Traffic Service Solution for Rural Settlements by Means of Tertiary Country Roads

Rješenje prometnih usluga za ruralna naselja pomoću tercijarnih ruralnih cesta

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Summary

The article focuses on the issue of traffic service for rural settlements and related production, tourist and recreation activities in rural areas in the conditions of the Czech Republic by means of rural tertiary roads. The article declares their critical importance for assurance of traffic service and penetrability of the Czech rural areas. Theoretical grounds have been specified for their designing , as well as basic criteria and parameters. A selected territorial segment is used to demonstrate a system approach to this issue and traffic flows are classified in terms of the type, direction and intensity. In conclusion, the article summarizes benefits of the solution defined by the described method.

KEY WORDS
traffic service
rural settlements
tertiary roads

Sažetak

Ovaj rad bavi se temom prometnih usluga za ruralna naselja i s time povezanom proizvodnim, turističkim i rekreacijskim aktivnostima u ruralnim područjima u uvjetima Republike Češke pomoću ruralnih tercijarnih cesta. U radu je istaknuta njihov bitni značaj za osiguranje prometne usluge i dostupnost čeških ruralnih područja. Navedene su teorijske osnove, kao i osnovni kriteriji i parametri za njihov dizajn. Korišten je odabrani segment territorija kako bi se demonstrirao sustavni pristup ovom problemu, a prometni tokovi svrstani su prema tipu, pravcu i intenzitetu. U zaključki, rad sumira koristi od rješenja nastalog opisanom metodom.

KLJUČNE RIJEČI
prijevozna usluga
ruralna naselja
tercijarne ceste

INTRODUCTION

The road network in general is a part of the human living space in which it is integrated and which it provides with a certain scale, framework, rules and thus it becomes a live element in the landscape [1] [2]. In the conditions of the Czech Republic the solution of traffic service for rural settlements, industrial, agricultural, forest and fishery enterprises, as well as for other non-production activities, particularly of recreation character, is hard to imagine without tertiary rural roads (hereinafter tertiary roads). The network of tertiary roads provides interconnection with the surrounding environment, its presence and traffic flows result in landscape fragmentation [3] and it forms relatively natural borderlines and barriers [4]. Therefore it is necessary to strongly focus on the road network as early as in the conceptual and land-use planning materials [5] in order to limit negative effects on the landscape fragmentation [6] as a result of tertiary roads. Tertiary roads may be typically defined as less significant roads in municipalities, forest and dirt roads, roads in settlements made up of weekend cabins etc. [7] and they are used to interconnect settlements, interconnect real estates with other types overland roads or for cultivation of farming and forest land [1]. In the conditions of the Czech Republic the tertiary roads are systematically addressed within the nationwide landscape design and they are newly designed and implemented on ca. 20 % of all cadastral districts of the Czech Republic [8] [9] [10]. It is expected that a comprehensive system of rural tertiary roads with a multifunctional character will be finalized and implemented on the territory Czech Republic in the coming 2-3 decades [11].

THEORETICAL GROUNDS FOR THE DESIGNING

Tertiary road SYSTEMS

Based on their layout the following systems of tertiary roads have been defined [12]:

- *Parallel (chessboard) system* - the system forms a parallel network with approximately perpendicular intersections which enables to create land plots of regular form - this is the advantage of this network type. The disadvantage of this system is a longer transport distance between the land plots and the production unit [13].
- *Radial system* **-** rural roads are arranged radially in respect to the production center or to the settlement, in the shortest directions to reach the individual parts of the economic district [12]. The advantage consists in the fact that the transport distance is by up to one third shorter and that it is possible to distinguish between the individual roads based on significance and intensity of the traffic while the disadvantage consist in inconvenient shapes of the land plots at the road connections [4].
- *Combined system* **-** the system features advantages of both the above-mentioned systems and it can be adapted both to the conditions of landscape articulation and to achieve a practical shape of the land plots [14].
- *Gyratory system* is convenient for hilly regions with long moderate slopes [15]. The gyratory road network is made up of contour line roads and therefore the system is the most suitable from the viewpoint of anti-erosion protection [12].

CATEGORIES OF TERTIARY RURAL ROADS

The categories are defined based on the spatial arrangement in the cross-profile and based on the design speed which depends on the ground conditions [15]. Individual categories are characterized with a fraction which contains:

a) in the numerator: the letter symbol for rural road (P) and clear width of the rural road in meters [16],
b) in the denominator: the design speed in $km.h^{-1}$.

CRITERIA AND DESIGNING PRINCIPLES

The basic requirements for outlining and designing of tertiary roads are specified in the Czech standard ČSN 73 6109 Design of rural roads. The design of the road network shall respect criteria relating to traffic, environment, soil protection, water management, aesthetic appearance and economy. The design shall enable:

- interconnection of neighboring municipalities,
- access to plant production areas,
- access to animal production units,
- interconnection between agricultural businesses or farms,
- transport between agricultural businesses or farms and sales points of the farming products,
- interconnection between other production units,
- provision of access to the landscape and penetrability of the agricultural land, routes for marked hiking, cycling or running trails

When designing the road network from the viewpoint of a common measures plan it is advisable to observe the following principles**:**

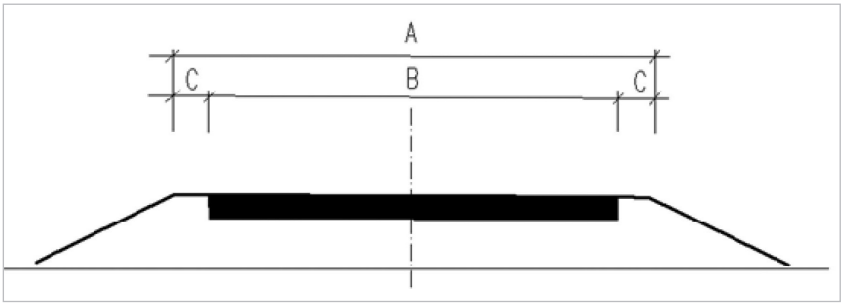
- the design should take into account the shape of the territory, ground configuration and location of the built-up part of the municipality in the cadastral district,
- a parallel network of regular shapes is suitable for a flat territory while dissected topography requires to take into account drainage conditions, anti erosion requirements and mostly a centrally located municipality,

Table 1 Categories of tertiary rural roads

Rural road			
Main		Secondary **)	Supplementary ***)
Double-lane	Single-lane	Single-lane	Single-lane
P 7.0/50	P 5.0/30	P 4.5/30	P 3.5/30
P 6.5/50**)	P 4.5/30**)	P 4.0/30**)	P 3.0/30
P 6.0/40	P 4.0/30	P 3.5/30	-

*)For hard-surface rural roads the proposed shoulder is 2 x 0.50 m and the width of the roadway is the remaining distance up to the clear width of the road.
**) Recommended design category for this type of a rural road.
***) Supplementary rural roads are usually designed without shoulders.

Source: ČSN 73 6109



CAPTION:
A Clear width (crown) of the road
B Running surface (roadway)
C Shoulders

Figure 1 Design category of a hard-surface rural road

Source: ČSN 73 6109

- farming transport shall be totally excluded from the settlements and from roads of the main network,
- the estimated catchment area of a main rural road is ca. 100 – 150 ha, as long as the transport is only for farming purposes,
- land plots up to 20 ha in a flat landscape and up to 5 ha in undulated landscape can be made accessible only from one side,
- the road network in the landscape should be designed so that it does not create land plots smaller than 3 ha. If the land plots are smaller then the non-working travel distances of farming machinery are too long,
- the road network design should eliminate or limit to the maximum extent any establishment of easements.

EXAMPLE SOLUTION ON A SELECTED TERRITORIAL SEGMENT

The principle of designing and optimization of a system of tertiary roads has been demonstrated on a selected territorial segment. The layout No. 1 presents the initial status of traffic service based on a completed survey (for more details see the section 4.1 Survey).

The following stage of the works - proposal - contains a solution which responds to a set of requirements for repairs, reconstruction or development of new tertiary roads, in agreement with the requirements specified in the first analytical stage (for more details see the section 4.2 Proposal).

The final balance stage (layout No. 3) contains quantification of requirements and benefits resulting from the proposed solution in respect to provision of traffic service on the concerned territory. Priority is given to the requirements for traffic service for rural settlements and to all production, tourist and recreation activities on the territory. The data are summarized in a balance table which serves as a binding input for development of a set of measures to be adopted in the concerned territory from the viewpoint of the road network. The final output is a set of repairs, reconstruction and development of new tertiary roads, including accompanying facilities, such as entrances, slip roads, culverts, railings, re-vegetation, trenches etc., including the schedule and implementation procedure.

SURVEY

In the concerned territorial segment there is a network of regional and supra-regional roads and a network of local tertiary roads which are connected to the former ones. The roads of regional and supra-regional importance (identified 1.1 through 1.4) form a network that is rather radial and locally connects the municipalities of Hodětín, Nová Ves, Blatec, Sudoměřice, Březnice, Klečaty and Komárov. The network of the roads concentrates two-way flows of people, plant, animal and forestry products and also flows that supply the population. For the purposes of analysis the flows are classified as open, which means that the described flows of people, products and services go outside the borders of the defined territorial segment, to other municipalities and further to towns and to other centers that perform production, product processing and provide services.

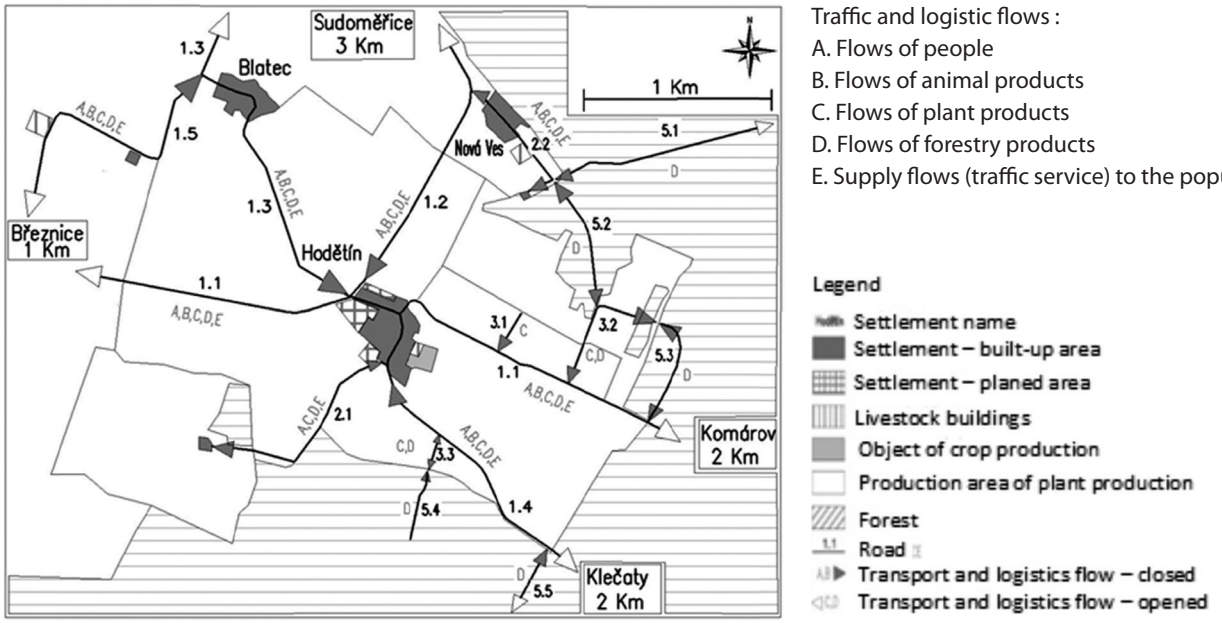
The road structures are two-lane, with roadway widths of 5 - 7 meters. The road surface is asphalt, with some defects (potholes, cracked surface). In all the cases the road body is drained with a ditch on one or both sides. The water ditches are provided for protection of the road against negative effects of water and they also function as a water management network to safely drain water from built-up parts of municipalities and agricultural landscape into recipients – water courses. Along the roads there is accompanying greenery (fruit trees) with various levels of involvement of growths and of different age and health condition. The accompanying greenery represents an important landscape-forming, aesthetic and ecological-stabilizing element in the agricultural landscape.

The radial network of roads of regional and supra- regional importance is in the local scale of the concerned territorial segment sufficient for mutual interconnection between the municipalities. The widths of the roads are also sufficient with regard to the low intensity of supra-regional transit traffic. However, in several cases the poor technical condition of the road surface is viewed as a problem.

The efficiency of the road network, with regard to the traffic service for individual parts of settlements and production centers, still depends on the condition of the network of tertiary roads of local importance that are linked to the above-described road network.

The radial network of roads is currently linked only to several tertiary roads of local importance. They are identified as 2.1 and 2.2 (main tertiary roads) and 3.1 through 3.3 (secondary tertiary roads). The road 2.1 is a main; one-lane road with asphalt surface, drained with a ditch and it concentrates nearly all logistic flows, except animal farming. The road 2.2 is a main road of the same character providing for all logistic flows. The roads 3.1 through 3.3 are classified as secondary and they provide one-way or two-way flows of products from plant and forestry production. The secondary road has the roadway 2.5 to 3 meters wide, the surface is only partly hardened, with gravel or dirt surface and muddy in bad weather. The existing forest tertiary roads are identified as 5.1 through 5.5. They provide for forestry product flows within the forest complexes and out from those complexes, towards the road network and to the tertiary roads.

This existing layout of the network of local tertiary roads ensures only the minimum, absolutely necessary level of logistic service. The existing network is sparse. Many of the plant and forestry production centers are not accessible in an optimum manner. Technical condition of the existing roads is unsatisfactory since the intensity of traffic is relatively high and the roads are in some cases insufficient in terms of width and method of surface hardening.



Layout 1 Analysis of the current status

PROPOSAL

A binding input document for development of measures proposed on the road network in the defined territorial segment is the analysis of the current status of the roads and logistic traffic flows, as indicated in the respective layout and in the balance table.

The proposed complex of measures consists both in reconstruction of the existing road network in the concerned territory and in adding of new tertiary roads into the network. The result is a developed optimized spatial network of roads of appropriate widths, surface hardening, drainage and potentially also with additionally planted trees.

The overall arrangement selected for the concerned territorial segment combines the radial and gyratory systems.

The following section provides a description of specific proposed measures.

a) Proposed measures for roads of regional and supra-regional importance

Road 1.1 – It has been proposed to clean the drain ditches and to perform maintenance and additional planting of accompanying wood plants.

1.2 - It has been proposed to clean the drain ditches.

1.3 – It has been proposed to refurbish the road surface and to clean the drain ditches. Further, it has been proposed to perform sanitation maintenance, thinning and additional planting of accompanying wood plants.

1.4, 1.5 – It has been proposed to refurbish the road surface and to clean the drain ditches.

b) Proposed measures for tertiary roads of local importance

Proposed measures for the existing roads:

2.1 - It has been proposed to clean the drain ditches.

2.2 – It has been proposed to repair the surface.

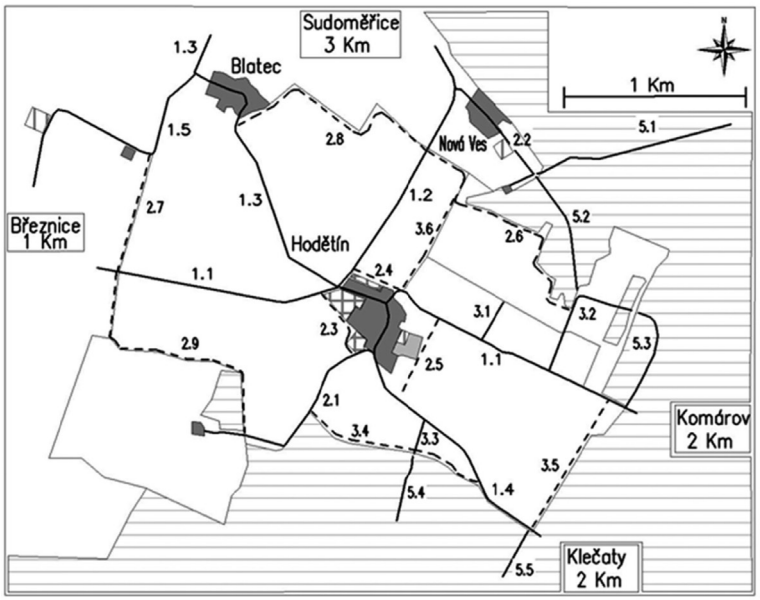
3.1- A complete refurbishment of the road has been proposed: widening to the category "P 4,0/30" while keeping the existing route of the road. The surface will be hardened with gravel. However, in the connection point to the road "1.1" the surface will be asphalt, which is desirable to prevent the gravel from being carried to the main road by farming machines.

3.2 - A complete refurbishment of the road has been proposed: widening to the category "P 4,5/30" while keeping the existing route of the road. The surface will be hardened with asphalt. On its section from the road "1.1" it has been proposed to plant a fruit tree line on one side of the road.

3.3 – A complete refurbishment of the road has been proposed: widening to the category "P 4,5/30"while keeping the existing route of the road. The surface will be hardened with gravel. However, in the connection point to the road "1.4" the surface will be asphalt, which is desirable to prevent the gravel from being carried to the main road by farming machines. The adjoining land plots are waterlogged and therefore a drain ditch has been proposed to be developed on both sides of the road. The ditches will fall into the existing ditch along the road "III/1479", which will be cleaned. This will ensure safe removal of water. Further, sanitary thinning of the accompanying wood plants and new planting have been proposed.

2.3 and 2.4 – are newly proposed tertiary roads of local importance that concentrate logistic flows of people, plant products and services. The selected category of the road is "P 6,0/30". The surface will be asphalt. The road "5" will be from the western side completed with a drain ditch to safely remove water from the surface of the adjoining part of the agricultural block outside the built-up area of the municipality. Moreover, planting of accompanying greenery has been proposed along both the roads to aesthetically separate the residential area from the agricultural landscape.

2.5 – is a newly proposed tertiary road of local importance for farming transport which provides for plant and animal product flows. The development will significantly divert farming machinery traffic from the built-up area of the municipality. It is expected that the intensity of farming traffic will be high and



Layout 2 Proposed solution

there fore the proposed road category is "P 6,0/30" with asphalt surface. A tree alley has been proposed on one side along the eastern side of the road to aesthetically separate the farming complex from the open landscape.

2.6, 2.7, 2.8, 2.9, 3.4, 3.5, 3.6 – are newly proposed tertiary roads of local importance that provide for agricultural and forestry product flows. In some cases they are newly built agricultural roads in category "P 4,5/30" with asphalt surface. A tree line has been proposed to be planted in the free agricultural landscape on one side of the road and it will represent a distinct landscape-forming element.

The proposed complex of measures on the communication network will enable the optimum spatial solution of all logistic flows in the concerned territorial segment.

Technical solution of the road "2.3"

Territorial connections, links to the network of existing roads

The newly proposed road runs from the existing road "2.1" to the class II road "1.1". It serves for logistics of agricultural plant production and to ensure access to the existing and proposed built-up areas and to supply the population.

Category and design speed

The category of the road is a tertiary main road "P 6,0/30". It is a two-lane road. The design speed is v_n=30 km.h^{-1}.

Directional alignment

The route has been designed in 2 straight sections and 2 circular curves.

The smallest recommended radius of the circular curves R_{dop} for the respective design speed v_n and super elevation of the road p shall be calculated using the following formula:

$$R_{dop} = 0{,}25\frac{v_n^{\,2}}{p}$$

where:

R_{dop} … the smallest recommended radius of the circular curve [m],

v_n … design speed [km.h^{-1}],

p … road super elevation [%].

The selected value of road super elevation was p = 4.5%. Then the smallest recommended radius of the circular curve is:

$$R_{dop} = 0{,}25\frac{v_n^{\,2}}{p} = 50 \text{ m.}$$

A simplified detail of the technical solution of the road route is shown in Figure No. 2. The detail contains, in addition to territorial connections, particularly the axis of the road for the selected directional alignment with calculated recommended radii of the directional curves R_{dop} = 50 m. Further, it contains a schematic outline of the axis of the accompanying water ditch on the western side of the road and planting of accompanying tree greenery.

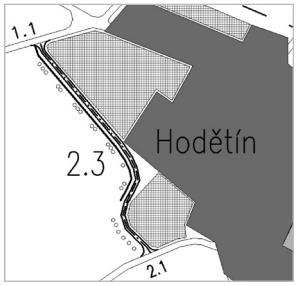


Figure 2 A simplified detail of the technical solution of the route of the road "2.3"

Vertical alignment

The proposed road is vertically aligned slightly above the existing grade level to ensure descending access to the adjoining land plots and so that the road body does not significantly influence the drainage conditions and to minimize the costs of earth-moving works.

Structural solution of the road body

The road body has been proposed with asphalt concrete surface. A complete list of all structural layers is provided in Table No. 3.A sample cross section of the road body with dimension figures, including a drain ditch and accompanying greenery, is provided in Figure No. 3**.** It also indicates the gradient of the road slopes (1:1, 1:1.5 and 1:2) and cross gradient of the road surface (2.5 %).

Table 3 Road "2.3" – Road surface and structural layers

Structural layer	Layer thickness [cm]
ASPHALT CONCRETE	5
ASPHALT-COATED AGGREGATE	8
BED MADE OF AGGREGATE FRACTION 32-64 mm	20
CRUSHER RUN MATERIAL (AGGREGATE FRACTION 63-125 mm)	20

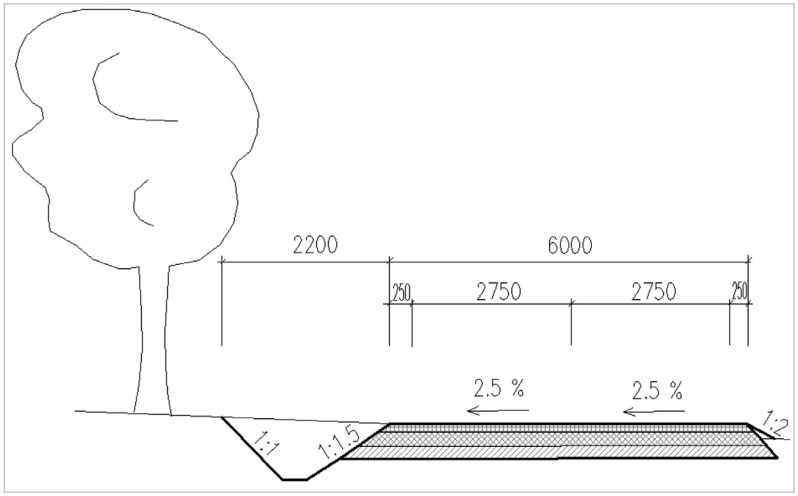
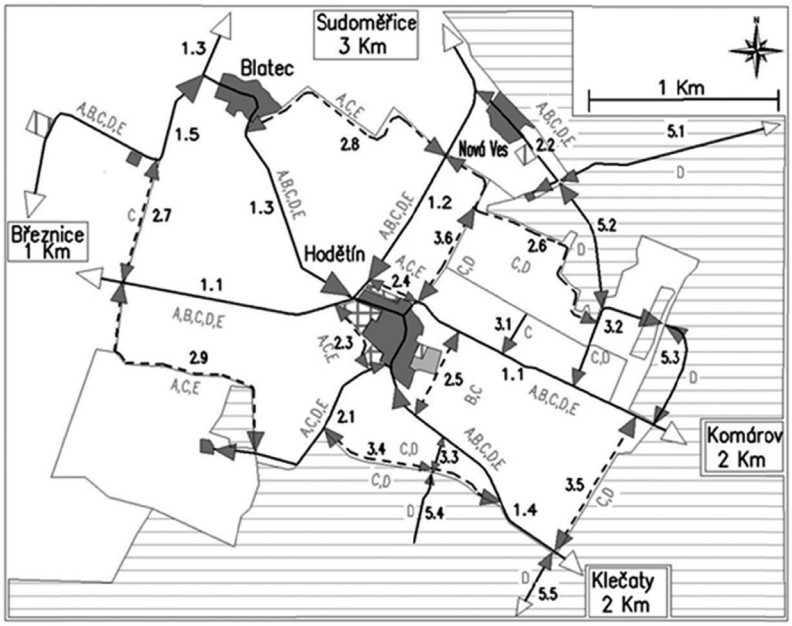


Figure 3 A sample cross section of the body of the road "2.3".



Layout 3 Balance condition

The balance table (Table 2) contains a transparent summary overview of logistic flows of people, products and services in respect to the specific road network. The table enables to evaluate traffic exposure of the road with regard to various types of logistic flows and their directions.

Table 2 Balance table of the road network and flows

CONCLUSION

The network of rural roads dates back to the Middle Ages and it is used for economic purposes and for connection between neighboring settlements. In the past the number of roads had been much higher since each farmer needed access to his fields and to the surrounding landscape. Rural roads were also used for traveling to visits, to attend festive events, to go to church or to market in the town. A certain portion of such ancient roads gradually transformed into hard-surface roads between villages, another portion has survived in a better or worse condition until now and yet another portion disappeared completely or has overgrown with grass and self-seeding vegetation.

In the current stage of development of human society the road network in general is considered a critical attribute

of development in each territorial unit. Therefore, when making a strategic and land-use forecast of development, it is essential to primarily address the traffic service system which is indispensable for achievement of objectives in related human activities. This requires a good knowledge of requirements of all subsystems on the concerned territory. A strong point of the proposed approach is creation of feasible conditions for application of the above-mentioned principle, i.e. the traffic service solution is seen as a priority subsystem in the context of related subsystems, such as industrial, agricultural, forest and settlement subsystems, including the social subsystem. The experience acquired up to now in the Czech Republic in designing and implementation of tertiary roads (mostly funded from EU structural funds) in agreement with the principles described above has shown advantages of the described approach and has proved that the presented procedure can be used.

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