Best Practice on Road Infrastructure Safety Management

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Presentation Outline

1. Background (5)

2. Road Infrastructure Safety Management (18)

3. Best Practice on Road Safety Infrastructure Investments (18)

4. Conclusions (3)
Background
Background

➢ **Road infrastructure safety** may be critical for road safety enhancement, especially in emerging economies.

➢ Traditional **«reactive» approach** to road safety (e.g. high risk site management) is becoming ineffective in more advanced countries.

➢ Moving towards a **Safe System approach** where the Road Administration has responsibility for the safety of the infrastructure.
Road Infrastructure Safety Management

➢ The **Road Infrastructure Safety Management (RISM)** is defined as:

the total procedures supporting the road infrastructure management authorities to prevent future road accidents and/or to limit their consequences.
Not all procedures are easy to be implemented

- Terminology
  - e.g. Black Spot? Hazardous Location? High Risk Site?

- Implementation Area
  - Where and when?

- Requirements
  - What tools and data are needed?

- Other barriers...
  - Why they are not used?
Description of RSIM Procedures

- Introduction
- Tools and data needed
- Common practices
- A synthesis:

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Compare different implementation scenarios from road safety point of view</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>RIA is generally undertaken at planning stage (stage 1) and before a major upgrading of the infrastructure (stage 6).</td>
</tr>
<tr>
<td>Where</td>
<td>Part of the road network potentially influenced by a measure.</td>
</tr>
<tr>
<td>Data</td>
<td>Roadway related, Traffic related, Measures related</td>
</tr>
</tbody>
</table>

Source: OECD/ITF 2015 – “Road Infrastructure Safety Management”
Targets of RSIM Procedures

- **Assessment of the results** of specific road safety measures or programs.
- Early identification of **new road safety problems**.
- Identification of the **most hazardous parts** of the road network.
- Identification of the **most significant contributors** to road accidents and injuries.
Road Infrastructure Safety Management
Road Infrastructure Safety Management Procedures

**Data required**
- Traffic data
- Road data
- Crash data
- Measures related data

**RISM Procedure**
1. Road Safety Impact Assessment - RIA
2. Efficiency Assessment Tools - EAT
3. Road Safety Audit - RSA
4. Network Operation - NO
5. Road Infrastructure SPI
6. Network Safety Ranking - NSR
7. Road Assessment Programs - RAP
8. Road Safety Inspection - RSI
9. High Risk Sites - HRS
10. In-depth Investigation

**Purpose**
- Compare different scenarios from road safety point of view
- Identify the most efficient measure from a list of potentially effective
- Maintain the current level of safety of roads
- Assess the current level of safety of a road network
- Identify infrastructure or traffic-related factors increasing injury/accident risk
- Rank elements of a road network based on their safety level
- Other, e.g., Identify vehicle related factors that increase injury or accident risk
Life-cycle Stages of a Road Infrastructure

1. Planning & Design
2. Construction & Pre-Opening
3. Normal Operation
4. Maintenance & Renewal
5. Error correction, Hazard Elimination
6. Major upgrading & Renewal
Stage 1: Planning & Design

- Planning & Design
- Construction & Pre-Opening
- Normal Operation
- Maintenance & Renewal
- Error correction, Hazard Elimination
- Major upgrading & Renewal

- Road Safety Impact Assessment (RIA)
- Road Safety Measures Efficiency Assessment Tools (EAT)
- Road Safety Audit
1. Road Safety Impact Assessment

- A RIA is a methodology used at the planning stage to assess changes in the network safety level resulting from the introduction of a modification in the road network configuration or operation.

- It requires the estimation of the safety level of a part of the road network.

- Its aim is to compare different implementation scenarios from road safety point of view.
2. Road Safety Measures Efficiency Assessment Tools

- **Economic resources** for transport in general and for road safety in particular should be distributed in the most efficient way.

- The tools for measuring the efficiency of measures (e.g. cost-benefit analysis) determine the **social benefit of an investment** in order to set the appropriate priorities.

- The aim is to compare different scenarios from road safety point of view and identify the most efficient measure from a list of potentially effective measures.

- Applied at the **planning stage** and before a major upgrading of the infrastructure.
3. Road Safety Audit

- A Road Safety Audit (RSA) is commonly defined as a safety check of an infrastructure project, be it a new (section of) road or an intersection, or a substantial modification to the existing network, covering all stages from planning until the initial operation.

- A RSA is a formal, detailed and systematic process that should be carried out by an independent and well-trained auditor (or team of auditors).

- Its aim is to identify infrastructure or traffic related factors increasing injury or accident risk.

- Undertaken during planning, design, construction, pre-opening and early operation stages.
Stage 2: Construction & Pre-Opening & Stage 3: Normal Operation

1. Planning & Design
2. Construction & Pre-Opening
3. Normal Operation
4. Maintenance & Renewal
5. Error correction, Hazard Elimination
6. Major upgrading & Renewal

- Road Safety Audit (RSA)
- Network Operation (NO)
- Road Safety Performance Indicators (SPIs)
- Network Safety Ranking (NSR)
4. Network Operation

- Gradual change in **infrastructure and / or traffic characteristics**, with consequences on road safety.

- Information on **scheduled or unscheduled events** that may increase the risk level on the road network.

- The aim of NO is to **maintain the current level of safety** of roads.

- Undertaken during **normal operation** of a road and during maintenance.
5. Road Safety Performance Indicators

- The purpose of SPIs is to assess risk factors related to road infrastructure at two levels:
  - the road network level and
  - the road design level (e.g. percentage of road network not meeting design requirements).

- The safety performance of the existing road network during normal operation of the infrastructure is monitored.
6. Network Safety Ranking

- NSR is a systematic **road safety ranking and management** approach at the level of road networks.

- According to the **EU Directive** on Road Infrastructure Safety Management (2008/96/EC): “Network Safety Ranking” means a method for identifying, analysing and classifying parts of the existing road network according to their potential for safety development and accident cost savings.”

- Generally undertaken during **normal operation** of the road network.
Stage 4: Maintenance & Renewal

1. Planning & Design
2. Construction & Pre-Opening
3. Normal Operation
4. Maintenance & Renewal
5. Error correction, Hazard Elimination
6. Major upgrading & Renewal

- Network Operation (NO)
- Road Safety Inspection (RSI)
- Road Assessment Programme (RAP)
7. Road Safety Inspection

- Regular, systematic, on-site inspection of existing roads covering the whole road network.

- RSI aims to identify potentially hazardous conditions and deficiencies that can result in severe accidents.

- Generally undertaken during normal operation of a road and may also contribute to error correction and hazard elimination.
8. Road Assessment Programme

- A process for the assignment of a score to a road section based on the existence or the absence of essential design features related to road safety.

- Applies to the whole or part of the road network.

- Generally undertaken for identification and correction of errors on the road infrastructure.
Stage 5: Error correction, Hazard Elimination

- High-Risk Site Treatment (HRS)
- Road Safety Inspection (RSI)
- Road Assessment Programme (RAP)
- In-Depth Investigation
9. High-Risk Site Treatment

- Specific road sections where the number of accidents is remarkably high.

- The approach of high risk sites is based on the perception that, in specific sections of the road network, there is a combination of factors leading to an increased number of accidents.
10. In-Depth Investigation

- The In-depth Investigation concerns the collection of all necessary data and the identification of one or more of the following:
  - the cause(s) of an accident,
  - the injuries, the way they were caused and their results,
  - how accidents and injuries could have been prevented.

- Undertaken to identify and remove safety issues emerging from the interaction between human factors and infrastructure.
Stage 6: Major upgrading & Renewal

- Road Safety Impact Assessment (RIA)
- Road Safety Measures Efficiency Assessment Tools (EAT)
Putting it all together

1. Planning & Design
   - Road safety Impact Assessment
   - Efficiency Assessment Tools
   - Road Safety Audit

2. Construction & Pre-opening
   - Road Safety Audit

3. Normal Operation
   - Road Network Operation
   - Safety Performance Indicators
   - Network Safety Ranking

4. Maintenance & Renewal
   - Road Network Operation
   - Road Safety Inspection
   - Road Assessment Program

5. Error correction, Hazard elimination
   - High Risk Sites
   - Road Safety Inspection
   - Road Assessment Program
   - In-depth investigation

6. Major upgrading & Renewal
   - Road safety Impact Assessment
   - Efficiency Assessment Tools
Best Practice on Road Safety Infrastructure Investments
Key Handbooks and Systems (1/8)


- State-of-the-art summaries of current knowledge on the effects of 128 road safety measures:
  - policy instruments
  - road design, equipment, maintenance, traffic control
  - vehicle design, protective devices, inspection
  - driver training and regulations,
  - public education & information,
  - police enforcement and sanctions,
  - post-crash care

- Formal techniques of meta-analysis were used.

- A systematic framework was used to assess the validity of the studies.
The ROSEBUD Handbook (2006)
«Examples of assessed road safety measures»

The handbook includes information about various assessed road safety measures.
- User related
- Vehicle related
- Infrastructure related

The assessment methods used are cost effectiveness analysis (CEA) or cost-benefit analysis (CBA).

According to the Benefit-Cost ratio, measures are ranked as poor, acceptable and excellent.
Key Handbooks and Systems (3/8)

- **The SUPREME Handbooks** (2007)
  “Best practices in road safety”

- Handbook of measures at **country level**
- Handbook of measures at **European level**
  - Best practice (B/C ratio available)
  - Good practice (sound theoretical basis)
  - Promising practice (new measures)

- **Nine thematic areas**
  - Education, campaigns, driver training
  - Rehabilitation and diagnostics
  - Vehicles
  - Infrastructure
  - Enforcement
  - Statistics and in-depth analysis
  - Institutional organisation
  - Post-accident care
Key Handbooks and Systems (4/8)

- The CEDR Report (2008) «Best Practice on Cost Effective Road Safety Infrastructure Investments»
- A review of 56 road infrastructure investments (literature and national CEDR questionnaires)
  - motorways, rural roads, urban areas
  - Simple road sections, bends, junctions
- Five most promising investments were identified:
  - Roadside treatment
  - Speed management
  - Junctions layout
  - Junction traffic control
  - Traffic calming
- Safety effects, Other effects (mobility, environmental etc.), Investments costs, CEA/CBA results, Strengths and weaknesses, implementation barriers.
The AASHTO Highway Safety Manual (2010 & 2014)

Provides information and methodologies on measuring, estimating and evaluating roadways in terms of crash frequency and crash severity, applicable to:
- rural two-lane highways,
- rural multilane highways,
- urban and suburban arterials,
- at-grade intersections,
- motorway segments,
- interchange ramp segments
- interchange ramp terminals (crossroads)

Quantitative estimation of the safety performance of roadways, as well as of potential infrastructure countermeasures.
Key Handbooks and Systems (6/8)

- **Highway Safety Manual Complementary Systems:**
  - **FHWA CMF Clearinghouse**
    A searchable online database of approximately 7,000 Crash Modification Factors used to estimate the effectiveness of infrastructure countermeasures
  - **Tatum SPF Clearinghouse**
    A searchable online database of Safety Performance Functions
  - **FHWA Interactive Highway Safety Design Module (IHSDM)**
    A decision-support tool that provides estimates of a highway design's expected safety and operational performance, checks existing or proposed highway designs against relevant design policy values, and assists in economic analyses
Key Handbooks and Systems (7/8)

- The **Austroads Road Safety Engineering Toolkit**

  Information on **67 road infrastructure treatments**, including:
  - relevance to specific crash types,
  - addressing specific road safety deficiencies, and
  - affecting particular road user groups.

  Information for each treatment includes:
  - key benefits
  - implementation barriers
  - crash reduction effectiveness
  - cost rating
  - treatment life estimation
  - reference to technical papers, studies and guides

- The **iRAP Road Safety Toolkit**

  Information on **42 road infrastructure treatments** and how these are related to specific crash types or affect particular road user groups.
The European Decision Support System (DSS) developed within the SafetyCube, EC Horizons 2020 Project (2018)

The main contents of the SafetyCube DSS concern:
- road accident risk factors and problems
- road safety measures
- best estimate of effectiveness
- cost-benefit evaluation
- all related analytic background

More than 270 studies on infrastructure related risk factors have been coded.

Approximately 3,500 effects were found for the examined risk factors.

37 synopses have been authored for inclusion in the DSS (including 5 original meta-analyses) (some of the original 50 topics factors were merged)
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.
  - Estimation of the safety effect: "Before-after studies"
Accident And Implementation Cost

- **Accidents cost calculation** includes three major cost items:
  - Material damage costs.
  - Generalized costs, including administrative costs.
  - Human costs, based on the Value of Statistical Life and the loss of quality of life.

- Definition of suitable **units of implementation** for the investment.

- **Implementation costs**: social costs of all means of production (labour and capital) employed to implement the investment.
Key Infrastructure Investment Areas

- **Motorways:**
  - Development of motorways
  - Interchanges

- **Rural roads:**
  - Horizontal Curvature treatment (various individual investments)
  - Cross-section treatment (various individual investments)
  - Roadside treatment (various individual investments)
  - Traffic Control and Operational Elements (various individual investments)
  - E-Safety systems
  - Road surface treatment (various individual investments)
  - Lighting treatment
  - Rail / road crossings treatment

- **Junctions:**
  - Roundabouts
  - Junctions layout (various treatments)
  - Traffic control at junctions (various individual investments)

- **Urban areas:**
  - Urban traffic calming schemes
  - Bypasses
  - Improvement of land use rules
### CEDR - Preliminary Selection of Most Promising Investments

- **Investment areas and individual investments with high safety effect and low implementation cost** are the most interesting.

- **High cost/high safety effect** investments are also considered, due to increased safety effect.

- **Low cost/low safety effects** investments are only exceptionally considered in specific cases (i.e. minor and local road safety issues).

- **High cost/low safety effect** investments should only be considered under certain circumstances.

<table>
<thead>
<tr>
<th>Implementation costs</th>
<th>Safety effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Development of motorways</td>
<td>Implementation of guardrails</td>
</tr>
<tr>
<td>Development of interchanges</td>
<td>Replacing guardrails with softer ones</td>
</tr>
<tr>
<td>Increasing curve radii</td>
<td>Changing from unrestricted speed to speed limit</td>
</tr>
<tr>
<td>Introduction of transition curves</td>
<td>Reducing speed limit</td>
</tr>
<tr>
<td>Super-elevation treatment</td>
<td>Creation of speed transition zones</td>
</tr>
<tr>
<td>Reducing gradient</td>
<td>Traffic signs (regulatory)</td>
</tr>
<tr>
<td>Improvement of sight distances</td>
<td>Traffic signs (warning)</td>
</tr>
<tr>
<td>Increasing lane width</td>
<td>Rumble-strips</td>
</tr>
<tr>
<td>Introduction of shoulder</td>
<td>Implementation of artificial lighting</td>
</tr>
<tr>
<td>Increasing shoulder width</td>
<td>Improving existing lighting</td>
</tr>
<tr>
<td>Introduction of median</td>
<td>Protection of rail/road level crossings</td>
</tr>
<tr>
<td>Increasing median width</td>
<td>Junctions channelization</td>
</tr>
<tr>
<td>Flattening side-slopes</td>
<td>Implementation of stop signs</td>
</tr>
<tr>
<td>Establishment of clear zones</td>
<td>Improvement of existing traffic lights</td>
</tr>
<tr>
<td>Creation of speed transition zones</td>
<td>Traffic calming schemes</td>
</tr>
<tr>
<td>Weather info VMS</td>
<td>Improvement of land use rules</td>
</tr>
<tr>
<td>Congestion info VMS</td>
<td>Traffic signs (guide)</td>
</tr>
<tr>
<td>Individual info VMS</td>
<td>Traffic signs (warning)</td>
</tr>
<tr>
<td>Development of VMS</td>
<td>Delineators and road markings</td>
</tr>
<tr>
<td>Development of roundabouts</td>
<td>Raised road markers</td>
</tr>
<tr>
<td>Development of 2+1 roads</td>
<td>Chevrons</td>
</tr>
<tr>
<td>Development of bypasses</td>
<td>Post-mounted delineators</td>
</tr>
<tr>
<td>Development of roundabouts</td>
<td>Navigation routing</td>
</tr>
<tr>
<td>Development of VMS</td>
<td>Implementation of yield signs</td>
</tr>
</tbody>
</table>

- **Investment areas and individual investments with high safety effect and low implementation cost** are the most interesting.

- **High cost/high safety effect** investments are also considered, due to increased safety effect.

- **Low cost/low safety effects** investments are only exceptionally considered in specific cases (i.e. minor and local road safety issues).

- **High cost/low safety effect** investments should only be considered under certain circumstances.
CEDR - Most Promising Investments

- Roadside treatments (clear zones, guardrails)
- Speed limits
- Junction layout (roundabouts, re-alignment, staggering, channelization)
- Traffic control at junctions (traffic signs, traffic signals)
- Traffic calming schemes
- Lighting treatments
Example: Roadside Treatments - Investments

- Flattening side slopes
- Establishment of clear zones
- Installation of guardrails along the embankment
- Replacement of guardrails (CEN standards)
- Median guardrails on divided highways
- Median guardrails on undivided highways
- Combination of guardrails installation and roadside obstacles removal
## Example: Roadside Treatments - Safety Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Measure</th>
<th>Description</th>
<th>Country / Region</th>
<th>Urban</th>
<th>Rural</th>
<th>Highways</th>
<th>Number of sites</th>
<th>Evaluation method</th>
<th>Safety effect (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEDR (Questionnaire 2)</td>
<td>Guardrails</td>
<td>Flaten side slope from 1:3 to 1:4 mostly on two-lane roads</td>
<td>France</td>
<td></td>
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<td>8</td>
<td>Meta-analysis</td>
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<td></td>
<td></td>
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<td>-18</td>
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<td>-50</td>
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<td>CEDR (Questionnaire 2)</td>
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<td>Flaten side slope from 1:3 to 1:4 mostly on two-lane roads</td>
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<td>-11</td>
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<td>CEDR (Questionnaire 2)</td>
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<td>Flaten side slope from 1:3 to 1:4 mostly on two-lane roads</td>
<td>Spain</td>
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<td>-49</td>
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<tr>
<td>Elvik and Vaa, 2004</td>
<td>Side slopes</td>
<td>Flatten side slope from 1:3 to 1:4 mostly on two-lane roads</td>
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<td></td>
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<td>Elvik and Vaa, 2004</td>
<td>Side slopes</td>
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<td>Elvik and Vaa, 2004</td>
<td>Guardrails</td>
<td>Guardrails along embankments</td>
<td>USA, Australia, Sweden</td>
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<td>Elvik and Vaa, 2004</td>
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<td>Changing to softer guardrails</td>
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<tr>
<td>Elvik and Vaa, 2004</td>
<td>Guardrails</td>
<td>Median guardrails on divided highways</td>
<td>USA, United Kingdom, France, Sweden, Denmark</td>
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<td>-43</td>
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<tr>
<td>Carlsson et al., 2001</td>
<td>Guardrails</td>
<td>Allie median guardrails on undivided highways</td>
<td>Sweden</td>
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<tr>
<td>Corbin et al., 1997</td>
<td>Clear zone</td>
<td>Marking of roadside obstacles</td>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-23</td>
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<tr>
<td>Zeeger et al., 1988</td>
<td>Clear zone</td>
<td>Increase of the roadside clear recovery distance on two-lane rural roads</td>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>ROSEBUD, 2006</td>
<td>Clear zone and guardrails</td>
<td>Setting-up guardrails and cutting trees</td>
<td>France</td>
<td>38.5 km of road</td>
<td>1990 - 2003</td>
<td>-95</td>
<td>(-99)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

s.s: statistically significant
Example: Roadside Treatments - Summary (1/2)

**Investment:** Roadside treatment

**Network:** Mainly interurban / rural

**Maximum safety effect:** Installation or replacement of guardrails seem to have higher safety effects, as well as their combination with other roadside works.

**Minimum (or negative) safety effect:** Flattening side slopes, especially from 1:4 to 1:6 on two-lane undivided roads seem to have the lower safety effect, which is though very significant (-24% ; -22% reduction).

**Max B/C ratio:** 32:1, considering only safety effects

**Min B/C ratio:** 8,7:1, considering only safety effects

**Implementation costs per unit:**
- Installation of guardrails: 32.500 - 220.000€ per km, depending on the type
- Installation of guardrails and other works: ~1.000.000€ in total
Other effects:
- Negative effects on environment in some cases
- Slight increase on average speed

Strengths:
- Significant safety effects on the number of accidents with casualties, 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:
- Long and complicated administrative and financial procedures
Comparative Overview of Most Promising Investments

- Important **interrelations** exist between the six most promising investments.

- Roadside treatments, junction layout treatments and speed limit interventions could be considered as a main set of most promising investments in **interurban and rural roads**.

- Traffic calming, junctions layout, traffic control and lighting treatments may be considered as a main set of most promising investments in **urban areas**.

- There may seldom be a single answer to a specific road safety problem; a **set of infrastructure interventions** will be required.

- The safety effects of the most promising investments cannot be guaranteed; **efficient planning and implementation** of an investment is required.

### Safety Effect (%) * Implementation cost (€) Benefit / Cost ratio

<table>
<thead>
<tr>
<th>Investment</th>
<th>Sub-investment</th>
<th>Safety effect (%)</th>
<th>Implementation cost (€)</th>
<th>Benefit / Cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadside treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear zones</td>
<td></td>
<td>-23</td>
<td>n/a</td>
<td>&lt; 1:1</td>
</tr>
<tr>
<td>Side-slopes</td>
<td></td>
<td>-22</td>
<td>n/a</td>
<td>&lt; 1:1</td>
</tr>
<tr>
<td>Guardrails</td>
<td></td>
<td>-30</td>
<td>35,000 per km</td>
<td>8:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>220,000 per km</td>
<td>32:1</td>
</tr>
<tr>
<td><strong>Speed limits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introducing speed limits</td>
<td></td>
<td>-22</td>
<td>300 per km</td>
<td>&gt; 1:1</td>
</tr>
<tr>
<td>Reducing speed limits</td>
<td></td>
<td>-9</td>
<td>300 per km</td>
<td>&gt; 1:1</td>
</tr>
<tr>
<td><strong>Junctions layout</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundabouts</td>
<td></td>
<td>-11</td>
<td>-88</td>
<td>2:1</td>
</tr>
<tr>
<td>Re-designing junctions</td>
<td></td>
<td>-17</td>
<td>-50</td>
<td>3.1</td>
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<tr>
<td>Channelizations</td>
<td></td>
<td>+16</td>
<td>-57</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65,000 per junc.</td>
<td>3:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,650,000 per junc.</td>
<td>2.5:1</td>
</tr>
<tr>
<td><strong>Traffic control at junctions</strong></td>
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<td></td>
<td></td>
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<tr>
<td>STOP signs</td>
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<td>-19</td>
<td>-45</td>
<td>&lt; 1:1</td>
</tr>
<tr>
<td>Introducing traffic signals</td>
<td></td>
<td>-15</td>
<td>-36</td>
<td>8:1</td>
</tr>
<tr>
<td>Upgrading traffic signals</td>
<td></td>
<td>+60</td>
<td>n/a</td>
<td>&lt; 1:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>700 per sign</td>
<td>8:1</td>
</tr>
<tr>
<td><strong>Traffic calming</strong></td>
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<td></td>
</tr>
<tr>
<td>Area-wide traffic calming</td>
<td></td>
<td>-8</td>
<td>-50</td>
<td>2:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,300,000</td>
<td>4:1</td>
</tr>
<tr>
<td><strong>Lighting treatment</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Installing lighting</td>
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<td>-28</td>
<td>26,500 per km</td>
<td>2.1</td>
</tr>
<tr>
<td>Increasing lighting level</td>
<td></td>
<td>-32</td>
<td>30,000 per km</td>
<td>2.5:1</td>
</tr>
</tbody>
</table>

* on target injury accidents
n/a: not available
Conclusions
Conclusions (1/3)

- RISM procedures are **effective** and **efficient**.
  - **RIAs and EATs provide better information to policy makers in order to make better decisions.**
  - **RSAs and RSIs have shown positive cost-benefit-ratios, up to 99:1.**

- **Road Authorities** are key players for improving road safety.

- **Road design standards** cannot guarantee road safety in all conditions.
  - **Design standards are important to keep up with nominal safety. Substantive safety must be considered in design process to care for safety in principle.**
Conclusions (2/3)

- **Success factors** for the implementation of a RISM procedure are:
  - adequate level of investment
  - a supporting regulation
  - road safety data.

- A critical requisite is an **adequate institutional management capacity** to support the development and implementation of effective interventions.

- Several **tools** supporting road infrastructure safety management are already available.
Conclusions (3/3)

- Each country has **specific needs** and has to cope with specific barriers to the implementation of RISM as different conditions exist.

- Road safety performance **monitoring** helps to achieve safety target of road authorities.
  - A **target** should be defined and progress toward the safety target should be monitored.

- Road infrastructure should be improved with the development of **self-explaining roads** to guide drivers to adopt appropriate behaviours.
Best Practice on Road Infrastructure Safety Management

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