2014 European Workshop
AFB20 (2) Roadside Safety Design
International Research Activities Subcommittee
Brussels, 05 November 2014

Effectiveness of Roadside Safety Measures

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The need for the assessment of road safety measures

Road Safety
is a typical field

with high risk
of important investments
not bringing results

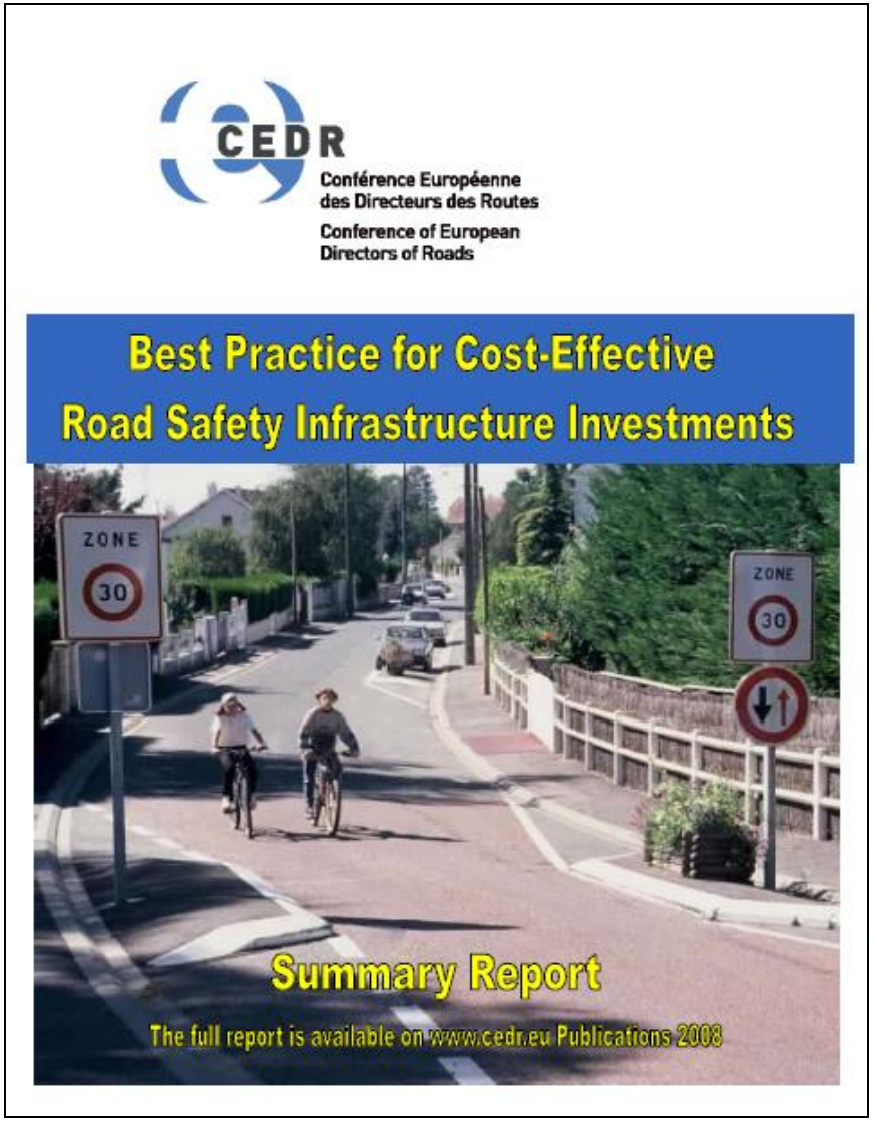
Background (1/2)

This research is part
of a research project

carried out by the
National Technical
University of Athens

for the
European Conference
of Road Directors (CEDR)

aiming to develop
best practices on cost-effective
road safety infrastructure investments.



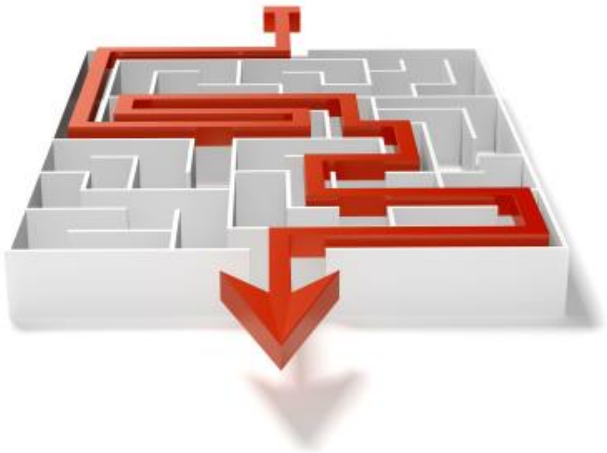
Background (2/2)

- A complete list of 56 examined road safety measures, classified according to 18 measure areas, into 4 groups (motorways, rural roads, junctions, urban areas).

- Applied on simple road sections, on bend sections and on junctions.

Preliminary review of each road safety measur

- Description of the measure
- Safety effect of the measure
- Other effects (mobility, environmental etc.)
- Measures costs
- CEA/CBA results



Roadside safety measures were found to be among the most promising infrastructure safety measures.

An in-depth analysis of these most promising investments was then carried out.

Efficiency Assessment Methodologies

- **Cost-effectiveness** analysis:

$$\text{Cost-effectiveness} = \frac{\text{Number of accidents prevented by a given measure}}{\text{Unit costs of implementation of measure}}$$

- **Cost-benefit** analysis:

$$\text{Benefit-cost ratio} = \frac{\text{Present value of all benefits}}{\text{Present value of implementation costs}}$$

Safety Effect:

- Expected **reduction in target accidents/casualties** following the implementation of a treatment, given in the form of a percentage.

Most promising measures:
high safety effect and low implementation cost

Objectives

The assessment of the effectiveness of road safety measures at roadsides

A review and in-depth analysis of the safety effects and cost-effectiveness of various roadside safety treatments, namely:

- establishment of clear zones
- flattening of side slopes
- installation of safety barriers along embankments
- replacement of safety barriers to meet the EN 1317 standard
- median safety barriers on divided highways / undivided highways
- combination of safety barrier installation and roadside obstacle removal

Methodology

An **exhaustive review** of the literature was carried out.

Selection criteria:

- Studies reporting specific figures
- Only statistically significant results

Roadside treatments' in-depth analysis:

- Description
- Safety effects
- Implementation costs
- Other effects
- Benefit / cost ratio
- Strengths and weaknesses
- Implementation barriers

Emphasis on the identification of the **implementation conditions** associated with the magnitude of the effects in each case.

Ranges of **implementation costs per unit** of implementation

Reference Documents

More than 25 **international studies** were examined:

- the AASHTO Highway Safety Manual
- the “Handbook of Safety Measures” (Elvik et al. 2009)
- CEDR Reports on Roads (*Most Effective Short-, Medium- and Long-Term Measures to Improve Safety on European Roads*).
- European research projects (ROSEBUD, SUPREME, PROMISING, etc.).
- Other key publications (e.g.PIARC-Road Safety Manual)
- An important number of scientific papers, reports and national studies

Additional information from **national studies**:

- Questionnaire addressed to the CEDR member states

Overview of Measures

- **Flattening of side slopes**
- **Establishment or extension of clear zones**
  - remove/relocate/delineate obstacle
  - redesign the obstacle to be safely traversed
  - reduce impact severity by using a break-away device
- **Safety barriers**
  - installation along embankments
  - replacement to meet the EN 1317 standard- median safety barriers on divided highways / undivided highways
- **Combination of safety barrier installation and roadside obstacle removal**

Overview of Safety Effects

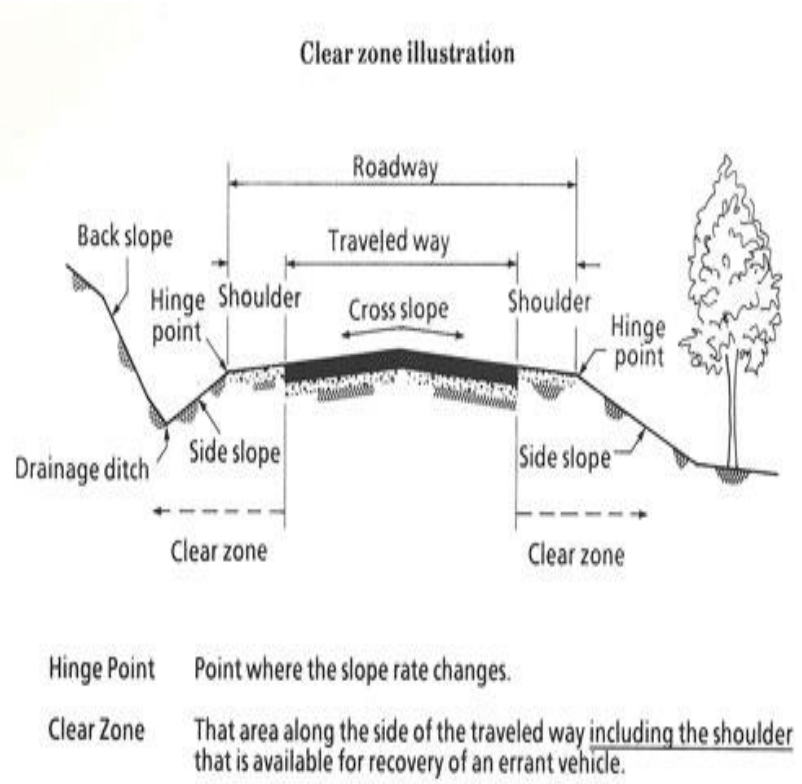
Source	Clear zones	Side slopes	Safety barriers	Description	Country / Region	Road network				Evaluation method		Safety effect (%)										
						Urban	Rural	Highways	Number of sites	meta-analysis	before/after	Best estimate	95% conf.int.	run-offroad and head-on accidents	single vehicle run-off accidents	single vehicle accidents with trees	all accidents	fatal accidents	injury accidents	Material damage accidents	fatalities	Injuries
Corben et al, 1997	●			Marking of roadside obstacles	Australia	-	-	-	-		●	**-23**	s.s.						●			
Corben et al, 1997	●			Removal of roadside obstacles	Australia	-	-	-	-		●	**-2**	s.s.						●			
Zeeger et al., 1988	●			Increase of the roadside clear recovery distance on two-lane rural roads (between 1,5m - 6,2m)					-		●	**(-13;-44)**	s.s.	●								
ROSEBUD, 2005	●		●	Setting-up safety barriers and cutting trees	France		●		26,5 km		●	**-95**	(-59;-99)			●						
Elvik and Vaa, 2004		●		Flatten side slope from 1:3 to 1:4 mostly on two-lane roads	USA		●		-	●		**-42**	(-46;-38)						●			
Elvik and Vaa, 2004		●		Flatten side slope from 1:3 to 1:4 mostly on two-lane roads	USA		●		-	●		**-29**	(-33;-25)							●		●
Miaou, 1996		●		Flatten side slope from 1:3 to 1:4 mostly on two-lane roads			●		-	●		**-28**	s.s.		●							
Elvik and Vaa, 2004		●		Flatten side slope from 1:4 to 1:6 mostly on two-lane undivided roads	USA		●		-	●		**-22**	(-26;-18)						●			
Elvik and Vaa, 2004		●		Flatten side slope from 1:4 to 1:6 mostly on two-lane undivided roads	USA		●		-	●		**-24**	(-26;-21)							●		●
Miaou, 1996		●		Flatten side slope from 1:4 to 1:6 mostly on two-lane undivided roads			●		-	●		**-24**	s.s.		●							
Allaire et al., 1996		●		Flatten side slopes			●		60	●		**(-3;-50)**	-		●				●			
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	FR				8			**-17**	-				●					
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	FR				8			**-18**	-								●	
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	NL				-			**-50**	-				●					
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	NL				-			**-50**	-									●
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	ES				-			**-11**	-				●					
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	ES				-			**-49**	-								●	
CEDR (Questionnaire 2)			●	Setting-up safety barriers along embankments	ES				-			**-26**	-									●
Elvik and Vaa, 2004			●	Setting-up safety barriers along embankments	USA, AUS, SE		●	●	-	●		**-44**	(-54;-32)					●				
Elvik and Vaa, 2004			●	Setting-up safety barriers along embankments	USA, AUS, SE		●	●	-	●		**-47**	(-52;-41)						●			
Elvik and Vaa, 2004			●	Changing safety barriers	USA, AUS, SE		●	●	-	●		**-41**	(-66;+2)					●				
Elvik and Vaa, 2004			●	Changing safety barriers	USA, AUS, SE		●	●	-	●		**-32**	(-42;-20)						●			
Elvik and Vaa, 2004			●	Median safety barrier on divided highways	USA, GB, FR, SE, DK			●	-	●		**-43**	(-53;-31)					●				
Elvik and Vaa, 2004			●	Median safety barrier on divided highways	USA, GB, FR, SE, DK			●	-	●		**-30**	(-36;-23)						●			
Carlsson et al., 2001			●	Wire median safety barrier on undivided highways	SE			●			●	**-23**	-									●

s.s: statistically significant

Note: A negative safety effect corresponds to a reduction of accidents

In-depth analysis – Clear zones

- **Clear zones** present relatively high implementation costs
- The maximum safety effect of 23% may be further increased and reach a reduction of 95% when this type of treatment is combined with other roadside treatments such as safety barriers.



In-depth analysis – Side slopes

- The steeper the initial slope before treatment, the higher the safety effect observed after treatment.
- The minimum safety effect concerns flattening from 1:4 to 1:6, and the maximum safety effects concerns flattening from 1:3 to 1:4.

In-depth analysis - Safety barriers

- All types of **safety barriers** are very cost-effective, especially when they are implemented along embankments on rural roads.
- Not all safety barrier types of all materials have the same safety effect, especially when their relative effects on certain specific groups of road users (e.g. motorcyclists, heavy goods vehicles) is taken into consideration.
- Safety barriers that meet the EN 1317 standard are recommended.
- Safety barriers appear not to be a top-priority treatment for roadside obstacles in all countries.

Roadside Treatments - Summary (1/2)

Investment: Roadside treatment
Network: Mainly interurban / rural

Maximum safety effect:

- Installation or replacement of safety barriers (-47%)
  - especially when combined with other roadside works.

Minimum (or negative) safety effect:

- Flattening side slopes (-24%)
  - especially from 1:4 to 1:6 on two-lane undivided roads .

Max B/C ratio:

- Safety barriers, considering only safety effects 32:1

Min B/C ratio:

- Safety barriers, considering only safety effects 8.7:1

Roadside Treatments - Summary (2/2)

Implementation costs per unit:

- Installation of safety barriers 130,000 - 220,000 € per km, depending on the type

Other effects:

- Negative effects on environment in some cases (e.g. tree removal)
- Slight increase on average speed

Strengths:

- Significant safety effects on the number of accidents, but also on accident severity
- Validated cost-effectiveness
- High acceptability by road users

Weaknesses:

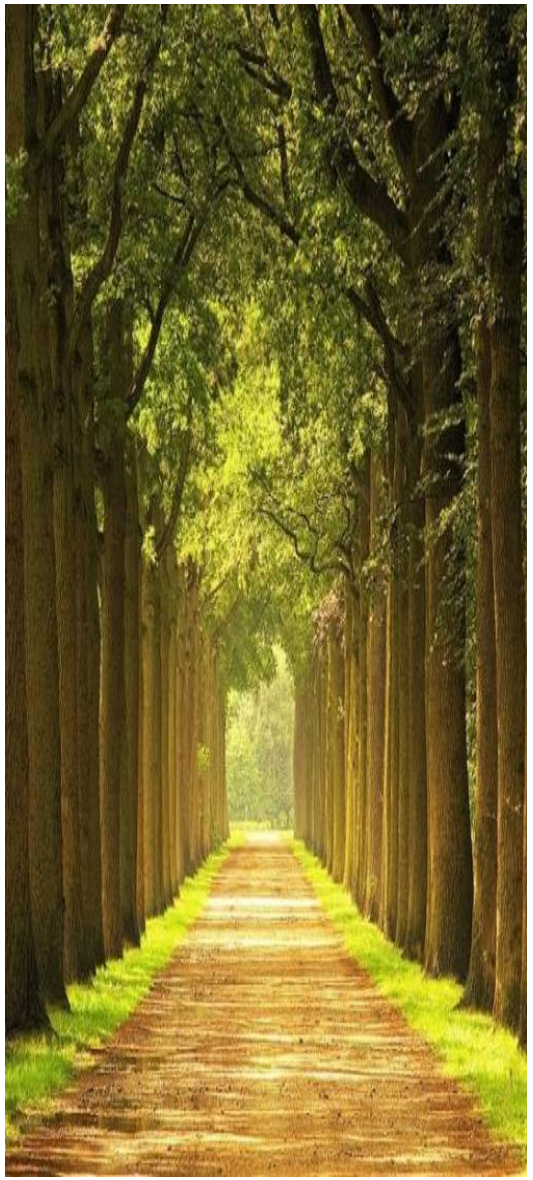
- Relatively high implementation cost
- Side effects to the surrounding environment/landscape
- Slight increase in the number of damage-only accidents in some cases

Implementation barriers:

- Possible long and complicated administrative and financial procedures

Conclusions (1/2)

- Roadside treatments have **very positive safety effects** and no inconsistency or particularity in their implementation might compromise these effects.
- However, given that certain treatments present relatively high implementation costs, they are **not always cost-effective**.
- The available studies on the cost-effectiveness on such treatments are limited and concern specific cases.
- It is recommended that cost-benefit ratios and safety effects are always examined in conjunction with each other.
- Moreover, **transferability of results** among different settings or countries should be examined with particular caution.



Conclusions (2/2)

- The in-depth analysis revealed the **range of safety effects**, implementation costs and eventual cost-effectiveness that can be expected.
- Given that only statistically significant and well-documented results were taken into account in the above synthesis, the degree of uncertainty is minimized.
- These examples could be optimally used as **an overall guide** towards a more efficient planning of the treatments.
- **Thorough analysis on a case-specific basis** is always required (extent of the implementation, implementation period and specific national or local requirements).

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