the indicator of the traffic intensity is a variable indicator, for example, the connection of other roads to the relevant road communication. For this reason, two ratios were selected that measure the significance of the communication to the selected residential structure on the relevant communication. In terms of traffic variability, it is necessary to evaluate the indicator as a whole for the relevant communication. Another significant indicator is the TV/SV indicator, which represents the percentage load of heavy vehicles and thus the economic importance of the road.

The ratios are expressed as follows

$$U_{min} = \frac{\text{The highest intensity}}{\text{The highest number of people}} * 100;$$

$$U_{max} = \frac{\text{The highest intensity}}{\text{The lowest number of people}} * 100;$$

$$U_k = \frac{\text{TV U(min)}}{\text{SV U(min)}} * 100.$$

3. Results

From the Table 6, it can be predicted that the lower the variance of the U_{max} and U_{min}, indicators, the more uniform stratification of the settlement structure on the given road. Furthermore, the higher the value of the U_{min} indicator, the more important the road is in terms of social and economic importance. The U_k ratio is the percentage of heavy vehicle weight. In general, it can be said that the higher the percentage, the higher the economic importance of the road.

Table 6 | Significance of communication (%)

Significance of communication (%)					
	SV Indicator		*TV Indicator*		
Road number	*U (min)*	*U (max)*	*U (min)*	*U (max)*	U_k *Ratio*
II/128	36.6	1363.6	7.7	287.8	21.04
II/409	41.8	91.4	6.0	13.0	14.35
II/132	44.0	64.8	9.3	13.7	21.14
II/112	181.9	203.9	2.3	39.0	1.26
II/406	73.6	476.9	12.1	11.8	16.44
II/602	24.1	239.2	3.8	38.2	15.77
II/130	55.3	413.1	3.4	125.9	6.15
II/345	33.0	118.0	5.6	20.1	16.97
II/344	13.8	789.9	2.2	127.0	15.94
II/150	17.6	77.8	2.3	10.2	13.07
II/347	14.5	22.6	1.6	2.5	11.03
II/405	10.0	13.6	1.4	2.0	14.00
II/360	19.0	1168.0	2.2	135.7	11.58
II/360	26.5	226.6	4.8	40.9	18.11
II/152	60.1	109.3	9.1	16.6	15.14
II/408	42.8	42.8	3.0	3.0	7.01
II/410	24.0	24.0	1.0	1.0	4.17
II/152	62.2	263.5	16.6	40.1	26.69
II/399	202.9	2473.4	31.2	379.8	15.38
II/399	74.3	1554.8	11.5	240.7	15.48
II/379	64.6	64.6	12.3	12.3	19.04
II/357	34.3	450.6	1.8	24.1	5.25
II/387	223.4	223.4	32.6	35.6	14.59
II/345	55.8	168.4	10.4	31.5	18.64
II/352	2.9	28.7	0.3	2.7	10.34
II/351	19.4	25.6	3.7	4.9	19.07

Source: (Černý, 2015)

Table 7 | Terrestrial roads arranged according to Indicator *U (min)*

SV Ratio			***TV Ratio***		***TV/SV indicator is calculated from the value U (min)***
Road number	***U (min)***	***U (max)***	***U (min)***	***U (max)***	
II/387	**223.4**	223.4	**32.6**	35.6	**14.59%**
II/399	**202.9**	**2473.4**	**31.2**	**379.8**	**15.38%**
II/112	**181.9**	203.9	2.3	39	1.26%
II/399	**74.3**	**1554.8**	**11.5**	**240.7**	**15.48%**
II/406	**73.6**	**476.9**	**12.1**	11.8	**16.44%**
II/379	**64.6**	64.6	**12.3**	12.3	**19.04%**
II/152	**62.2**	263.5	**16.6**	40.1	**26.69%**
II/152	**60.1**	109.3	**9.1**	16.6	**15.14%**
II/345	55.8	168.4	**10.4**	31.5	**18.64%**
II/130	55.3	**413.1**	3.4	**125.9**	6.15%
II/132	44	64.8	**9.3**	13.7	**21.14%**
II/408	42.8	42.8	3	3	7.01%
II/409	41.8	91.4	6	13	**14.35%**
II/128	36.6	**1363.6**	**7.7**	**287.8**	**21.04%**
II/357	34.3	**450.6**	1.8	24.1	5.25%
II/345	33	118	5.6	20.1	**16.97%**
II/360	26.5	226.6	4.8	40.9	**18.11%**
II/602	24.1	239.2	3.8	38.2	**15.77%**
II/410	24	24	1	1	4.17%
SV Indicator			***TV Indicator***		***TV/SV Indicator is calculated from the value U (min)***
Road number	***U (min)***	***U (max)***	***U (min)***	***U (max)***	
II/351	19.4	25.6	3.7	4.9	**19.07%**
II/360	19	**1168**	2.2	**135.7**	11.58%
II/150	17.6	77.8	2.3	10.2	13.07%
II/347	14.5	22.6	1.6	2.5	11.03%
II/344	13.8	**789.9**	2.2	**127**	**15.94%**
II/405	10	13.6	1.4	2	14.00%
II/352	2.9	28.7	0.3	2.7	10.34%
III/3507					

Source: (Černý, 2015)

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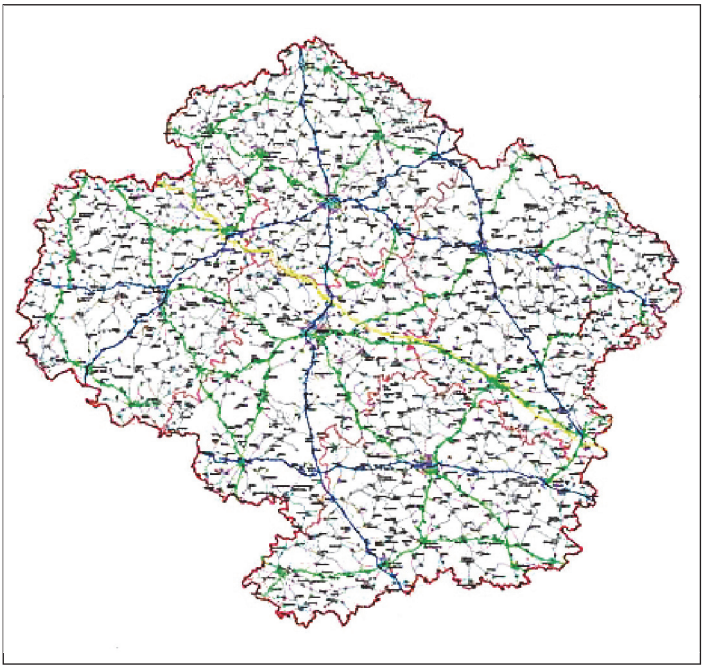
Terrestrial roads were analysed on the basis of SV, TV, and TNV. The values of SV > 1500, TV > 200 and TNV > 100 were set to determine the extent of the road network where the road management system could be introduced. Based on these values, a new layout of the backbone network of the Vysočina Region was established. In addition, the roads were analysed as to whether they are of economic significance (i.e. they are only used by freight transport or are of a social nature, i.e. they are predominantly used by passenger cars). These indicators are important in terms of technological procedures. The table below shows the revision of the existing backbone network and the proposal for the exclusion and inclusion of new sections.

Figure 1 | New arrangement of the backbone road network of the Vysočina Region



Legend:			
	Highway		*Regional border*
	I. Clas road		*District border*
	II. Clas Road		*Built-up area*
	III. Clas road		
	Does not participate in the backbone network		

Source: (Ksusv.cz, 2015)

Figure 1 shows the network with a total length of 703,107 km, of which 635,84 km are II. Class roads and the remainder are III. Class roads.

The system for implementing individual repairs and forms of road maintenance is not the subject of this article. To address the issue, based on the basic division of winter maintenance, then full maintenance in a chemical form needs to be discussed. In this case, the roads are cleaned of snow and the surface is treated with chemical spraying. This form of maintenance is the most costly. The second version is the displacement of inert material in order to provide better adhesion conditions when the tyre of a vehicle passes over the road. This procedure is applied especially in areas with low traffic intensity or where chemical substances cannot be used due to nature and landscape conservation. From the viewpoint of spending on winter maintenance, the best way is to simply ploughthe roads without any sprinkling. This method is especially used for third class roads with low traffic intensity and little importance from an economic or social point of view.

4. The Impact of the Road Network on Public Transport

The above information can be regarded as general when it affects the operation of transport as a whole system. Although in recent decades there has been a growing importance and intensity of individual automobile transport, as evidenced by data from the above summation, traffic intensity and public support cannot be ignored. In the case of the Vysočina Region, for the most part, it is a public transport service (hereinafter referred to as ZDO), which is mostly ordered by the region. Of course, the highway network of the highlands also uses many other lines, especially long-distance and international ones, but it usually only concerns road 1. Therefore, these lines will not be dealt with in this article. The largest share consists of suburban and intercity lines, which provide transport for citizens to school, healthcare facilities, and work. Of course, this includes the provision of return transport as stated by current Czech legislation. This service is primarily based on lower class roads and, therefore, the quality of the infrastructure, the arrangement, and maintenance of the infrastructure is of great importance. Particularly in the case of winter maintenance, its plans are adapted in many cases to the times of regular bus services.

This public transport procedure has lasted two decades and has undergone many changes, which reflect the structural changes in the economy, changes in the demographic structure of the region, as well as the mass development of individual traffic. Infrastructure is often a limiting factor shortening driving times as one of the competitive factors of this mode of transport. Other factors include, for example, comfort and cost, which are also affected by the infrastructure. Therefore, it is desirable to coordinate the planning of transport routes, maintenance, building, and changes with regard to public transport as an alternative promoted to the individual. The issue of transport service provision is very broad, and therefore its assessment did not proceed from a purely economic point of view but also from the perspective of sustainable development and social responsibility. It is important to take steps that will help increase traffic efficiency and stop the falling number of passengers. In particular, this is the continuous improvement of the condition of the infrastructure so that it is technically possible to shorten driving times and maintain transfer connections. Quality infrastructure also helps reduce fuel consumption and thereby increases the economic efficiency of the whole system.

Conclusions

The contribution is based on a multi-criteria evaluation and introduces a new arrangement of the backbone road network of the Vysočina Region. The highlands region is very specific in many respects, whether in terms of its weather, landscape or socio-demographic. All these aspects are also reflected in the organisation of the road network. Ground communications in the new backbone network layout must be evaluated in terms of their significance and whether they are more of a social or economic significance. The backbone network is made up of the motorway and first class roads that are managed by the MD of the Czech Republic and are connected to these roads by other second and third class roads. Quality and safety are often referred to in terms of transport infrastructure by concepts that, from the owner's point of view, also add value to efficiency and effectiveness. As part of this article, a selection of roadways has been identified on which it is appropriate to introduce a system of road management and set up measures for the technological process. This is the efficient management of the limited financial resources of the owner of the roads as the focal point for the future.

The design of the backbone road network is crucial for increasing the efficiency of the funds spent, which comprise a large part of the expenditure within the regional budget. It is these budgets that are often enormously burdened with expenditure on the construction and maintenance of transport infrastructure while their income, according to many opinions, is inadequate. Discussions are usually about the breakdown of fuel and grease tax revenue or road tax. A systemic management solution is a strategic decision that is particularly important in terms of planning and financing the road network in the long run. In this contribution, the issue of public transport, which is realised after these roads, was briefly omitted. Public transport is one of the aspects of addressing unemployment in some parts of the districts where it is desirable to ensure sufficient mobility for the population in order to reverse this situation. High-quality transport connections and connections to the backbone road and motorway network are one of the decisive factors for placing a significant investment, as many companies prefer freight transport exclusively on the road, often in the Just in Time system. In terms of the structure of the national economy, the condition of the transport infrastructure is a limiting factor for the whole economy, and therefore attention needs to be paid to this issue.

Due to its location in the Czech Republic, the Vysočina Region can benefit from its connection to the most important highway passing through the Czech Republic although it is necessary to also pay close attention to the lower class roads. In this respect, not only to the efficient and economical maintenance of roads, as discussed in this article, but also to the construction of new roads and bypasses for municipalities in view of increasing traffic density and safety aspects. The interconnection of each impact on transport infrastructure is important to mention as a whole. For example, public transport is often the factor that is historically crucial, particularly in the planning of winter maintenance. However, other influences, in particular, political decisions, when large investment and lobbying become the subject of pre-election campaigns, are often affected by transport infrastructure. In connection with the issue, the possibility of imposing a charge on these roads, especially for heavy goods vehicles, is often discussed. It is this decision that can have a significant impact on maintenance issues due to the potential changes in traffic density on individual roads.

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