



MARKING THE WAY TOWARDS A SAFER FUTURE

AN ERF POSITION PAPER ON HOW ROAD MARKINGS CAN MAKE OUR ROAD SAFER



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1. Introduction



Despite significant progress achieved during the last ten years in the field of casualty reduction at EU level, approximately 80 people still lose their lives on a daily basis on Europe's roads. Put differently, it is comparable to a town of 27,000 inhabitants disappearing over Europe every year.

The European Transport Safety Council has set the value of a human life at € 1.84 m based on the willingness to pay (WTP) approach¹. Relying on this figure, which is endorsed by the ERF for the purposes of this position paper, we arrive at the conclusion that road fatalities cost the EU a staggering € 51 billion in 2012.

Moreover, once the cost of injuries is included, the figure increases dramatically. If one includes the cost of medical treatment and of losing members of the workforce, and the extra financial burden placed on insurance, legal and social support systems, the EU's road injuries give rise to a combined annual bill of around 2% of GDP, i.e. € 250 billion². All in all, road accidents cost the EU economy € 300 billion annually.

Cheap and effective solutions currently exist that can make an immediate difference, saving lives and reducing the immense socio-economic burden road traffic accidents place on the economy.

The current position paper outlines how the road infrastructure sector and, in particular, the road markings industry can help make a difference immediately, cheaply and effectively.

George Lee
Chairman of the ERF Working Group on Road Markings

¹ A methodological note on the WTP approach is available here http://www.etsc.eu/documents/Methodological_Note_PINReport2011.pdf

² COMMISSION STAFF WORKING DOCUMENT: On the implementation of objective 6 of the European Commission's policy orientations on road safety 2011-2020 – First milestone towards an injury strategy

2. Executive Summary



Road markings are one of the most cost-effective traffic safety solutions available to policymakers and road authorities. Yet, as a result of the fiscal pressure on state budgets, the quality of the road markings on Europe's roads has been steadily declining in recent years and in some cases, they have even disappeared altogether.

As Europe's population is ageing, it is expected by 2020 that approximately 25% of drivers on Europe's roads will be over 65 years, who as a result of reduced reaction and visual abilities, will need clear and visible guidance on the road.

Moreover, the gradual integration of Lane Departure Warning / Lane Keep Assistance systems into vehicle will mean that in the future, many accidents linked to run-offs and cross-over could be avoided,.

This, however, requires a comprehensive policy for the maintenance of road markings and the establishment of a minimum intervention policy which can guarantee that markings do not fall under a specific performance in order to be visible to drivers and to the intelligent car. Only this ensures the potential reduction of accidents, thus helping save many lives.

Based on analysis of relevant research, empirical evidence and a review of current regulations in different Member States, the ERF is proposing the establishment of an intervention and maintenance policy that can be summarised as 150x150.

In other words, road markings on Europe's roads should have a minimum width of **150 mm for all roads and their performance should not be allowed to drop below 150 mcd/lux/m² (R3) in dry weather conditions and 35 mcd/lux/m² (RW2) in wet and rainy conditions.**



3. Road infrastructure as a sine qua non for a safe road transport



Road safety ultimately depends on taking coordinated actions at all levels of government (European, regional, local etc.) and acting on all pillars of the road safety triangle, i.e. the vehicle, the driver and the infrastructure.

As a result of financial crisis and the inevitable pressure put on national coffers, governments and road authorities have in recent years increasingly focused their efforts on the vehicle and the driver, often neglecting the huge road safety benefits that can be achieved by investing in road infrastructure.

According to a report by the United Nations Road Safety Collaboration “Working Group 4 – Infrastructure”, targeted investment in road infrastructure can generate crash cost savings of up to 60 times the cost of construction.³ That is, for each € 1 invested, there was a return of up to € 60 in terms of crash costs avoided.

Further research performed by the Road Safety Foundation has shown that low-cost improvements at high risk sites can generate even higher returns. More specifically, the Second Review of the Government’s Road Safety Strategy performed by the Department of Transport in 2007 analysed the effectiveness from all the small safety engineering schemes across England in one year. This English annual programme cost a little over £100m and delivered an estimated average ‘first year rate of return’ of over 300 per cent.⁴

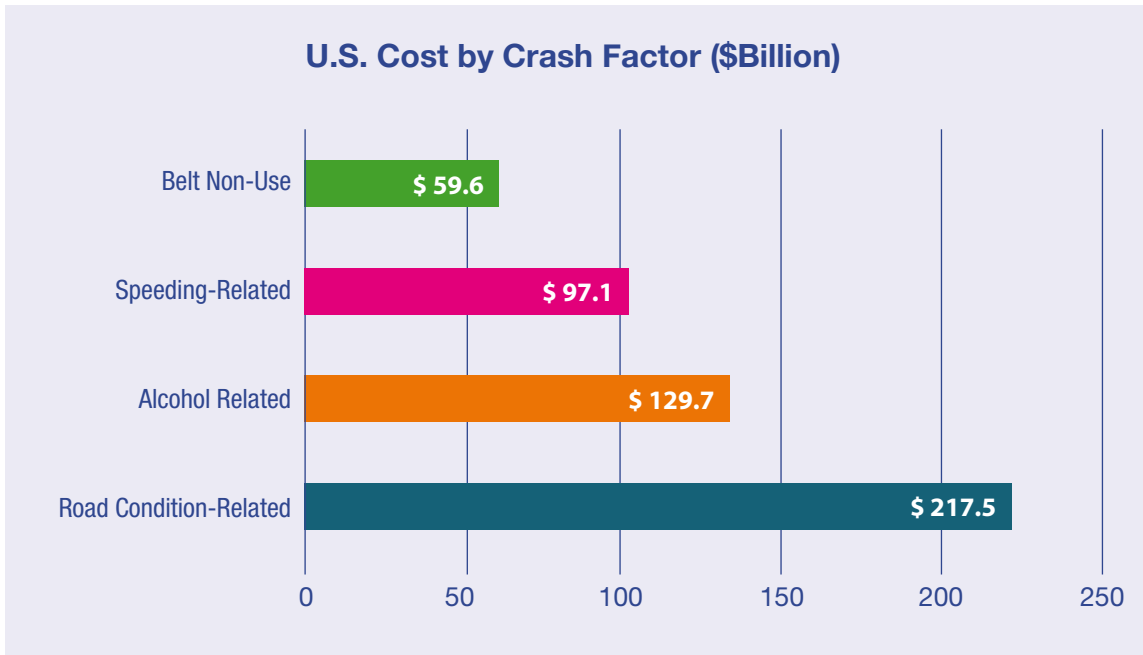
If acting on the road infrastructure can result in high safety gains, the lack of proper maintenance can, no doubt, increase the safety risk of drivers circulating on the roads. According to a study recently published in the USA by the Pacific Institute of Research and Evaluation entitled ‘On a crash course: dangers and healthcare costs and deficient roadway conditions’⁵, more than half of U.S. highway fatalities are related to deficient roadway conditions – a substantially more lethal factor than drunk driving, speeding or non-use of safety belts.



³ Safe Roads for Development: A POLICY FRAMEWORK FOR SAFE INFRASTRUCTURE ON MAJOR ROAD TRANSPORT NETWORKS <http://www.fiafoundation.org/publications/Documents/safe-roads-for-development.pdf>

⁴ Road Safety Foundation – Getting Ahead [http://eurorap.org/media/2261/20081001_CSRD_GettingAhead_bookletWEBv3\[1\].pdf](http://eurorap.org/media/2261/20081001_CSRD_GettingAhead_bookletWEBv3[1].pdf)

⁵ <http://www.nssga.org/government/PIRE.pdf>

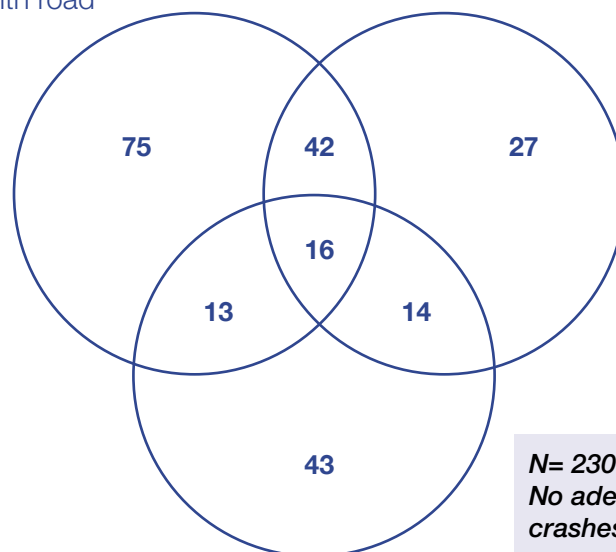


Similar research performed in Sweden has confirmed that deficient road conditions are often a contributing or deciding factor in fatal road crashes. An in-depth analysis of 230 fatal crashes occurred throughout 2004 found that non-compliance with road safety criteria was exclusively responsible for 32,6 % of the fatal accident and a contributing factor in 30,8%.⁶

Reasons for fatal outcomes divided into noncompliance with safety criteria for the road, the vehicle, and/or the road user (Step 2)

Non-compliance with road safety criteria

Non-compliance with vehicle safety criteria



N= 230
No adequate criteria for 18 crashes

Non-compliance with road-user safety criteria

⁶ Helena Stigson , Maria Krafft & Claes Tingvall (2008): Use of Fatal Real-Life Crashes to Analyze a Safe Road Transport System Model, Including the Road User, the Vehicle, and the Road, Traffic Injury Prevention, 9:5, 463-471

4. Road Markings: the indispensable road element



Road markings can be described as one of the most cost-effective safety solutions available to road authorities. They provide much needed spatial awareness to drivers by delineating the boundaries of the road, thereby significantly reducing the risk of head-on and run-off collisions. Depending on the road surface, weather and light conditions, a variety of customised solutions exist to ensure a high level of safety and comfort for the driver. Road markings are an affordable solution to provide a good perception/conspicuity of the driving lanes and spaces, contributing to a predictable trajectory. Moreover, road markings can fulfill the expectations of the road users insofar that they can contribute to give visual cues to categorise the road properly (SWOV 2006). Road users understand intuitively the nature of the road and the expected driving behavior. Typical road designs based on road markings implement self-explaining roads and incite drivers to adapt their speed accordingly (SPACE 2010⁷).

Several studies to date have provided convincing evidence of the highly beneficial role of road markings for road safety.

In 2007, the Road Safety Markings Association (RSMA) published the report 'White Lines Save Lives', which, amongst others, provided a cost-effectiveness analysis of the performance of new road markings in selected counties.

Cheshire County Council decided to apply a wet-night visible material on a section of the A556 highway which, during the last three years, had recorded 16 personal injury accidents at an estimated cost of £1, 4 m to the UK economy.

After the application of the enhanced wet-night performance product, the number of total accident fell significantly as indicated in the table below:

Accidents before and after application of wet-night visible product

Status	Total Accidents	Serious accidents	Slight accidents	Wet-Dark accidents
Before treatment	16	2	14	4
After treatment	6	0	6	0

⁷ SPACE (2010) Speed Adaptation Control by Self-Explaining Roads, Self-Explaining Roads Literature Review and Treatment Information. Deliverable Nr 1, June 2010, Dr Suzy Charman, Graham Grayson, Dr Shaun Helman, Dr Janet Kennedy, Olinde de Smidt and Brian Lawton: TRL, UK Mag. Georg Nossek, DI Leonhard Wiesauer, DI Alexander Fördös, DI Verena Pelikan: KfV, Austria Pavel Skládány, Petr Pokorný, Michal Matějka, Pavel Tučka: CDV, Czech Republic Advancing SWOV (2006). Sustainable Safety National Road Safety Outlook for 2005-2020

In similar fashion, Durham City Council undertook extensive work during the period 2003-2006, to junction layout improvements involving enhanced road markings. Analysis of the effectiveness of these measures includes:

- A 50% reduction in accidents associated with improved markings layout
- A reduction of speed in 85th percentile
- Reductions in vehicles breaking the speed limit
- An average first year return of 1,868%

An older report published by The Royal Society for the Prevention of Accidents in 1997 made a cost-benefit analysis of a number of low-cost engineering interventions carried out in the United Kingdom within the context of Local Safety Schemes implemented by local authorities. In total, forty-three road marking interventions were implemented at an average cost of £ 2020 leading to a reduction in accidents of 43% and an estimated First Year of Return (FYRR) of 957%.⁸

Similar evidence is also available from studies on the other side of the Atlantic. The Federal Highways Administration (FHWA) launched in 2006 a study to look at the safety of wider pavement markings. A nationwide survey was conducted to assess states that have wider pavement markings on all or some of their highways. Three states were found to have the required information set out by the FHWA, those being i.e. Michigan, Illinois and Kansas.

In Illinois, a total of 3973 segments (1817 miles) were analysed consisting of 3224 segments (1511 miles) with 4-inch edge lines and 749 segments (306 miles) with 5-inch edge lines. An analysis carried out over 5 years (2001-2006) found that the presence of wider edge lines had a positive effect on driver safety by reducing the number of crashes.⁹

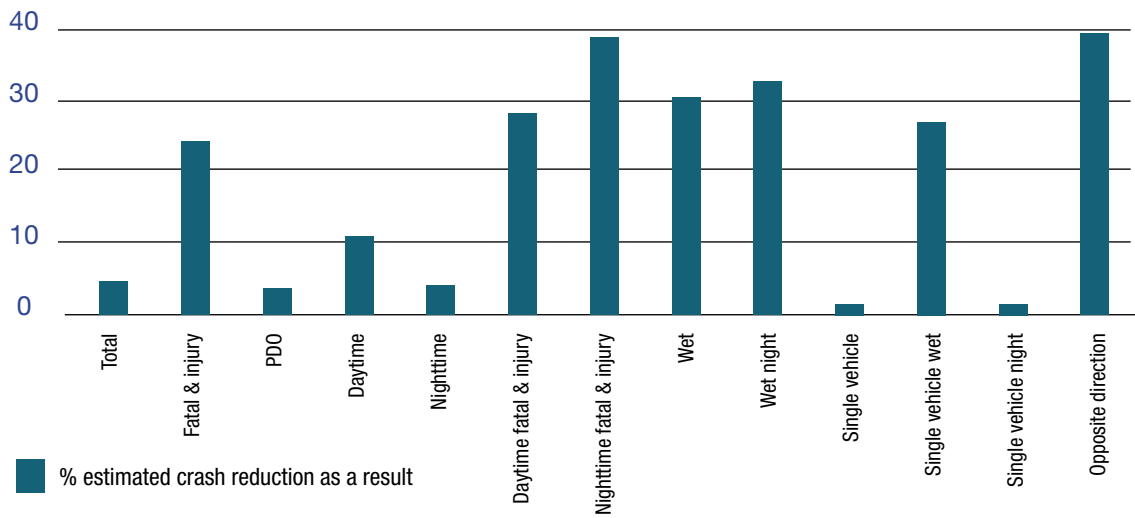
In Michigan, before-after evaluations were conducted with 3 years (2001-2003) of before and 2 years (2005-2006) of after data obtained from 386 rural two-lane segments corresponding to 1223 miles of rural two-lane roads. The subsequent analysis resulted in the following crash reduction estimates: total (5.8 %), fatal and injury (24.6%), PDO (3.9%), daytime (10.9%), nighttime (3.6%), daytime fatal and injury (28.7%), nighttime fatal and injury (39.5%), wet (30.9%), wet night (33.2%), single vehicle (1%), single vehicle wet (27.6%), single vehicle night (0.9%), and opposite direction (39.3%). All of these crash reduction estimates except night time, single-vehicle and single vehicle night crashes were statistically significant to the 95th percentile¹⁰.

8 Road Safety Engineering – Cost-effective local safety schemes: the Royal Society for the Prevention of Accidents

9 Carlson P.J., Park, E. S., Andersen C.K (2008), The Benefits of Pavement Markings: A renewed perspective based on recent and ongoing research, TRB 88th Annual Meeting,

10 Ibid

% estimated crash reduction as a result of using wider pavement markings



5. The Problem: From white to grey

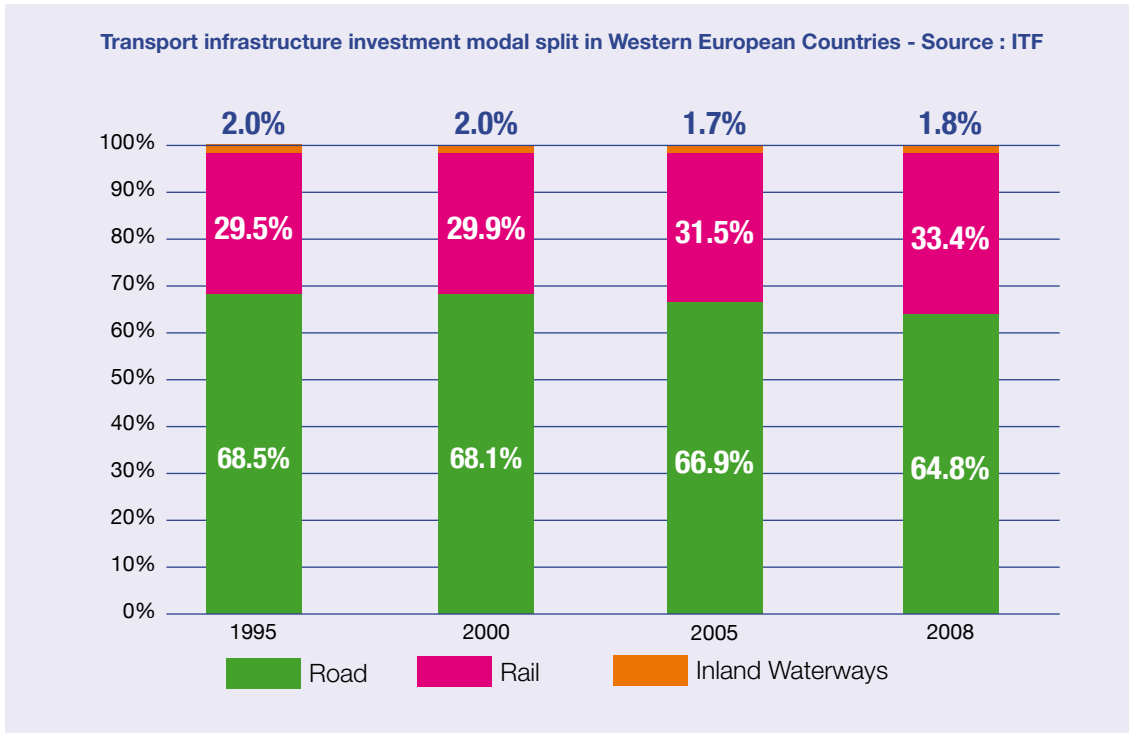


5.1 Declining investment into roads

Despite the proven benefits of road markings both in terms of safety and economics, road authorities are consistently failing to ensure proper maintenance.

According to the OECD's International Transport Forum investment in transport infrastructure has steadily declined since the 1970's from a peak of 1,5 % of GDP in 1975 to around 0,8 % in 2000, where it has remained stable until the financial crisis. While consolidated data after that is not available, it can be reasonably assumed that transport budgets have been further reduced as governments try to balance their books.

In addition to the overall decline in absolute numbers, the % of funds dedicated to roads in Western Europe has decreased compared to railways and inland waterways.



This is leading to a rapid and serious deterioration of the quality of markings on Europe's road network.

In 2012, the Road Safety Markings Association made an extensive survey of the condition of road markings on 7250 km of roads across England, Scotland and Wales. The results found that:

- 40% markings on Scotland's motorway and dual carriageways need immediate replacement
- 40% markings on dual carriageways in Wales need immediate replacement
- 38% of markings on dual carriageways maintained by the Highways Agency in England need immediate or scheduled repairs
- 25% of markings on HA single carriageways need replacing now; 19% scheduled

A similar study carried out by the Swedish research centre VTI on behalf of the Swedish Transport Administration found similar results. Published in May 2013, the study shows the results of a large scale survey carried out in 2012 to assess the condition of road markings on Swedish roads. The general conclusion of the report is that ***'in most regions, the share of road markings fulfilling the requirements regarding dry road markings in the regulations was less than 50 per cent. For wet-road markings, the corresponding figure was 21 per cent'***.^{1,12}

Even more alarming was how quickly the state of the markings had deteriorated compared to 2011. According to the report produced by VTI, the share of dry markings that fulfilled the minimum criteria retro-reflectivity level on European and country roads fell from 52% to 38%, whilst the percentage of wet road markings fulfilling the minimum retro-reflectivity level in general fell from 45% (2011) in 2011 to 21% (2012)!

¹² Sven-Olof Lundkvist, Jonas Ihlström and Mohammad-Reza Yahya, 'Condition assessment of road markings 2012 summary of the results from all regions in Sweden' <http://www.vti.se/en/publications/pdf/condition-assessment-of-road-markings-2012-summary-of-the-results-from-all-regions-in-sweden.pdf>

Last but not least, a report from the Court of Auditors in the German Land of Schleswig-Holstein in 2011 (concerning the budget execution of 2009) found that, even though significant amount of public money was spent on road marking, these expenditures were ineffective because most tenders asked for cheap paint with poor durability (79%) and type I markings which are invisible in rainy conditions (85%). One of the key recommendations of the report was to improve the quality of the markings tendered and to increase quality surveillance.

5.2 Reduced Driver Comfort and the challenge of an ageing population

Given that road markings improve driver comfort and increase the ability of drivers to keep their lane trajectory, it can be assumed beyond any reasonable doubt that the gradual deterioration of the condition of road markings on Europe's roads is bound to a long term negative impact on road safety.

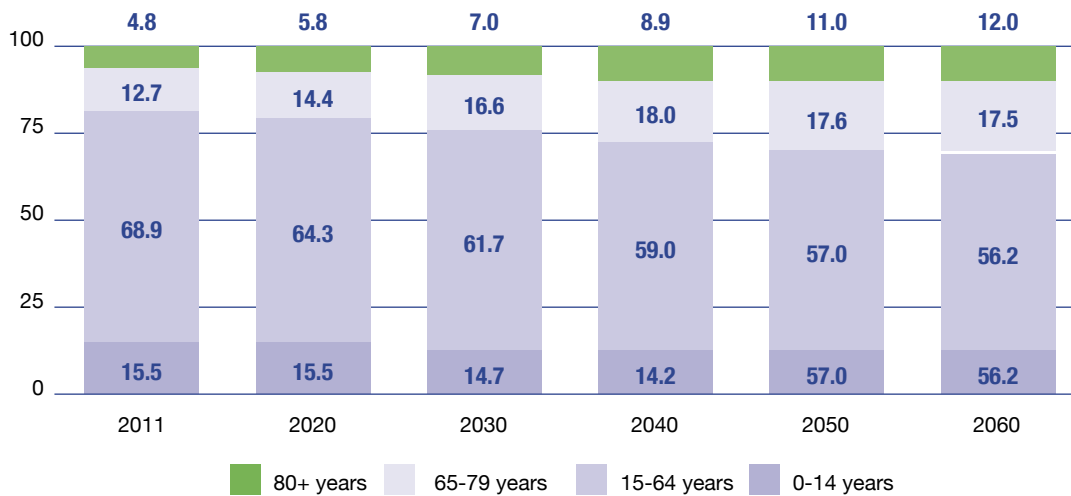
The positive impact of road markings has already been scientifically substantiated by the research project COST 331 'Requirement for Horizontal Road Markings'. Conducted from 1996 to 1999 with the participation of road authorities and laboratories, the project concluded that increased visibility of road markings led to more safety, especially during night time. This was deduced from that fact that, while some increase in the average speed of the drivers was noted, this was not significant enough as to absorb the benefits of higher reactivity time. In other words, 'although drivers consumed some of the benefit (of more visible road markings) by driving faster, the greatest part of that benefit was used to increase preview time. This meant that drivers had a bigger margin for error than before'.

As Europe's population is ageing, the presence of good road markings on Europe's roads is actually becoming ever more important.

It is estimated that the percentage of older drivers, i.e. above 65 will increase from 17,5 % of the overall population in 2011 to 23,6 % in 2020 progressively raising to 28,6 % by 2050 where it is expected to stabilise.



Demographic Projections for Europe (2011-2060)



Source: Eurostat

As a general rule, drivers over 60 tend to display a lower reactivity times compared to their younger counterparts as a result of a gradual loss of visual accuracy, difficulty in close vision, changes in colour perception, problems seeing in low light or night time conditions etc.

Longer life expectancy and greater mobility means that, in future, there will be a growing number of older drivers on Europe's roads and in this sense, it is important to assess how core infrastructure elements such as road markings need to be adapted.

On-going research from the RAINVISION project has found that the application of wet-night visible road markings (as opposed to baseline markings which are often found on roads) greatly enhances driver's feeling of safety and their ability to anticipate the road trajectory.

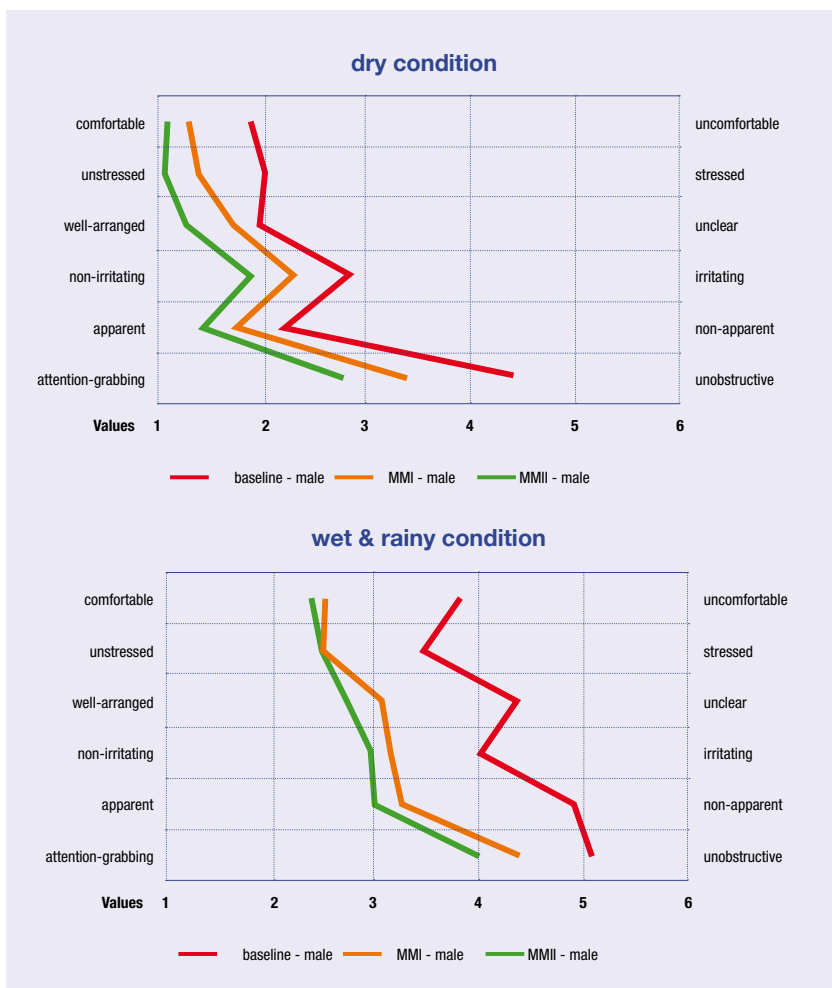
In particular, the project recruited eighty-eight volunteers from different age groups and asked them to complete different runs on a test-track during night-time applying different marking materials (baseline, marking material I, marking material II) and under different weather conditions, i.e. dry, wet and wet and rainy.

		Age Group			Total
		20 - 40 years	41 - 60 years	61+ years	
Gender	Female	15	16	10	41
	Male	17	15	15	47
Total		32	31	25	88

As can be shown from the graphs below, all subjects who undertook the test found that presence of wet-night visible materials had a significant impact on their comfort compared to standard markings, with the difference being especially noticeable during wet and rainy conditions.

14 RAINVISION aims to study the influence of road marking on driver behaviour, by mainly analysing how different age groups (young vs middle vs old) and different gender groups (male vs female) adapt their driving behaviour on the basis of the visibility and retroreflectivity of road markings under all weather conditions, (i.e. dry, wet, wet and rainy) during night time driving)

Mean questionnaire values of female subjects on dry and wet and rainy conditions



Mean questionnaire values of male subjects on dry and wet and rainy conditions



The impact was even greater when factoring in the different ages groups. More specifically, the report found that when analysing the speed behaviour of older drivers, it could be concluded that the more adverse the driving and/or weather conditions, the more the disproportionately complex the task for older drivers. The report went further to recommend installation of road markings at non-equipped locations as a means of 'neutralising' this disadvantage and thus, creating a more balanced traffic situation.



5.3 A Road that a Car cannot Read

In addition to the inherent risk of driving on a road without a clear delineation, the lack of proper maintenance for road markings on an ever growing number of roads effectively cancels the safety benefits that can be gained by new vehicle technologies.

Car manufacturers have developed a range of systems capable of reading road markings, i.e. Lane Departure Warning Systems (LDWS). In its timely consultation paper entitled 'Roads that Cars can Read'¹⁵ released in 2011, EuroRAP and EuroNCAP rightly pointed out the need to guarantee that road markings are maintained at levels that are visible to vehicles and of course, the human eye.

In December 2011, the German Automobile Club ADAC published a report about road safety and road markings on rural roads.¹⁶ Approximately, 1/3 of all accidents happen due to run off accidents caused by distraction or a lack of attention from the driver. The report found that good road markings could help to reduce the number of crashes, especially, when combined with automatic lane departure warning systems. It pointed out, however, that the latter only works when well maintained and visible edge markings are installed. Due to budgets cuts, fewer and fewer rural roads have edge markings despite this being a legal requirement for roads wider than five metres.

¹⁵ Roads that Cars can Read – A consultation paper
<http://www.euroncap.com/files/Roads-that-cars-can-read---0-41b5e8b7-ae0d-4fd0-bc3-0c4548cd697e.pdf>

¹⁶ Eicher, C. C., 'Gefährlicher Geiz', ADAC Motowelt, December 2011

6. The solution



6.1 Establishment of minimum intervention and maintenance level on Europe's roads

The ERF, and its entire membership representation, believes that the best of way of ensuring our road markings are kept properly maintained and visible for the benefit of users is the **establishment of minimum intervention and maintenance on Europe's road that have to be guaranteed.**

Currently, such specifications exist only in a number of countries where either the road authorities or the contractor has to ensure that the road marking performance live to a certain standard.

The main problem is that little is done to monitor performance and to enforce maintenance standards that determine when a road marking should be replaced/maintained after its initial performance period.

On average, marking materials are presumed to have a functional life of 2 years (i.e. the time during which they will maintain their initial performance criteria) which implies that, at the end of the two year period many of the markings will require replacement. However, this often does not happen and even any form of cyclical (or timed) maintenance seems to be lacking. As a consequence large stretches of road will have sub-standard markings.

It is thus imperative to arrive at a common definition of a **'good road marking'**, i.e. a **marking that at all times remains visible both to the driver and the intelligent vehicle irrespective of light conditions (day vs night), weather conditions (dry vs wet vs wet and rainy) and age (young vs old).**¹⁷

In the opinion of the ERF, this is a road marking whose minimum performance level under dry conditions is 150 mcd/lux/m² and which has a minimum width of 150 mm for all roads. For wet and rainy conditions, the minimum performance level should be 35 (RW2) .



¹⁷ To arrive at this definition, the ERF Working Group on Road Markings collected and analysed the national requirements for road markings in several European countries (Austria, Belgium, Czech Republic, Denmark, Germany, Italy, Sweden and United Kingdom) and also took into account the results of previous and on-going research.

Given that existing technology for road markings is capable of delivering such performances, this is essentially a call on road authorities at all levels to **establish comprehensive minimum intervention and maintenance policies that can, on the basis of regular inspections, guarantee that drivers can rely on visible horizontal signage all year around.**

It is a solution that:

- Is feasible both from a technical and economic point of view as it is being already implemented in European countries which boast impressive best road safety records.
- Takes into account the growing visual needs of an ageing population and contributes to maintain the autonomy of older drivers.
- Should be sufficient to guarantee the optimal operation of LDW/LKA systems in the intelligent vehicle
- Helps improve safety and accessibility on our roads by giving drivers on the road a preview time of approximately 3 seconds.
- Produces a socio-economic 'surplus' when one considers the potential of avoiding accident and their potential consequences vs the cost implied.

In addition, and in line with the recommendations emanating from the Vienna Convention, the COST 331 project and the Ouput Report of the 'Roads that Cars can Read' Working, the ERF **fully supports the use of continuous edge lines for Europe's for all non-urban roads.**

Last but not least, the ERF would encourage road authorities to consider the more widespread use of profiled road markings which, by alerting drivers drifting off the roads, can prevent run-off accidents, especially on Europe's secondary network.



Conclusion and next steps



This position paper could not have been timelier. Following years of under-investment in our roads, a 'wind of change' seems to be blowing as policymakers realise that a Europe without a modern and safe infrastructure can be neither competitive, nor prosperous.

In May 2013, Transport Ministers of the International Transport Forum issued a joint declaration on the importance of sustainable transport funding, released on the occasion of their gathering in Leipzig, Germany, organised under the theme 'Funding Transport'. In their words, 'transport infrastructure is much more than asphalt, concrete or steel; it is the backbone of national economies, providing connections for people and goods, access to jobs and services, and enabling trade and economic growth'.

Adding further hope to this symbolic declaration, UK government announced in July 2013 the biggest spending package for roads since the 1970s, i.e. a trebling in funding for motorways and major A-roads. The words voiced by the UK Transport Secretary Patrick McLoughlin could hardly resonate more strongly: 'Our major roads are vital to the prosperity of our nation, connecting people to jobs and businesses to markets. They carry a third of all traffic and two thirds of all freight traffic but in recent decades we have failed to invest properly in them'.

Given that resources will continue to be limited in the near future, it is imperative that investments in our roads are as efficient as possible and with this position paper, the ERF wishes to outline the importance of having good markings on our roads as a means of increasing driver comfort and making the most of new vehicle technologies, thus increasing overall safety in a cost-effective manner.

The adoption of a proposal for minimum intervention and maintenance standards for road markings necessitates as a next step, a broader dialogue with key stakeholders and in particular, road authorities, vehicle manufacturers and consumer associations.

In particular, it is recommended to:

- Engage road authorities in the EU Member States to discuss how the concept of intervention and maintenance standards can be put into practice in a coordinated manner with the industry
- In cooperation with the vehicle manufacturers and OEM suppliers to further develop the concept of 'Roads that Cars can Read' and to understand the requirements for road markings LDWS, LKA can properly work



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About the Authors

The European Union Road Federation (ERF) is a non-profit European association representing private and public entities linked to road infrastructure. It acts as a European platform for dialogue, expressing the road sector's ideas and opinions on mobility issues and promotes research into viable, efficient and sustainable transport.

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Snoline
SWARCO
Walloon Road Administration*



Place Stephanie, 6/B
B-1050 Brussels
(Belgium)

Tel. (+32) 2 644 58 77
Fax. (+32) 2 647 59 34

info@erf.be

www.erf.be