Do Intelligent Transport Systems have potential to improve the safety of vulnerable road users?

the 4th Annual Scientific Seminar of the NTSA

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Background

- ITS systems have assisted in the decrease of road traffic fatalities in the EU
- ITS development has mainly been vehicle-centric
- VRU fatalities have not decreased in the same level as other road users:
  - Fatalities among car occupants were reduced by 50% between 2000 and 2012, whereas decreases were only 34% for pedestrians, 31% for cyclists and 17% for motorcyclists (IRTAD, 2014)

➢ There is a need for ITS which specifically address VRUs as an integrated element of the traffic system, addressing safety, mobility and travel comfort of VRUs
VRUITS project

- Improving the safety and mobility of Vulnerable Road Users through ITS applications

- Main objectives:
  - Assess societal impacts of selected ITS, and provide recommendations for policy and industry regarding ITS in order to improve the safety and mobility of VRUs;
  - Provide evidence-based recommended practices on how VRUs can be integrated in Intelligent Transport Systems and on how HMI designs can be adapted to meet the needs of VRUs, and test these recommendations in field trials
Impact assessment methodology

System descriptions

Description of effects on behaviour and safety (for 9 mechanisms)

Selection of systems for more detailed assessment (workshop)

Qualitative assessment
23 ITS

Mobility effects

Estimation of effects (%) by mechanism

Quantitative assessment
10 ITS

Estimation of accident trends (2020 and 2030)

Calculation of effects (2020 and 2030; fatalities and injuries)

Expert assessment

Estimation of penetration rates (2020 and 2030)
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**Estimation of penetration rates (2020 and 2030)**
Mechanisms through which ITS affects safety
(Kulmala 2010, Draskóczy et al. 1998)

- M1: Direct modification of the task of road users
- M2: Direct influence by roadside systems
- M3: Indirect modification of user behaviour
- M4: Indirect modification of non-user behaviour
- M5: Modification of interaction between users and non-users
- M6: Modification of road user exposure
- M7: Modification of modal choice
- M8: Modification of route choice
- M9: Modification of accident consequences
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Expert survey
## ITS selected for assessment

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blind Spot Detection (BSD)</td>
</tr>
<tr>
<td>2</td>
<td>Intelligent Pedestrians Traffic Signal (IPT)</td>
</tr>
<tr>
<td>3</td>
<td>Intelligent Speed Adaptation</td>
</tr>
<tr>
<td>4</td>
<td>Red Light Camera</td>
</tr>
<tr>
<td>5</td>
<td>Intersection Safety (INS)</td>
</tr>
<tr>
<td>6</td>
<td>Pedestrian Detection System + Emergency Braking (PDS+EBR)</td>
</tr>
<tr>
<td>7</td>
<td>Navigation System for non-motorised VRUs</td>
</tr>
<tr>
<td>8</td>
<td>PTW Oncoming Vehicle Information System (PTW2V)</td>
</tr>
<tr>
<td>9</td>
<td>VRU Beacon System (VBS)</td>
</tr>
<tr>
<td>10</td>
<td>Digital bicycle rearward looking assistant</td>
</tr>
<tr>
<td>11</td>
<td>Roadside Pedestrian Presence warning system</td>
</tr>
<tr>
<td>12</td>
<td>Urban Sensing System</td>
</tr>
<tr>
<td>13</td>
<td>Automatic Counting of Bicycles and Pedestrians</td>
</tr>
<tr>
<td>14</td>
<td>Night Vision and Warning</td>
</tr>
<tr>
<td>15</td>
<td>Information on Vacancy on Bicycle Racks (IVB)</td>
</tr>
<tr>
<td>16</td>
<td>Bicycle to Car Communication (B2V)</td>
</tr>
<tr>
<td>17</td>
<td>Rider Monitoring System</td>
</tr>
<tr>
<td>18</td>
<td>Crossing Adaptive Lighting (CAL)</td>
</tr>
<tr>
<td>19</td>
<td>Infotainment</td>
</tr>
<tr>
<td>20</td>
<td>Real-time Information Systems for Public Transport</td>
</tr>
<tr>
<td>21</td>
<td>Road Weather Warning for Pedestrians</td>
</tr>
<tr>
<td>22</td>
<td>Forward Obstacle Detection for Cyclists</td>
</tr>
<tr>
<td>23</td>
<td>Green Wave for Cyclists (GWC)</td>
</tr>
</tbody>
</table>
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- Estimation of penetration rates (2020 and 2030)
- Calculation of effects (2020 and 2030; fatalities and injuries)
Estimation of effects (%) by mechanisms

- The systems were allocated to partners
- The responsible partner
  1) studied the relevant literature and system functioning in detail
  2) conducted the safety assessment
- Several rounds of reviewing among all safety partners to crosscheck and validate the estimates made by responsible partners
- **Expert survey**
  - 77 answers from 19 different experts; 1–13 answers per system
  - The responses were exploited by the responsible partners mainly when drawing the numerical estimates of the safety effects
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Mobility effects

- The results of mobility and comfort assessment (Johansson et al., 2014) were directly used for the estimates regarding mechanisms 6–8
- The effects of the modal change were only included for vulnerable road users
- The exponents used when calculating the safety effects of exposure (same values for fatalities and injuries):
  - Pedestrians = 0.38 (Jonsson, 2002)
  - Cyclists & mopedists = 0.4 (Jacobsen, 2003)
  - Motorcyclists = 0.7 (Marizwan et al., 2014; previous projects)
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Accident data

- CARE database; covers accidents on a European wide level
- The data from CARE database was used to classify the fatalities and injuries according to several background variables (collision type, road type, weather conditions, lighting conditions, location and age)
- For the countries and criteria where no detailed information was available on the background variables the average values from the cluster in which the country belong to were used
- The clusters were formed based on the prevalent safety situation in each country
### Clusters used in safety impact assessment

<table>
<thead>
<tr>
<th>Clusters</th>
<th>Countries</th>
<th>Road fatalities per million inhabitants, 2010–2012 (average per cluster)</th>
<th>VRU fatalities per million inhabitants, 2011 (average per cluster)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>United Kingdom, Sweden, Netherlands, Malta, Denmark, Ireland, Germany, Spain, Finland</td>
<td>39</td>
<td>18</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>France, Slovakia, Austria, Luxembourg, Slovenia, Italy, Estonia, Hungary, Cyprus, Czech Republic, Belgium, Portugal</td>
<td>68</td>
<td>30</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>Latvia, Bulgaria, Croatia, Lithuania, Romania, Poland, Greece</td>
<td>96</td>
<td>50</td>
</tr>
</tbody>
</table>
## Distribution of fatalities and injuries by collision type

<table>
<thead>
<tr>
<th>Variable</th>
<th>Classification</th>
<th>Proportion of fatalities</th>
<th>Proportion of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collision type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle - Pedestrian accidents</td>
<td>21%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Single vehicle cycle accidents</td>
<td>1%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Multi vehicle accidents involving cycles</td>
<td>7%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Single vehicle moped accidents</td>
<td>1%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Multi vehicle accidents involving mopeds</td>
<td>3%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Single vehicle motorbike accidents</td>
<td>4%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Multi vehicle accidents involving motorcycles</td>
<td>10%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Single accidents involving cars</td>
<td>20%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Other accidents with two vehicles</td>
<td>34%</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Accident trends

- The accident numbers for 2020 and 2030 were calculated based on accident trends.
- The assumption was that the rate of decrease observed between 2002 and 2012 continues; the accident numbers for 2020 and 2030 were obtained through regression analyses.
- Separate trends
  - for accidents related to pedestrians, cyclists, moped riders, motorcyclists and cars
  - for fatalities and injuries
Totals used in the calculations

- The total number of fatalities for 2012 used in the impact assessment calculations for EU-28 was taken from the Statistical pocketbook.
- No information on the number of injuries (only injury accidents) and thus the total number of injuries was taken from the CARE database.

Table 1. Total number of fatalities and injuries used in the calculations.

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td>28,126</td>
<td>16,555</td>
<td>8,833</td>
</tr>
<tr>
<td>Injuries</td>
<td>1,429,888</td>
<td>1,055,760</td>
<td>748,317</td>
</tr>
</tbody>
</table>
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Estimation of penetration rates (2020 and 2030)
Estimated penetration rates for 2030
Based on questionnaires (n=33)
# Penetration rates used in the calculations

**(including estimated usage)**

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th></th>
<th></th>
<th>2030</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>medium</td>
<td>high</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>BSD</td>
<td>2.5%</td>
<td>4.4%</td>
<td>13.5%</td>
<td>17.5%</td>
<td>27.5%</td>
<td>45.0%</td>
</tr>
<tr>
<td>B2V</td>
<td>0%</td>
<td>0%</td>
<td>0.3%</td>
<td>0.2%</td>
<td>1.2%</td>
<td>2.8%</td>
</tr>
<tr>
<td>CAL</td>
<td>1.0%</td>
<td>3.0%</td>
<td>6.0%</td>
<td>6.0%</td>
<td>10.0%</td>
<td>18.0%</td>
</tr>
<tr>
<td>GWC</td>
<td>0%</td>
<td>0.2%</td>
<td>0.6%</td>
<td>0.5%</td>
<td>1.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>IVB</td>
<td>1.0%</td>
<td>2.5%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>10.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>IPT</td>
<td>1.0%</td>
<td>6.0%</td>
<td>10.0%</td>
<td>5.0%</td>
<td>25.0%</td>
<td>32.0%</td>
</tr>
<tr>
<td>INS</td>
<td>0%</td>
<td>1.0%</td>
<td>2.5%</td>
<td>3.5%</td>
<td>10.9%</td>
<td>16.9%</td>
</tr>
<tr>
<td>PDS+EIR</td>
<td>7.0%</td>
<td>12.0%</td>
<td>16.0%</td>
<td>24.0%</td>
<td>36.0%</td>
<td>49.0%</td>
</tr>
<tr>
<td>PTW2V</td>
<td>0%</td>
<td>0.3%</td>
<td>1.2%</td>
<td>0.4%</td>
<td>5.5%</td>
<td>11.5%</td>
</tr>
<tr>
<td>VBS, ped</td>
<td>0%</td>
<td>0%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0.9%</td>
<td>1.6%</td>
</tr>
<tr>
<td>VBS, cyc</td>
<td>0%</td>
<td>0.2%</td>
<td>0.5%</td>
<td>0.2%</td>
<td>2.7%</td>
<td>4.8%</td>
</tr>
<tr>
<td>VBS, PTWs</td>
<td>0%</td>
<td>0.4%</td>
<td>1.4%</td>
<td>0.5%</td>
<td>7.2%</td>
<td>12.8%</td>
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Summary of main modifications to the method

- Main modifications were related to
  - the nine mechanisms which were modified to cover vulnerable road users,
  - safety impact assessment tool which was updated to include more detailed information on accident involving vulnerable road users,
  - additional background variables which were added to the accident data,
  - expert survey which was used to enhance the value of estimates for the nine mechanisms, and
  - calculation of the safety effects of exposure changes
Two main reasons to explain on how powerful the systems are in contributing to traffic safety:
1) Targeted vulnerable road user groups
2) Extent of the safety problem the systems target
Results of safety impact assessment, (2/2)

- More realistic view about the expected effects
- Quite low levels of penetration rates were assumed
- Decreasing accident trends
Main facts of VRUITS project


Consortium:

Associated Members:

Ertico, ECF, FEMA, ACEM, Finnish Transport Agency, Rijkswaterstaat, Finnish Transport Safety Agency, City of Helmond, City of Valladolid, Psychological University Berlin, University of Maine, CERTH/HIT