SAFER ROAD DESIGN
MANAGING THE DRIVER CHALLENGE

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ABSTRACT

The emergence of a consensus on the safety benefits of road design and management, as materialised by a draft Directive currently under examination by the European Parliament, should not overshadow the fact that all too often, it is still road injuries and deaths that trigger reactive measures by network managers.

Abundant empirical evidence suggests that many accident types tend to happen in clusters, especially if there is a road infrastructure element in the problem. It is a well-known phenomenon that certain roads induce driver drowsiness or, worse, mislead the user into inappropriate driving choices. It is less obvious however that physical road properties also constitute an important input into the improvement of on-board active safety technology, such as Antilock Braking Systems and Electronic Stability Programmes.

Concepts that have emerged since the 1980s, such as 'positive guidance', 'road readability' and 'self-explaining roads', all raise the question of how the road infrastructure could support drivers' activity. These different approaches have in common that they recognise that the road environment conveys a wealth of information that guides drivers' activity and their interactions with others in situ. They also stress the need to structure the road network by adopting homogenous and consistent design principles that take account of the different tasks to be performed by the various road users and the constraints on their execution

Thanks to RANKERS, an ongoing project co-funded by the European Commission, new knowledge is being gained to meet the needs of road operators by offering a set of practical recommendations to avoid the constitution of accident cluster zones through preventive identification mechanisms and remedial measures ranked according to cost-effectiveness criteria.

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Keywords: engineering safer roads, human factors, behaviour-setting road design

1. THEORETICAL BACKGROUND

1.1 Driving seems so easy….

The starting point is to consider that most crashes happen when people make ordinary mistakes. Responsible, law-abiding drivers frequently die on Europe's roads because they unexpectedly face a momentary situation with which they cannot cope.

Like many activities performed in dynamic environments, driving is characterised as:

- A complex task, subject to temporal constraints and calling for a continuous adjustment to evolving road situations;

- A task that implies the organisation and performance of multiple inter-related sub-tasks associated with the control of the vehicle, on the one hand, and the control of road events, on the other;

- A task in which the driver is facing uncertainty and has to take decisions that involve risks, given the number of interactions to be negotiated.

Errors, incidents and accidents demonstrate the limits of drivers' adaptation to their task, and the factors responsible for that need to be analysed, understanding the reasons for such deviations, identifying the conditions in which they are most likely to appear and analysing the mechanisms that could explain their occurrence.

Most of the research studies point out that human error is implicated in most of the accidents, meaning for instance that at that particular moment which preceded the accident an alert driver would not have made that particular error.

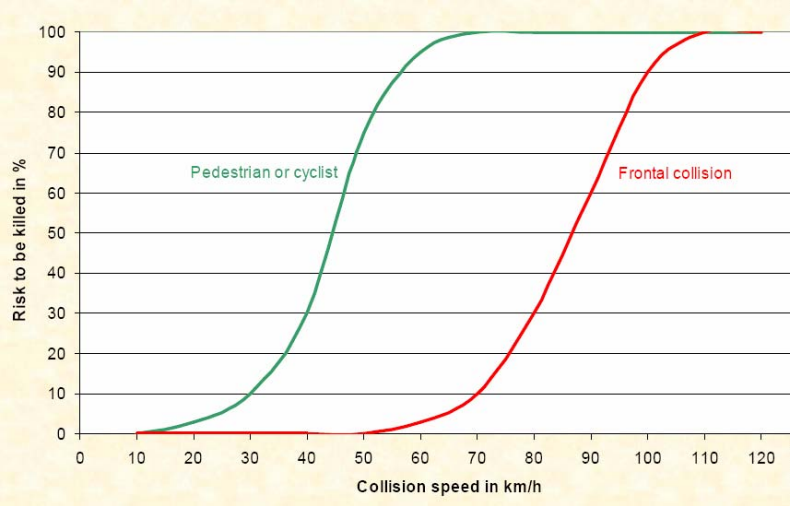
However, if we identify human error as the major component in traffic accidents and then implicitly blame the driver, we are in danger of blaming the victim of a poor traffic system. We know that the individual accident is an unpredictable event, but we also know that accidents as an aggregate are systematically over-represented at certain locations and in certain circumstances. Rather than blaming the road user, we should blame the designers and operators of the traffic system as a whole for creating a situation in which human fallibility inevitably leads to injury and death.

A novel branch of road engineering, safe road design considers the human physiological and psychological abilities, limitations and needs of road drivers. It considers the complex interaction between the three key components of the road transport system: users, vehicles and roads in order to minimise the chance of dangerous situations arising and, if they do occur, to minimise the severity of the crash.

The human being is not just the most fallible, but also the most vulnerable component of the road transport system. Critical speed limits testing shows that

- For people with fastened seat belt, on board of a recently built car, frontally colliding with a similar vehicle or a fixed obstacle, survival probabilities are fairly reasonable up to cruise speed of 70 km/h. Above that speed however, chance of survival dwindles quite quickly, if not dramatically.
- For a side collision (a quarter of all fatal or serious injuries), the critical speed drops to 50 km/h.
- For pedestrians and cyclists, the critical speed, when hit by a passing car, is just 30 km/h.

These three categories of accidents today account for most crashes resulting in the disabling injuries or deaths that destroy lives.

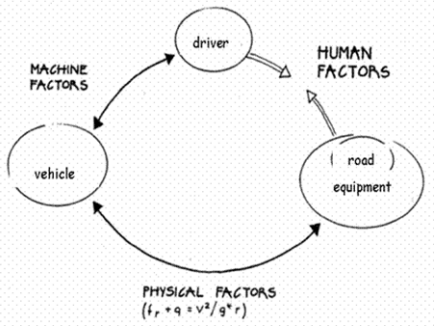


1.2 Basic axioms

The interaction between vehicle and road is described in several technical guidelines and is well known. The interaction between drivers and vehicles is well described by psychological and ergonomic standards used by the automobile industry. The interaction between road users and road features has not been systematically described until now and is not available to road designers under the form of well harmonised pan-European guidelines.

The road infrastructure conveys a wealth of information that guides drivers' activity and their interactions with others in situ (explicitly through devices such as road signs and road marking, and implicitly by means of the environmental context and road layout, for example). The design of the infrastructure and the formulation of the rules determining its use result from choices made by the designers of the road system in the broadest sense (including in particular road and traffic engineers and the legislators of the highway code), so one can regard the road infrastructure as an interface between road designers and drivers.

Therefore, an effort is worth being made so that human behaviour is understood as part of a system that should work together. An optimised safety infrastructure is the one providing the most suitable environment for drivers and their vehicles, mitigating the effects of accidents but also reducing the risk that they occur.



- ✓ ***The 300m-Axiom:*** *the road must provide sufficient adjustment ime*

The re-adjustment from one traffic situation to the next one or the adjustment to new requirements takes much more time than is generally assumed. Today we know, that the time for a shock reaction is in average 4 to 6 seconds to change the driving programme. At a speed of 100 km/h he drives a distance of up to 300 metres during this time. A user-friendly road allows a reliable adjustment of driver's behaviour to a new situation. It gives the driver enough time to re-organize his driving programme safely.

Conclusion: Don't surprise the driver! At a minimum of 300m before straining points: arrange transitional areas, remove view barriers, make junctions perceptible, use additional markings to indicate bus stops, bicycle paths, etc.

- ✓ ***The Field-of-vision-Axiom*** *: the road must offer the driver a safe field-of-vision*

The road offers together with its equipment an integrated field-of-vision. This can either stabilize or destabilize the behaviour of the driver. Depending on the level of strain, it can tire or activate him. A good quality of the field-of-vision effectively guides the motorized driver and keeps him from drifting to the edge of the lane or even leaving it. The field-of-vision also affects lane keeping abilities. If the road provides the driver a good visual support in slopes and bends, then the driver will steer his car in a sufficient distance to the centreline.

Conclusion: Don't misguide the driver! Avoid: Monotonous approaching areas and surroundings of a road, Unsymmetrical and / or different-high superstructures and those, which are non-parallel to the view axis, objects, sticking out of the road scenery, e.g. trees, buildings, technical facilities , ptical guiding lines, which are non-parallel to the road edge e.g. markings, hard shoulders, crash barriers, plants, …

Formattati: Elenchi puntati e numerati

- ✓ ***Logic-Axiom:*** *the road must follow driver's perception logic*

The driver follows the road with an expectation and orientation logic, which was formed by his experience and recent perceptions. it affects his perception and reaction. the perception of the lane, the edge of the lane and the lane periphery lead to an integrated impression, on which the driver reacts with his operations. in most cases this is an unconscious process.

Unexpected abnormalities disturb this automated chain of operations, for instance avoid roads with discontinuous bends. when planning of new road sections, it is always a good idea to them to the existing road characteristics before and behind this point. the aim is to exclude any sudden changes. by contrast, the driving environment can signal important changes, such as a change in function of the road.

Conclusion: Do not confuse the driver! Avoid especially Continuous road characteristics despite a change in function („town entrance effect" / „avenue effect"), sudden changes of the course characteristics despite habit and routine because of new junctions or changes in the right of way etc. („effect of habit and routine", sudden changes of the driver's strain, because of a flood of information („jungle of road signs") or the accumulation of decisions and driving actions by the driver (accumulation of straining points).

2. RESEARCH LINES

2.1 Background

When road safety policy is analyzed, three main areas of action can be defined corresponding to the three main actors involved in road safety: human, vehicle, and infrastructure. The three of them, usually called "the three safety pillars" are addressed in different ways. However, this range of domains must be dealt with subject to budget limitations. Consequently, cost efficiency of systems and measures needs to be a decisive factor for policy making. **Road infrastructure**, as the most visible component of the road transport network, represents an area where **safety investments can have an immediate benefit**.

In this context, **RANKERS** (RANKing for European Roads Safety) pursues the ambitious objective of developing scientifically-researched guidelines enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections. Co-funded by the European Commission, RANKERS is a research project designed to gain new knowledge by performing research and empirical studies of the road's interaction with the driver and his vehicle in order to identify optimal road recommendations and predict their impact on safety. The main output of the project will include an index used for assessing and monitoring road safety and a comprehensive catalogue of road infrastructure safety recommendations ranked according to their cost-effectiveness.

RANKERS is unique in that it proposes to address traditional passive safety measures ("forgiving roads") together with a better understanding of the accident causation scenarios, leading to a significant mitigation of the risks posed by the road and its environment. The roads design should be directly focused to the concept of making "self-explaining roads", that is to say, advocating a traffic environment which elicits safe driving behaviour simply by its design so that the road user is neither confused nor invited to take risks.

2.2 Objective and methodology

RANKERS is a research project designed to gain new knowledge to meet the needs of network operators, road administrations as well as policy-makers. As such, it will attempt to bridge the divide between European policy-making and the operational needs of road engineers.

RANKERS follows the RISER Project (Roadside Infrastructure for Safer European Roads) but goes a step further by proposing to address traditional passive safety measures – **"forgiving roads"** – along with a better understanding of the accident causation scenarios, leading to a significant mitigation of the risks posed by the road and its environment.

Thus, RANKERS will develop comprehensive, scientific-based and practical guidelines to enable optimal cost-effective decisions by road engineers in their efforts to eradicate dangerous road sections and decrease risks posed by the road environment. RANKERS is highly innovative in that it proposes addressing the "infrastructure safety pillar" in its interrelation with driver behaviour and vehicle design, by means of extensive data collection and analysis, along with field tests.

RANKERS will perform research and empirical studies of the road's interaction with the driver and the vehicle in order to identify the critical shaping conditions for possible road recommendations

and their impact on safety. The recommendations that will result from the project will suppose a best use of limited resources reducing the return time for road safety improvements and investments.

The implementation plan for RANKERS comprises three main areas of work:
(1) identification of accident scenarios and accident causation mechanisms based on existing research on road safety reviews,
(2) analysis of road passive safety infrastructure, vehicle-road surface interaction and human behaviour, and
(3) recommendations for safe road infrastructure management validated by field tests.

2.3 Identification of accident scenarios

Prioritising engineering measures requires a sound understanding of frequent accident causes. As part of the initial work carried out within RANKERS, accident causes on dual carriageway roads in 5 European countries were analysed over a period of four years. Multiple linear regression analysis helped identify four main accident scenarios prevalent on European motorways:

- Loss of car control with no reaction from the driver (long journey and/or presence of particular fatigue, heavy sleep, run-off with no action on the steering wheel);
- Loss of car control with driver reaction (reduced driver vigilance, slight drowsiness, sharp turn of the wheel);
- Rear-end collision (reduced driver vigilance and/or unexpected event, resulting in a rear-end crash);
- Lane-changing collision (reduced driver vigilance, unawareness of the vehicle presence on the side leading to lateral impact)

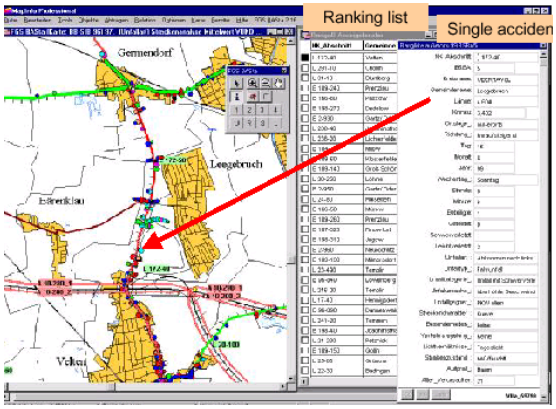
A key assumption behind the project is that many of these accidents can be avoided through objective road infrastructure measurements coupled with a better understanding of the behavioural component of driving patterns. In many cases, the data needed to produce an enhanced safety assessment of specific infrastructure elements is already available through routine road maintenance operations. For instance, road administrations are increasingly using laser technology with to measure conditions of the road surface. The results of this measurement are then used to estimate maintenance performance and costs of road networks. RANKERS is taking advantage of data which is saved in a system called PMS (Pavement Management System) and completing with other needed information to study effect of road condition on traffic safety. Similarly, installation details for new road elements (lights, signs, barriers, etc) can be used to study the effectiveness of different countermeasures in before/after studies.

In parallel, further experimental work is being carried out to study actual driving behaviour in response to such stimuli as roadside elements or features affecting lateral position and speed, weather and visibility conditions influencing driver's perception of the environment and road layout leading the driver to commit mistakes. This is a notoriously difficult exercise owing to simultaneous stimuli but, over the past few years, the development of on-board observation methods using video and other on-board devices have offered the possibility of gathering large amounts of behavioural data that can be more easily related to controlled variations in the driving situation.

2.4 Expected results

Road Safety Index

One of the main outputs of RANKERS will include **an index used for assessing and monitoring the objective risks posed by the road environment.** This index will give evidence of the risk factor of a road section by means of the estimation of its driver protection (passive safety) and prevention levels (active safety). By building accurate, objective criteria for the evaluation of each safety feature of a road, current Road Safety Audit and Inspection procedures will be upgraded and roads sections will be prioritised according to their objective needs.



Catalogue of recommendations

The second major RANKERS deliverable will be **a comprehensive catalogue of road infrastructure safety recommendations ranked according to their efficiency**. This list is intended to provide practical information to road operators, national road authorities and safety auditors on a cost-efficient and safety oriented management of road infrastructure. Specifically, the ensuing recommendations must enable practical decision-making, by giving road authorities the means to identify safety levels and implement practical recommendations with clear references to solutions available from the industry, cost-effectiveness criteria, existing standards and estimated impact to society.

END NOTES

In comparison with previous research projects in the area of road infrastructure safety, RANKERS is innovative in its commitment to deliver results that are directly applicable in the field by the road professionals – road managers, operators, or authorities – by addressing together the two aspects of major concern to them: safety and cost. In the long term, projects such as RANKERS can be the starting point for new industrial strategies, as they will challenge commercial organisations in their product development in the framework of a single market and a growing European culture of safe road design.