

# DESIGN OF A NETWORK OF CYCLING ROUTES IN THE KUTNÁ HORA DISTRICT

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**ABSTRACT.** Cycling is a dynamically expanding transport mode of today. At the same time, cycling is an alternative to individual car transport as well as to public transport. The basis of a good cycling infrastructure is a comprehensive network of safe cycling routes linking transport sources and destinations in the area. The partial objectives of the project are to evaluate the management of the existing cycle routes according to the way cyclists are guided and according to the surface of the individual route sections, as well as to determine the basic sources and destinations. The main objectives of the project are to design a network of bicycle routes with a focus on keeping them separate from motorized traffic and linking the identified resources and destinations, as well as determining the difficulty of each newly proposed route.

**KEYWORDS:** Cyclist transport, path for cyclists and pedestrian, path for cyclists, cycle traffic safety, cycle route management, path for cyclists categorization.

## 1. INTRODUCTION

Cycling is a dynamically expanding transport mode of today. The European Union is aware of this trend and annually releases funds for the development of cycling in individual EU countries. Cycling is an alternative to individual car transport as well as to public transport. Cycling has many benefits. It helps to reduce the risk of various illnesses, such as diabetes, some forms of cancer, cardiovascular diseases, and depression. Cycling not only improves physical health, but also has a positive impact on mental health and subjective well-being. Cycling takes you from door to door, it offers individuality, flexibility, and freedom (ample opportunity for adapting travel times, speed and routes). If people switch from a car to a bicycle, it saves 150 g of CO<sub>2</sub> per kilometre and 0.2 g of NO<sub>x</sub> per kilometre and 0.01 g of particulate matter per kilometre [1]. This article discusses the design of a network of cycling routes in the Kutná Hora district. First, it evaluates the current state of cycling routes, then it maps the significant sources and destinations of transport in the area, then tries to link the identified sources and destinations, and finally determines the difficulty of the individual newly proposed cycle routes. The Kutná Hora district is located in the south-eastern part of the Central Bohemia Region (NUTS II) [2]. In terms of geomorphology, the district is located between the Elbe and Sázava rivers. The surface is considered to be rather hilly, due to the occurrence of the Hornosázava Hills, the Čáslav Basin and the Polabská lowland. The district covers an area of 917 km<sup>2</sup>. In terms of cycling, it is not a well-developed district, as there are only 19 marked cycle routes, which are also largely guided on class II and III

roads. The potential in the form of a varied and very attractive surface for cyclists is not fulfilled. Most of the Class III roads are relatively bicycle-friendly with their low volumes of car traffic. However, due to the latest road traffic rules, which require the driver of a motor vehicle to leave a minimum lateral separation of 1.5 m [3] when overtaking a cyclist, the routing of cycle routes no longer appears to be entirely safe even on these roads. Figure 1 shows unsuitable sections of cycle routes that are integrated with high volume car traffic.

## 2. ANALYSIS OF THE CURRENT STATE OF CYCLING TRANSPORT

There are in total 19 marked cycling routes in the Kutná Hora district. Most of them are integrated with car traffic on roads of II. and III. class. The territory of the district is crossed by the European EuroVelo 4 cycle route, the spinal long-distance Class I cycle route No. 1 and the long-distance Class II cycle route No. 19. The other cycle routes are considered to be Class IV cycle routes. Table 1 lists the individual cycle routes in the territory of the Kutná Hora district. The first column indicates the number of the cycle route. The second column shows the individual municipalities through which a given cycle route runs through. The third column presents the total length of the cycle route in the Kutná Hora district [5].

The sections of the individual cycle routes are divided into three categories in terms of the way they are routed: integrated, calmed and protected. An integrated cycle route is a cycle route shared with car traffic where the speed of car traffic is higher than 40 km h<sup>-1</sup>. A calmed cycle route is a cycle

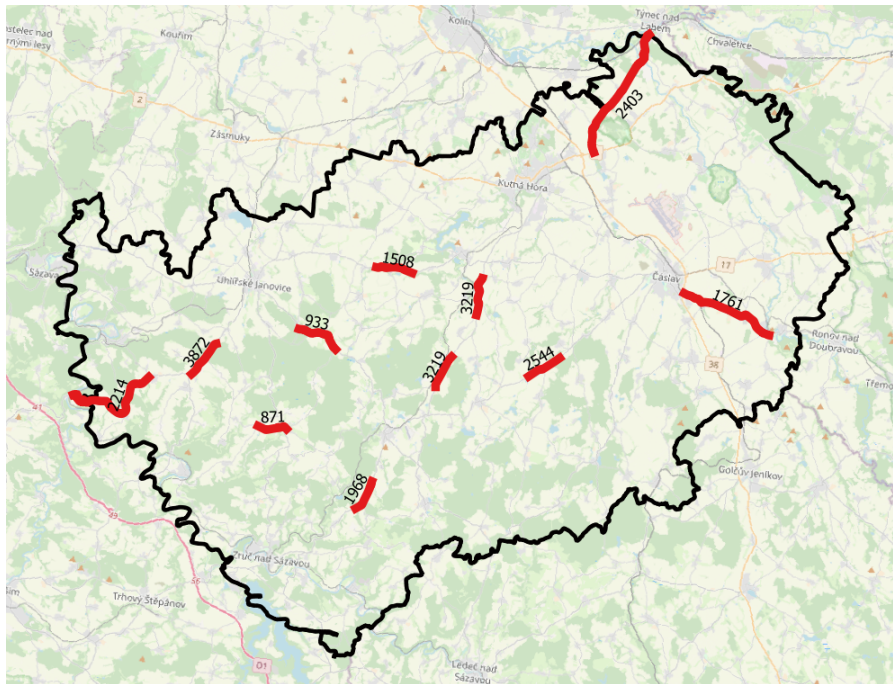


FIGURE 1. Sections of Class II roads currently used for cycling routes, and their intensities [4].

Cycle route number	Cycle route management	Length [m]
EV4	Hořany, Kutná Hora, Neškaredice, Třebešice, Čáslav, Žáky, Tupadly, Potěhy, Horky, Hostovlice, Zehuby	30087
1	Solopysky, Dobřeň, Karlov t., Doubrava, Tuchotice, Nová Lhota, Bylany, Kutná Hora, Vrchlice, Neškaredice, Třebešice, Čáslav, Žáky, Tupadly, Potěhy, Horky, Hostovlice, Zehuby	40356
0128	Svatá Kateřina, Nové Dvory, Ovčáry, Jakub, Církvice, Třebešice	10383
0106	Hořany, Kutná Hora, Vrchlice, Poličany, Malešov, Roztěž, Albrechtice, Bedřichov, Miletice, Nepoměřice, Žandov, Sudějov, Janovická Lhota, Uhlířské Janovice, Silvánka, Smilovice, Úžice, Talmberk	42415
0117	Čáslav, Tupadly, Schořov, Bratčice, Hostovlice	15658
0097	Chlístovice, Týniště, Bykáň, Krupá, Úmonín, Lomec, Lomeček, Paběnice, Újezdec, Petrovice I, Michalovice, Třebětín, Tasice	24086
0120	Vavřinec, Chmeliště, Uhlířské Janovice, Rašovice	11708
0127	Úžice, Smrk	5635
19	Sázava, Talmberk, Rataje nad Sázavou, Ježovice, Podveky, Zalíbená, Otryby, Český Šternberk, Radonice, Zdebuzevy, Tichonice, Kácov, Zliv, Holšice, Chabeřice, Zruč nad Sázavou, Horka II, Březina, Vlastějovice, Pavlovice	57531
0118	Čáslav, Filipov, Markovice, Žleby, Zehuby	7082
0098	Černíny, Opatovice I, Červené Janovice, Zhoř, Bludov, Tasice	18037
0096	Malešov, Chlístovice, Zdeslavice, Švábínov, Rápošov, Zbraslavice, Radvančice, Řeplice, Bohdaneč, Kotoučov, Tasice, Bělá, Jedlá	35090
0099	Chotoměřice t., Pančava, Krasoňovice, Hodkov, Hranice, Ostrov, Bohdaneč, Dvorecko	18490
0121	Žandov, Pivnisko, Kamenná Lhota, Morány, Čestín	7255
0122	Podveky, Zbizuby, Nechyba, Vlková, Petrovice II, Kasanice, Čestín, Krasoňovice	15842
0119	Mirošovice, Opatovice II, Mitrov, Kochánov, Janovická Lhota	9808
0123	Zbizuby, Vranice, Kácov	6323

TABLE 1. Management of existing cycle routes.



FIGURE 2. The current state of cycling routes [6].

route guided on less congested roads with speeds of  $40 \text{ km h}^{-1}$  or less. Protected cycle route guidance is the guidance of cyclists on dirt, forest or paths for cyclists or on roads with mixed pedestrian and cycling traffic. Figure 2 shows the current state of cycle routes in the Kutná Hora district. The subsections are coloured according to the distribution defined above. Integrated sections are red, calmed sections are blue and protected sections are green.

The total length of the network of cycling routes in the Kutná Hora district is 356 km. The length of integrated sections is 298 km, the length of calmed sections is 55 km and the length of protected sections is 3 km. The integrated sections therefore account for almost 84% of the total network, which is a very unsatisfactory and dangerous state.

### 3. DESIGN OF CYCLING ROADS

Cycling roads are designed in accordance with ČSN 73 6110 (Design of local roads), especially according to TP 179 (Design of roads for cyclists), which specify the requirements for the design of roads in terms of cycling traffic. Cycling roads are designed to be safe and comfortable for bicycle use. The cyclist is a full participant in traffic, so the principle of self-explanatory and forgiving roads must also be applied to cyclists [7]. Cycling measures should logically build on each other and the cyclist should not be confused. In general, each cyclist measure should be continuously maintained for as long a distance as possible. Frequent changing of cycling measures reduces the safety of cycling [8, 9]. In recent years, two possible ways of guiding cyclists have come into conflict. Guiding cyclists in an integrated way with car traffic

and guiding cyclists together with pedestrians on the path for pedestrians and cyclists. Modern bicycles and electric bicycles reach speeds of  $30\text{--}40 \text{ km h}^{-1}$  on the plain. These speeds are relatively high in shared space with pedestrians and already very dangerous for pedestrians. In integrated lines with car traffic, on the other hand, these speeds are still low and therefore dangerous for cyclists themselves. For this reason, only separate cycle paths should be implemented in the extravilan sections. When designing a network of bicycle routes, it is important to identify key sources and destinations that are attractive to bicycle traffic. The most important sources and destinations are primarily all cities, towns, and villages. The mapping process identifies the largest catchment centres to which linkages should be provided from adjacent smaller communities and between which a basic network of spinal cycle routes should be established. At the district level, cycling does not only represent a traffic function. It is more of a tourist, recreational and sporting function, so the design of the cycle route network should also take into account leisure destinations. Leisure destinations include castles, chateaux, churches, fortresses, ruins, water surfaces, rock formations, recreation centres, golf resorts, lookout towers, museums, children's parks, breweries. The first step of designing the network of cycle routes was to identify the largest catchment villages, among which an aim was to find the most direct spinal routes leading on forest and dirt roads. The Czech Republic's advantage over other European countries is undoubtedly the possibility of unlimited use of forest and dirt roads. In foreign countries, these routes are usually private and completely inaccessible. The possibility



FIGURE 3. Cycling routes management in the new concept [6].

of running cycle routes on these roads is therefore out of the question. In our country, if we can negotiate with individual road managers to agree to mark out a cycle route on their road and provide a suitable surface for all types of bicycles, newly proposed protected cycle route corridors can be implemented with a significantly lower cost than would be in the case for completely newly designed roads in the open countryside. Of course, the ensuring (in the context of financial investment) of adequate surfacing on these routes would not be provided by the administrator from its own resources but could be helped by subsidies from the European Union, that makes substantial sums available each year for the development of cycling. Kutná Hora, Čáslav, Zbraslavice, Zruč nad Sázavou, Uhlířské Janovice, Kácov and Rataje nad Sázavou were identified as the most important municipalities among which the spinal cycling routes run. For each municipality, the aim was to ensure that the individual routes led to the most important directions.

#### 4. DESCRIPTION OF THE NEWLY PROPOSED CYCLING ROUTES

The new concept of cycling routes in the territory of the Kutná Hora district counts a total of 40 cycling routes. 7 of them were determined to be spinal. The remaining cycling routes are complementary. The main aim was to find the most direct routes among the largest centres of the district leading on the forest and dirt roads and also to connect the identified sources and destinations. The alignment of the newly proposed cycle routes is represented in Table 2. The newly proposed cycle routes can be seen in Figure 3.

The total length of the newly proposed cycle route network is 593 km. Integrated sections amount to 176 km, calmed sections amount to 92 km and protected sections amount to 325 km. It can be seen that there has been an increase in the total length of cycle routes and a significant reduction in integrated sections, which increases the safety and overall attractiveness of the Kutná Hora district cycle network. Almost 71 % of the total length is made up of calmed and protected sections. This is an essential fact, because it must not be forgotten that the cyclist is one of the most vulnerable road users [10]. The newly proposed cycle routes were divided into three categories in terms of slope parameters. If the maximum longitudinal slope on a specific cycle route does not exceed 6 % or exceeds it only slightly on a negligible number of sections, the cycle route is suitable for all cyclists, including families with children. The second category consists of cycle routes with a maximum longitudinal slope in the range of (6.8) %. These routes are intended for normal adult cyclists. The last category consists of cycle routes with a maximum longitudinal slope exceeding 8 %. These routes are intended for fit, trained cyclists. Figure 4 shows all the newly proposed cycle routes specified by colour according to the above classification. Cycle routes suitable for all cyclists, including families with children, are coloured green, cycle routes for normal adult cyclists are coloured yellow and cycle routes for fit, trained cyclists are coloured red.

#### 5. CONCLUSION

Cycling should be considered as a separate mode of transport. Managing cycling traffic in an integrated

Cycle route number	Cycle route management	Length [m]
EV4	Hořany, Kutná Hora, Neškaredice, Třebešice, Čáslav, Žleby, Ronov nad Doubravou	32927
1	Solopysky, Dobřeň, Karlov t., Doubrava, Tuchotice,, Nová Lhota, Bylany, Kutná Hora Vrchlice, Neškaredice, Třebešice, Čáslav, Žleby, Ronov nad Doubravou	43307
19	Sázava, Mrchojedy, Leděčko, Rataje nad Sázavou, Malovice, Český Šternberk, Soběšín, Kácov, Zliv, Holšice, Čížov, Chabeřice, Zruč nad Sázavou, Vlastějovice, Budčice, Chřenovice	59055
0066	Čáslav, Močovice, Krchleby, Vodranty, Nová Lhota, Úmonín, Bykán, Malešov	16542
0091	Kutná Hora, Přítoky, Kutná Hora	8790
0096	Kutná Hora, Malešov, Hetlín, Zbraslavice, Chotoměřice t., Pančava, Hodkov, Želivec, Zruč nad Sázavou	34265
0097	Třebětín, Michalovice, Újezdec, Paběnice, Lány, Lomeček, Lomec	15284
0098	Bělá, Tasice, Červené Janovice	12613
0099	Hranice, Bohdaneč, Řeplice	12522
0106	Mrchojedy, Talmberk, Úžice, Smilovice, Mirošovice, Uhlířské Janovice, Rašovice, Onomyšl, Vidice, Nová Lhota, Bylany, Kutná Hora, Červené Pečky, Nebovice, Kolín	36294
0111	Bělá, Dvorecko	2373
0117	Čáslav, Schořov, Bratčice, Hostovlice, Žleby	17372
0119	Opatovice II, Malejovice, Podmoky	5043
0120	Zbraslavice, Janovická Lhota, Uhlířské Janovice, Chmeliště, Vavřinec, Církvice	17029
0121	Onomyšl, Žandov, Kamenná Lhota	11177
0122	Petrovice II, Kasanice, Čestín	2587
0123	Zbizuby, Vranice, Kácov	6329
0127	Úžice, Smrk, Skvrňov, Církvice	5635
0128	Třebešice, Církvice, Jakub, Ovčáry, Nové Dvory, Starý Kolín	12844
0199	Zruč nad Sázavou, Řendějov, Polipsy, Kácov	10302
0200	Bylany, Miskovice, Mezholezy, Vysoká, Suchdol	6302
0201	Miskovice, Červené Pečky	3483
0299	Kácov, Račíněves, Čestín, Chotoměřice t. Pančava, Zbraslavice, Radvančice, Zhoř, Chvalov, Plhov, Paběnice, Hraběšín, Březí, Schořov	32932
0700	Rataje nad Sázavou, Mirošovice, Opatovice II	9391
0701	Rataje nad Sázavou, Útěchvosty, Podveky, Zbizuby, Vestec, Hroznice, Vlková, Nové Nespěřice, Stará Huť, Kamenná Lhota, Vernýřov, Černíny, Opatovice I, Korotice, Úmonín	34985
0702	Uhlířské Janovice, Staré Nespěřice, Stará Huť, Tlučeň, Petrovice II, Losiny, Kácov	15783
0800	Kutná Hora, Nové Dvory, Svatý Mikuláš, Habrkovice, Záboří nad Labem, Bernardov, Horušice, Brambory, Semtěš, Starkoč, Zbyslav	37109
0801	Čáslav, Chotusice, Rohozec, Svatý Mikuláš	11099
0802	Kutná Hora, Hlízov	7999
0803	Jakub, Rohozec	2581
0804	Rohozec, Žehušice, Horušice	5993
0805	Kutná Hora, Vrchlice, Poličany, Křesetice, Krupá, Bykán	5655
0900	Čáslav, Vrdy, Dolní Bučice, Zbyslav, Zařičany, Brambory	16064
0901	Vodranty, Hraběšín, Damírov, Zbýšov, Klucké Chvalovice	15993
0902	Horky, Vrdy	4967
0903	Třebešice, Kluky, Olšany, Nová Lhota	7000
0904	Nová Lhota, Souňov, Lomec, Korotice	6118
0905	Čáslav, Žáky, Krchleby	5788
0906	Michalovice, Dědice, Dobrovítov, Čejkovice, Chlum, Klucké Chvalovice, Přibyslavice	14773
ZS	Kutná Hora	3483

TABLE 2. Management of existing cycle routes.

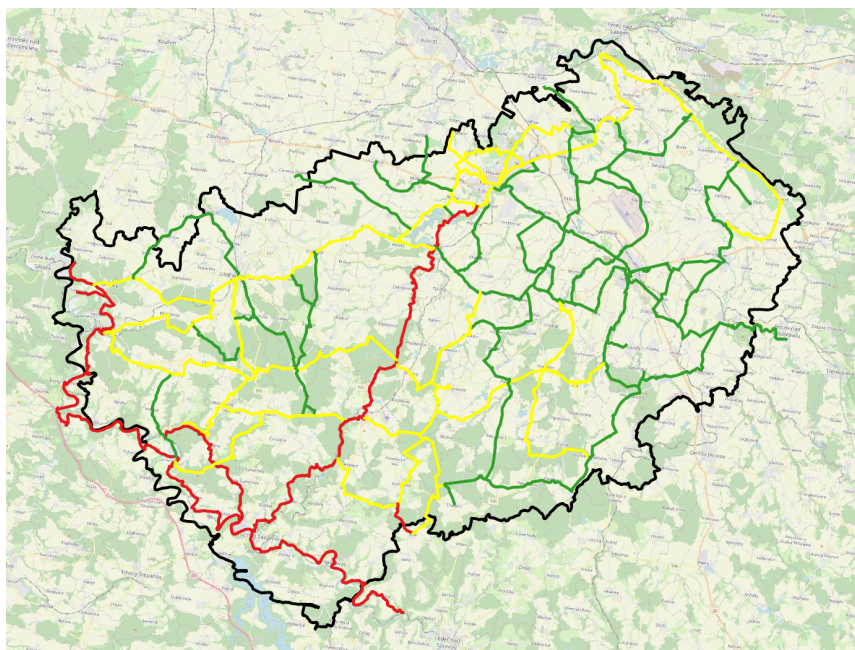


FIGURE 4. Distribution of the newly proposed cycling routes according to difficulty [5].

way with car traffic in extravilan sections with higher car traffic intensities is always an inappropriate solution. A good quality cycle route network should therefore, for the most part, include protected sections where cyclists are routed away from car traffic. Of course, it is not economically desirable to have 100 % of cycle routes segregated from car traffic, but leaving cycling integrated with car traffic is only possible on a small number of sections with very low motorised traffic intensities. Only in this case will the cycle route network be safe and attractive for potential users. The main aim of this concept was to design a cycle route network that connects all the important sources and destinations in the area while being safe, as most of the sections will be routed away from traffic. Approximately 70 % of the cycle routes run away from unsafe motorised traffic, the remaining 30 % of the cycle routes were maintained on very low volume roads, as in these cases no alternative was found in the form of a comparably direct connection between the identified destinations on forest or dirt roads. However, psychological features highlighting the presence of cyclists (e.g. SDZ A 19, VDZ V 15 with the pictogram SDZ A 19 or VDZ V 18) are envisaged on these roads so that drivers of motor vehicles can anticipate a possible collision with this vulnerable road user. The new concept can be implemented in the cycling concept of the Central Bohemian Region for the period 2017–2023 with a view to 2027 and can serve as a basis for subsequent detailed phases of designing cycling routes in the territory of the Kutná Hora district. The construction of a kilometre of cycle path costs approximately 3–5 million. The exact amount depends on the location of the cycle path (whether intravilan or extravilan) and the type and strength characteristics of the surface used. In this concept,

the cycle paths are mainly in the extravilan area and better-quality surfaces are proposed, as heavy agricultural and forestry equipment is expected to be allowed to enter. The economic calculation therefore assumes an amount of 5 million per 1 km of cycle path. The length of the newly proposed sections to be paved is approximately 323 km. The total cost of construction is therefore CZK 1 615 000 000.

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