Roads to Respect

A European Programme
for Better Road Safety Engineering

European Transport Safety Council

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I. Introduction: Roads to Respect

The "Roads to Respect" (R2R) programme focuses on treating high risk infrastructure sites as this is an area of road safety work where substantial and sustainable casualty reductions can be achieved in relatively short time and at relatively low cost.

The programme rests on four strategic elements:

-the LECTURE

-the CAMP

-the Road Safety CAMPAIGN

- the AWARD CEREMONY

ETSC will give in 2010 a LECTURE on improving the safety of road infrastructure to universities in Italy, Poland, Serbia and, for the first time, Bosnia. The LECTURE will draw on scientific evidence illustrating the lack of infrastructure safety and highlight solutions on how to improve the safety of roads. The LECTURE will help launch the call for applications to the Camp amongst students. Those students interested in taking part in the R2R programme will have to select a high risk site on their hometowns and to develop a low cost project to improve safety conditions on that spot.

At the CAMP, selected candidates from each country will be invited to receive road safety training during a five-day course in Brussels. The aim of this Camp is to build basic road safety knowledge amongst the participating students. The students will also receive training from professional campaigners, road safety experts and journalists in running a road safety campaign. During the R2R Camp, the participants will have to present their selected high risk sites and the initial conception of the road safety Campaign they plan to run. The purpose of this presentation at the R2R Camp is to take advantage of the presence of international road safety experts and professional campaigners to improve the quality of their individual projects.

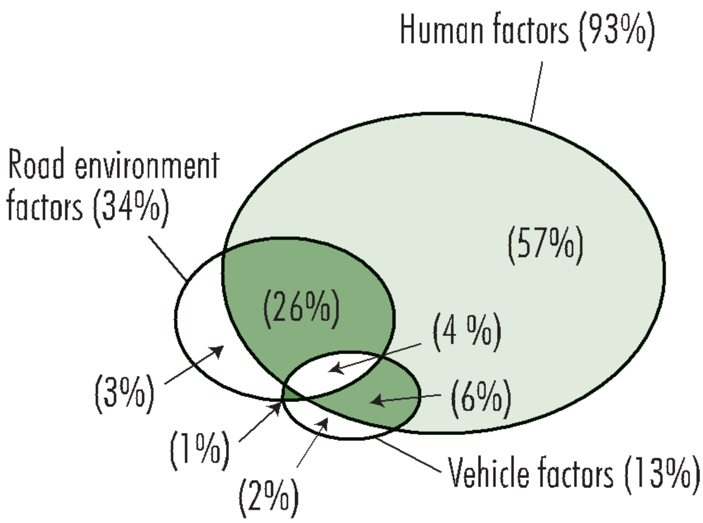
The Road Safety CAMPAIGN: After returning to their countries the students will try to treat a high risk site of their choice by developing the structure of their own science- based campaign. They will need to involve all the relevant stakeholders (local authorities, universities, citizens, mass media…) to get their projects implemented in a short period of time. Their final reports' on the actions carried out during their road safety

Campaigns will be evaluated by a group of international road safety experts, the R2R Jury.

On the basis of their results, the three best students will be invited to Brussels to attend an AWARD CEREMONY and to present the results of their efforts to road safety scientists, policy makers and private companies. This event will provide good opportunities for all actors involved to learn about best practice examples and to share their experience in science-based road safety campaigning.

Why focus on Infrastructure?

According to the EU Commission, road infrastructure and road design are a contributing factor in one out of three fatal accidents. Road safety research shows that safer road design and layout would do most to reduce the rate of death and serious injury. Present road design results from many decades of construction and maintenance in a time when safety issues where diluted among other considerations. Many roads do not meet latest safety requirements. On top of that, traffic conditions have changed dramatically.



Source: PIARC Road Safety Manual, PIARC Technical Committee on Road Safety (C13)

With safer roads, deaths and injuries are preventable. Good roads enforce desired traffic behaviour by assisting the task of driving and offer an environment that is adapted to the limitations of human capacity. Good road design enforces desired traffic behaviour by assisting the task of driving and offering an environment that is adapted to the limitations of human capacity.

The way roads are laid out and designed can reduce the exposure to traffic of vulnerable road users, reduce the probability that crash and injury occur when these users are exposed and reduce the severity of injury if it occurs.

Previous Experiences: R2R 2007-2009

In 2007 ETSC developed the first edition of the Roads to Respect Programme. Between May and June 2007 ETSC delivered lectures in 17 of the best universities in Italy, Spain, and Poland to raise awareness on the need to improve the safety of road infrastructure and recruit students to participate in the R2R experience.

In September 2007, 19 highly motivated students attended the Roads to Respect Camp; a one week training course on road safety with a special focus on infrastructure safety and how to lobby local authorities to get high risk roads treated.

The strategy followed was to involve as many stakeholders as possible (University, citizens, police officers, local businesspersons, large companies…) in persuading the infrastructure managers to act on a dangerous situation.

During the CAMPAIGN students used the knowledge acquired both in their academic life and during the R2R CAMP. They were able to reach considerable success (six high risk sites were positively treated) and, more important, they developed a life-long commitment towards road safety.

Four students were awarded at the CEREMONY held in Brussels on the 1st of October 2008. Stefano Cara from the Polytechnic University of Milano and Lorena Ruiz from the University of Valencia were respectively the Italian and Spanish winners. Iwona Sulkowska and Piotr Paleczny from the Krakow University of Technology were the Polish winners. They also received the prize for the best project of R2R 2007.

In 2008, the 2nd edition of Roads to Respect moved to 7 new countries: Bulgaria, Croatia, Cyprus, Greece, Romania, Serbia and Slovenia. Nineteen students from eleven universities participated in the 2008 CAMP. Their road safety CAMPAIGNS started in October 2008 and their success has been astonishing so far. Nine of the Campaigns succeeded and some of the measures proposed by the students have been already put into practice. Petar Krasic, from the University of Novi Sad (Serbia), Petros Sekeris, from the Democritus University of Thrace (Greece) and Marios Philippou, from the University of Cyprus (Cyprus) received respectively the third, second and first R2R 2008 Award in ceremony held at the European Parliament on 30th September 2009.

R2R 2009 wants to use the experience gathered in the two previous editions reinforcing the impact of the Roads to Respect Programme on the European road network. 25 transport and civil engineering students from Czech Republic, Germany, Hungary, Italy, Poland and Portugal were selected to take part in R2R 2009 after introducing the programme to more than 1,000 students in 23 engineering faculties. The R2R Camp 2009 took place in Brussels from 28 September to 2 October 2009 and there the students presented their initiatives to treat a high risk site. In this edition, the majority of the projects will focus on ensuring the safety for vulnerable road users, particularly pedestrians.

Examples of High Risk Sites treated in R2R 2008

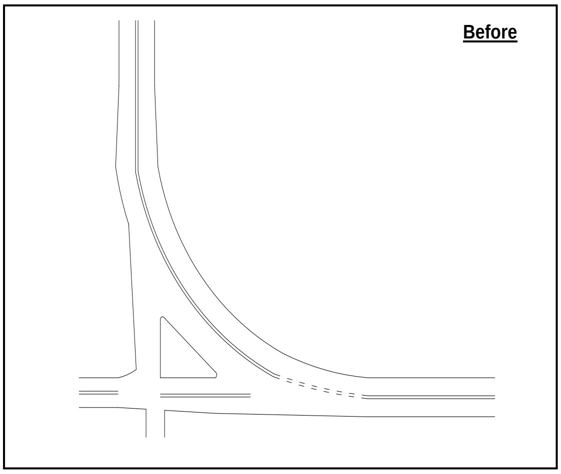
As already stated, R2R programme aims at treating high risk sites in relatively short time and at relatively low cost.
R2R students have been committed to propose low-cost measures in the area they selected to improve road infrastructure safety.

The pictures below will give an idea of successful projects developed by the students who have been awarded at the R2R Ceremony on 30th September 2009:

Marios Philippou (Cyprus): R2R 2008 Winner

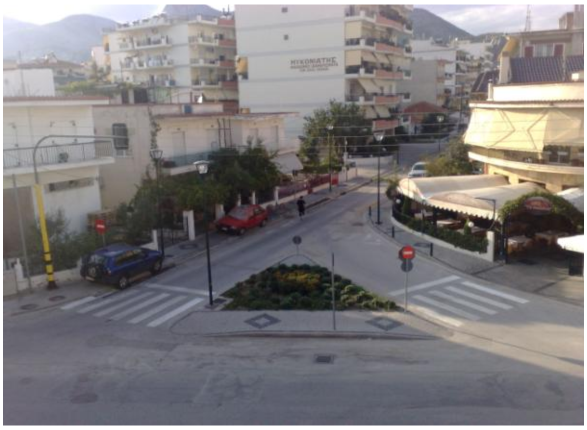
Marios improved the safety situation on a road section (one kilometer) in Cyprus by painting new markings, installing vertical signals in the right place and introducing reflective materials on the road sides. The final objective was to improve the visibility of the drivers and lighting in that section.

Petros Sekeris (Greece): R2R 2008 2nd Award



Petros treated a particularly dangerous site in a built-up area in Northern Greece, which tends to get very busy during summer. The main problem related to the spot is the lack of visibility and adequate road markings in addition to the absence of any priority signs.
He improved the safety of the area by installing vertical and horizontal signs at the junction to make the spot more clear and visible to all the users of the road.

Petros was also able to run a second campaign on another high risk site in the city of Xanthi. His project has been successfully implemented, as the pictures below show.



Petar Krasic (Serbia): R2R 2008 3rd Award

Petar’s high risk site is a local road in Serbia designed without any protective crash barrier. Furthermore there is not enough space to avoid a potential car crash. If vehicles get off from the road, it will hit a tree. Road pavement have moreover a waved form so that in some places it gives insufficient visibility. Petros proposal consisted in installing safety barriers and road studs alongside of the road, and traffic signs and road markings to avoid scarce visibility of curves.

II. Safe Road Design: Theory

Any road traffic system is highly complex and hazardous to human health. Elements of the system include motor vehicles, roads and road users and their physical, social and economic environments. Making a road traffic system less hazardous requires a "systems approach" – understanding the system as a whole and the interaction between its elements, and identifying where there is potential for intervention. In particular, it requires recognition that the human body is highly vulnerable to injury and that humans make mistakes. A safe road traffic system is one that accommodates and compensates for human vulnerability and fallibility.

One overarching rule:

"The infrastructure should prevent collisions of moving objects with large differences in direction, speed, and mass and should also inform the road user what behaviour is expected. "

Differences in mass, speed, and direction of vehicles is a basic risk factor for accidents

Pedestrians are also 'moving objects' and their speed and mass differ greatly from that of other objects such as motor vehicles that are present in their vicinity. In all countries, road networks are laid out and most roads are designed largely from the perspective of motor vehicle users. From the perspective of pedestrians and cyclists, mixing them with motor vehicles capable of traveling at high speeds is the most important road safety problem. Pedestrians and cyclists are relatively safe only on roads where motor vehicles are traveling at less than 30 km/h.

Three core principles should be applied to make sure that collisions are prevented.

Core Principles:

Core principles governing safe infrastructure design can be found in the Dutch' 'Sustainable Safety' approach, according to which a road network should integrate. (SWOV, 2006):

FUNCTIONALITY

A road network planned for safety has a hierarchy of roads, with several levels or classifications of road, each intended to serve a certain function. In 1998, the Netherlands launched a programme of reclassifying its roads and then modifying them so that every road would have a clear, unambiguous function. An earlier study predicted that this clarification of function for all roads could reduce by more than one third the average number of road traffic injuries per vehicle–kilometer traveled.

Roads can be broadly categorised into 3 functions: '***through***', '***distribution***', or '***access***' roads.

Through roads have rapid and uninterrupted movement (motorways, national roads etc.). ***'Through'*** roads are higher-speed roads (motorways, expressways and multi-lane divided highways) and they should have restricted access; horizontal and vertical curves of large radius; crashworthy shoulders; median barriers; and grade-separated junctions with entry and exit ramps. If such features are present, these are the safest of all roads.

'Distribution' roads distribute traffic from different districts or residential areas (regional roads). Rural roads should have periodic lanes for overtaking and for turning across oncoming traffic; median barriers to prevent overtaking in hazardous stretches; lighting at junctions; roundabouts; advisory speed limit signs before sharp bends; regular signs to remind of speed limits; rumble strips; and roadside hazards such as trees and utility poles removed. Transitional roads connecting higher-speed roads with lower-speed roads or moving from higher- to lower-speed stretches (such as rural roads entering villages) should have signs and other design features to encourage drivers to slow down in good time. Rumble strips, speed bumps, visual warnings in the pavement and roundabouts are possibilities.

'Access' roads provide access to final destinations: houses, shops etc. (local roads). Residential access roads should have speed limits of no more than 30 km/h and design features that calm traffic.

Together, these 3 categories make up a road network.

Taking account of different road functions by defining a road hierarchy is an important step towards the improvement of road safety. At the moment many roads are multifunctional and used by different types of vehicle users with substantial differences in speed, mass of vehicle and degree of protection.

Requirements for functionality:

- Removal of all function combinations by making roads ***mono-functional***, i.e. creating purely through, distributor and access roads.
- Minimum journey time along unsafe roads
- Trips as short as possible
- Safest and shortest route should coincide

Figure II-2

Schematic Illustration of a Functionally Classified Rural Highway Network

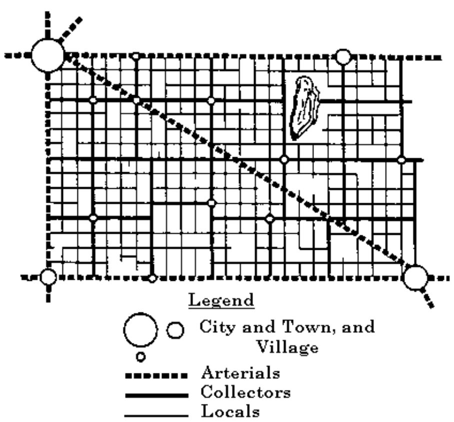
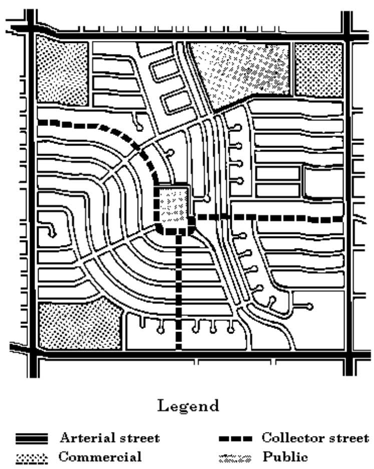


Figure II-3

Schematic of a Portion of an Urban Street Network



Source: http://www.fhwa.dot.gov/planning/fcsec2_1.htm

HOMOGENEITY

Safest roads are motorways because they are homogenous. Although driving speeds are the highest, ***speeds are uniform*** and there are ***no variations in driving directions***. Distributor roads are the most dangerous as vehicles travel at relatively high speeds and there is a great deal of intersecting traffic.

Requirements for homogeneity:

- Traffic movement control (traffic signals; roundabouts etc.)
- Separate vehicle types (separate foot and cycle path etc.)
- Reduce speed at potential conflict points
- Avoid obstacles along carriageway

RECOGNISABILITY

With Self-explanatory roads, drivers know at which speed to drive and what to expect (whether cyclists are likely to be on the road etc.).

Requirements for recognisability:

- Avoid unpredictable behaviour by clear designing, marking and signing.
- Make road categories recognisable and their number limited. The layout of a road should 'automatically' enforce the desired speed.
- Users must be able to recognise the road category by a small number of design elements. These elements must also be uniform for all roads within that category.

FORGIVINGNESS

Forgivingness in the physical sense means that the road design is such that any crashes will end as good as possible. A vehicle that goes off the road should not hit any obstacles or other fixed objects, because this leads to severe injury. The vehicle itself should provide equal protection to both its occupants and the collision opponent.

III. Safe Road Design and Assessment: Methodologies

III.i EU Road Infrastructure Safety Management Directive

On the 5th of October 2006, the European Commission released a package of measures geared at harmonising safe road management practices on the Trans-European Network (network of main European roads).

After a long debate in the European Parliament and the Council of Minister this proposal (COM(2006)0569) resulted in the Directive on Road Infrastructure Safety Management (Directive 2008/96/EC) finally approved on 19 November 2008.

The legal scope of the Directive is restricted to the Trans-European Road Network (TERN), comprising 89,000 km of motorways and main roads (Articles 71 and 154 of the Treaty) whether they are at the design stage, under construction or in operation. Member States may freely decide to extend the Directive to other portions of their road network, especially in the cases where EU funding is involved in the construction of the road network.[1]

The Directive proposes a comprehensive system of road infrastructure safety management, centred on four procedures which are already implemented in several EU Member States[2] and a group of accompanying measures:[3]

Road safety impact assessment

Road safety impact assessment designates a comparative scenario analysis of the impact that different variants of alignment or interconnection points of new roads or a substantial modification to the existing network will have on the safety performance of the adjacent network. They are carried out at the initial planning stage and therefore should play a crucial role when routes are being selected.

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[1] http://www.saferoads.eu/?part=1

[2] In 2006, the Austrian Presidency polled the Member States on the level of application of infrastructure safety measures: Impact assessments applied or under preparation: 43 %, Safety audits applied or under preparation: 92 % (on a voluntary basis in 57% of cases), Safety inspections applied or under preparation: 80% (no standards in 61% of cases), Black spot management programmes: 81% (on a voluntary basis in 59% of cases)

[3] http://www.saferoads.eu/?part=1

Together with the road safety audits, this procedure enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. They thus complement the use of these same skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures.

According to the new EU Directive, the road safety impact assessment shall indicate the road safety considerations which contribute to the choice of the proposed solutions, including a cost-benefit analysis of the different options assessed (article 3.3)

Road safety audit

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme - whether new construction or an alteration to an existing road.

Well-documented experience in Europe and elsewhere shows that formal systematic safety audit procedures are a demonstrably effective and cost-beneficial tool to improve road safety.

Article 4 of the EU Directive on Road Infrastructure Safety Management indicates that Member States shall ensure that an auditor is appointed to carry out an audit of the design characteristics of an infrastructure project. The audit shall form an integral part of the design process of the infrastructure project at the stage of draft design, detailed design, pre-opening and early operation. The auditor shall set out safety critical design elements in an audit report for each stage. If unsafe features identified but design not rectified, competent entity shall state reasons in report.[4]

The benefits of both safety audits and safety impact assessment are in:

- Minimising the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes.
- Reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes.
- Reducing the long-term costs associated with a planning decision or a road scheme.
- Enhancing the awareness of road safety needs among policy-makers and scheme designers.

[4] Tom Antonissen, *Infrastructure Engineering to improve Road Safety: European framework and legal requirements* R2R Award Ceremony, Brussels, 1st October 2008

Network safety management

Network safety management is a method to monitor the safety standard of the road. The characteristics of the road are measured to verify to which degree the road safety requirements are met.

Network safety management enables road administrations to detect those sections within the network where an improvement of the infrastructure is expected to be highly cost-effective.

The purpose of network safety management is:

- To determine sections within the road network with a poor safety performance based on accident data and where deficits in road infrastructure have to be suspected.

- To rank the sections by potential savings in accident costs in order to provide a priority list of sections to be treated by road administrations.

Article 5 of the Directive on Road Infrastructure Safety Management oblige the Member States to introduce a method to identify, analyse and rank road sections, in operation for over 3 years, with large number of fatal accidents in relation to traffic flow (Ranking of high accident concentration sections). To classify their network according to potential for safety development and to carry out 3-yearly reviews of operation of road network, where the sections showing higher priority are evaluated through site visits followed by targeted remedial treatment (according to highest benefit-cost ratio)

Finally, Member States, shall install corresponding signs to warn road users of segments undergoing repairs as well as high accident concentration sections.

Road safety inspections

Safety inspection designates a periodical review of a road network in operation by trained experts from a safety point of view. It involves visiting the road network.

Routine safety inspections are regularly carried out on the road network to identify physical defects in the road infrastructure. As a result, improvements of the road environment could be decided, most often in terms of low cost measures.

The new EU Directive foresees that Member States shall ensure that periodical safety inspections are undertaken in order to identify the road related features and prevent accidents (article 6.1). Furthermore, Member States shall adopt guidelines on temporary safety measures applying to road works and an appropriate inspection scheme to ensure that those guidelines are properly applied (article 6.4).

Supporting measures

Together with the four main instruments, the Road Infrastructure Safety Management Directive introduces some supporting measures:

For each accident involving one or more fatalities or severe injuries occurring on the TERN, a complete accident report must be drawn up by the competent entity (article 7.1). Moreover, Member States shall calculate the average social cost of a fatal accident and the average social cost of a severe accident occurring in its territory (article 7.2). Road safety auditors must undergo or have undergone an initial training resulting in the award of a certificate of competence, and follow periodic re-training at least every seven years (article 9.2).

Member States shall ensure that national provisions necessary to comply with the EU Directive are adopted by 19 December 2010.

III. ii The POGSE approach

This is a simple aid to quickly and effectively analyse and solve problems, POGSE stands for:

- **P**roblem
- **O**rigin (cause)
- **G**oal (objective)
- **S**olution
- **E**valuation

This analyse would ideally be conducted with all concerned stakeholders (infrastructure providers, road users etc.).

Problem: A problem is mainly related to a location (junction) or a road link. It can be determined on the basis of accident records, but may also follow from complaints of local residents.

Origin: At this stage, clear, independent research is indispensable. It is essential for all explanations/opinions to be examined, as more than one cause can lead to an identified problem.

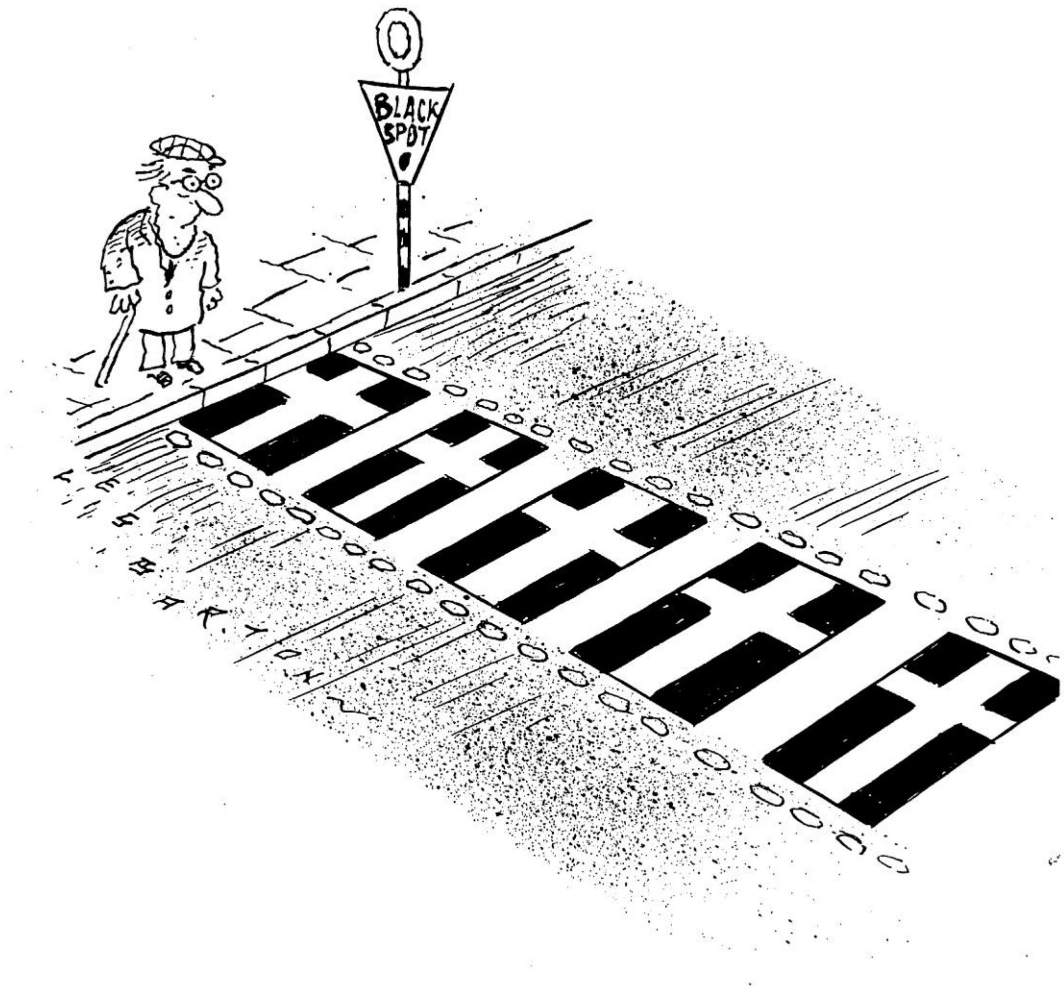
Goal: Make sure the objective can be measured by defining a quantified improvement.

Solution: final choice is made by considering the following:

- Which solutions have the best effect
- What is the cost?
- Are other works foreseen to combine with specific measures?

Evaluation: continuous monitoring of the effects of measures, followed by comparison with the set goals. Monitoring means collection and analysis of traffic data, accident data, and complaints. Experience shows that implemented measures do not immediately lead to an improvement of the situation; it may even worsen initially.

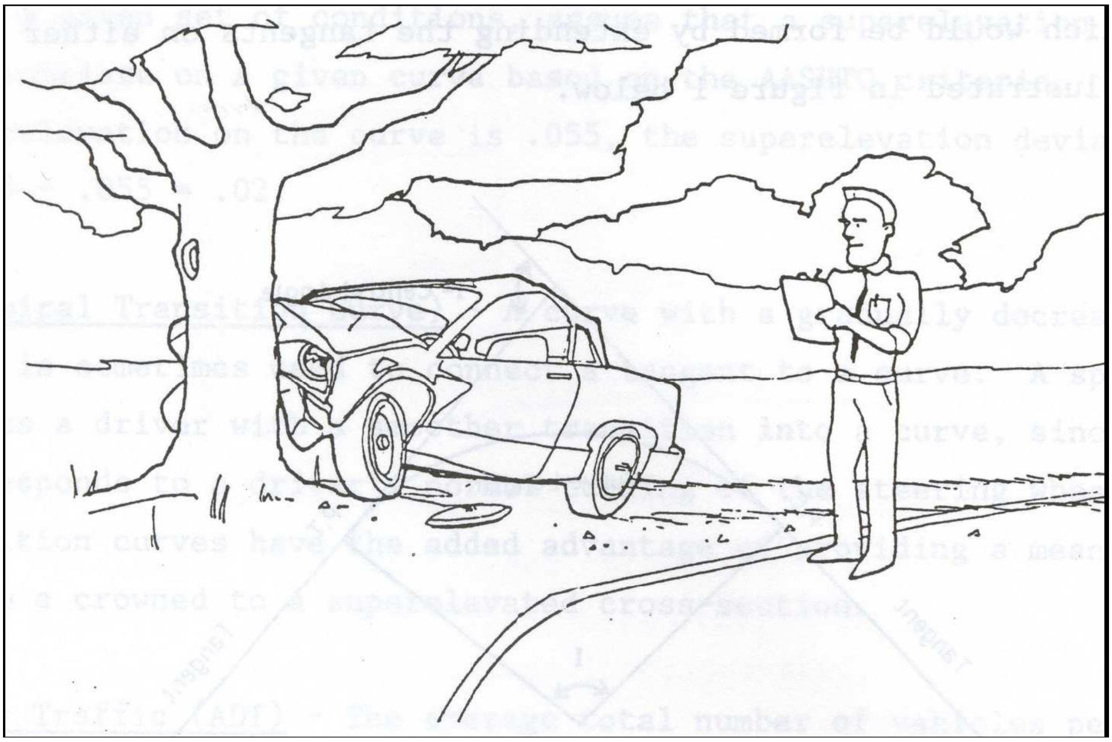
IV. Identifying High Risk Sites or so-called 'Blackspots'



Road crashes are not evenly distributed throughout a road network. They occur in clusters at single sites, along particular sections of road or scattered across whole residential neighbourhoods. Even where area-wide impact assessment and road safety audits are carried out, experience may show that certain sites, sections or areas are hazardous and need improvement.

Safety defects may also arise through poor maintenance: for example, road surfaces and signs are deteriorated and roadside lights do not function.

The improvements needed to make an entire road network or a hazardous site safer often cost little but can result in huge benefits in terms of reduced incidence of road crash and injury. Nevertheless, a 1996 survey of 12 European Union countries found that only seven reported having formal policies on remedial action at high-risk sites, only three did evaluations as a matter of course and only three had separate budgets for remedial action.



IV.i EuroRAP

The European Road Assessment Programme (EuroRAP) rates European roads against harmonised safety protocols. The aim of EuroRAP is to provide a Europe-wide safety rating for roads across Europe: crash risks (number of killed and seriously injured road users per km driven) are shown on a colour-coded road map. Roads will also be rated using a (still under development) Road Protection Score (RPS). The RPS will look at the road protection potential in case of four different crash types: head-on collisions, run-off the road crashes, impacts at intersections and accidents with vulnerable road users. This will generate consumer information for the public and give road engineers and planners vital benchmarking information to show them how well, or badly, their roads are performing compared with others, both in their own and other countries.
The primary objective of EuroRAP is to rapidly reduce death and serious injury on European roads through a programme of systematic testing of risk that identifies major safety shortcomings which can be addressed by practical road improvement measures.

EuroRAP has been keen to illustrate that preventing death and injury on the road need be neither expensive nor complex - promoting the message that simple engineering measures, often at low cost, together with information through effective road markings and signs, can significantly reduce routine road accidents. Whilst recognising that it does need financial investment, it also requires discipline from authorities in engaging people with the right skills to measure where people are being routinely killed and maimed, to apply systematically the known remedies, and to maintain roads properly.

Case Study: The United Kingdom

Rating the safety of Britain's motorways and A roads

EuroRAP 2009 results

In the past 10 years, two million people have been killed or suffered life changing injury in road crashes in the countries of the EU, according to the Road Safety Foundation.
Its last report, carried out as part of the European Road Assessment Programme (EuroRAP) initiative, is an analysis of the safety of motorways and A road network outside urban cores in Britain, totally 45,000 km of measured and mapped roads. That is where the highest number of road fatalities has been registered.

The main findings show that there has been an 18% reduction in road deaths across the road network analysed from 2005 to 2007.
Among the most improved roads, casualties have halved in the years 2005-2007 from over 600 to under 300.

Figures show that 12% of the network can be considered "high risk" and once again single carriageways are twice the risk of dual carriageways. Motorways are six times safer than the average single-carriageway road.
One third of all road collisions occurs at junctions and the likelihood of an accident on main roads that run through villages or outskirts of towns is 15 times greater than on the safest roads.

"A safe road needs road users who obey traffic law, manufacturers who provide safe vehicles and authorities who provide safe roads" says Dr Joanne Hill, head of the UK's Campaign for Safe Road Design.
"(…) there is an urgent need for public policymakers to understand the new EuroRAP mapping and how we can cut road casualties by up to a third through affordable safety engineering on high-risk roads" says Hill.

"Road crashes cost Britain a staggering 1.5% of GDP. Car occupants account for some 70% of road deaths. Nearly two-thirds are killed outside urban areas with deaths concentrated on Britain's forgotten A road network", states John Dawson, chairman of the Campaign for Safe Road Design.

Examples of casualty reductions in built-up areas along rural routes include:

-the UK's most improved road is the A40 Llandovery to Carmarthen, with a 81% reduction in fatal and serious collisions, thanks to resurfacing, anti-skid surfacing, drainage improvements and junction improvements interventions.

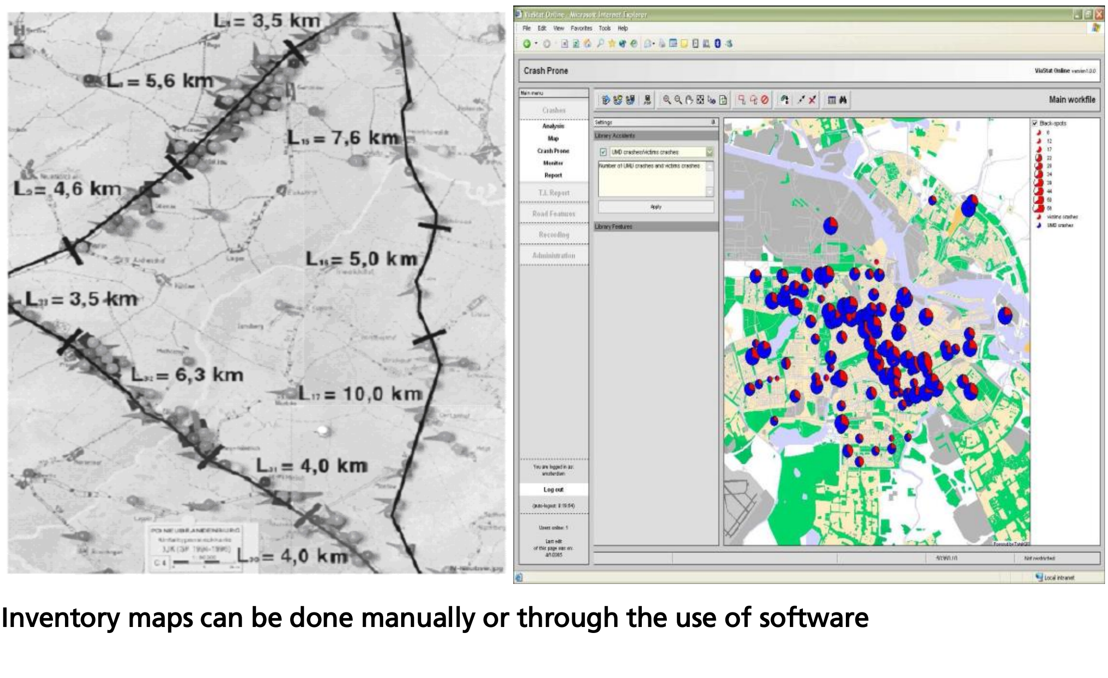
- Reduced speed limit, bend realignment and speed reactive signing cut serious accidents along the A3055 Totland to Ryde by 57%.
- Speed limit reduction, fixed speed cameras and signing improvements has reduced accidents by 43% along A12 Ipswich to Lowestoft.

Source: EuroRAP, 2009.

IV. ii Methodologies

Highway engineers and traffic police generally know of the tendency for road accidents to cluster together at certain locations, commonly termed 'accident blackspots'. Two common methods for tracking high risk sites are:

- ***List:*** Based on accidents statistics, a list is drafted indicating concentrations with the highest frequency of accidents involving injury. The list is then divided into junctions and road links, the latter specifying the number of accidents involving injury per kilometre.
- ***Inventory Map***: Usually managed by the road owner or road authority, this is a regularly updated map with a record of all accidents. Each new accident is located on the map with a colour pin and the colour of the pin varies according to the seriousness (injury/fatality) of the accidents. This provides a quick way to visualise the most dangerous spots and sections of roads.



Inventory maps can be done manually or through the use of software

It is important to think in terms of ***accidents, density and severity***. There will generally be specific locations at which accidents occur, for example at unexpected sharp bends or at junctions (here it is necessary to think in terms of ***average number of accidents per annum***). Elsewhere, accidents may occur along a section of road without any obvious single feature. Here it is necessary to think in terms of ***accidents per kilometre***, that is, the accident density along a particular road link.

Accidents can also be weighted to take into account their severity. Accidents with fatal and serious injuries are more costly in both social and economic terms. If sufficient research has been carried out, then accidents can be weighted relative to their cost. Thus, if a fatal accident costs a society 20 times more than a similar slight injury accident, it can be counted as 20 accident units. Using weighting however has the disadvantage that a few, 'random' fatal accidents can sometimes dominate the selection. If cost information is not available, qualitative weighting can be employed to 'score' accident sites (e.g.: 12 for fatal; 3 for injury and 1 for damage only accidents). Care should be taken to choose sites where remedial action will be most effective. For example treating a site with three injury and three damage only accidents might be more effective than treating a site with one fatal accident.

Traffic volumes should also be considered. In simple terms, more traffic would be expected to lead to more accidents. If traffic flow data are available it can be helpful to compare sites in terms of accidents per unit of traffic. These are often expressed as accidents per million vehicles entering an intersection or accidents per million vehicle km on a link. Sites can then be compared in terms of these rates that give an indication of their relative safety given their traffic volumes.

Reasonably accurate and complete records are essential; without precise data, accidents location, density, and severity cannot be identified with any certainty. However, in the total absence of data it may be possible to make a start on remedial works at 'known' or 'obvious' high risk sites, based on local knowledge of sites where accidents occur most frequently or careful observation.

IV. iii Recurring High Risk Sites

Major accidents:

There are just four main types of crash responsible for 80% of deaths and serious injuries (European Road Safety Observatory, 2006). These accidents usually correspond to particular sites and types of roads. These four types are:

- Head on collisions (front of vehicle)
- Collisions with unfenced objects by the side of the road (run off accidents)
- Side impacts at junctions
- Collisions involving pedestrians and motorbikes

It results that most dangerous sites are junctions and single carriageways.

Most dangerous roads: single carriageways

These are usually 'distributor' function roads. Single carriageway is the British designation for the most common type of road; one with no physical separation (central reservation) between opposing flows of traffic. It usually has two or more marked traffic lanes, one in each direction, although narrow rural roads and residential streets may have no markings. On single carriageways the risk grows rapidly as traffic flow increases and speed is important.

Single carriageway with poor markings and single carriageway with poor visibility

A road with no central reservation is a single carriageway regardless of the number of lanes of traffic in each direction.

Roadsides

According to research in Australia and several European Union countries, collisions between vehicles and solid roadside objects contribute to 18–42% of all fatal crashes. Such collisions frequently involve young drivers, excess or inappropriate speed, the use of alcohol, driver fatigue or restricted visibility. Roads and roadsides should be designed and maintained to minimise the opportunities for serious effects when vehicles veer off course.

Unforgiving roadside objects include trees, poles, road signs and other street furniture which represent an important safety problem. Research and experience indicate that the positioning and design of off-road objects can play a major role in reducing such collisions and the severe consequences that are typically associated with them.

Linear villages

A linear village is that part of a (transit) road which lies within a built-up area. The pressure of the fast-growing amount of transit traffic means that an even larger part of the public environment, within the built-up area is used for traffic flow. This large-scale layout, which is inconsistent with the small-scale nature of the rest of the village, turns the road into a dividing element in the residential area and means the urban harmony is lost. The layout of the road does not suit the character of the environment at all. Roads within a built-up area often look just like the road outside the built-up area, and in many cases the road is an asphalt road with a width of 7-12 metres or more, without any speed-reduction measures or specific provisions for crossing pedestrians. Although the residential areas have speed limits of 60 km/h, 50 km/h or 40 km/h, these speed limits are generally ignored as a result of the character of the road. The urban section of the transit road is not only important for access to and from the built-up area, or the area around it, but in many cases also for carrying long-distance transit traffic. Within the built-up area, there is not only housing alongside the cross-town link, but often also public buildings with a 'service' function, and commercial properties.

Tunnels

Many European tunnels were built several decades ago when traffic density and vehicle characteristics were different from what they are today. As a result of recent tunnel accidents the EU has adopted a Directive (Directive2004/54/EC) aimed at ensuring a minimum level of safety in road tunnels on the trans-European network. The measures take into account both organisational and technical matters.

Other hazards

This is not an exhaustive list of all the dangerous sites that can be encountered.

Sometimes features that are not part of the initial road design can create hazard. For example, one should think of elements in the environment that disrupt visibility (e.g.: vegetation in front of signs or low traffic lights that can be hidden by trucks at junctions).

V. Treating high risk sites

There are four basic strategies for accident reduction through the use of countermeasures:

- Single Site ('black spot' programmes) – the treatment of specific types of accidents as a single location.
- Mass Action Plan – the application of a known remedy to locations with a common accident problem.
- Route Action Plans – tile application of know remedies along a route with a high accident rate.
- Area with Schemes – the applications of various treatments over a wide area of town/city, i.e. including traffic management and speed reducing devices.

Systematic identification and treatment of hazardous locations can improve road safety substantially, and the potential for accident reduction through simple low-cost measures is particularly high. Examples include the use of road signs and markings to channelize traffic through complex intersections or to provide safe waiting areas for turning vehicles.

Monitoring the entire road traffic system, identifying problems as they emerge and correcting them are all important measures for ensuring road safety.

As Member States make their road infrastructure safety management more systematic, each will need to make its own judgement how quickly its emphasis should shift from mainly high risk site management, driven by recorded occurrence of accidents, towards wider network safety management driven by the setting and application of standards for the safety characteristics of the infrastructure.

It is important for Member State to develop and implement in due course high and verified standards of road safety management in the circumstances that prevail locally. But it is equally important that in the meantime road authorities act without delay and with increased priority to reduce death and injury on their roads – by the means and with the resources that are most readily available to them here and now. Development of more advanced quality management techniques for further reduction in death and injury after the worst high risk sites have been dealt with must in no way delay the early identification and treatment of these sites in Member States that still have many such sites (Allsop, 2006).

Low cost measures

Low-cost road and traffic engineering measures comprise those physical measures, taken specifically to enhance the safety of the road system, that have low capital cost, can be implemented quickly, and offer high ratios of benefit to cost. Examples are small changes in road layout or junction control and improvements in signs and markings.

The application of low cost measures is a highly cost-effective method of reducing road accidents and casualties at high-risk sites, on high-risk route sections, and on an area-wide basis. Achieved ratios of benefit to cost from 3 upwards to double figures are widely reported, and many schemes pay for themselves in casualty savings within a year.

Common examples illustrating the range of LCM are:

- Changes in condition and layout of the road to make existing use safer

Laying of skid-resistant surfacing Improvement of lighting, markings and signs Creation of extra lanes for opposed turning traffic Introduction of central refuges and islands Removal of roadside objects Installation of crash barriers Improvement of winter maintenance

Crash barriers offer protection from roadside objects such as trees

- Alteration of junction operation:

Changes in priority Installation of small roundabouts Installation and modification of signal control

- Changes in layout of the road to influence its use and the behaviour of users:

Pedestrian crossings, cycle lanes and paths Road humps and road narrowing Relocation of parking Improved zones of transition from rural to urban areas

These measures are often designed to make the roads and traffic more comprehensible to drivers and other road users in order to reduce accident occurrence. The use of LCM to help road users to feel safer even where there is no record of accidents is not ruled out, but should await substantial progress in the treatment of sites, route sections and areas where reduction in actual occurrence of accidents can be achieved.

Low cost treatment of high risk sites in Norway

High risk sites and sections in Norway are identified on the basis of the Norwegian accident register. An accident high risk site is defined as a place with a maximum length of 100 metres, where at least four injury accidents have been reported to the police in the course of 4 years. A high risk road section is defined as a stretch of road of maximum length of 1 km, where at least 10 injury accidents have been reported to the police over a four year period. The majority of high risk road sections consist of high risk sites which are located close to one another (for example, a series of intersections in city streets).

Identifying, analysing and improving high risk sites have a long tradition in Norway. In the period 1984-1987, which is the last period for which a nation-wide survey is available, accidents at high risk sites comprised 14% of the total number of injury accidents recorded by the police on national highways. In towns and cities the percentage was higher (Elvik and Vaa, 2004).

Table 1 gives an example of low cost measures that have been introduced in Norway to treat high risk sites. The table gives the mean cost per location, the benefit-cost ratio and the mean annual average daily traffic (AADT) at the locations where the measures were introduced.

Treatment	Mean cost (NOK)	Mean AADT	Cost-benefit ratio
Pedestrian bridge or underpass	5,990,000	8,765	1:2.5
Converting 3-leg junction to roundabout	5,790,000	9,094	1:1.6
Converting 4-leg junction to roundabout	4,160,000	10,432	1:2.2
Removal of roadside obstacles	310,000	20,133	1:19.3
Minor improvements (miscellaneous)	5,640,000	3,269	1:1.5
Guard rail along roadside	860,000	10,947	1:10.4
Median guard rail	1,880,000	42,753	1:10.3
Signing of hazardous curves	60,000	1,169	1:3.5
Road lighting	650,000	8,179	1:10.7
Upgrading marked pedestrian crossings	390,000	10,484	1:14.0

1 Euro = 8.21 NOK (December 2006)

Table 1: Some examples of low cost road safety treatments in Norway. Source: Elvik and Rydningen, 2002.

The cost-benefit ratios are impressive, exceeding one to ten for many of the safety treatments. Bearing in mind that Norway is a high-cost country that has a comparatively good road safety record; there is little reason to doubt that very favourable cost-benefit ratios can be achieved by systematically applying similar road safety measures in other European countries.

Junctions

A junction is a potential danger point in the road network. In the Netherlands, more than half the accidents on single carriageways occur on at grade junctions. Safety measures at the junction are often more cost effective than measures on road links. A junction has to fulfill a number of general design requirements:

- Recognisable: if a limited number of junction forms are used, with uniform (main) characteristics, then the road user will recognise the situation as such more quickly and the situation will comply with expectations.
- Visible: a junction must be visible in time, conspicuous and clearly recognisable and locatable as such. To see something from a

distance, it must have at least a certain size to which the road user's attention and perception can be directed. Contrast, colour, shape and movement are important factors here. Finally, the information 'signs' need to be installed in logical, clearly visible places in the field of vision.

- Overseeable: when approaching a junction the road user must be able to oversee the junction and part of the approaching roads and any traffic on them, in time.
- Comprehensible: a junction is comprehensible to the road user when perceptions of shape, scope, signposting, marking and traffic regulations can be interpreted quickly, correctly and unambiguously on approach.
- Negotiable: negotiability of a junction means that the various design elements fit together sufficiently smoothly. The elements themselves must also be easily negotiated.
- Balance: a balanced junction structure means that the various design elements (including the approach roads) and the traffic measures must form an integrated whole.
- Completeness: a junction is complete when the traffic at the site of the junction can continue on its way in all possible and intended directions.

In principle there are three basic forms of 'at grade' road junction:

- Roundabout;
- Priority junction without traffic lights;
- Priority junction with traffic lights.

The **roundabout** is very suitable as a junction both inside and outside built-up areas and the roundabout is currently the safest 'at grade junction'. Roundabouts both promote the fluid flow of traffic and have a strong speed-reducing effect. Roundabouts therefore make a substantial contribution to road safety. In the view of road safety, capacity, clarity and uniformity, to name a few, the traffic on the roundabout should always have the right of way.

Advantages of roundabouts:

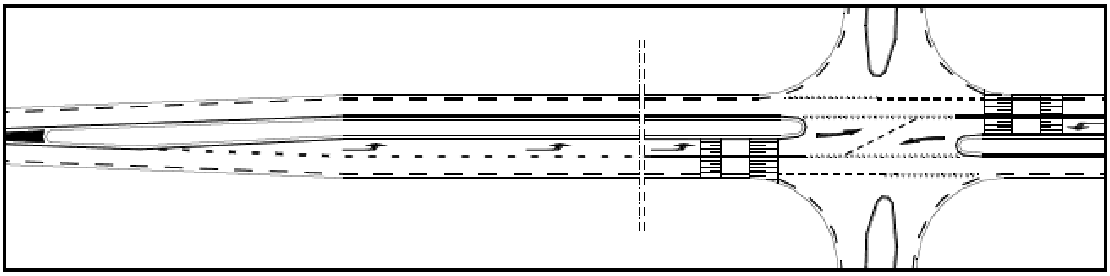
- The actual speed of the drivers both, with and without right of way is (very) low. The lower the driving speeds, the slighter the risk of (serious) conflicts or (injury) accidents.
- On a traditional junction the number of potential conflict points is multiple. On a roundabout there is one conflict point for each adjoining road.

The safest roundabouts are single-lane roundabouts.

Priority junction without traffic lights: The prescribed marking of priority junctions with traffic signs is usually not sufficient. The design should also be such that the perception of the priority corresponds with the priority rule at the location. The design should clearly support the priority rules and show which of the roads is the main road and which the minor road. This can be done by providing a physical difference between the two roads by, for example, applying a (long) median in the main road and a traffic island or refuge in the minor road.

A standard priority junction (without traffic lights) in a distributor road should have at least the following design elements (see diagram):

- Maximum of one lane per direction;
- Separate left-turn lane;
- Traffic island(s).



Priority junction with traffic lights: it is only acceptable to install traffic lights at a priority junction when:

- The waiting times for the subordinate traffic flows are unacceptably high;
- Other solutions, such as constructing a roundabout, do not offer a satisfactory solution;
- Road safety with either option is unacceptable, on the understanding that the installation of traffic lights can be expected to have a positive effect on road safety.

Application of traffic lights in single carriageways is, in principle, not recommended.

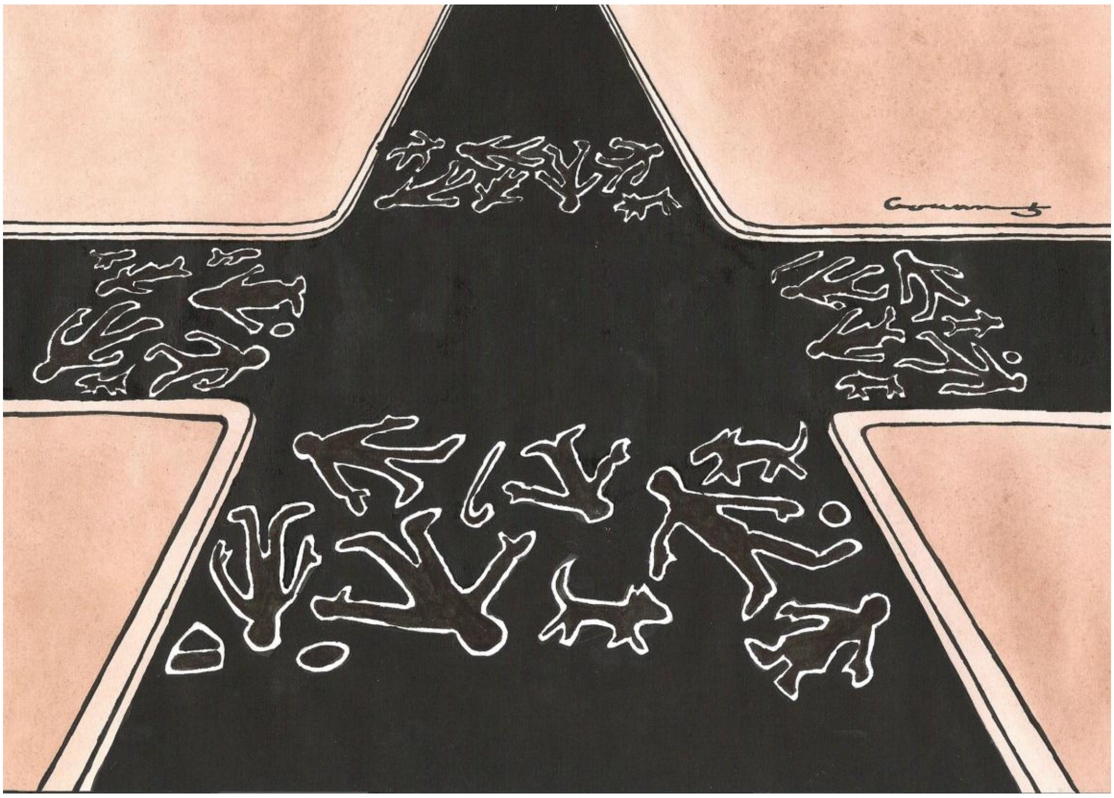
Design for pedestrians and cyclists:

The safety of pedestrians and cyclists can be achieved through area-wide road safety management that includes the following:

- Networks of segregated or separate pedestrian and bicycle routes connecting to a public transport system are the ideal. Such a network might consist of sections of footpath or cycle path separate from roads plus sections running alongside roads, with particular attention paid to safe crossings at junctions. Pedestrians have twice the risk of injury where pedestrians are not separated or segregated from motor vehicle traffic. Studies in Denmark have shown that providing segregated bicycle tracks or lanes alongside urban roads reduced deaths among cyclists by 35%.

• Traffic-calming measures discourage motorized traffic from traveling at speeds that put pedestrians and cyclists at high risk. They include road narrowing, roundabouts, rumble strips and speed bumps. Widespread experience with area-wide road safety management in Europe shows that it can reduce crashes and injuries by 15–80%. The town of Baden, Austria launched a management plan in 1988 that has resulted in about 75% of its road network being restricted to speeds of 30 km/h or less and an integrated system of public transport with pedestrian and bicycle routes. The rate of road casualties has declined by 60%.

Ideal: Trollhättan, Sweden (separate footway and bicycle lane; safe crossing; traffic calming measures...)



Not ideal!

Road markings and traffic signs

Clear and visible road markings, coupled with a high level of maintenance, are essential to ensuring a high level of safety on European roads. Road marking must be of the highest quality in order to be visible and lasting and to guarantee a skid resistance that is as good as the one of the adjacent road surface. Application skills will also highly impact on the level of performance and durability. Studies have shown that safe pavement markings should be visible during the night to a degree that allows the driver an absolute minimum of 2.5 seconds reaction time. This can be achieved by an adequate width and retro reflectivity specifications.

Visible Road Marking

Traffic signs are one of the primary interfaces between the roadway and the drivers and are used to communicate information to drivers that would otherwise be unobvious. They are there to remind drivers of traffic rules. They can also advice on special dangers and on the way to avoid them. In the modern traffic system driving without signs would be practically impossible or would happen at the cost of countless accidents. This is the reason why coherent, clear and conspicuous traffic signs are an integral part of a traffic system. To be effective, signs must be designed, built and displayed in such a way that the messages they convey are clear, unambiguous, visible and legible.

Four important principles for good signing:

- Signing systems should be consistent, complete, comprehensive and kept simple.
- Horizontal and vertical signing should be complementary and never contradictory.
- Drivers should perceive signing in the same way during daytime and night-time conditions.
- Road and traffic conditions presenting special difficulties or dangers should be dealt with special care (e.g. tunnels, bridges, work zones).

Together with adequate road markings, traffic signs have proven to be a low cost measure with high ratios of benefit to cost.

Forgiving Roadsides

Ideally, roads should be designed without dangerous off-road objects. However, this is clearly not possible in all situations and most of the interventions will have to be made on already existing roads. In such a case, objects should be removed, made more forgiving or protected with crash barriers where none of the other options are possible.

- Keeping roadsides clear of trees, boulders, steel and concrete pillars and posts and similar rigid roadside objects is especially important on roads where vehicles travel at high speeds.
- Collapsible lighting columns and signs, mounted on shear bolts or made of yielding material and designed for electrical safety, are recommended.
- Safety barriers can be used to contain motor vehicles within lanes, preventing head-on or side collisions, and to prevent them from leaving roads. These barriers should be designed to deflect or contain vehicles while doing no serious harm to occupants. Denmark, Sweden, Switzerland and the United Kingdom favour flexible cable barriers (rather than rigid concrete or semi-rigid steel), sometimes to prevent dangerous overtaking on single-carriageway roads. Used on dual-carriageway roads (with no pedestrians or bicycles) to prevent motor vehicles from crossing over and crashing into traffic going in the opposite direction, they have been found to reduce fatal and serious injuries by 45–50%.
- Crash cushions slow motor vehicles before they strike rigid roadside objects such as bridge pillars, safety barrier ends and utility poles. They have reduced fatal and serious injuries resulting from impact by up to 75% in the United States and by 67% or more in the United Kingdom.

The “intelligent” road: “self-enforcing” infrastructure

“Self-enforcing” roads help drivers stick to the legal speed limit by ensuring that they drive at the appropriate speed for different stretches of road. “Self enforcing roads” are an important part of the road safety equation. Progress to extend them further to the European road network could make a significant contribution to enhancing speed limit compliance and saving lives.

Many different types of infrastructure measures exist which can work to reduce speed. These include engineering measures related to road design such as speed humps, road narrowing and roundabouts. These form part of traffic calming, which is the specific integrated treatment of areas or stretches of road with various kinds of speed-reducing measures.
Another key to reducing speed through design is by narrower lane widths. This can be accomplished either by physically narrowing the travel

way or by creating an illusion of a narrower travel way (such as painting wider edge lines or eliminating centre line striping).These have been proven to be particularly effective tools for reducing speeds on rural roads.

Another method to physically narrow lanes is by introducing “2+1” roadways on high-volume rural roads. A passing lane is introduced, sandwiched between two opposing travel lanes, and drivers have the right to use the passing lane alternating between the two directions of travel.

VI. Conclusion

Identifying and solving high risk sites Europe-wide will lead to a substantial reduction in road deaths. The European Commission has recognised this potential by its Directive where it is stated that safety is integrated in all phases of road planning, design and operation of road infrastructure. Apart from requiring member states to adopt guidelines for road safety impact assessments, audits, and inspections, the Directive identifies the treatment of High Risk Sites as a major area of work for national authorities especially in Southern, Eastern and Central Europe.

It is important to highlight that the direct accident reduction is not the only safety effect of road infrastructure safety management: the use of the proposed instruments, including the treatment of High Risk Sites, will create awareness for safety at all stages of decision-making on road planning and road design. However, the Directive also stresses that new safety knowledge often takes too long to reach the authorities in charge of maintaining the road network and to be applied.

This is precisely the area in which the ''Roads to Respect'' Programme seeks to improve the building of awareness, knowledge and political leadership, in order to ensure that effective road infrastructure safety management becomes common practice in the EU.

We hope to create awareness amongst future road engineers and other road safety professionals and thereby help to get a life-long commitment to care about ''safe roads'' from those actors who will shape and implement future road safety policies in the Southern, Eastern and Central European Countries.

The R2R students' experience

"I would like to thank ETSC for giving me the opportunity through the R2R programme to work on such an interesting project and to be able to contribute to the road safety of my community in Chalkidiki and Xanthi and help within my power to improve quality and safety of streets in towns and the road network in my country and ultimately Europe.
I would also like to thank sponsors Toyota and 3M whose contribution gives young people opportunities. I hope they will continue supporting such endeavours in the future".

Petros Sekeris (Greece) – R2R 2008

"The Camp was great idea, it gave me a new knowledge and a good new friendships.
Working on this project I got experience that I never had before!"

Petar Krasic (Serbia) – R2R 2008

"I will like to thank ETSC to giving me the courage to do something, because last year I learned at the workshop that the right approaching to the local authorities is everything. Last year on the workshop I learned so much. Thank you for this".

Matej Moharic (Slovenia) – R2R 2008

"I want to thank ETSC for the possibility to know many aspects and many information about transport safety and for the possibility to know special people during the camp in September and all components of the team at ETSC and absolutely the students. I have known young engineer like me and also now I keep in touch with them, guys from Poland, Italy and Spain".

Stefano Cara (Italy) – R2R 2007

"The Program R2R was really nice and learning experience. It's really nice to know that some people manage to convince the authorities to treat theirs high risk sites .I also keep my fingers crossed for the rest especially for the project of Iwona and Piotr. But in Karkow there is still a lot to do to improve safety on roads-now I'm more aware how to do it".

Malgorzata Jedynak (Poland) – R2R 2007

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