Infrastructure risks and measures at the SafetyCube project
Safety CaUsation, Benefits and Efficiency

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SafetyCube Vision

- To create an inventory of evaluated road safety risks measures related to the road infrastructure, with results from accident risk factors analysis and measures cost-efficiency assessment, to be integrated in the European Road Safety Decision Support System (DSS)
Infrastructure analysis objectives

- The in-depth understanding of infrastructure related accident causation factors and the identification and evaluation of the most appropriate related measures.
  - to identify and rank risk factors related to the road infrastructure,
  - to identify measures for addressing these risk factors,
  - to assess the safety effects and the cost-effectiveness of measures.
Nearly 60 risk factors and 100 measures in more than 15 infrastructure areas -
- motorways, rural and urban roads -
- road segments and junctions -
Infrastructure ‘hot topics’

1. **Self-explaining and forgiving roads**: Removing obstacles, Introduce shoulder, Alignment (horizontal / vertical), Sight distance, Traffic signs, Raised crossings / intersections

2. **Urban road safety measures**: Pedestrians / cyclists, Upgrade of Crossings, New crossings, Junctions / roundabouts treatments for VRU, Visibility

3. **Road safety management**: Quality of measures implementation, Appropriate speed limits, Enforcement, Availability of cost-effectiveness data, Workzones

4. **ITS applications**: ISA, Dynamic speed warning, ADAS and active safety with V2I, VMS

*Identified after several stakeholders’ consultations*
Methodological approach

- **SafetyCube common methodology**
  - *Taxonomy of infrastructure risk factors*
  - *Exhaustive literature review and rigorous study selection criteria*
  - *Template for coding studies*
  - *Studies analysed for carrying out meta-analyses to estimate the effects of risk factors and measures.*
  - *Synopses summarising results / meta-analysing risk factors*

- **Systems approach**: links between infrastructure, user and vehicle risks / measures

- Assessment of the *quality of the data / study methods*
## Risks taxonomy

### Traffic flow
- Traffic volume
- Congestion
- Secondary accidents
- Traffic composition (share of pedestrians, cyclists, PTW, HGV)
- Distribution of flow over arms at junctions

### Road type
- Road type

### Road surface deficiencies (risk of run-off road)
- Inadequate friction
- Uneven surface
- Ice, snow
- Oil, leaves, etc.

### Poor visibility and lighting
- Poor visibility - darkness
- Poor visibility - fog

### Adverse weather
- Rain
- Snow / ice / low temperatures
- Wind

### Workzones
- Small workzone length
- High workzone duration
- Insufficient signage

### Horizontal/vertical alignment deficiencies
- Low curve radius
- Absence of transition curves
- Frequent curves
- Densely spaced junctions
- Poor sight distance - horizontal curves
- High grade
- Vertical curve radius

20/4/2017
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superelevation / cross-slopes (risk of ran-off road)</strong></td>
<td>superelevation at curve cross-slope</td>
</tr>
<tr>
<td><strong>Lanes / ramps deficiencies</strong></td>
<td>number of lanes narrow lane</td>
</tr>
<tr>
<td><strong>Median / barrier deficiencies (risk of crash with oncoming traffic)</strong></td>
<td>undivided road narrow median</td>
</tr>
<tr>
<td><strong>Shoulder and roadside deficiencies (risk of ran-off road or crash with obstacle)</strong></td>
<td>absence of shoulder narrow shoulder absence of guardrails or crash cushions absence of clear-zone roadside obstacles (per type of obstacle e.g. trees) sight obstructions</td>
</tr>
<tr>
<td><strong>Poor road readability</strong></td>
<td>absence of traffic signs misleading or unreadable traffic signs absence of road markings absence of rumble strips</td>
</tr>
<tr>
<td><strong>Interchange deficiencies</strong></td>
<td>inadequate ramp capacity insufficient ramp length insufficient acceleration / deceleration lane length absence of channelisation absence of access control poor sight distance</td>
</tr>
<tr>
<td><strong>At-grade junctions deficiencies</strong></td>
<td>high number of conflict points type of junction skewness / junction angle poor sight distance</td>
</tr>
<tr>
<td><strong>Rail-road crossings (risk of collision with train)</strong></td>
<td>uncontrolled rail-road crossing</td>
</tr>
<tr>
<td><strong>Poor junction readability</strong></td>
<td>uncontrolled junction misleading or unreadable traffic sign absence of road markings absence of marked crosswalks</td>
</tr>
</tbody>
</table>

*Risks taxonomy (2/2)*

20/4/2017
Results of analyses on risks

- **Wealth of studies** related to road infrastructure risk aspects

- Analysed approx. **300 studies on risks**
- Selection criteria:
  - Meta-analyses
  - Recent studies
  - High quality studies with quantitative results

- Authored **38 risk factor synopses**
- Carried out **7 original meta-analyses of risk factors**

- **Ranking of risk factors**: Colour Code

  *Analysis is completed and outcomes are already integrated in the DSS*
## Synthesis of results (1/2)

- **Ranking of risk factors**

<table>
<thead>
<tr>
<th>Red (Risky)</th>
<th>Yellow (Probably risky)</th>
<th>Grey (Unclear)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Volume</td>
<td>Occurrence of Secondary crashes</td>
<td>Congestion as a risk factor</td>
</tr>
<tr>
<td>Risks associated with Traffic Composition</td>
<td>Absence of Transition curves</td>
<td>Risks associated with the distribution of traffic flow over arms at junctions</td>
</tr>
<tr>
<td>Road Surface - Inadequate Friction</td>
<td>Risk of Different Road Types</td>
<td>Adverse weather - Frost and snow</td>
</tr>
<tr>
<td>Workzone length</td>
<td>Adverse weather - Rain</td>
<td>Workzone duration</td>
</tr>
<tr>
<td>Low Curve Radius</td>
<td>Poor Visibility - Darkness</td>
<td>Frequent curves</td>
</tr>
<tr>
<td>Number of Lanes</td>
<td>Cross-section deficiencies - Superelevation</td>
<td>Densely spaced junctions</td>
</tr>
<tr>
<td>Absence of paved shoulders</td>
<td>High grade</td>
<td>Interchanges - Acceleration / deceleration lane length</td>
</tr>
<tr>
<td>Narrow Shoulders</td>
<td>Presence of Tunnels</td>
<td></td>
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<tr>
<td></td>
<td>Narrow lanes</td>
<td></td>
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<tr>
<td></td>
<td>Undivided road</td>
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<td></td>
<td>Narrow median</td>
<td></td>
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<tr>
<td></td>
<td>Risks associated with Safety Barriers and Obstacles</td>
<td></td>
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<tr>
<td></td>
<td>Sight Obstructions (Landscape, Obstacles and Vegetation)</td>
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<tr>
<td></td>
<td>Interchange deficiencies - Ramp Length</td>
<td></td>
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<tr>
<td></td>
<td>At-grade junctions - Number of conflict points</td>
<td></td>
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<tr>
<td></td>
<td>Risk of different junction types</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At-grade junctions - Skewness / Junction angle</td>
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<tr>
<td></td>
<td>At-grade junctions - Poor sight distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At-grade junctions - Gradient</td>
<td></td>
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<tr>
<td></td>
<td>Uncontrolled rail-road crossing</td>
<td></td>
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<tr>
<td></td>
<td>Absence of road markings and crosswalks</td>
<td></td>
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<tr>
<td></td>
<td>Uncontrolled junction</td>
<td></td>
</tr>
</tbody>
</table>
### Synthesis of results (2/2)

- Detailed ranking of risk factors

<table>
<thead>
<tr>
<th>Infrastructure Element</th>
<th>Specific Risk Factor</th>
<th>Colour code</th>
<th>Crash risk</th>
<th>Crash frequency</th>
<th>Crash severity</th>
<th>Hot topic (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure</strong></td>
<td>Effect of Traffic Volume on safety</td>
<td>Red</td>
<td>↓</td>
<td>↑</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Risks associated with Traffic Composition</td>
<td>Red</td>
<td>↓</td>
<td>↑</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Occurrence of Secondary crashes</td>
<td>Yellow</td>
<td>↑</td>
<td>-</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Congestion as a risk factor</td>
<td>Grey</td>
<td>-</td>
<td>↑</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Risks associated with the distribution of traffic flow over arms at junctions</td>
<td>Grey</td>
<td>-</td>
<td>-</td>
<td>↑</td>
<td>N</td>
</tr>
<tr>
<td><strong>Road Surface</strong></td>
<td>Inadequate Friction</td>
<td>Red</td>
<td>↑</td>
<td>-</td>
<td>↑</td>
<td>N</td>
</tr>
<tr>
<td><strong>Road Type</strong></td>
<td>Risk of Different Road Types</td>
<td>Yellow</td>
<td>-</td>
<td>↑</td>
<td>↑</td>
<td>N</td>
</tr>
<tr>
<td><strong>Road environment</strong></td>
<td>Adverse weather - Rain</td>
<td>Yellow</td>
<td>-</td>
<td>↑</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Adverse weather - Frost and Snow</td>
<td>Grey</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Poor Visibility - Darkness</td>
<td>Yellow</td>
<td>↑</td>
<td>-</td>
<td>↑</td>
<td>N</td>
</tr>
<tr>
<td><strong>Presence of workzones</strong></td>
<td>Workzone Length</td>
<td>Red</td>
<td>↑</td>
<td>↑</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>Workzone Duration</td>
<td>Grey</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>Measures taxonomy</td>
<td>1/3</td>
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</tbody>
</table>

**Traffic flow**
- Flow diversion
- 2+1 roads
- Reversible lanes
- One-way traffic
- Ramp metering

**Traffic composition**
- HGV traffic restrictions
- Creation of HGV lanes

**Formal tools to address road network deficiencies**
- Road safety audits implementation
- Road safety inspections implementation
- High risk sites identification
- Land use regulations improvement

**Speed management & enforcement**
- Reduction of speed limit
- Dynamic (weather-variant) speed limits
- Individual dynamic speed warning
- Speed cameras
- Section control
- Speed humps
- Woonerf implementation
- Narrowings
- School zones
- 30-zones implementation
- Traffic calming schemes

**Road type**
- Upgrade/downgrade road class
- Upgrade road to motorway
- Creation of by-pass road

**Road surface treatments**
- Improve friction (type of surface)
- Road re-surfacing to improve evenness
- Ice prevention/winter maintenance

**Visibility / Lighting treatments**
- Installation of road lighting
- Improvement of existing lighting
<table>
<thead>
<tr>
<th>Measures taxonomy</th>
<th>2/3</th>
</tr>
</thead>
</table>

### Workzones
- Workzone length treatment
- Workzone duration decrease
- Workzone signage installation
- Workzone signage improvement

### Horizontal & vertical alignment treatments
- Creation of weaving area
- Increase horizontal curve radius
- Implement transition curves
- Reduce number of curves (re-alignment)
- Reduce tangent length
- Sight distance treatments
- Reduce gradient (re-alignment)
- Increase vertical curve radius
- Sight distance treatments

### Superelevation / cross-slopes treatment
- Superelevation improvement
- Cross-slope improvement

### Lanes / ramps treatments
- Increase number of lanes
- Increase lane width
- Create speed change lane

### Median / barrier treatments
- Installation of median
- Increase median width
- Change median type
- Implementation of rumble strips at centerline

### Shoulder & roadside treatments
- Shoulder implementation (shoulder type)
- Increase shoulder width
- Change shoulder type
- Safety barriers installation
- Change type of safety barriers
- Create clear-zone / remove obstacles
- Increase width of clear-zone
- Removal of sight obstructions

20/4/2017
<table>
<thead>
<tr>
<th>Measures taxonomy</th>
<th>Delineation and road markings</th>
<th>Sidewalks treatments</th>
<th>Cycle lanes</th>
<th>Traffic signs treatments</th>
<th>Traffic signals treatments</th>
<th>Driver information and alert</th>
<th>Interchanges treatments</th>
<th>At-grade junctions treatments</th>
<th>Rail-road crossings</th>
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</thead>
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<tr>
<td></td>
<td>Road markings implementation</td>
<td>Sidewalk installation</td>
<td>Cycle lane treatments</td>
<td>Traffic sign installation</td>
<td>Traffic signals installation</td>
<td>Variable message signs: incident/accident warning</td>
<td>Convert at-grade junction to interchange</td>
<td>Channelization</td>
<td>Rail-road crossing traffic sign</td>
</tr>
<tr>
<td></td>
<td>Installation of chevron signs</td>
<td>Increase of sidewalk width</td>
<td>Cycle lane treatments</td>
<td>Traffic sign maintenance</td>
<td>Improve traffic signals timing</td>
<td>Variable message signs: congestion/queue warning</td>
<td>Increasing ramp width</td>
<td>Sight distance treatments</td>
<td>Automatic barriers installation</td>
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<tr>
<td></td>
<td>Implementation of edgeline rumble strips</td>
<td></td>
<td>Increase of cycle lane width</td>
<td>STOP / YIELD signs installation</td>
<td>Implementation of pedestrian signal phase</td>
<td></td>
<td>Increasing ramp curve radius (ramp re-alignment)</td>
<td>Convert junction to roundabout</td>
<td></td>
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<td></td>
<td>Transverse rumble strips</td>
<td></td>
<td></td>
<td>STOP / YIELD signs maintenance</td>
<td></td>
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<td>Increasing acceleration/deceleration lane length</td>
<td>Convert 4-leg junction to staggered junctions</td>
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<td></td>
<td>Implementation of marked crosswalk</td>
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<td></td>
<td></td>
<td></td>
<td>Increasing lane width</td>
<td>Improve skewness / junction angle</td>
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</table>
Progress on measures analysis

- Several measures related to road infrastructure, but less focus on heavy engineering changes
- Already analysed more than 200 studies on infrastructure measures
- Selection criteria as per risks
- 38 synopses on measures effects are planned
- More than 35 meta-analyses available from the literature, and several original ones planned
- Cost Benefit analysis of selected measures planned
- Ranking of measures: Colour Code

Measures analysis is in progress and outcomes will be available to be integrated in the DSS by July 2017
SafetyCube DSS Objectives

The SafetyCube DSS objective is to provide the European and Global road safety community a user friendly, web-based, interactive Decision Support Tool to properly substantiate their road safety decisions for the actions, measures, programmes, policies and strategies to be implemented at local, regional, national, European and international level.

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

Special focus is given to linking road safety problems with related countermeasures.
SafetyCube DSS Structure

Home Page Main Menu (About - Search - Tools)

Three Levels of Search (Search - Results pages - Individual study pages)

Two Interlinked Search Streams (Risk Factors – Road Safety Measures)
SafetyCube DSS Homepage

- **Methodology**
  Basic Information about SafetyCube and the DSS

- **Search**
  - Text search (key-words)
  - Risk Factors
    (Risk factors search engine)
  - Road Safety Measures
    (Measures search engine)
  - Road User Groups
    (Risk factors and Measures search engines)
  - Accident Scenarios
    (Risk factors and Measures search engines)

20/4/2017
SafetyCube DSS Development

Next steps

• Development of the static DSS (Wire Frames)
  – Completed

• SafetyCube DSS Development phase
  – conducted between September and December 2016
  – including all risk factors (~3,500 effects from 600 studies) and several measures
  – linking of risks and measures also nearly completed

• SafetyCube DSS Pilot Operation
  – starting July 2017

• SafetyCube DSS Opening
  – Starting September 2017

• Continuous Enhancement and Update
  – Starting on April 2018 (end of SafetyCube project)

www.roadsafety-dss.eu
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