ROAD SAFETY

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TECHNICAL COMMITTEE 3.1
ROAD SAFETY

INTRODUCTORY REPORT

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EXECUTIVE SUMMARY

German research showed that family of traffic victims suffer tremendous emotional pain and may even withdraw themselves from public life for more than ten years. In order to put an economic figure on the issue, it is useful to remember that road crashes cost approximately 1 to 3 percent of a country's annual Gross National Product (GNP).

These are resources that no country can afford to lose, especially those with developing economies. It is estimated that developing countries currently lose in the region of 100 billion USD every year because of road accidents. This is almost twice as much as the total development assistance they receive. In developing countries in particular, these losses undoubtedly inhibit the economic and social development.

Improving road safety is a necessity.

This document outlines PIARC TC 3.1's perspective on infrastructure-related road safety issues. In other words: how to improve the roads so as to reduce deaths? It comes from the work of the TC from 2003 to 2007. Even though all topics were not dealt with in detail during that period, this document tries to give a comprehensive perspective on the issues at stake and available solutions.

TC 3.1 work made it clear that improvements to the infrastructure can help save lives. Formal procedures such as road safety audits of road projects and safety inspections of roads in operations are extremely efficient and have been described in PIARC guidelines.

Intelligent transport systems, be they in-car or infrastructure related, offer good opportunities for accident reduction as well, and should be investigated by road authorities in close cooperation with equipment and car manufacturers. PIARC guidelines help identify the most appropriate systems.

Overall, road infrastructure and equipment design procedures should take human factors into account whenever possible, since all road users have their physiological and psychological limitations. PIARC guidelines make this easier.

Accurate accident data is the basis for sound road safety policies, and PIARC guidelines help data collection and analysis strategies.

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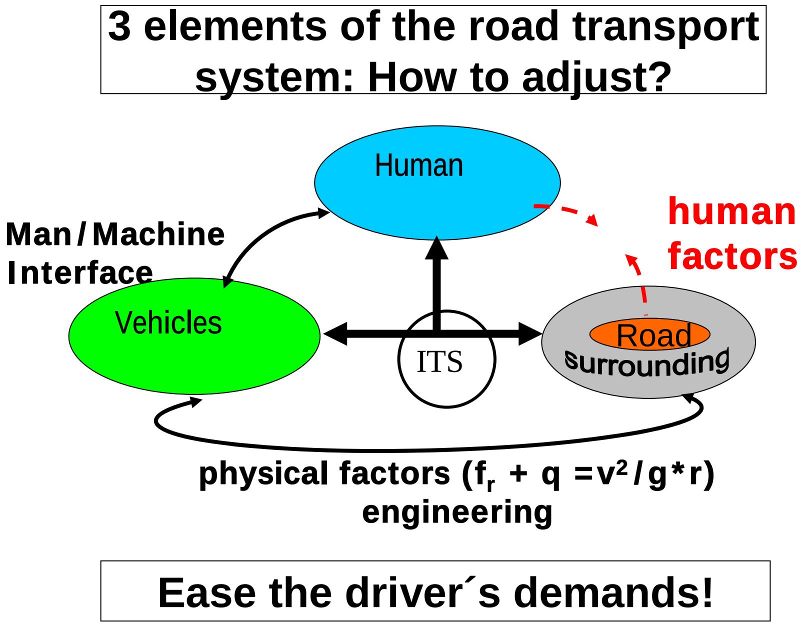
1. WHAT CAN BE DONE TO IMPROVE THE ROADS SAFETY-WISE?

Driving involves drivers, vehicles and roads simultaneously and improving road safety thus requires a systematic approach which involves tackling all three subsystems.



Road engineering is traditionally located at the interface between vehicles and driving environment (the road itself and its surroundings), where geometry, dynamics and optics are the main physical factors. But even the most thorough engineering design and measures of education and enforcement will have little impact without appropriate integration of all three factors and their interfaces. The potential for accident reduction of this approach has been shown to be more than 50 % in most countries.

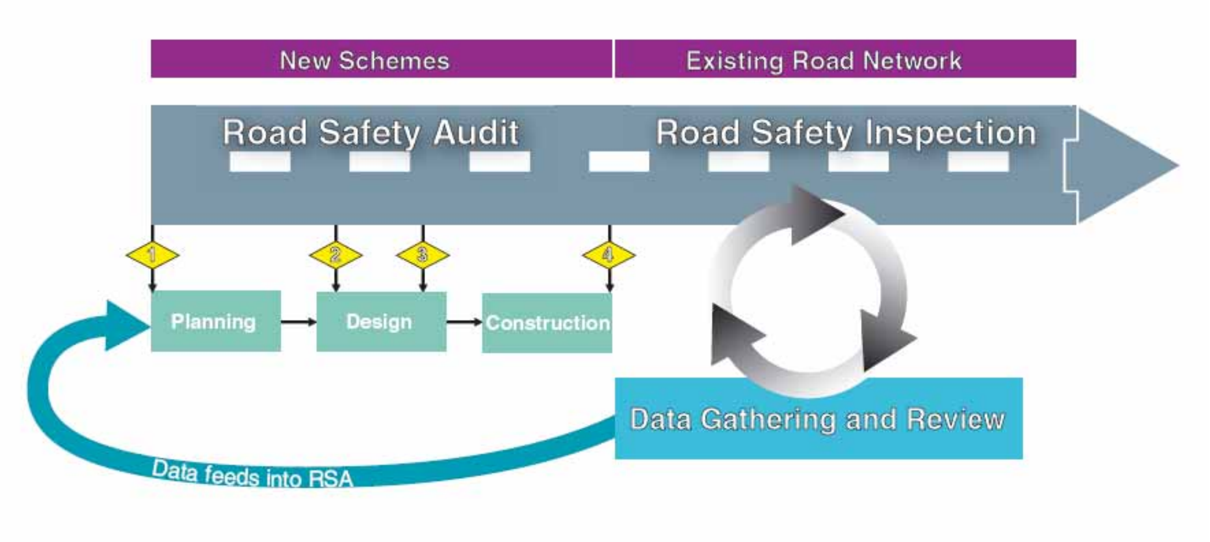
While traditional road safety theories put forward driver error as the major factor in road crashes, more and more countries are adopting a “safe system” approach where infrastructure and vehicle safety are paramount. Some state that the main causes of road accidents are driver behaviour and vehicle condition, and conclude that investigating the impact of the infrastructure on road safety is useless and would be too expensive. That is untrue. The road, its equipment and its surroundings can save lives in different ways:

- land use and the structure of settlements along roads will have a great influence on road safety
- some designs should just be avoided because they are dangerous and can cause accidents
- the road can entice drivers to drive calmly, responsibly and thus safely
- the road can help drivers avoid accidents
- in case of accidents, the infrastructure can reduce the severity of the accidents

Various infrastructure improvement processes can be undertaken for new roads and existing roads. These include road safety audits of new projects, network safety inspections, accident accumulation location ("black spot") analysis and detailed crash investigations.

PIARC TC3.1 has taken into account experience worldwide and has identified several fundamental processes and proposed precise definitions of these. They are:

- **Road safety audits**: at the project design stage, before any construction has started, screen the designs on paper for any safety issues. This is a formal process best conducted by an independent auditor.
- **Road safety inspections**: drive along the whole road, look at each road segment and check whether a series of items are consistent with road safety concerns. These inspections are usually repeated regularly.
- **Network safety management**: analyse accident prone zones, understand the reasons for the accident, prioritise actions, implement required improvements on the infrastructure and follow-up by assessing the decrease in accidents on that zone.



Even if no accident data is available, much can actually be done to improve the roads safety wise: audits and inspections do not require accident data, and are extremely effective at a low cost. **Accident data is**, however, very valuable to target specific zones on which to concentrate analysis and resources. Accident data collection also enables feedback towards network safety management as well as towards audits and inspections, for identification of specific problems to keep aware of.

In implementing new projects or countermeasures on existing roads, there is a need to ensure **human factors are taken into account**. Everything from design and construction, to road side equipment, should be planned and implemented from the point of view of the road users. Roads may be too straight and consequently lead drivers to drive too fast. Road signs may be too numerous or incoherent and drivers may be lead to overlook them.

PIARC TC 3.1 has prepared guidelines and checklists on these issues. PIARC has also prepared an easy to use catalogue of good and bad examples in road design which includes a range of low cost countermeasures. What follows is a short summary of these documents as well as indicators to areas that still require more work.

2. TAKING HUMAN FACTORS INTO ACCOUNT

The human factors concept regard the accident as the outcome of an operational mistake from the driver, caused by lack or misinterpretation of available information. Since the driver's characteristics cannot be changed, attention should be focused on the road characteristics: how can they be altered so as to take into account the driver's perception, information processing and reaction patterns and compensate for the fact that drivers have limited physiological and psychological capabilities for action and reaction?

It is the aim of the human factors concept to reduce the likelihood of operational mistake through user-friendly and self explaining road designs. The road user should neither be confused nor invited to take conscious or unconscious risks.

Based on this concept, it is possible to identify road features that lead to accidents. Such dangerous features need to be examined carefully and treated on road projects (through RSA) and on the network in operations.

The human factors approach is based on three distinct fundamental principles:

- The "**6 seconds principle**": the road should give drivers sufficient time for appropriate orientation (identification of the critical point), planning (decision of the appropriate speed or track) and reaction (braking or steering) on transitional areas driving adaptation is required. This is equivalent to 300 meters at 100 kph. Critical points are numerous: junctions, road bends, bus stops etc.
- The "**field of vision principle** ": the road should give drivers a safe field of vision, noting that speed considerably alters the field of vision itself. The road and road side features such as tree alignments can indeed stabilize the driver and help him/her accurately steer the car, or reversely act as distractions or suggest misleading information. Monotony should also be avoided.
- The "**logics principle**": the road should follow the driver's perception expectancy. Planners should keep road characteristics stable on a given itinerary, and induce changes as early and as clearly as possible. Breaking and changes of logics are likely to cause operational mistakes.

The PIARC report on human factors describes these principles in detail, giving examples of improper infrastructure features that do not give drivers enough time for action, or do not lead them properly or do not follow perception expectancies.

It also includes checklists of characteristics to take into account when analysing a road project or existing infrastructure, and suggests possible remedial measures.

3. COLLECT AND USE ACCIDENT DATA

PIARC has produced guidelines on how to create and update accident-type maps. Key elements of these guidelines are summarized here.

3.1. Introduction

Detailed knowledge of accidents can be used in many ways, and consequently it is recommended that road operators collect and compile such data:

- accidents tend to happen at the same places: accident data can identify "accident accumulation locations ("black spots")" which will be a prime target for careful expert work
- the causes of accidents can be assessed from careful analysis of accidents: such knowledge can indicate what actions are to be taken locally to eliminate identified accident sources
- nationwide, causation patterns may be identified, such as people not wearing their seat belts or road side elements being hazardous: such knowledge can indicate what actions are to be taken nationally

Various techniques exist to collect such data for each accident, archive the data, compile it nationally, use it to detect accident accumulation locations ("black spots") and identify causes.

It is essential to note that accident numbers have to be analysed in comparison to traffic data. For example, the meaning of five accidents per year is totally different if the road carries high levels of traffic (such as on a motorway) or low levels of traffic (such as a rural road).

3.2. What data

Accident data should include as many of the accidents registered as possible, that is all accidents with personal injury plus all accidents with serious property damage only and as far as possible, all other accidents with minor property damage only.

An accident database has to be tailored to help meet specific target objectives, which usually are to reduce the social costs of accidents, i.e. mainly to reduce fatalities and injuries. Consequently, data collection systems should concentrate on personal injury accidents.

Information needed for accidents with casualties can be found in the police accident report and sometimes more due to criminal and administrative laws. However, the police do not get information on all accidents. Therefore, as a complement, it is usually useful to collect data from hospitals (they keep track of injuries), insurance companies (for damages to the vehicles) and other sources.

Summary reports of accidents should contain the following details as far as possible:

- date and time of accident
- road users involved (number and mode of transport)
- precise location of accident and thus whether the area is built-up or not etc.
- a simple sketch of accident (not necessarily to scale)

The following data, which takes little additional effort, is also desirable:

- accident type
- indication in sketch of party responsible for accident
- key cause of accident
- details of special features such as collision with a roadside obstacle
- road condition, lighting conditions
- traffic-management measures
- geometry

Quality control of the data should be made to make sure that the recording of, for example, the place where the accident happened is correct.

This data needs to be archived properly. An accident report archive is an archive of the copies of the completed accident forms, sorted by location. It should be organised in a way that ensures swift access to the documents whenever the base data contained is required for a local accident investigation. A complete accident report archive should contain the documents from at least three, preferably six, consecutive calendar years.

Limited data collection is better than no collection at all. If local resources are restricted, it is possible and useful to simply put pins on a paper map, which will show accident accumulation locations ("black spots") in a very easy manner. If computers and GPS systems are used, this is even better.

3.3. How to use accident data

The purpose of evaluating road-traffic accidents at the local level is to detect accident accumulation locations and examine them in detail: determine where accident accumulation locations ("black spots") are, why accidents occur at those precise locations and what measures would appear appropriate to eliminate identified accident source. This requires accident maps to be created, as well as maps by accident type.

For road sections where there is a particularly large number of accidents or concentrations of comparable accidents, collision diagrams should be produced.

These documents must be carefully analysed, since comparable accidents often indicate that the characteristics of the road are defective or the traffic-management system inadequate.

The maps themselves should be very legible: printed in black and white, and at a detailed scale. They should include all relevant information (place name signs/major urban roads/traffic lights/special features etc.).

Various maps can be used for the same location: one-year maps showing all accidents, and three-year maps showing severe accidents. The necessity for one-year and three-year maps stems from the observation that accidents with serious personal injury are distributed differently across the road network than accidents overall and accidents with minor personal injury. Since there are far fewer severe accidents, the observation period has to be increased from one to three years.

For non-built-up roads (including short cross-town links), it may be advisable to only include those accidents with serious personal injury on a three-year map.

In order to indicate accidents, it is a good idea to use a variety of different coloured pins with different head diameters: the colour indicates the type of accidents, the diameter indicates the severity of the accident.

Removing the pins from the first year on a manual accident-type map at the end of the three-year period and adding the new accidents on the same map is not recommended because errors are inevitable and their impact will increase over the course of the years and the period that can be evaluated varies between two and three years.

3.4. Accident types

The accident type describes the traffic situation which led to the accident. It is determined on the basis of the manoeuvre(s) being performed at the time of the accident, not the cause of the accident or the "kind of accident". Such classification helps in analysing large number of accidents.

There are different accident type systems, such as the Hungarian or German system, and common types are used in the framework of CARE, the accident database of the European Union.

As an example, here are the German accident types (simplified):
- Driving accident: caused by a loss of control of the vehicle
- Turning-off accident: caused by a conflict between vehicles at an intersection or junction
- Turning-into/crossing accident: caused by a conflict between a vehicle which had to give way and a vehicle with the right of way at an intersection or junction
- Crossing-over accident: caused by a conflict between a vehicle and a pedestrian on the street
- Accident caused by stopping/parking: caused by a conflict between a vehicle in moving traffic and a vehicle parking/stopped or attempting to stop/park
- Accident in longitudinal traffic: caused by a conflict between road users moving in the same or opposing directions
- Other accident: u-turns, reversing, collisions between parking vehicles, obstacle or animal on the road, sudden vehicle damage etc.

4. ROAD SAFETY AUDITS

4.1. Description

Road safety audits (RSA) describes an independent review of a project to identify road or traffic safety concerns. It can be regarded as part of a comprehensive quality management system. RSA is a pro-active approach with the primary aim of identifying potential safety problems as early as possible in the planning process so that decisions can be made about eliminating or reducing the problems, preferably before a scheme is implemented or accidents occur.

The essential elements of this definition are that it is:

- At the project stage, not on existing roads
- A formal process, not an informal one;
- An independent process;
- Carried out by someone with appropriate experience and training;
- Restricted to road safety issues.

4.2. Recommendations for audits

A RSA should be undertaken on any design for new roads or on any proposal for changes in existing roads or road environment, which are likely to alter interactions between different road users, or between road users and their environment. A variety of road improvement schemes can be audited: major highway schemes, minor improvements, major traffic management schemes, development schemes and major maintenance activities.

The earlier the project is audited within the design and development process the better. Early auditing can lead to the early elimination of problems and, consequently, minimisation of time and cost of redesign at later stages. In most countries where RSA is practised, it is repeated a certain number of times during the project. These can be at several, or all, of the following key stages:

1. Feasibility stage
2. Preliminary design stage
3. Detailed design stage
4. Pre-opening stage
5. Post-opening stage i.e. monitoring performance.

To ensure that safety aspects have not been overlooked during the procedure, checklists should be used to assist the auditors in considering the relevant issues. The checklists are an aid for the application of the knowledge and experience and to make sure that all factors are considered. They identify issues and problems that can arise at the relevant stage of an audit. The auditors should use their own judgement about the safety of any particular feature. Different checklists have been developed by PIARC for different stages of a project's development.

4.3. The audit process

The ***client*** (generally the Road Authority and project owner), the ***designer*** and the ***auditor(s*)** are the three main parties participating in the audit process and their roles and responsibilities must be clearly defined. It is important to clarify this issue in the policy and the general procedure.

The general RSA procedure includes three main phases: ordering, reviewing which ends with a Written Audit report being given to the client, completion including a Written Response to the audit report. All recommendations must be given due consideration. Those that are accepted should be implemented without delay. Those problems identified that are considered to be insignificant, outside the terms of reference or that solutions recommended are not considered suitable must be addressed by means of a formal response. It is important that this formal response gives reasons why the recommendations are not accepted. This response acts as an evidence trail through the decision making process.

A RSA is an integral part of the design process but independent from the design itself. The audit process provides, at regular intervals, an independent assessment. The client remains responsible for the ultimate design and should consider that assessment. In PIARC guideline, clients are the decision makers in the design process such as national and local road administrations, companies for public roads and in special cases, the donors of financial means.

For maximum effectiveness it is very important that RSA is carried out by independent auditors. Auditors can be from private firms or road administration but they have to be independent of the project design team. This is crucial.

4.4. RSA auditors

RSA should be conducted by a team of auditors with adequate experience in Road Safety engineering principles and practices, traffic engineering and traffic management, road design, accident investigation and prevention. An auditor who has an understanding of road user behaviour and human perception is also important because the interactive nature of road user behaviour with the road environment.

The independence of the auditors is important for an impartial and unbiased judgement and evaluation. Independence in this context means that the audit is carried out by auditors who do not carry responsibility for the project and who are also not involved in producing the design that is to be audited. Auditors need to be objective in their assessments.

4.5. Effectiveness

There is strong evidence that audits are highly cost-effective. A study by Austroad on the benefit of the RSA has demonstrated substantial benefit from the process. For the design stage audits, it was demonstrated that benefit cost ratio (BCR) of implementing all the recommendations from individual audits ranged from 3 to 1 to 242 to1. Also, 75 % of recommendations had a BCR greater than 10 and 90 % of recommendations had a BCR greater than 1. In terms of crash reduction benefit, the United Kingdom experience suggests that at least 33 % of accidents can potentially be avoided or their severity reduced by conducting the RSA.

5. ROAD SAFETY INSPECTIONS

5.1. Definition of RSI

A Road Safety Inspection (RSI) is defined as a systematic on-site review of an existing road or section of road to identify hazardous conditions, faults and deficiencies that may lead to serious accidents. It is important to note that:

- A RSI is systematic – this means it is both comprehensive and carried out in a methodical way.
- A RSI is carried out by expert(s) who are not involved in the maintenance of the road
- A RSI relates to an existing road not roads being constructed.
- A RSI is pro-active, trying to prevent accidents rather than responding to recorded crashes.

5.2. Key points

The RSI process is systematic and not just focused on a particular accident accumulation location ("black spot") identified by accident data or anecdotal information from local police or local residents. RSI's aim to identify any features that may lead to <u>future</u> accidents, so that remedial treatment may be implemented <u>before</u> accidents happen.

A RSI is different from routine maintenance, which is a regular process where key infrastructure issues such as overhanging branches, the road surface, potholes and poor quality signage are reviewed and remedied. On the other hand, RSI is a process in itself, solely dedicated to road safety issues.

PIARC has prepared a guideline on RSI. It suggests road safety inspections become a routine process, carried out at regular, if well-spaced, times. However, exact timing is a decision for the road authority and could vary according to the road, investment patterns and available funding. A regular inspections regime could see a road inspected fully once every ten years for example.

5.3. Recommendations for inspections

All inspections should take into account a range of human factors which relate to driver errors that are induced by the road. Issues that should be investigated include **workload** issues, **perception, choice of speed, orientation and anticipation.**

Any road can be inspected, but a road authority may wish to prioritize for some reason, including funding restrictions. The prioritization could be based on location, traffic volume or accident data. As mentioned above, accident data can assist by indicating the worst roads in terms of crashes and these roads could be the first roads inspected.

It is strongly recommended that inspections take place BOTH during the day and at night. It is also suggested that consideration be given to inspections in different seasons if the seasons are vastly different e.g, snow in winter and very dry and hot conditions in summer. Specific issues – if the road includes a school for example, the inspection should take place partly when school children and arriving or leaving the school. Similarly if the road includes a shopping district, the inspection should incorporate busy shopping times.

Alternatively, if road conditions are known to have changed e.g. new signing and/or markings, new plantings, lighting and surface conditions, a focused road safety inspection limited to these topics can be carried out by the road administration.

5.4. RSI procedure

There are four steps in the RSI process:

- step 1 preparatory office work
- step 2 on site field study
- step 3 RSI report
- step 4 follow up

Depending on the complexity of the work, an inspection may be done by a single inspector or by a group of up to five inspectors. The members of the road safety inspection group should have very good specialised knowledge and in-depth knowledge of the region as well as an understanding of potential countermeasures and what is required for their implementation.

For the field study the road safety inspector will also use checklists as an aid for remembering the crucial connections between the roadway and drivers' mistakes. PIARC TC has developed checklists from international experiences for motorways, interurban and urban main roads.

5.5. Cost effectiveness of the RSI process

Road safety inspections should lead to treatments that are proven as effective in improving road safety. A Norwegian study highlighted that, for example, adding guard rail along an embankment can reduce accidents by between 10 and 40%, replacing fixed light poles with frangible (yielding) light poles can lead to a reduction in accidents of up to 75%.

5.6. Road safety Inspectors

Road safety Inspectors should also get a certificate to confirm that he or she has the appropriate training or experience.

6. PIARC CATALOGUE OF 'GOOD AND BAD' DESIGN PRACTICE

Road safety engineering has been common in many other countries around the world for a number of years now and this has been successful in driving down the numbers of killed and seriously injured on our roads.

PIARC is developing a catalogue of 'good and bad' design practice to assist designers and road safety engineers to both ensure designs are done better at the start or, where a road safety problem already exists, suggest possible solutions that can be implemented. The catalogue aims to graphically illustrate the potential problems and solutions and give an indication of comparative costs to assist in developing the most cost-effective solutions.

The catalogue cannot possibly address every situation that designers or road safety engineers will come across. It is intended, however, to highlight the key elements in planning, design and operation of road networks that contribute to road safety.

It can be of assistance when devising your own RSI and RSA systems and related checklists.

7. INTELLIGENT TRANSPORT SYSTEMS (ITS)

7.1. Introduction

Intelligent Transport Systems (ITS) have been used for more than twenty years, and as such include actually commonly used and widely tested tools, even if new systems are entering the market regularly. ITS are transport related systems employing information and communication technologies. They are extremely diverse and include traffic data collection systems (loops etc.), road-side systems such as variable message signs, in-car systems such as real-time traffic information, intelligent speed adaptation systems etc. ITS systems may ease the task of the driver, or promote multimodality, reducing the driver's risk of being involved in a crash or increasing the chances of surviving a crash. Applied effectively, Intelligent Transport Systems can reduce congestion, save lives and money as well as reduce threats to our environment.

ITS systems do interact with the drivers and their behaviour, and road authorities consequently have to have good knowledge of those systems and take them into account in their road safety action plans. PIARC has prepared a report aimed at road authorities, detailing ITS systems as well as their effects on road safety, in order to help them define their own strategy as regards deployment and cooperation with suppliers and operators.

7.2. Examples of effective ITS

The report focuses on road safety impacts of various ITS systems, as well as distinguishing between those that are fully ready for deployment and those that are still being tested.

Some infrastructure based ITS have proven to be effective in reducing the number of road fatalities. The best benefit-cost ratios have generally (e.g. Perrett and Stevens 1996) been found for signal control (intersection signal control or network signal control) that are usually implemented in urban areas.

Dynamic traffic management and local danger warnings for bridges or tunnels have a benefit-cost ratio well above 1 at higher traffic volumes.

Another example relates to Variable Message Sign (VMS) messages: they can be harmonised across borders, and the comprehensibility of the messages can be improved. European projects such as FIVE (Framework for harmonised implementation of VMS in Europe), among others, have made proposals on such harmonization.

Some ITS measures have been proven to have a very positive impact on road safety and are quite ready for deployment or at least extensive testing:

- seat belt reminders
- automated traffic enforcement: speed cameras, red light cameras, distance control in tunnels, alcohol locks
- incident management: automated incident detection, variable message signs, in-vehicle or infrastructure based warning systems

- provision of real-time travel and traffic information, that have considerable impacts on network efficiency and incident management
- locate accidents with GPS

Some systems look promising and have to be studied extensively:
- Electronic Stability Programme or Control (ESP) is a stability enhancing system, which improves vehicles lateral stability
- intelligent speed adaptation / speed alerts: if the vehicle is too fast, alerts sound or some physical feedback helps the driver reduce the speed; this requires speed limit databases, that keep track in real time of static or variable speed limits
- eCall systems: in case of an accident, a message is automatically sent to emergency services along with location data
- lane departure warning and lane keeping assistance systems

7.3. Most effective ITS - Measures

The table shows the seven ITS-measures with the best estimates of effects on the number of killed in road crashes.

Type of ITS		Type of crash affected	Estimated reduction in fatalities in this specific type of crash	Source
Road	Automated Enforcement of Traffic Rules	Crashes involving violation of traffic rules like speeding, red light running	-15…-25 %	Kumala 2005
Road	Intersection Signal Control	Crossing and turning crashes, pedestrian run-overs	-15…-25 %	Kumala 2005
Road	Dynamic Traffic Management and Local Danger Warning	Crashes in adverse conditions like pile-ups	-5…-25 %	EU safety effects database and Safety Forum 2005
Road and Vehicle	Intelligent Speed Adaptation (ISA), Speed Adjust and Speed Alert	Crashes involving speeding	-15…-25 %	EU safety effects database 2006, COWI 2006 and Safety Forum 2005
Road and Vehicle	eCall	All serious crashes	-2…-15 %	Safety Forum 2005
Vehicle	Electronic Stability Control or Program (ESC/ESP)	All but especially single crashes, loss of control, crashes on wet and slippery roads	-15…-40%	Safety Forum 2005
Vehicle	Alcohol (Ignition) Interlock	Crashes involving intoxicated drivers	-20…-25 %	Safety Forum 2005

Note: effects of vehicle systems suppose a 100% market penetration; effects of road systems estimated at the equipped road section and sometimes nearby.

7.4. Road authorities' role

ITS are very useful tools in improving road safety and PIARC recommends that road authorities should prepare and enforce a medium term ITS action plan. Developing countries can benefit as well since ITS systems are not always expensive and some have a very high cost benefit ratio.

This includes purely infrastructure related systems for which road authorities are fully responsible. The ITS action plan should be based as well on a common vision shared with car manufacturers, equipment manufacturers, service providers and the telecommunications industry. The PIARC report distinguishes between infrastructure based systems, vehicle based systems and systems that combine infrastructure based and vehicle based technologies, and recommends actions for road authorities accordingly:

- infrastructure based systems: deploy the proven systems on all networks and study promising systems
- vehicle based systems: recommend at the highest level that they are deployed
- systems that combine infrastructure based and vehicle based technologies: engage in cooperation with car manufacturers and suppliers to work out the required interfaces and standards, speed deployment and deploy the proven systems on all networks

When budgets are constrained, it is worth remembering that priority has to be given to the most cost effective systems rather than the most high-tech, comparing them with more traditional efforts such as crash barriers or road surface treatment. Continuous technology development and emerging new solutions set great challenges as systems seem to become obsolete quite quickly. Nevertheless, the basic building blocks are quite stable in the form of positioning, identification, real-time transport network status information, data communication interfaces and systems architecture. For this reason, road authorities can make investments in ITS without extensive worry about aging technology components.

The role of road authorities also encompasses regulatory missions:

- check that vehicle based systems do not distract drivers from the main task of driving, and enforce man-machine interface safety standards
- monitor the quality of the systems and services and, for their own services and systems, define and publish the quality levels as maintained
- monitor standardisation activities and, where necessary, undertake common measures so that their needs are met. Relevant examples are cross border data exchange, systems architecture, and traffic control.

They also can get involved in research efforts and pilot projects especially on areas neglected by international forums and industry, such as vulnerable road users (since vehicle-based systems almost always focus on improving the safety of the car drivers and occupants only).

For effective vehicle based systems road authorities can put pressure on vehicle manufactures to include the systems as a standard features and they can influence governments to lower taxes on those systems if appropriate. For road based systems road authorities can implement those systems at given locations where they are expected to have measurable influence on the number of crashes. The same is the case with systems incorporating both road and vehicle technology.

8. CONCLUSIONS

The technical committee’s founding principle is that driving involves drivers, vehicles and roads simultaneously and improving road safety thus requires a systematic approach which involves tackling all three subsystems.

8.1. Actions for PIARC

Enforcement and driver's education

Enforcement and driver's education are generally regarded as effective ways of improving road safety overall. However, they do not fall within our TC's scope. TC 3.1 thus recommend that:

- PIARC needs to define its position on law enforcement and driver's education
- If interested, we recommend that PIARC build another additional TC devoted to these topics
- In that case, cooperation between the infrastructure engineering TC and the enforcement and education TC needs to be properly defined
- Since other organizations such as WHO are working on these topics already, active cooperation between them and PIARC would be required

Road safety manual

PIARC produced a Road Safety Manual in 2003, which is a compendium of road safety procedures. It needs to be regularly reviewed.

8.2. General recommendations

All the above procedures have been proven effective in improving road safety. All countries and road operators are encouraged to deploy them over their network.

Priorities may vary from country to country and they need to be defined locally. Nevertheless, road safety audits can be put into practice immediately in every country.

Developed countries usually have comprehensive accident data and some accident accumulation location ("black spot") treatment measures. Nevertheless they would still find it beneficial to invest in RSA and certainly in RSI.

Countries in transition should absolutely focus first on RSA for their numerous projects. They may be looking for cost effective returns as well and should therefore also invest in accident accumulation location ("black spot") treatment.

Donor organizations should make Road safety audits a condition for the funding for all road projects. They should also make funding available for road safety measures on the existing road network, such as RSI, accident accumulation location ("black spot") treatment and accident data collection.

Each country needs to define a national accident data collection strategy and need to enforce it with all partners involved (police forces etc.).

Efforts should continue so that human factors are taken into account whenever possible: all road users (drivers, pedestrians, cyclists…) have their physiological and psychological limitations, and road infrastructure and equipment design procedures should take them into account at every stage.

8.3. Ways for the future

During the period 2004-2007, we have also identified topics that need more detailed study so as to come up with background data and recommendations.

<u>Legal framework for road safety practitioners</u>

Who is in charge of ordering a road safety audit? Who is responsible if an audit's remarks are not properly taken into account? How often should a network segment be inspected? How are inspectors or auditors certified? What is their liability level?
How is access control to private properties regulated? How are the needs of vulnerable road users regulated?
How is road safety implemented in the road acts? Road planning and operation is mostly in conflict with other interests, planning's and values (assessments). How is road safety defended against these competitive influences?
=> A catalogue of existing practices would help authorities decide on the best legal framework in their country.

<u>Network safety management (NSM)</u>

NSM identifies locations of the road network where accidents occur at a high frequency, and aims at understanding the reasons behind this and then making recommendations for remedies. NSM takes a wide perspective on the infrastructure and the driving procedure, so that it is able to take into account all factors affecting the drivers on a given itinerary.
=> A guideline on NSM would be very useful.

<u>Accident accumulation location ("black spot") treatment</u>

Accident data, even if it is rudimentary, makes it possible to identify accident accumulation locations. Accident accumulation location treatment is the process to identify, investigate and suggest solutions for accident accumulation locations with significantly high number of accidents.
=> A guideline on accident accumulation location ("black spot") treatment would be very useful, especially for countries in transition

Road safety in urban areas

TC 3.1 has focused on the safety of interurban roads. Urban areas pose a more complex problem due to mixed usage of the network, high numbers of vulnerable users and high variations of speeds. This issue is all the more important since urban areas are spreading all over the world, and recent data in some developed countries has shown that safety has improved on motorways but not so in urban areas.
=> A guideline on road safety on urban areas could benefit both developed and developing countries

Safety around work zones

Accidents at work zones on roads are unfortunately too frequent and are all the more politically and economically sensitive since injured and killed staff were working on improving the infrastructure itself. What's more, network managers have access to a large number of preventive measures and increasingly feel that safety around work zones is a personal priority.
=> A guideline on safety measures around work zones would help managers prevent dangerous situations.

Cost effectiveness of all safety measures

A large variety of measures are available for improving road safety: RSA, RSI etc. for infrastructure improvement as well as drivers' education, law enforcement, organization of emergency services etc.
=> Knowledge of the comparative cost effectiveness of all these measures will help allocate resources in the most effective way.

Political procedures to promote road safety

A large number of government bodies and private institutions have a role in the improvement of road safety: road authorities, transport authorities, network operators, police forces, education department, insurance companies, health department, hospitals, emergency services etc. Close coordination of all these bodies through a structure such as a "national road safety council" is required to identify priorities, set objectives and monitor achievements.
=> Recommendations on how to set such a council and how to organize it would contribute to reducing casualties.

These topics will hopefully be addressed in the period covering 2008-2011.