The Future of Rural Mobility: Necessity, Affordability, and Implementation of an Integrated Planning for Rural Road Networks

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Abstract: The Western European countryside is rapidly changing from an agricultural domain into a multi-functional green space. The present network of minor rural roads developed in the past for mainly agricultural use cannot offer the desired safe and comfortable access for the present-day use of the green space. A multi-functional use by people, including those recreationally walking or biking through the area, and by wildlife, threatened by different aspects of habitat fragmentation caused by roads and their traffic flows, calls for a new strategy for planning rural road networks. We aim to show how an integrated strategy based on the concept of rural traffic calming that uses both trunk roads (motorways and rural arterials) and minor roads can provide a safe and attractive hierarchical network for access to the multi-functional rural space. On a regional scale, the trunk roads form a rope netting over the landscape for through traffic. Within the meshes of this trunk-netting, a dense network of minor rural roads consisting of collector and access roads opens up the countryside. Minor roads are primarily designed for short-distance, local-bound traffic and therefore receive a modest technical design not suited for high speeds and fitted to the local landscape as much as possible. In our proposed integrated strategy, the concentration of traffic flows on trunk roads considerably improves traffic safety by lowering risk per driven kilometre while lower volumes and speeds on minor roads reduce maintenance costs and create more liveability for people living along these roads, more attractive surroundings for tourists, better opportunities for daytrips with green modes, and better conditions for de-fragmentation for wildlife.

Key Words: rural traffic calming – impacts – Western European countryside

1 Introduction

Rural areas with their network of minor roads are traditionally connected to agriculture. However, the Western European countryside is becoming a multi-functional space with agriculture developing within a globalization process [1]. New rural functions such as providing an asset for sustainable urban living conditions, (agro)tourism, and new industries in former barns are generating new traffic flows in these areas. Even farmers, the traditional users of these roads, are adding to the new traffic flows; although their numbers have been decreasing for decades, those continuing to farm have augmented their production and as such are generating more agricultural traffic on public roads [2]. This increase in minor road traffic is, however, not the only development. Already in the early 1990s an English study explained a projected general traffic growth as a major issue with enormous implica-

tions for the countryside and its minor roads [3]. Less than 20 years later some rural areas are indeed suffering from rat-run traffic on minor roads caused by drivers wanting to avoid congestion on trunk roads [4]. In addition to its growing volumes, minor road traffic is also threatening local wildlife. While this threat is often undervalued, minor road traffic enormously impacts an area's habitat destruction, noise load and traffic mortality [5].

Most public minor rural roads are paved and have a pavement width between 2.5 and 5.5 metres. The majority of these roads, however, are below 4.5 m and thus have only one traffic lane for two-directional traffic. With this small width, minor roads have to serve mixed traffic (cars, trucks, agricultural vehicles, bicycles and pedestrians) with large differences in mass between participants. Differences in speed are also evident: high speeds of cars versus low speeds of 'soft green modes' [5]. Not surprisingly, minor rural roads are relatively unsafe [6]. This fact conflicts with a safe and comfortable access to the modern multi-functional green space, including its use by those recreationally walking or biking in the area [7].

In this paper we aim to show how an integrated strategy based on the concept of rural traffic calming, which considers both trunk roads (motorways and rural arterials) and minor roads, can provide a safe and attractive hierarchical network for access to the multi-functional rural space.

This paper is structured as follows. In the following section we describe the different approaches to rural road networks and the ideas behind rural traffic calming. Afterwards we analyse an example of rural traffic calming and its impact in practice. We then discuss the consequences for road network planning with respect to the changing role of rural areas in society and the need for an integral approach when planning rural road networks. Finally, we draw some conclusions.

2 Rural road networks

2.1 Dismantling the traditional networks

The rural road network can be subdivided into three groups on different geographical scales and with different functions for transportation: (1) motorways for fast long-distance trips; (2) rural arterial highways for regional access and regional trips; and (3) minor rural roads, distinguished between collectors and access roads for local access only. Table 1 shows the length of these networks in the Netherlands as well some characteristics of the networks and related road characteristics and traffic flows [8]. Minor roads are used for a mix of traffic modes and occasionally have separated facilities for bicycles [9]. Motorways are the exclusive domain of motor vehicles. The same holds for arterial highways, but agricultural vehicles are occasionally allowed here [10].

Despite this hierarchical subdivision, the three groups function as one system. Therefore, regional and local transportation planning must be carried out for the rural network as a whole. On a regional scale the motorways and rural highways form a rope netting over the landscape. Within this mesh of arterial trunk roads, a dense network

of minor rural roads consisting of collectors and access roads opens up the countryside on a local scale.

In practise, however, this functional distinction is less clear, and in contrast to their modest original design standards, many minor roads suffer from high volumes and/or speeds. Given the occurrence of mixed traffic (lorries, cars, bicycles and pedestrians) on these roads with one carriageway and frequently with only one traffic lane, it is not surprising that the risk (expressed in accidents per 10^6 motor vehicle kilometres) on minor rural roads is considerably higher than it is on major roads (see Table 2).

Table 1. Characteristics of minor and major roads outside built-up areas in the Netherlands (elaborated from [6])

	Minor roads		Major roads (trunk roads)	
Scale of road network	Local		Regional	National
Road type	Access road	Collectors	Arterial highway	Motorway
Network characteristics				
Length (paved) [km]	47 652 [2)]		7 508 [1)]	2 291
Road density [3)] [km km^{-2}]	1.55		0.24	0.07
Mesh width [3)] [km]	1.3		8.2	26.8
Road characteristics [4)]				
Cross-section width [m]	5.5 – 9.5	6.5 – >10	± 20	± 40 – 60 [5)]
Pavement width [m]	2.5 – 4.5	4.5 – 6.2	± 7.5	2×(12 – 21) [5)]
Number of carriageways	1	1	1	2
Number of traffic lanes	1	1 or 2 [6)]	2	≥ 4
Traffic characteristics				
Traffic volume [×1000 vehicles d^{-1}]	0.1 – 1	0.5 – 5	2 – 25	20 – 200
Legal speed limit [km h^{-1}]	60/80 [7)]	60/80 [7)]	80/100	100/120

[1)] Including 868 km arterial highway belonging to principal national routes (non motorways)
[2)] Road statistics do not allow the local network to be specified by road type
[3)] Based on 30,682 km^2 land outside built-up areas
[4)] Profiles based on the Dutch concept of sustainable traffic safety
[5)] Based on a 2x2 and a 2x4 motorway respectively, total width including two verges of 5 m
[6)] For 2 lanes, a minimum pavement width of 5.5 m is required
[7)] Both limits are still in use. The official limit has been 80 km h^{-1} since 1974, unless 60 is signposted. The latter speed has been striven for since the mid-1990s and is currently applied to more than 35,400 km of minor roads [11].

Table 2 - Index numbers for the traffic safety of road types in 1995.

Category of road	Casualty accidents per 10^6 motor vehicle kilometres	Victims per casualty accident	Casualties per 10^6 motor vehicle kilometres	Fatalities per 100 casualties
Motorway	0.05	1.49	0.07	4.41
Arterial highway	0.23	1.34	0.31	4.59
Minor rural road	0.51	1.26	0.64	4.86

The high accident risk, combined with the long length and frequently high traffic volumes on the network of minor rural roads, leads to a fair amount of accidents with traffic fatalities and injured who need to be treated in hospital: 30% and 21%, respectively, in 2005 [12].

2.2 Networks within an approach of sustainable safety

In 1992, the concept of Sustainable Road Safety (SRS) was launched in the Netherlands with the ambition of "an infrastructure design inherently and drastically reducing crash risk. Should a crash occur, the process that determines crash severity is conditioned in such a way that severe injury is almost excluded" [13]. The concept uses an approach focused on accident prevention. For the road network, this approach is based on three principles: (1) mono-functionality of roads, (2) homogeneity of mass and/or speed and direction, and (3) predictability of road-course and road-user behaviour with a recognizable road design. The SRS was further developed, and in 2005, it became a new policy, the Advanced Sustainable Safety (ASS), with the addition of two other safety guiding principles: (4) forgivingness of the environment and of road users, and (5) state awareness by the road user [14]. Both the SRS and the later ASS programme are concerned with all roads within the built-up area in cities and villages as well as those in rural areas. In this contribution, we focus on the roads outside built-up areas and particularly on minor rural roads.

The principle of monofunctionality in SRS allows for 3 types of roads: through roads, distributor roads and access roads, in a hierarchically structured network. The road function for through roads is 'to facilitate traffic flow', and for access roads 'to provide access to destinations'. The distributor road is introduced to provide a proper transition between 'giving access' and 'facilitating traffic flow'. In ASS, these 3 main categories are maintained for the functional categorization with a subdivision into 2 types. Figure 1 shows the proposed profile of the minor rural access road type I, the collector road. As mentioned in Table 1, the collector road's carriageway is between 4.50 and 6.20 m wide. This allows the driving strip to be between 3.00 and 4.50 m wide. On each side of the edge marking is an edge strip, called a non-compulsory bicycle lane. Rural access road type II has a carriageway width below 4.50 m, its driving strip is as wide as the carriageway, and it has no markings.

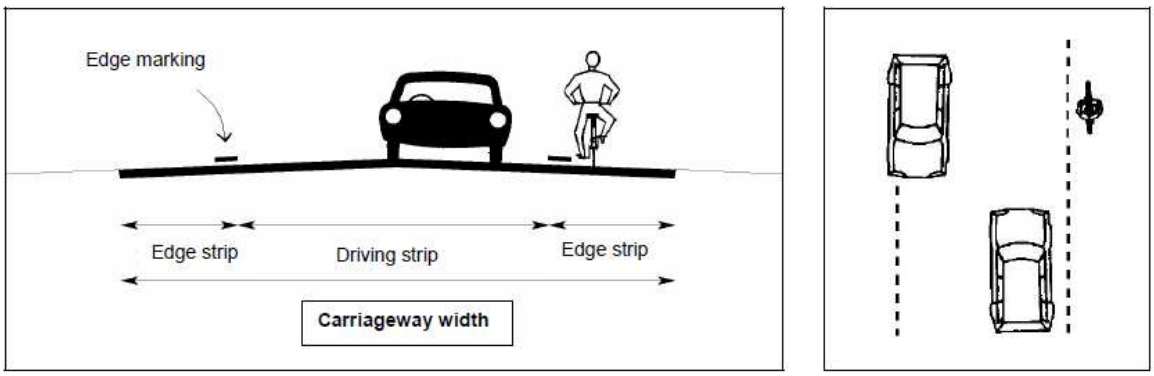

Figure 1. Minor rural access road type I as proposed by the SWOV Institute for Road Safety Research: driving strip with edge strips. Cross section (left) and view from above (right). Source: [9]

2.3 Rural traffic calming: the way from traditional to sustainable safe networks

During the early 1970s, the concept of urban residential traffic-calmed areas was developed with restricted access for motorised traffic and a specific design forcing low speeds. This concept has become an international model [15] and is the basis for the

concept of “traffic-calmed rural areas” [16]. Rural traffic calming is meant to concentrate (through) traffic -- as much as possible -- at the trunk roads. These roads are designed to cope with higher volumes and somewhat faster speeds, and so leaving the minor roads for local access and use by soft modes for recreational purposes.

Around the traffic-calmed area a network of major roads offers fast routes for through traffic and concentrates the diffuse traffic flows, previously found on both major and minor roads, at major roads only. At the intersections between major and minor roads, a legal speed limit of 60 km h^{-1} has been signposted for the minor road. This “gate” is intended to underline that car drivers are entering an area designed for local functions and not for intensive traffic flows. To actually achieve this limit, further speed reducing measures on the minor roads are needed, for example, speed humps and raised level crossings [17]. Because the minor roads are primarily designed for short-distance, local-bound traffic, these roads receive a moderate technical design for low traffic volumes. This design is tailored to the local landscape as much as possible and is not suited for high speeds [18]. Depending on local circumstances, minor roads can be further subdivided into type I (as in Figure 1) and type II.

With rural traffic calming, a clear separation can be made between living space for local inhabitants, relaxing city dwellers as well as wildlife, and space for (through) traffic flows. In contrast to the traditional approach, roads in traffic-calmed areas are designed for the preferred land use functions and not for the actual (through) traffic flows.

Even when total distances travelled are somewhat longer, the concentration on major roads of former diffuse flows on minor roads considerably improves safety because the risk of accident is much lower on major roads (Table 2). Furthermore, reducing traffic speed and volume in the traffic-calmed areas also decreases maintenance costs of the minor roads [19], lowers noise levels for people living nearby minor roads, and, for wildlife, reduces the effects of barrier [20] and mortality [5]. Finally, depending on the local landscape, the attractiveness for recreational activities, especially with soft green modes, may also considerably improve [7].

However, traffic calmed areas do have some disadvantages. Their most serious disadvantage is the increase in vehicle kilometres travelled because the route along major roads is often longer in length and time than the route along minor roads. That said, calculated differences in time between the road types are, on average, small [16] [20]. To illustrate the potential of rural traffic calming, we discuss the results of the ORVO study [21].

3 The ORVO study

3.1 The research area

The ORVO study was carried out in the rural Municipality of Ooststellingwerf in the south-eastern part of Friesland, one of the northern provinces of the Netherlands. The study area (Figure 2A) covers about 80 km^2. It is situated between the small town of Oosterwolde (9600 inhabitants) and the villages of Haulerwijk (3200 inhabitants), Waskemeer (830 inhabitants) and Donkerbroek (1900 inhabitants). Haule

(570 inhabitants) is a small, long-stretched village in the centre of the study area. The N381 in the west is an arterial highway connecting the area with the national network of motorways. Further, the N917 (in the north), the N918 (from Haulerwijk going south to Oosterwolde) and the N919 (in the south) are classified as rural highways but have a low technical standard. The area itself is mainly grassland with some forested zones and is important as a wet and dry corridor zone in the national ecological network with some roads acting as barriers, especially for larger animals [16].

The ORVO study, reported in the mid 1990s in [21], was initiated by the Municipality of Ooststellingwerf after some local residents complained about speeding and safety on specific road sections. Several meetings on the local level with residents, farmers, local entrepreneurs and interest groups initiated the research. Measurements showed that rat-run traffic on long distance routes played an important role in the area's safety problems (Figure 2B). The rat-run traffic was mainly caused by the relatively low quality of the regional major road network; many drivers preferred taking the minor rural roads for their long distance trips because several of these roads offered a level of service comparable with the major network in the area. If the area's traffic situation had continued to develop autonomously, the rat-run traffic on the minor roads would have worsened (Figure 2C). Therefore, the idea of rural traffic calming was developed to assign every road-section its own function and to concentrate through traffic on a few roads suited for higher traffic volumes. This would also lead to a considerable reduction of volumes on most minor roads (Figure 2D).

3.2 Impacts of the traffic calming

Table 3 presents the impacts on vehicle kilometres and traffic safety in 1994, the time of the study, and the predicted situation 11 years later in 2005.

Table 3. Impacts of rural traffic calming on vehicle kilometres travelled and traffic safety [21]

	Situation in 1994 in absolute numbers	Predicted situation for 2005 (percents; 1994=100%)	
		Without traffic calming (Fig. 2C)	With traffic calming (Fig. 2D)
Vehicle kilometres travelled per day on:			
Minor roads	61,085	100	43
N917, N918 and N919	56,659	116	140
N384	55,082	118	113
All roads	172,825	111	96
Traffic safety (KSI-accidents per year), in which individuals are:			
Killed	2.4	108	88
Hospitalized	50.6	108	85

Without traffic calming, traffic flows are expected to grow by 11%, and traffic safety will worsen by 8%. Traffic calming considerably changes the distribution of flows with a shift from minor to major roads. Consequently, fewer accidents with fatalities or seriously injured people will occur (Table 3). Lower volumes on minor roads also im-

prove conditions for (recreational) walking and cycling in this attractive landscape. Additionally, the predicted changes in traffic mortality for roe deer were investigated [22]. The results show a considerable decrease for most conflict points in Figure 2A.

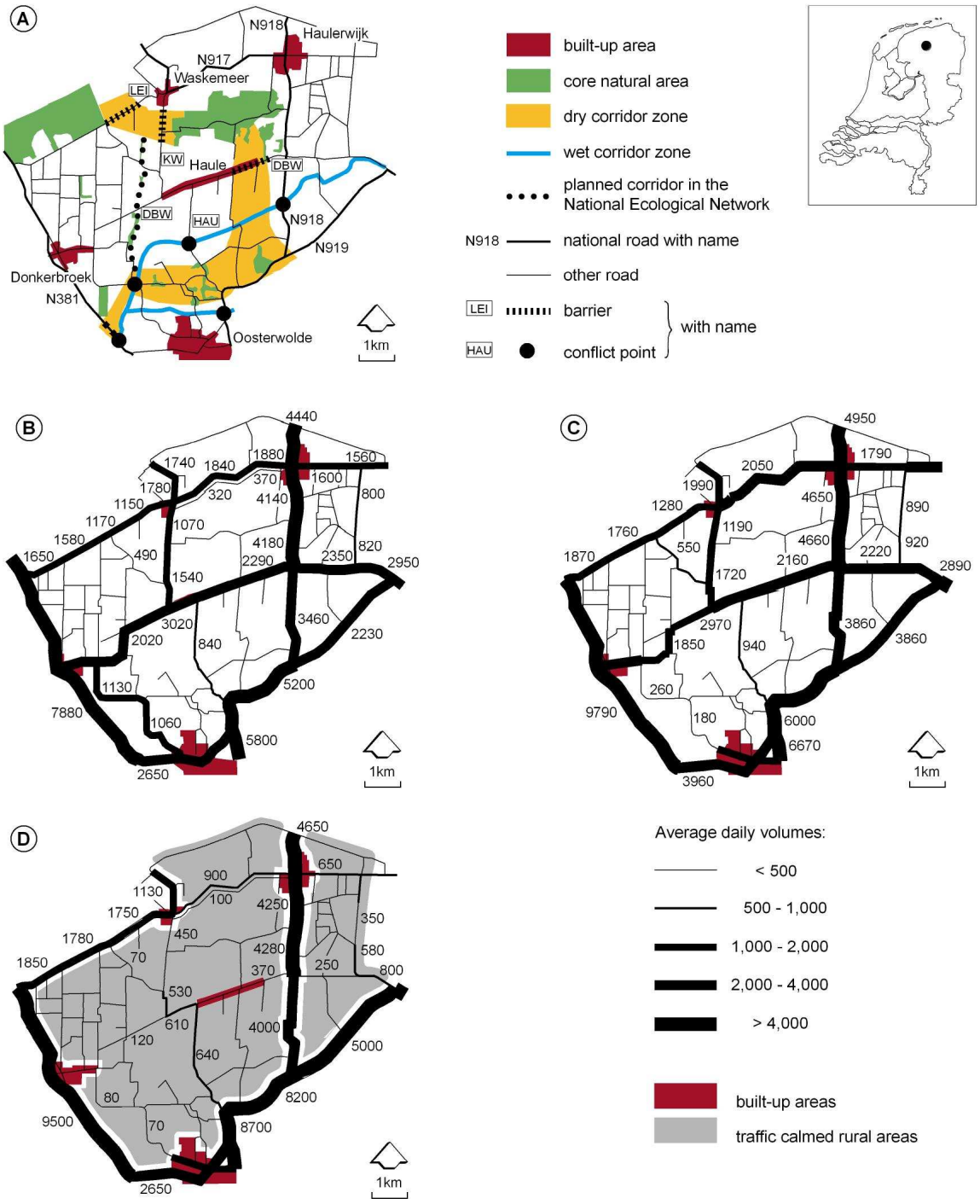

Figure 2. The ORVO study in the region of Ooststellingwerf, The Netherlands [5]. (A) Geographical situation with core nature areas, dry and wet corridors, and barriers and conflict points for wildlife movement. (B) Present traffic volumes in 1994. (C) Predicted volumes after 11 years, without traffic-calming. (D) Predicted volumes after 11 years when applying the concept of traffic-calmed rural areas.

In the situation with traffic calming, travel times slightly increase. However, given that the maximum distances in traffic calmed rural areas such as reported in ORVO are

about 10 km, this impact is restricted to only circa 1 minute for the longest trips on minor rural roads compared with the actual situation [16].

3.3 The process of the traffic calming

Following these results, the municipality decided to develop a Traffic Management Plan envisioning the structure of the total municipal rural road network. Despite consulting a wide range of actors during the research, the translation of the management plan into concrete measures proved to be difficult. A breakthrough was reached when the municipality became aware of the opportunity to considerably reduce the costs of road maintenance because lower volumes on many of the minor roads would greatly reduce road wear.

The Municipality of Ooststellingwerf then launched a project to improve the integration of rural roads into the landscape. This approach was an alternative to implementing several, mostly technical, sustainable safety measures. In addition to road safety, the project also focused on the area's cultural heritage. Pilot projects, like crossings on roads for through traffic within villages and some rural road sections, were successful because they not only improved traffic safety and greatly reduced maintenance costs but also integrated the landscape's cultural heritage with the speed reduction measures. Although no hard figures are available, the Municipality of Ooststellingwerf has stated that the measures have effectively slowed traffic and that the measures taken in the villages have shown especially positive results.

4 Discussion

4.1 The changing role of rural areas

The change in the Western European countryside from an agricultural dominated landscape into a multi-functional space does not change the need for a rural road network. However, this network now has to afford other services in addition to its traditional agricultural function. Rural tourism and individuals from nearby urban areas seeking relaxation prefer a situation with low traffic volumes and modest speeds of motorized traffic, especially when walking or biking in the area.

Minor rural roads should fit into the landscape without a predominantly technical design and without artificial physical measures to reduce speed. To achieve this goal, "green" measures with a design adapted to the local landscape should be used [18]. Implementing such measures is possible within an approach of rural traffic calming, which aims to concentrate (through) traffic as much as possible on the trunk roads. These roads are designed to cope with higher volumes and somewhat faster speeds, and in doing so, they leave the minor roads open for local access and use by recreational soft modes. This approach can also reduce wildlife habitat fragmentation [5].

4.2 The need for an integral approach

When used for recreational purposes, infrastructure has a paradoxical role: it enables city dwellers to travel to and within attractive landscapes, but it also constrains visitor

experience of that landscape [23]. Unlike a problem, a paradox by definition rules out finding a solution because it is about wanting two things that simply are not possible to realise at the same time. This particular paradox is about the various types of traffic flows in rural areas, each with specific physical requirements for infrastructure (Table 1), and each with potential conflicts where the activity patterns, i.e., the traffic flows, intersect and/or coincide. Conflicts also appear with animals moving through the landscape (Figure 2A). Each type of traffic, including dispersing animals, requires another road design, but it is quite impossible to fully separate the types of traffic into their own physical road networks.

Conflicts due to intersections and coinciding incompatible flows will have to be accepted as a fact of life. The challenge is how to cope with them. To do this, network design and road section layout should be approached within a wider perspective, as a subject of spatial planning, rather than simply as an aspect of transportation and road safety. Because spatial planning also considers other interests, such as nature conservation and rural tourism, it can deal with undesired effects in the future and search for opportunities to optimise the road network within an integral approach of the area's spatial development [23]. The concept of rural traffic calming with modestly designed minor roads primarily designed for short-distance, local-bound traffic and not suited for high speeds and fitted to the local landscape as much as possible can be helpful for such an approach [16].

5 Conclusion

In conclusion, the need for a rural road network in a rapidly changing Western European countryside remains unaltered. However, its affordability has to be adapted to serve not only the existing agricultural functions but also new interests such as nature conservation, rural tourism and cultural heritage. To provide a safe and comfortable access for present-day use of the multi-functional green space, transportation planning needs a wider approach, as a subject of an integrated spatial planning. The concept of rural traffic calming fits with implementing this wider approach serving road safety as well as new rural functions.

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