The 8th European Transport Safety Lecture

Safety in rural Europe
Reducing casualties on country roads in the EU

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Acknowledgements

The European Transport Safety Council (ETSC) is a Brussels-based, independent non-governmental organisation dedicated to the reduction of transport deaths and injuries in Europe. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

Once a year, ETSC, together with one of its members, organises the European Transport Safety Lecture. The lecture is given by a high-level policymaker with a strong research record or interest in transport safety science. The aim of the ETSL is to increase awareness of innovations and research-based transport safety policy making amongst senior levels of government, parliament and the private sector.

By mounting this annual event ETSC's objective is to stimulate a high level debate across the European Union, to exchange knowledge and experience and to help forge new commitment to efforts to reduce the risks and costs of transport crashes.

ETSL 2006 took place in Dresden with the help of ETSC German members, namely the German Road Safety Council (DVR) and the German Automobile and Travel Club (ARCD). This publication contains the lecture on the importance of safety on rural roads given by Prof. Maier, followed by the responses prepared by Prof. Tracz and Dr.-Ing. Mikulik. In addition, a special section dealing with the treatment of high-risk sites in rural areas with the aim of improving the safety of vulnerable road users has been included as an annex.

ETSC would like to thank all those who contributed to a successful Lecture, in particular, Mrs. Jacqueline Lacroix, Mr. Bernd Opolka, Prof. Reinhold Maier, Prof. Marian Tracz and Dr. Josef Mikulik.

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Safety in rural Europe - Reducing casualties on country roads in the EU

By Prof. Reinhold Maier
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Introduction

People tend to like driving on rural roads. As opposed to urban roads or motorways, driving on rural roads seems to be more pleasant. Given the choice, if a driver or a motorcyclist is not in a hurry, he or she might prefer to travel on a rural road. The idea of danger or risk does not affect their decision. Ellinghaus' study (2003) based on a questionnaire to assess drivers' attitudes shows that road users are normally not aware of the safety risks especially on rural roads. When asked to point out possible dangers on rural roads, drivers tend to think first of narrow curves and cross sections or poor road markings. They tend to underestimate other factors such as roadside obstacles and poor visibility when overtaking that play a big role as well.

Therefore, the causes of accidents on rural roads are ignored to a great extent. Tree-lined roads can be beautiful for walking and cycling, but they are potentially dangerous for car drivers or motorcyclists. Road users and most of the road planners or engineers seem to have neglected this problem so far.

It is therefore important to draw the attention of all road safety stakeholders to the safety problems on rural roads, and to highlight effective measures that should be implemented in order to improve the situation.

1. The safety problem at European level

The number of road accidents resulting in personal injury is estimated to be 1.4 million per year across the 25 EU Member States. If no serious action is taken, 450,000 people are likely to be injured or killed in accidents on rural roads every year.

According to more detailed accident data available in 14 EU Member States, more than two thirds (68%) of road deaths took place on roads outside cities. Data also show that the number of serious accidents is higher outside built-up areas. This trend is confirmed by data from 2003: 33% of all deaths occurred within built-up areas while 67 % took place outside built-up areas. Regarding this it should be noted that safety on rural roads has a direct impact on the overall road safety in Europe[1].

[1] SafetyNet reports, 2004 and 2005.

This safety problem affects particularly motorised road users on rural roads. Accidents involving pedestrians and cyclists occur more frequently in urban areas. In some of the member states due to structural distinctions there can be found higher numbers of non-motorised road users. Vehicle occupants and motorcycle riders represent more than 60% of all deaths in road traffic accidents. Therefore particular attention should be paid to car occupants and motorcyclists outside urban areas.

In light of the high number of serious accidents occuring on rural roads all over Europe, one has to look more into the details of these accidents. Where do they occur along the road network? When do they occur? Who is involved? Which kind of vehicles is involved? In order to obtain more information, the data available in the "Deutschen Statistischen Bundesamt" for 2003, 2004 and 2005 were used here for a detailed analysis.

2. Characteristics of rural road accidents

Approximately two thirds (60% in 2005, 64% in 2004) of road casualties in Germany took place on rural roads. Seriously injured persons correspond to 41% (2005) and 45% (2004) and slightly injured persons to 27% (2005) or 29% (2004).

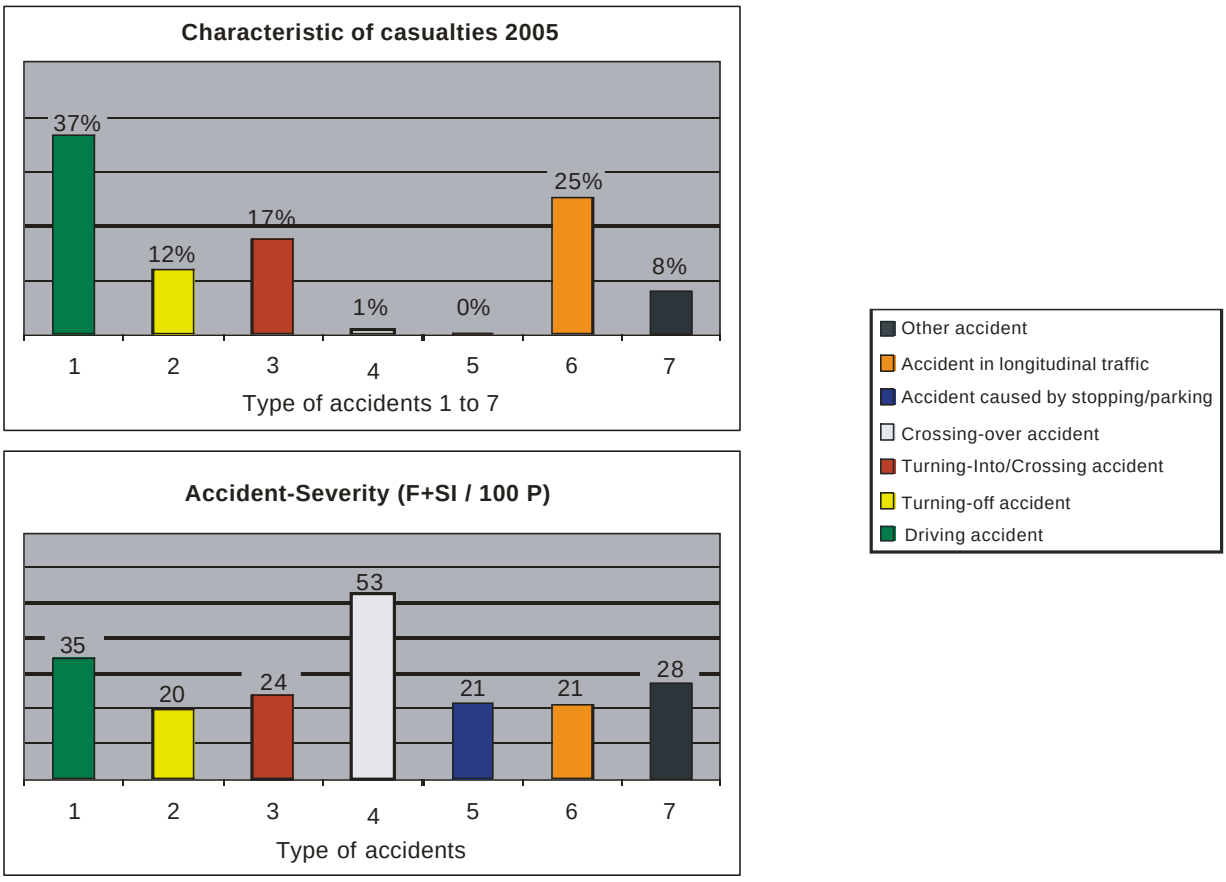

Fig. 1: Characteristic per accident type of all casualties and accident severity (Deaths and serious injured persons/100 casualties) on rural roads (Germany 2005, DEStatis)

On rural roads there are four major types of serious accidents:

(1) Driving off the road after losing control of the car due to inadequate speed or after overtaking lead to serious injuries. 37% of all accidents are of the type "driving accident", 44 persons in every 1,000 accidents are killed when vehicles run off the road,

The severity of accidents caused by veering off is higher when an impact against roadside obstacles occurs. The number of deaths per 1,000 accidents increases to more than 90 when trees are hit, and to more than 50 when cars crash against bridge columns or similar obstacles. Even safety fences/guardrails can increase the severity of accidents, compared to open areas: 39 persons in every 1,000 accidents are killed during collisions with safety fences, while only 17 persons die when a car runs off the paved carriageway without colliding with road barriers or obstacles. Therefore, forgiving roadsides can play a major role in reducing such collisions and the responsible authorities should eliminate unnecessary obstacles, move (where possible) obstacles away from the roadside, or, in the last resort, isolate existing obstacles by means of an energy absorbing barrier. Regional comparisons in Germany show that in certain *Länders* where most parts of the road section are equipped with rigid barriers comparatively fewer serious injuries are reported.

(2) Accidents at intersections caused by crossing or turning manoeuvres represent 29% of all accidents, if the two related types (turning into/crossing and turning off) are summed up. These accidents can lead to severe consequences, if the speed of the vehicles is high. Therefore two major problems are to be identified. The first one is the poor visibility of minor approaches to an intersection, preventing a driver from giving the priority. The second problem is the inadequate speed on the major road. At intersections equipped with traffic lights, all not compatible directions must be separately regulated by individual time-phases. This is also important for left-turning vehicles on the major road.

(3) Accidents caused by overtaking often result in collisions with cars from the opposite direction. 25% of all accidents belong to this type, 34 persons in every 1,000 accidents are killed in collisions with oncoming traffic. These head-on collisions also occur when car drivers lose control of their car due to inadequate speed. This is a very common occurrence on rural roads because of the diversity of traffic composition. Drivers of passenger cars expect to travel at high speed and feel hindered by slow traffic e.g. lorries or agricultural vehicles.

(4) Regarding the severity of accidents, the involvement of pedestrians should be the focus of improvements. In Germany accidents involving pedestrians represent only 1% of the accidents on rural roads, but their severity is the highest. One should consider this in combination with cyclist-involvement, because the suitable measure – a separated path for non-motorised road users – is useful to improve the safety for all kinds of slow and unprotected road users.

3. Characteristics of motorcycle accidents

Accidents involving motorcyclists also tend to be serious. The risk of fatal accidents involving this road user group is 7 times higher than those involving vehicle users with the same mileage. Most of the accidents are caused by motorcyclists themselves:

- About one third of all fatal accidents involving motorcyclists are single vehicle accidents without collisions with other vehicles.
- Another third happens in collisions with other vehicles where the motorcyclist is blamed for causing the accident.
- In only one third, motorcyclists are not at fault.

The reasons are obvious, as can be shown by accident statistics:

- Motorcyclists often speed. In general, motorcyclists like to be faster than other road users. They also tend to act on the assumption that their speed will not be checked.
- Drivers and pillion riders of motorbikes are considerably less protected than passengers of other vehicles. At low speeds, protective clothing and crash-helmets can help to a certain extent, but they are obviously less effective at high speeds.
- Motorcyclists often take hazardous routes such as winding mountain roads, and roads that cut through forests. Loosing control of the motorbike, and colliding with roadside barriers is a common cause of accidents.
- Rather than protecting motorcyclists in case of a collision, conventional safety-fences tend to cause more serious injuries.

4. Strategies to improve safety on rural roads

According to the findings in analyses of deaths and serious injuries on rural roads, the following recommendations should be taken into consideration:

a) Avoiding excessive speed

A high number of accidents on rural roads can be linked to excessive speed. Most of the EU Member States set speed limits on rural roads, but, in order for them to be respected, speed controls are necessary. If the set speed limit in high-risk sites (curves, approaching intersections and junctions) is controlled partly with mobile or fixed speed cameras, large sections of the rural road network remain unchecked. Furthermore, mobile speed monitoring has only a limited effect. Only fixed speed monitoring devices can achieve an effective speed decrease. The longitude of the impact is restricted, but for many sections this treatment is sufficient. For example to improve accidents at high risk accident sites there is a need to only reduce speed on a limited section.

An encompassing strategy including a combination of measures would be more effective in controlling speed. At dangerous locations with a history of accidents, fixed and mobile cameras would be needed. Supplementary controls should be undertaken

with frequent mobile monitoring at different points, so that a high level of monitoring of non speed compliance can be achieved.

b) Safe overtaking

On rural roads, overtaking is the most dangerous manoeuvre. Drivers generally are not able to judge distance and the speed of oncoming vehicles. As a result, individual judgements cannot be expected to be safe when overtaking. Therefore infrastructure should allow the driver to overtake safely as well as to anticipate potentially dangerous manoeuvres. New types of cross sections that manage overtaking manoeuvres and prevent them at dangerous sections can be useful.

c) Running off the road

In some EU Member States road sides are free of obstacles by standard regulations concerning road design on a large scale. Exemplary regulations consist of road sides free of road side hazards within a distance of 6 to 8 m beside the carriageway. Therefore, in countries where road sides are not legally free of barriers, mesures should be implemented in order to prevent collisions with barriers at road sides. This is especially relevant for tree-lined avenues and roads through forests that seem to be environmentally friendly. Even inclines and roads beside waters and railway lines are dangerous in this sense. Serious injuries resulting from leaving the carriageway can be avoided by passive protective devices which protect the passengers if the car is veering off.

Another alternative strategy can be seen in speed regulation and speed enforcement systems. Vehicle speed (both two-wheelers and cars) should not be allowed to exceed a speed of more than 80 km/h in tree-lined roads or similar situations. Since motorists often tend to drive above the posted speed limits, speed monitoring systems are needed. Efficient monitoring-systems are, for example, local systems with distances of maximum 4 km.

d) Safe design of crossings and T-junctions

Accidents at priority junctions and collisions of left turning vehicles with oncoming traffic have to be considered as a comprehensive safety concept. To improve safety some different ways are recommended:

- Local accident analysis should identify the road sections where frequent accidents at crossings and T-junctions occur and which type of accident is most common.
- Regarding priority accidents caused by an approaching road user on the minor road, measures to upgrade sight and perceptibility are recommended. If there is furthermore a high accident severity, additional measures necessary to reduce speed in the major road are recommended.
- If severe accidents are caused by left-turning vehicles, speed of the oncoming traffic should be reduced.

- In the case of light-controlled crossings the signal control has to be checked against safety shortcomings. Usually two-phase-operating traffic-light systems are not functional to guarantee safety and turn-vehicles must be protected separately. Traffic lights with a separate phase for the left-turn vehicles should be installed.
- If accidents with crossing cyclists play an important role traffic lights can upgrade safety at rural crossings.
- Roundabouts are measures with a high safety potential, but they have a limited capacity. Special considerations should be done before the introduction of roundabouts.

5. Conclusions and recommendations

Even though most of the accidents are caused by human mistakes, there is a need to investigate the impact of human behaviour on road design and traffic management. This leads to the need for relevant safety standards in designing new road transport facilities as well as for maintenance and management of existing infrastructure. In this case, in Germany some steps have just been taken which should lead to a better and improved safety level of all road traffic facilities. In this process, the issue of best possible safety level safety is the main focus, more than in the former guidelines.

At first there are specific design-guidelines for rural roads to develop. Until now the standards of cross section and intersection design were more or less similar for all road types within and outside built up areas. Following the actual considerations there will be specific regulations for rural roads, different from those for inner city streets or motorways. Thus the particular safety requirements of the special road situation are taken into consideration.

Besides that up-to-date results and existing knowledge concerning safe road design are included in new guidelines. Cross sections and intersections that supply an unfavourable safety level, are not recommended for new traffic facilities. Specific demands on operational characteristics of traffic facilities will be included in the guidelines. Therefore rural roads with 4 lanes will only be recommended combined with lane separation by a median barrier, for two lane roads safe overtaking areas will be included, safe distances for overtaking will be redefined and on intersections grade-separated solutions and roundabouts will be recommended for all situations where it is reasonable on rural roads. Intersections with traffic signals should always be supplied with protected left turns. If there is a need for cycle and pedestrian facilities, separate paths along the roadway are recommended.

Road safety audits will be carried out for all construction and reconstruction measures to consider the current state-of-the art. In training courses experienced road planners get to know additional safety aspects and are therefore able to check planning projects and identify safety deficiencies in advance. The responsibility of realising the considerations of the auditor still belongs to the road administration.

The procedure of network safety management is proposed for the need of extension of the road network and the renewal of long road sections. Then the difference between the current accident risk and the best safety level is calculated for defined road sections. This difference shows the safety potential that can be reached with a design which is compatible with the guidelines. The priority of road measures should comply with the amount of this potential.

Finally a continuing quality assurance for the existing road network considering road safety exists. Two procedures are used. The examination of traffic facilities for obvious deficiencies is conducted at regular intervals in a specific safety inspection. Safety relevant deficiencies are mainly signs for priority junctions, the proper equipment like guardrails and speed limits. Roads of high importance are inspected more often than roads with less traffic volume.

The local accident investigation identifies accumulations of accidents of the same kind on several spots in the road network. Reasonable priorities are possible through an additional rating of the accident severity. The regular identification and treatment of high risk sites on several locations and defined road sections can prevent up to one third of severe accidents.

In conclusion, a distinct safety benefit can be reached on the basis of the existing knowledge and experience with technical measures. On rural roads with a high accident risk, severe consequences can be expected because of high speeds and the chance of head on collisions. This separates rural roads from urban streets, that show lower speeds, and from motorways, that have no oncoming traffic, no intersections, no drivers taking a left turn. Rural roads can supply better safety levels by the previously described standards, just if the following main rules are obtained:

- appropriate speed limits and the acceptance of traffic rules by regular and frequent enforcement
- secure overtaking possibilities e.g. additional lanes and the prevention of overtaking manoeuvres where no safe over taking is possible
- roadways with more than one lane per direction should have a separation by a median barrier
- keep the road side free of any obstacles but at least include guardrails if there are non-removable obstacles
- on road sections with high numbers of motorbikes supply appropriate guardrails
- supply separate paths beside the roadway if there is a need for slow traffic like pedestrians, cyclists and agricultural vehicles
- upgrading of intersections on rural roads with high speeds to grade-separated junctions
- always include left turning protection on traffic signals
- roundabouts on intersections with low and uniformly distributed traffic streams

New and unfamiliar measures should be accompanied with appropriate public relations to reach a high level of understanding of the road users. All road users should understand that the changes in the traffic facility are made for their safety and therefore the compliance with the traffic rules is in their own interest. A new "thinking

environment" in road traffic should be created, in order to create a high level of safety. It should be published which traffic facilities are of a low safety standard and what are the reasons for this. This would result in a higher acceptance of unpopular measures like prohibition of overtaking and speed limits.

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Response to the 8th European Transport Safety Lecture

By Prof. Marian Tracz
Technical University of Cracow

Ladies and Gentlemen,
Prof. Maier,

Let me first thank you Prof. Maier for your excellent and convincing presentation. There are many similarities between the characteristics of rural roads safety in Germany and Poland and the suggested strategies to improve situation on rural roads. But, taking into account the Polish specificities, i.e. the recent developments in motorisation, in the road network and road environment, I cannot endorse all your conclusions and proposals.

1. Accident statistics

In 2005 in Poland 48100 accidents were recorded of which 29% on rural roads. More that 54% of all deaths and 32% of all injures were recorded on these roads. In the last 10 years, the overall number of killed and injured persons in road accidents decreased by 14%, whereas on rural roads it dropped only by about 10%. In this period, population dropped down by 1.24% and cars increased by 58%. The basic rates describing road safety are as follows: 14.5 killed/100 000 inhabitants, 3.5 killed/10 000 vehicles, 11.2 killed/100 accidents.

Table 2 shows a comparison between the number of deaths and injuries on all roads and on rural roads in the period 1996-2005 in a few categories of road users. The comparison shows a high severity of accidents on rural roads in all categories, and a very high percentage of victims among car drivers and car occupants on rural roads in comparison to other categories of road users.

Users	Year	Killed			Injured		
		Total	on rural roads	% on rural roads	Total	on rural roads	% on rural roads
All users	1996	6359	3265	51,3	71 419	22 356	31,3
	2005	5444	2949	54,2	61 191	19 793	32,3
	2005/1996	0,86	0,90		0,86	0,89	
Pedestrians	1996	2436	865	35,5	20 895	2234	10,7
	2005	1756	602	34,3	14 846	1298	8,7
	2005/1996	0,72	0,70		0,71	0,58	
Cyclists and motorcyclists	1996	693	314	45,3	6960	1463	21,0
	2005	656	309	47,1	6528	1274	19,5
	2005/1996	0,95	0,98		0,94	0,87	

Drivers and passengers of cars	1996 2005 2005/1996	2607 2526 0,97	1711 1718 1,005	65,6 68.0	35 378 33 770 0,95	15 287 14 687 0,96	43,2 43,5

Fig. 2. Comparison of trends in numbers of killed and injured on rural roads in Poland in 1996-2005 in a few categories of road users.

In 10 years, the number of deaths among car drivers and passengers on rural roads has slightly increased, whereas the number of injured in this category shows the lowest decrease. A significant decrease was recorded in the pedestrian group (30% in deaths and 42% in injuries) and a small one in the category of cyclists and motorcyclists. No doubt that the rise in the number of cars and the drop in pedestrian flows on rural roads have had an impact, but the reasons are also to be found in an increasing number of risky overtaking and excessive speeding.

On rural roads, car drivers and occupants (58.3% of all deaths, 74.2% of all injuries), pedestrians (20.4% of deaths), and cyclists and motorcyclists (10.5% of deaths) are particularly vulnerable. The percentage of trips of the last group is only 1 to 2% (Fig. 3).

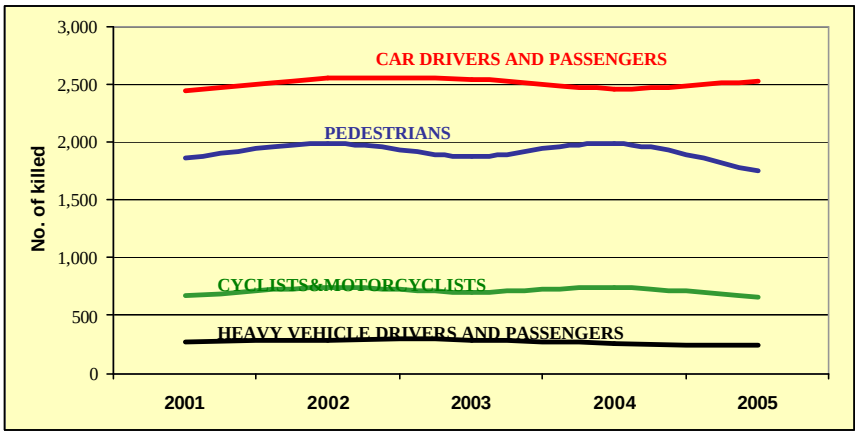

Fig.3 Killed in road accidents in Poland in period 2001-2005

2. Most important problems on Polish rural roads

No doubt that traffic congestion, lower speed limits, several traffic control measures and better speed enforcement make the severity of accidents in urban areas much lower than on rural roads. Inappropriate speed was identified by the police as the first cause of accidents (29%) on rural roads. The second was disregarding the right of way – mainly at intersections and pedestrian crossings (24%). Errors in performing manoeuvres such as overtaking was identified as the third cause (11%).

Violation of speed limits -which is common on rural roads- and incorrect overtaking cause very serious accidents. In Poland, on average, 45% of drivers exceed the speed limits. On national roads, 62% of drivers speed. In sections where these roads cross small towns and villages, 84% of drivers exceed the general or posted speed limits. I agree with Prof. Maier that due to the composition of traffic with widespread speed

dispersion there is still a high occurrence of overtaking linked with speed violation. This results in an increase in the number and severity of accidents, whereas risky overtaking causes serious off-road manoeuvre accidents. Rational speed limits, possibility of safe overtaking, categorisation of roads and better speed enforcement can significantly reduce this type of accident. Accidents caused by running off the lane after losing control of the vehicle can be slightly reduced by barriers and gentle slope of embankments in high-risk locations.

Accidents involving hitting fixed obstacles and trees on rural roads resulted in 12% of deaths and 7% of injuries in Poland. These accidents, which are typically caused by driving too fast, are frequent in some regions. In practice, narrowing a road decreases speed and, as a result, the severity of accidents can be lower. In practice though, changing the location of trees along the roads seems to be the only reasonable solution, in spite of some protests by environmentalists.

In curves, poor or incorrect traffic signs and the poor state of pavements (poor skid resistance and ruts) can cause several running-off accidents. Therefore, a special traffic sign system for horizontal curves, providing more information and better guidance, is being tested in Southern Poland.

Furthermore, a better protection of vulnerable road users is needed. A specific space should be dedicated to them when possible and bus stops and associated pedestrian crossings should be protected with specific lighting and additional signing.

There are doubts related to the effectiveness of the increasing number of traffic signs on rural roads on pedestrian crossings and on intersections without proper speed reduction and other safety measures. These issues need further investigations.

3. A longer and somewhat different way to improve safety on rural roads

I am convinced that a lot can be done in order to improve road safety on rural roads through the improvement of road infrastructure, road users' behaviour and planning of road environment development. One of the results of economical transformation has been the construction of new road sections without right planning and access control. Therefore reconstruction of the network is now more expensive and time consuming. As a result, the target of reducing accidents by 50% by 2010 included in the Polish Road Safety Program GAMBIT-2005 for the period 2005-2013 may not be reached as shown in Fig.4.

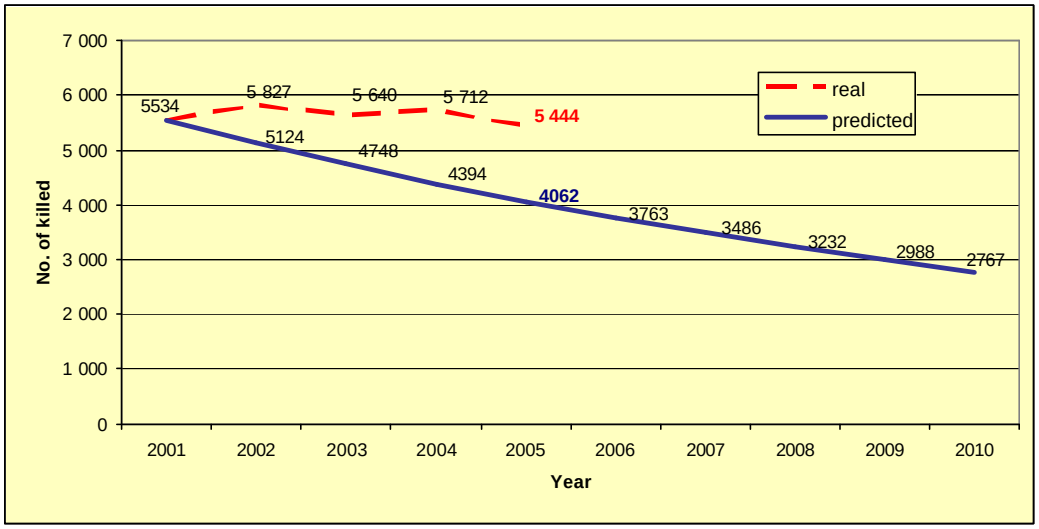

Fig.4 Predicted decrease and real numbers of deaths in Poland in period 2001-2005

Analyses of accidents on rural roads indicate that the following infrastructure measures can be very effective in improving safety:

(a) Better hierarchisation of the whole road transport network between motorways, express-roads, by-passes, together with required access control (through traffic calming measures) and better adjustment of the function and class of roads to the characteristics of their surroundings.

(b) Better segregation of traffic between various road users.

(c) Development of footpaths and cycle lanes with a minimum number of well protected conflict points with motorised traffic, especially on sections of national and regional roads through small towns and villages. Better clarification of priority rules on pedestrian crossings, in particular on "zebra" crossings, should be introduced too.

(d) Several improvements and measures in the design and reconstructions of new or existing roads, including:

- construction of facilities for safe overtaking such as additional lanes for overtaking or 2+1 sections taking into account existing access to road environment. The recommendations for the provision of overtaking possibilities have not been fully realised in the past, because of the low occurrence of overtaking, but recently due to increase of traffic volumes overtaking occurs much more frequently,
- reconstruction of almost 4000 km of two-lane roads with paved shoulders (provided originally for pedestrian and cycle traffic), which are frequently used as slow moving lanes giving way for risky overtaking by faster drivers on the basic lane,

- rebuilding existing intersections (including some channelised intersections), depending on a required capacity, as roundabouts and channelised intersections by taking into account the results of recent research and accident studies in these areas (shapes of islands, obstruction of visibility by vehicles, perceptibility, driveability, dynamic visibility, etc.)
- improvement of visibility on vertical and/or horizontal curves and on intersections,
- improvement of quality of road pavements through the removal of ruts and slippery sections,
- reconstruction or changes in traffic management in high risk locations such as dangerous intersections, pedestrian crossings and bus stops.

(e) Extending road safety audit (RSA) to all phases of planning, design and operation of national roads (only preliminary design and detailed design is audited today) and of other roads (regional, district and communal roads).

The RSA, which can efficiently remove most of the planning, geometrical designing, signing, marking and other errors, requires a good road safety training for auditors, designers and members of the road administration.

In the Road Safety Program GAMBIT 2005 some other tasks were included such as:

- Reconstruction of the road network in order to improve its hierarchisation and access control,
- Improvement of the quality of road pavements,
- Application of the highest safety standards in designing new infrastructure,
- Improving the road inspection standards,
- Implementing RSA on all roads,
- Increasing enforcement activities,
- Better protection of vulnerable road users through education campaigns and infrastructure measures

The whole process of traffic education needs continuous efforts and improvements, with a special emphasis laid on the education of learner drivers, novice drivers, as well as driving schools teachers.

A better enforcement of traffic law in the field of speeding, drink driving and seat belt use will help reducing the number and severity of accidents on rural roads. The use of mobile and fixed speed cameras, as well Intelligent Speed Adaptation, can significantly decrease speeding and risky overtaking. Drink driving offences should be systematically followed-up. Around 34% of car drivers and passengers still do not use safety belts.

Several measures recommended here are the same as those suggested by Prof. Maier. This confirms the need for coordinated actions to make our rural roads safer in a united Europe.

Response to the 8th European Transport Safety Lecture

By Dr.-Ing. Josef Mikulik
Czech Transport Research Center (CDV)

Executive Summary

This paper is the response to the paper of Professor Maier of the German Technical University in Dresden on road accidents on rural roads in Europe. The paper gives a case study of the road accident situation on rural roads in the Czech Republic and gives an overview of ways in which this problem is dealt with in the Czech Republic, one of the new EU member states. It stresses the importance of international co-operation in this field and gives some examples of best practice in some European countries.

Dear Professor Maier,
Ladies and Gentlemen,

It is a great honour for me being invited to this important ETSC Road Safety Lecture on road safety on rural roads across Europe. Because Professor's Maier paper is aimed at road accident data of 15 EU countries, I would like to focus on one of the new EU member states, my homeland the Czech Republic.

After that I would like to mention some best practice examples of various European countries, which have brought positive results in term of improving road safety on rural roads.

1. General road accident situation on rural roads in the Czech Republic

The Czech Republic has a population of 10 267 000 inhabitants and a GDP per capita of 15 082 US$. The road network consists of 518 km of motorways, 6 121 km of 1st class roads, 48 808 km of 2nd and 3rd class roads, and approximately 57 000 km of urban roads. Rural roads are a big part of our road network.

Road traffic accidents are still a serious health and social problem in the Czech Republic. There were 140 deaths per million inhabitants in 2003, which is twice as much as in Sweden and the United Kingdom. In 2005, there were 199 262 road accidents, 1 127 people killed, 4 396 seriously injured and 27 974 slightly injured people. Even though the situation in 2005 seems to be better according to 2004 data, it is still a serious one. The annual socio-economic costs are over 50 billion CzK.

	1995	*1996*	*1997*[2]	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Number of Deaths											
Rural Roads	772	786	828	740	815	816	764	813	486	777	702
Urban Roads	612	600	583	464	507	520	455	501	833	438	425
Number of Accidents											
Rural Roads	45960	49954	45774	50085	55456	51172	50316	51373		55319	53704
Urban Roads	129560	151743	152657	160053	170234	160344	135348	139345		141165	145558

Fig. 5: Number of road accidents and persons killed on rural and urban roads in the CR

Firstly, allow me to give you a brief overview of the basic statistical data of 2005 in the Czech Republic:

- on national rural 1st class roads, 39% of persons were killed,
- on regional rural 2nd class roads, 22.3% of persons were killed,
- on district rural 3rd class roads, 16.8% of persons were killed,
- on rural 1st class roads, 18% of all road accidents,
- roughly 30% of road accidents and 40% of persons killed were on rural roads including motorways,
- there were 53 704 road accidents with 702 people killed and 2 091 seriously injured and 11 514 slightly injured on rural roads, out of which 4 874 road accidents, 38 persons killed, 130 seriously and 565 slightly injured were on motorways,
- the trend seems to be positive – on rural roads there were 1 615 fewer accidents comparing to 2004, 75 fewer deaths, 251 fewer seriously injured, and 509 fewer slightly injured persons,
- 84% of road accidents were caused by drivers of motor vehicles, 1% by drivers of non-motorised vehicles, 0.2 by pedestrians, 12.2% by animals, 0.3% by inappropriate road surfaces, and 1.4% by technical failure of a vehicle on rural roads in 2005. This proportion has remained the same during the last decade,
- the highest accident rate is on straight stretches and in junctions,
- the highest number of persons killed is on straight stretches followed by bends caused by speeding – almost 54%,
- pedestrians, cyclists and motorcyclist are very vulnerable groups on rural roads; the first two groups especially at night (67% of pedestrians killed on rural roads were killed at night),

[2] In 1997, the 50 km/h speed limit was introduced in urban areas and the speed limit on motorways was raised from 110 to 130 km/h.

- concerning cyclists on rural roads, it should be stated that roughly 50% of them are killed on rural roads every year (data of 2004 and 2005 are that 50 and 45 cyclists were killed on rural roads).

Type of Road	*Number of Accidents*	*Number of Persons Killed*
Motorway	4874	38
1st Class Road	35150	440
2nd Class Road	29006	251
3rd Class Road	21637	189

Fig. 6: Data on road accidents on various types of rural roads (2005, Czech Republic)

Type of Road	*Transport Performance in million of vehicle km*	*Number of Killed on 1 billion of vehicle km*	*Number of Road Accidents involving injury on 1 million of vehicle km*
Motorway	11	11.3	99
1st Class Road	47.8	30.5	324.1
2nd Class Road	31.6	25.1	451.9
3rd Class Road	21.1	26.2	527.7

Fig. 7 Data related to transport performance

The tables above show that even though they have relatively very high transport performance, the motorways are safest types of roads in the Czech Republic, but the 1st class roads with the highest transport performance are the most dangerous ones. Data show that construction and maintenance parameters of roads play a very important role in road safety on rural roads. High traffic volumes, especially of haulage transport on lower classes of roads leading consequently to damage of road surface result into higher accident rates. This is not very visible in police road accident statistics due to the fact that there is an article in the Highway Code stating that the driver should adjust their style of driving to the road conditions. This fact should be investigated in more detail especially in the case of road accidents on rural roads.

Regarding the types of road accidents on rural roads, I fully agree with Professor Meier – head on collisions, accidents with solid obstacles are a serious problem. For instance, 50% of children killed in the Czech Republic in 2005 as car occupants were killed by hitting a tree due to speeding of the driver (32% of all accidents were caused by the driver of a motor vehicle; 54% were due to so-called inappropriate driving – a very "special" cause of accident). Single motorcycle accidents caused by speeding are typical for this group of vulnerable road users in the Czech Republic as well as in the rest of EU member states.

2. Interventions with the aim of improving road safety on rural roads

The most important instrument in the fight against road accidents, including those on rural roads, is the National Road Safety Strategy, which was approved by the Czech Government in 2004. Following the EC Road Safety Action Programme, the goal of this Strategy is to halve the number of road deaths (in 2002) by 2010.

The Strategy includes the following measures in order to cut the number of accidents, people killed and injured on rural roads:

- better road signing and marking,
- implementation of data bank of best practice of high-risk site management and implementation of the national methodology for high-risk site management,
- introduction of a formal policy on remedial action on high risk sites,
- implementation of road safety audits,
- removal of billboards from the road network as very dangerous solid obstacles,
- improvement of visibility of pedestrians,
- better road maintenance,
- reconstruction of better-arranged junctions and intersections (including construction of roundabouts),
- safer crossing of railways by road traffic,
- improvement of road signing and information systems,
- adaptation of safety equipments to the existing road network,
- improvement of surface parameters of existing pavements,
- separation of cyclists and pedestrians from motorised traffic,
- launch of nationwide campaigns aimed at visibility of pedestrians and cyclists, especially at night.

Furthermore, special attention was given to enforcement practice targeted to dangerous driving, speeding, and seat belt wearing. In order to get more effective police enforcement especially in the case of speeding, a higher number of automatic speed cameras were introduced.

As you probably know, the Czech Republic has introduced very important changes in its Highway Code, which could be called revolutionary, on 1st July 2006. The main changes in the Highway Code are as follows:

- introduction of a penalty point system,
- mandatory day time running lights all year round,
- stricter penalties for traffic offences (up to 2000 EURO),
- mandatory cycle helmets for cyclists up to 18 years,
- mandatory child restraint devices for children up to 36 kg and up to 150 cm on all types of roads,
- possibility of the Czech Police Force to confiscate driving licences on the spot in case of serious traffic offences,
- the Czech Police Force has in case of serious offences, the right to clamp the wheel of a vehicle to prevent further driving,

- when leaving a roundabout a driver should signal his/her intention to change direction.

As the first data on accidents show, there has been a decrease by roughly 70% of accidents and roughly 60% of deaths the first 14 days after introduction of the above mentioned changes.

The situation is rather complicated by a lack of funds for the implementation especially of traffic engineering measures at all levels. So it is necessary to take the cost / benefit ratio into account when planning the introduction of various road safety measures.

3. Institutions involved in the improvement of road safety on rural roads

As can be seen from the Strategy, most rural roads belong to regional authorities (1st, 2nd and 3rd class roads) and therefore they have the highest level of responsibility for road safety on rural roads. The Ministry of Transport is responsible for motorways and express ways only and for its own institution – the State Fund of Road Infrastructure, which is responsible for collecting money from motorway toll and using them for road improvements. Unfortunately, only a small part of this budget, roughly 20%, is spent on financing road safety measures. Last but not least another agency of the Ministry of Transport – the Road and Motorway Directorate - should be mentioned.

In short, the main institutions involved in the improvement of road safety in the Czech Republic are, according to the Czech legislation, as follows:

- Ministry of Transport,
- Road and Motorway Directorate,
- State Fund of Road Infrastructure,
- Regional Authorities,
- Police Force, Traffic Police Branch through its Regional Directorates.

4. Potential effectiveness of interventions on rural roads from various studies in Europe – We should learn from each other

Professor Maier has mentioned some of the measures to improve safety on rural roads so I would like to add some more examples of the best practices, especially those related to traffic engineering and road planning we have used during preparation of the Czech National Road Safety Strategy.

An interesting overview of various road safety measures which could be taken in order to improve road safety on rural road can be found in the WHO EURO publication "Preventing Road Traffic Injury: A Public Health Perspective for Europe" (2004). I would like to mention some of them listed in this publication:

- Crash cushions – reduction of fatal and serious injuries resulting from impact by 67% or more (UK),

- Flexible cable barriers on dual carriageways with no pedestrians or bicycles – reduction of fatal and serious injuries by 45 – 50% (UK, DK, S, CH),
- Decrease of speed limit on rural roads by 20 km/h – reduction of deaths by 6% (CH),
- Decrease of speed limit on motorway by 10 km/h – reduction of deaths by 12% (CH),
- Speed enforcement on rural roads both by mobile and automatic devices could reduced fatal accidents on this type of roads by 14%; stationary speed enforcement alone can reduce fatal and injury crashes by 6% (source WHO).

This publication also recommends the improvement of road safety by planning and designing roads for safety including the adoption of a safety-conscious design of roads; designing road function to meet needs and vulnerabilities of various types of road users and performing safety audits, and implementing remedial action at high-risk sites. Even though this has been suggested for all types of roads this is applicable for rural roads as well. This recommendation is very similar to the one mentioned in another WHO publication, and in various other studies saying that each road should be designed according to its particular function in the road network. A key characteristic of well designed roads is that it makes compliance with the intended speed limit a natural choice for drivers.

The comprehensive WHO World Report on Road Traffic Injury Prevention advises the following measures on single – lane carriageways which could be applied to rural roads as well:

- median barriers to prevent overtaking and to eliminate head - on collisions,
- improved vertical alignment,
- advisory speed limits in sharp bends,
- regular speed limit signs,
- rumble strips,
- systematic removal of roadside hazards – such as trees, utility poles and other solid objects.

The Swedish model of road safety strategy, known as Vision Zero, could be one of the examples of best practice, especially the introduction of "forgiving roads" and "self – explanatory roads" as a way to proceed in decreasing the number of road accidents and their consequences on rural road as well.

Significant progress could be achieved by European wide agreement on tools creating conditions for safe road infrastructure including:

- Road safety impact assessment
- Road safety audits
- Road safety inspections
- High Risk Site Management

5. Conclusions

Road accidents on rural roads seem to be a very serious problem in most EU Member States and therefore it should be treated accordingly. One of the very important parts of the EC Road Safety Programme is aimed at improving road safety on rural roads by e.g. introduction of road safety audits[3].

I would like to stress that road safety on rural roads should be tackled with complex and co-ordinated measures taken by all actors involved – ministries, road administrations, regional authorities, police and NGOs. Special attention should be given, as Professor Maier mentioned in his paper, to speeding, giving way in junctions, and enforcing wrong overtaking. As I mentioned before – we should learn from each of other, therefore dissemination of knowledge and the best practices should not be forgotten. This European Safety Lecture could be a very good example of a platform for such co-operation in Europe.

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[3] Studies have shown that road safety audits have a very good cost/benefit ratio of 1:20. A Danish study assessed the value in cost/benefit terms of 13 schemes and found first year rates of return of well over 100% (source WHO).

Enclosure : Accident data on rural roads in the Czech Republik

	Speeding	*Wrong overtaking*	*Not give a way*	*Wrong way of driving*
Motorway	29.8	1.2	4.4	65.5
1st Class road	21	5.7	16.4	57
2nd Class road	27	4.5	17.3	51.4
3rd Class road	32.2	2.5	13.7	51.6

Main causes of road accidents according to type of rural road, CZ, 2005 (in %)

	Number of Killed
Moped	3
Small motorcycle	7
Motorcycle - driver	47
Motorcycle - passenger	5
Personal car - driver	280
Personal car - passenger	208
Lorry - driver	31
Lorry - passenger	14
Bus - driver	0
Bus - passenger	0
Bike	45
Pedestrian	82

Number of persons killed on rural roads according to road user category, CZ, 2005

	Number of Accidents
Tree	5509
Column	3759
Corner stone	3577
Stationary vehicle	427
Wall, part of a bridge or tunnel	3835
Railway gates	223
Obstacle on road construction works	356
Safety barrier	4446

Types of solid obstacles involved in road accidents, CZ, 2005

Annex:
Examples of treatment of high-risk sites in rural areas - making roads safer for vulnerable road users

ETSC launched the VOICE campaign in 2005 with the aim of improving the safety of vulnerable road users (VRUs) across Europe. In the context of this campaign, a series of location specific studies are being undertaken in 12 EU countries, each of which highlights a very specific infrastructure problem that places vulnerable road users at risk.

The idea behind identifying examples of treatment of high-risk sites in rural roads, taking into account the needs of VRUs, is to highlight the needs of this group of road users that is often neglected by road authorities and policy-makers. The information contained in these case studies also draw attention to the need for more thorough investigations to be carried out prior to and after implementation of the chosen infrastructure measures. Evidence suggests that, at present, very little research focusing on safety measures for pedestrians and cyclists in rural areas is available.

The countries featuring in this study are: Ireland, Greece, Austria, Hungary, and Lithuania. They are part of the 12 countries being monitored under the VOICE campaign.

Ireland

These are examples of locations that have been treated in three different rural areas of Ireland. Even though some of the locations presented below did not have a history of accidents involving VRUs, the measures implemented have taken their needs into consideration.

South:
N22 Srelane

- Background: There were a number of accidents at this location including 2 fatal accidents involving pedestrians crossing the road.
- Treatment included traffic calming works such as central and edge islands with warning approach gateway signage to the location and lighting.
- Results: Accident analysis is not yet available but speed checks carried out showed a reduction in speeds (see table below).

Srelane	Speeds			
Location:	Max	Mean	85%	% below 80kph
Centre of scheme, at pedestrian refuge island	118	63	75	91
At approach Gateway	132	68	81	83
Free speed on approach, outside the effect of the treated area.	142	74	84	72

Table 1. Speed checks carried out at N22 Srelane

Before

After

N22 Glenflesk

- Background: Rural junction that has a shop and a church. There was no major accident history at this location but pedestrians were crossing to access the shop on a regular basis.
- Similar treatment to Srelane was implemented at this location.

After

After

Northeast
N3 South of Virginia

- Background: Pedestrians regularly walk from an adjacent village along the edge of the road to a junction 4 km from the village.
- Treatment: The road edge was widened and a colour surface with ribbing on the edge line was used to provide a space for pedestrians to walk.

After

Greece

The case studies presented below illustrate different road safety measures implemented in rural areas in Greece.

The first example is of a rural coastal road close to Athens with a high concentration of night clubs which attracts a large number of people from the greater Athens area, especially during summer.

Rural road section "Athens-Sounio"

- Background: During the period 1992-1996, 227 accidents with casualties were recorded along this road section. In these accidents, 24 people were killed while 40 people were seriously injured and 353 were slightly injured. High-risk spots were identified along this network based on accident data recorded by the Police as well traffic data for different sections.
- Possible causes: The high-risk spots selected and treated are located at 29-30 and 30-31 kilometres of the road network. As mentioned above, this is an area with several night clubs. More specifically, two very popular night clubs ("On the Rocks" and "Ribas") are situated in the area (see drawing). The possible causes for the increased number of accidents are: road side parking; left turns and u-turns that take place during entering/exiting from the night clubs and their parking areas; pedestrian crossing outside marked crosswalks, or the underpass; reduced visibility, especially at night.

- Treatment: The following interventions were finally implemented in 2000: traffic lights were installed; left turns and u-turns were made possible only through a deviation; a median on both sides of the road was constructed; the area was lighted.
- Results: Based on available figures, it appears that the total number of accidents and casualties has slightly decreased after the interventions took place in 2000. It must be noted, however, that no thorough investigation or research has been carried out since then. These are only preliminary results.

Kilometer	Accidents	Fatalities	Injuries	
			Serious	Slight
23-24	14	0	4	15
24-25	28	0	8	47
25-26	19	5	13	15
26-27	16	0	9	33
27-28	5	1	0	6
28-29	12	1	1	21
29-30	**20**	**2**	**5**	**26**
30-31	**12**	**0**	**3**	**15**
31-32	11	1	8	14
32-33	13	0	5	21
33-34	9	0	5	10
34-35	16	1	5	21
35-36	14	2	4	19
36-37	8	6	5	13
37-38	14	1	1	17
38-39	7	1	5	4
39-40	9	1	5	7
Total	**227**	**22**	**86**	**304**

Table 2. Number of road accidents and casualties at the examined kilometers of therural road section "Athens-Sounio" (in yellow), 1997-2000.

Kilometer	Accidents	Fatalities	Injuries	
			Serious	Slight
23-24	1	0	0	1
24-25	26	2	3	44
25-26	13	3	2	15
26-27	18	0	1	30
27-28	5	3	0	10
28-29	11	2	3	11
29-30	**14**	**1**	**4**	**18**
30-31	**9**	**1**	**4**	**11**
31-32	10	1	0	19
32-33	14	2	12	19
33-34	8	0	0	15
34-35	20	0	8	29
35-36	18	3	2	27
36-37	13	1	3	24
37-38	25	4	1	30
38-39	9	4	2	16
39-40	4	1	2	4
Total	**218**	**28**	**47**	**323**

Table 3. Number of road accidents and casualties at the examined kilometers of the rural road section "Athens-Sounio" (in yellow), 2001-2004.

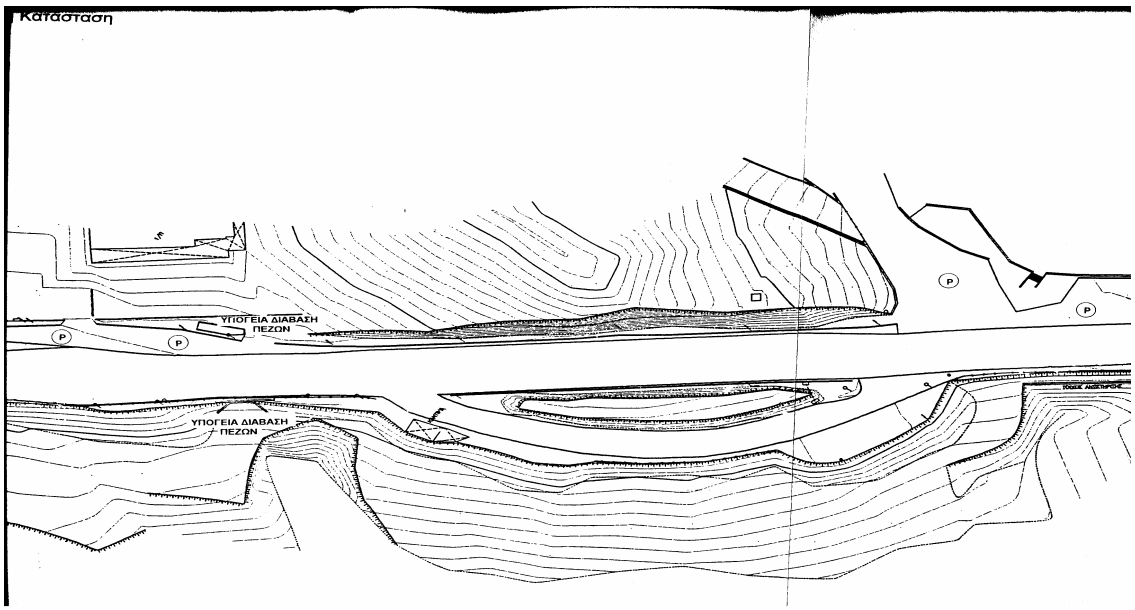


Figure 1. High risk spot on the rural road network "Athens-Sounio", Greece – Before

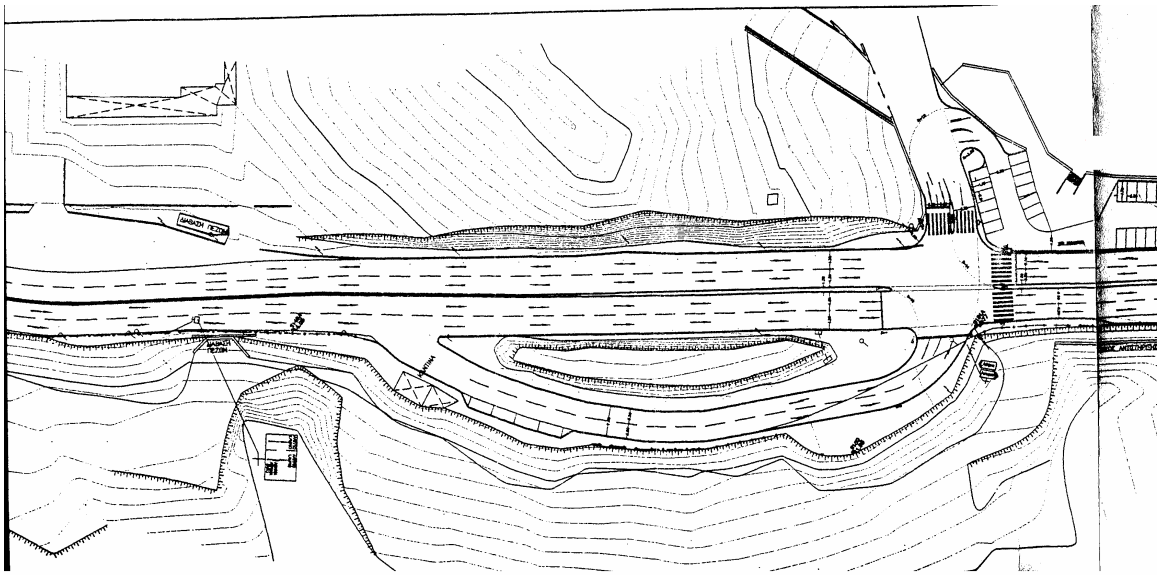


Figure 2. High risk spot on the rural road network "Athens-Sounio", Greece - After

The second example illustrates another attempt to improve the safety of vulnerable road users. This could serve as a useful reminder to road safety authorities that comprehensive policies encompassing a number of measures and initiatives are more likely to succeed.

National Road Patras - Pyrgos

- Background: There was a local request for a safe way for pedestrians to cross the dangerous National Road Patras-Pyrgos at the Lechaina areas. Even though there were traffic lights in operation in the area, the request was for either an overpass or underpass.
- Possible causes: This site is a rural road that is part of the National Road. The cross section consists of one lane per direction with a paved shoulder. There is no physical separation between the lanes. This is a typical example of the type of cross section implemented on rural roads in Greece in the past. Many accidents in the country occur in the rural road network. In this particular site, some of the possible causes of accidents are: the absence of a physical separation between lanes going in opposite directions; pedestrians crossing outside the marked crosswalks; drivers jumping the red traffic light; reduced visibility, especially at night; and the absence of police enforcement.
- Treatment: The Ministry of Public Works, responsible for the maintenance and operation of this specific road section, decided to construct a steel bridge. The construction of the pedestrian overpass was initiated in 2000, at the 58.9 km of the National Road Patras-Pyrgos. The existing traffic lights were located only 50 metres away.
- Results: As shown in the accident tables below, in the three-year period after the construction of the pedestrian overpass, 6 accidents occurred as opposed to the 5

accidents during the four preceding years. It should be noted that only one accident involving pedestrians occurred in each respective period. Nevertheless, only one person had been injured before as opposed to the two deaths after the bridge was constructed. The apparent lack of road safety improvement before and after implementation of the pedestrian facility may be due to the following factors:

- Pedestrian overpass lacking an attractive design and amenities.
- Pedestrians still tend to prefer crossing the road when vehicles stop at a red light.
- Lack of public awareness about road safety issues.
- Absence of a physical separation between lanes going in opposite directions.
- Car driving through red traffic lights.
- Reduced visibility.
- Absence of police enforcement.

Year	Type of vehicle/people-accident involved	Fatalities	Injuries
1996	passenger car & passenger car	0	3
1997	passenger car & heavy vehicle	3	2
1997	passenger car & passenger car	0	1
1997	passenger car & heavy vehicle	0	2
1998	passenger car & pedestrian	0	1
	TOTAL:	3	9

Table 4. Accident data for the period 1996-2000

Year	Type of vehicle/people-accident involved	Fatalities	Injuries
2001	motorcycle	0	1
2002	heavy vehicle & pedestrian	2	0
2002	passenger car	0	2
2003	passenger car & passenger car	2	2
2003	passenger car & heavy vehicle	0	4
2003	passenger car & passenger car	0	3
	TOTAL:	4	12

Table 5. Accident data for the period 2001-2003

It should be noted that no thorough investigation or research has been carried out allowing for safe and reliable conclusions to be revealed regarding this high-risk spot. These are only preliminary results and should be treated accordingly.

Pedestrian overpass

Austria

A high-risk site was identified along a rural road (km 18.150 – 18.200) near Traisen in Lower Austria where a number of accidents were recorded, including 2 involving vulnerable road users.

Road B 20 (km 18.150 – 18.200)

- Background: Near the town of Traisen in southern Austria, a canalised T-Junction along the B-20 road was identified as a high-risk spot. Accidents involved mostly drivers making right turns from one street into the other.
- Treatment: A roundabout was introduced between July and October 1997 and the speed limit was reduced to 60 km/h. Cost: 254 350 EUR.
- Results: Through the introduction of the roundabout, road safety improved. Accidents linked to giving way or involving pedestrians could be avoided. Savings resulting from the introduction of the roundabout were also high in the range of 70%.

Accidents, Casualties per year
BEFORE 1993 - June 1997 (4,5 Years)
AFTER Nov. 1997 - 2001 (4,17 Years)

Per Year	BEFORE	AFTER	Changes
Personal injr.	2,22	0,72	-68%
Casualties	2,44	0,72	-70%
Deaths			
Heavy injur.	0,67	0,24	-65%
Light injur.	1,78	0,48	-73%

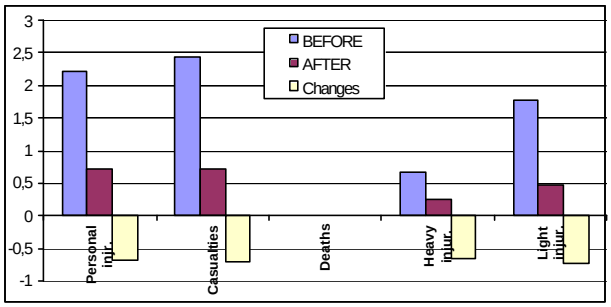


Table 6. Before – After Comparison (Before 1993 – June 1997, After November 1997 – 2001)

B20 direction Wilhelmsburg

B20 direction Lilienfeld

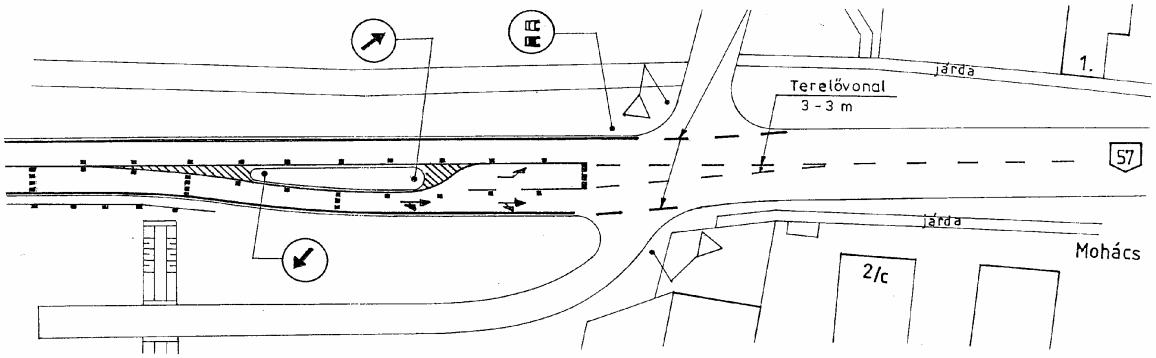
Hungary

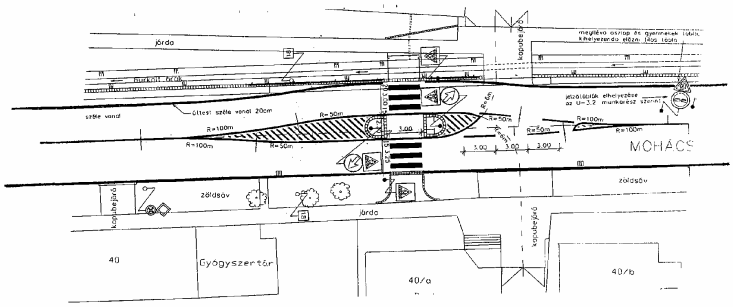
Baranya County, in Hungary, is characterised by a hilly landscape with many bumps and summit curves along its 1,600 km road network. The concentration of settlements (301 in total) in the area is considerably higher than the national average. Some of these settlements are very small, which discourages drivers from slowing down. Furthermore, many pedestrians tend to walk on the roads because of the lack of pedestrian facilities. Cycle lanes are also practically non-existent. Therefore, it is important to ensure that measures to protect VRUs are implemented. The examples below illustrate some of the initiatives taken to tackle this safety problem:

Széderkény and Kozármisleny

- Background: The Main Road 57 runs through Szederkény. There is heavy traffic and most drivers exceed the 50 km/h speed limit.
- Treatment: A traffic island was placed at the start of the settlement and a refuge at the primary school (figure 1). In Kozármisleny (figure 2), a refuge was placed between two bus-stops on opposite sides of the road. It was important to increase pedestrian safety here as many people use public transport to get to the city of Pécs.
- Results: Refuges have greatly increased the safety of pedestrians, especially near schools and bus stops.

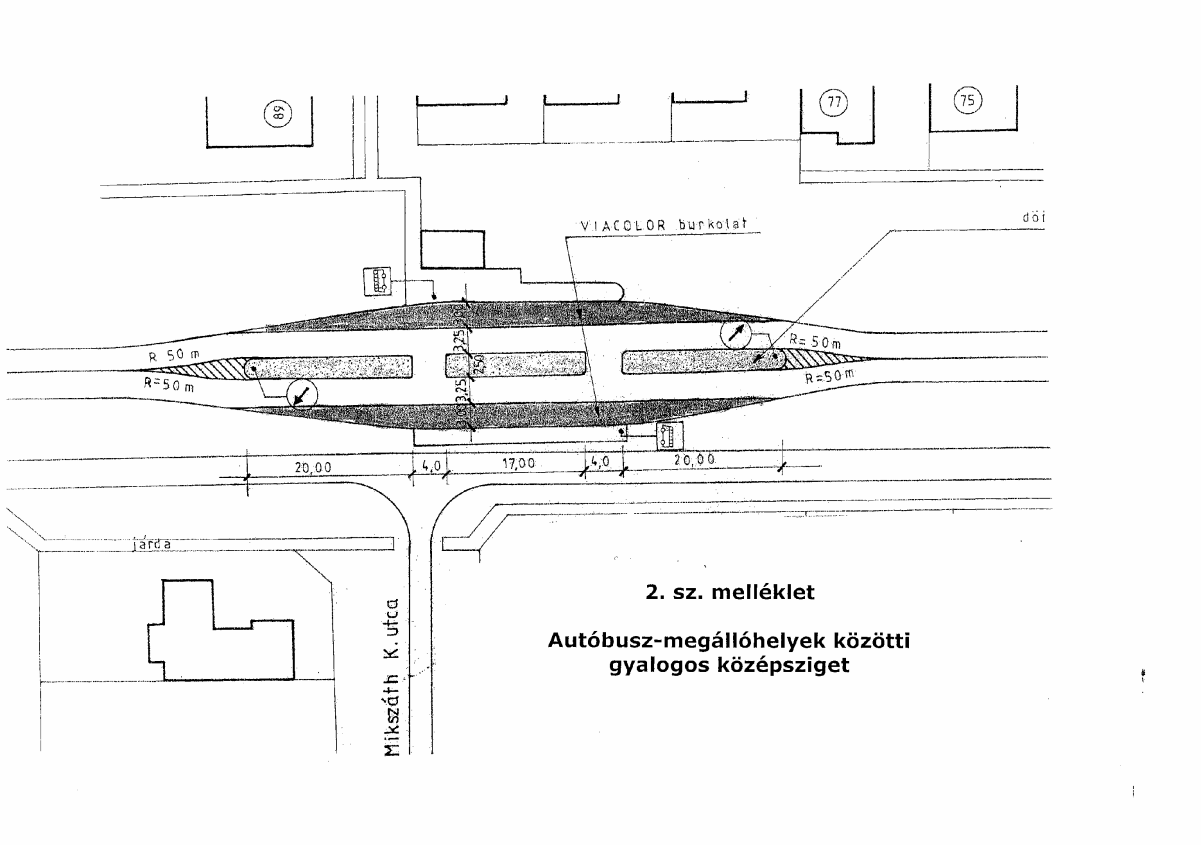
Széderkény





1. sz. melléklet

Forgalomcsillapító- és gyalogos középsziget



Kozármisleny

Magyarszék

- Background: In Magyarszék, a high number of pedestrians cross the main road in the city centre to access public buildings, schools and bus-stops.

- Treatment: Transversal road markings and speed limit signs painted on the road have been used. According to Hungarian road traffic regulations, they are normally used at the beginning of settlements where normally traffic islands would be placed, but not in this case due to lack of financial resources. The distance between the transversal road markings becomes smaller as one approaches the settlement thus making drivers slow down.
- Results: The speed of vehicles approaching the town has been reduced by 15 km/h since the implementation of this measure.

Magyarszék

Others examples

- Treatment: Automatic metres and infrared laser speed detectors have been placed in 10 settlements 200-300 metres from zones with the heaviest pedestrian traffic. This would ensure increased safety where it was most needed.
- Results: The devices were tested on the spot and were found to work well. The tests were carried out 200 metres after the sensors were placed. Results indicate that drivers exceeding the speed limit slowed down upon seeing the sensor.

Lithuania

This section describes, in more general terms, how high-risk sites are identified, analysed, treated, and evaluated in Lithuania.

Identification: In Lithuania, reports on high-risk sites are prepared by the Traffic Safety Group of the Transport and Road Research Institute. These consist of:

- The summary of all accidents on the road section studied (see examples below), which shows the number of accidents, dates, accident location, hour, accident type, driving conditions (pavement condition, visibility, weather conditions), accident circumstances, and the number of injured or killed persons;

- Photos of the road section studied;
- A scheme of the road section with existing road signs and accident locations;
- Accident data summary comprising: the number of casualties on the road; accident distribution by type, months, and weather conditions; road pavement condition; prevailing infringements of traffic rules; main accident causes.

Analysis: The analysis of high-risk sites determines the main accident causes and helps to select measures to reduce the number of accidents. The analysis takes into consideration road infrastructure, skid resistance, traffic measures suggested and solutions to reduce accidents. Based on the type of accident and other determining factors, remedial measures are selected, i.e. pedestrian and bicycle tracks, overtaking lanes, pedestrian islands, ring intersections, safeguards, and improved road marking.

Treatment: The following are some of the most common road safety measures implemented at high-risk sites, many of which are found in rural areas:

- Vulnerable road users: pedestrian lanes and cycle tracks, grade-separated intersections, traffic island on zebra crossing, illumination of zebra crossing, diversion of pedestrians and cyclists to minor roads;
- Road improvements: reconstruction of main roads, sign posts on rural roads, road widening, construction of overtaking lanes, paving gravel roads, placing bus stops near small settlements;
- Improving road environments: new lighting, replacement of rigid illumination poles with more flexible ones, visibility improvements, animal barriers on main roads;
- Road safety measures at intersections: building roundabouts or grade-separated intersections, reconstruction of X-shaped intersections into T-shaped intersections, installing traffic lights;
- Speed limits: increase and reduction of speed – speed limit changes in summer and winter;
- Road markings: painting central and edge lines, pavement markings at intersections; shoulder posts with reflectors;

Results: A cost-benefit analysis of road safety measures is carried out by TARVAL, a Finnish computer programme adapted to the Lithuanian context. It calculates the forecasted reduction in the number of casualties for one year, based on a four-year (1998-2001) accident rate, traffic volume on main and national roads, and impact coefficients of the suggested measures. A coefficient of the impact of a certain measure shows how many times the accident rate could be reduced after its implementation. Table 7 gives a forecasted change in the number of accidents after the implementation of certain road safety measures.

Road No.	No. of measure	Measure description	Section, from km to km	Section length, m	AADT veh/day	Accidents avoided per year	Deaths avoided per year	Injured people avoided per year
1	2	3	4	4	6	7	8	9
A1	608	Marking road pavement with the sign "Pedestrians"	25,70 – 26,20	500	12820	0,022	0,007	0,025
A1	804	Road maintenance improvement in winter	25,70 – 26,20	500	12820	0,022	0,007	0,025
A1	904	Erection of precaution signs (Nor.128, Nor.136)	25,50 – 26,40	900	12820	0,031	0,01	0,036
A5	204	Erection of overtaking lane; Repair of petrol station entry	10,80 – 11,20	400	7900	0,025	0,007	0,027
A5	508	Speed limit up to 70 km/h	72,80 – 73,40	600	4960	0,031	0,009	0,034
A5	604	Marking a central lane 1.1 and the edge lane	72,80 – 73,40	600	4960	0,034	0,01	0,037
A5	903	Erection of prohibitory signs (No.325)	72,80 – 73,40	600	4960	0,015	0,004	0,017

Table 7: Changes in the "black spots" on main and national Lithuanian roads

A systematic work on traffic safety has had a positive effect on Lithuanian roads. If in the period 1996-1999, the number of high-risk sites per 1 km of road was 0,0301, between 1997-2000 it dropped to 0,0274. However, it must be noted that increasing traffic flows are likely to generate new high-risk sites.

Evaluation: After the implementation of road safety measures, it sometimes happens that one or more high-risk spots are found not within the 15-20 accidents category but in 4-6 accidents, which are scattered along the length of 500 metres or more. Furthermore, their causes can be different, according to records. Therefore, police data registered in accident reports are insufficient. The number of locations with a high rate of accidents increases where the accident causes are unknown, in spite of the information available on road parameters, visibility, and traffic volume. With a lower accident rate, the impact of so-called occasional accidents is larger. Some of the causes of these accidents are clear – drunk or fatigued drivers, defective vehicles, inattentive pedestrians, defective horse-carts, and so on. However, other causes are not so easy to identify – persistent speeding, distraction and carelessness, etc. Occasional accidents distort and complicate the analysis, especially when the number of accidents at a certain location is not high.

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