Equal Effectiveness Study on Pedestrian Protection

Objective

Demonstration that effectiveness of combined primary and secondary safety solutions is at least as effective as EU Directive 2003/102/EC current phase 2 in reducing pedestrian injuries and fatalities when hit by passenger cars!

Steps

Analysis of upper legform to bonnet leading edge test regarding relevance for current car fleet

Review and assessment of previous effectiveness studies, to find the most appropriate study as basis for equal effectiveness

Determination of savings in seriously and fatally injured pedestrians with implementation of EU Directive 2003/102/EC current phase 2 in comparison to the implementation of EU Directive 2003/102/EC phase 1 and Brake Assist System
Analysis of Upper legform to bonnet leading edge test regarding relevance for current car fleet

from EEVC WG17 report

<table>
<thead>
<tr>
<th>AIS 2+ upper leg and pelvis injuries caused by the BLE (MUH 1985-1995)</th>
<th>&lt;1990 car model</th>
<th>&gt;= 1990 car model</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=40 km/h</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;40 km/h</td>
<td>17%</td>
<td>24%</td>
</tr>
<tr>
<td>All speeds</td>
<td>11%</td>
<td>7%</td>
</tr>
</tbody>
</table>

update with data of GIDAS and MUH since 1995

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=40 km/h</td>
<td>26 injuries by 471 injured pedestrians → 6%</td>
<td>0 injuries by 189 injured pedestrians → 0%</td>
</tr>
<tr>
<td>&gt;40 km/h</td>
<td>23 injuries by 178 injured pedestrians → 13%</td>
<td>4 injuries by 58 injured pedestrians → 7%</td>
</tr>
<tr>
<td>All speeds</td>
<td>49 injuries by 649 injured pedestrians → 8%</td>
<td>4 injuries by 247 injured pedestrians → 2%</td>
</tr>
</tbody>
</table>

conclusions:

Decrease from 8% (pre 1990) to 2% (post 1990) of AIS2+ upper leg and pelvis injuries caused by BLE

No injuries up to 40 km/h for post 1990 car model

No injuries for post 1996 car model

reference:

EEVC WG 17 report
page 10, table 2
Kalliske Bast 1998,
“Comparison of the evaluations of pedestrian injuries caused by the bonnet leading edge looking on AIS1+ and AIS2+ injuries”
Review and assessment of previous effectiveness studies, to find the most appropriate study as basis for equal effectiveness

method

review of previous effectiveness studies and used data sources

description of calculation methods, assumptions and effectiveness for all studies with consistent and comprehensible flow charts

assessment of each study in terms of 3 criteria

• calculation method
• data source
• up-to-dateness

definition of an overall assessment score (1 to 5, 1 as the most appropriate one)
## EES - Step 2

### Results

<table>
<thead>
<tr>
<th>Association</th>
<th>datasources</th>
<th>benefit calculation: method</th>
<th>benefit for fatalities</th>
<th>benefit for seriously injured</th>
<th>overall assessment score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>uninjured up to equivalent car speed-method</td>
<td>3%</td>
<td>10%</td>
<td>13%</td>
</tr>
<tr>
<td>ACEA 1995 (LAB)</td>
<td>police reports france (1990), LAB (1994-1995)</td>
<td>uninjured up to equivalent car speed-method</td>
<td>_</td>
<td>4 - 5%</td>
<td>_</td>
</tr>
<tr>
<td>DEKRA 2002 (Berg, Egelhaaf)</td>
<td>Hanover data (1985-1991), GIDAS data (1999-2001), IHRA data (1985-1995)</td>
<td>estimation with injury-causing car-parts</td>
<td>0,5 - 1,8%</td>
<td>0,5 - 1,9%</td>
<td>7,2 - 9,9%</td>
</tr>
<tr>
<td>BASSt 1994 (Bamberg, Zellmer)</td>
<td>Hanover data (1985-1991)</td>
<td>method of injury shift</td>
<td>_</td>
<td>3,3 - 7,3%</td>
<td>_</td>
</tr>
</tbody>
</table>

**BASt study of 1994 is the most appropriate study as basis for Equal Effectiveness**

Automated case by case analysis with utilization of Injury Risk Functions (IRF) based on the same dataset.
representation of effects of secondary safety measures – case-by-case method

current situation

- craniocerebral injury (CCI) 1st degree caused by 3rd third of the bonnet
  \[ \text{AIS}=2 \]
- multiple abrasions of forearm caused by ground impact
  \[ \text{AIS}=1 \]
- contusion of pelvis caused by bonnet leading edge
  \[ \text{AIS}=1 \]
- fracture of tibia caused by bumper
  \[ \text{AIS}=2 \]

\[ \text{MAIS}=2 \]

Injury Risk Function for current situation

situation after implementation of EU Directive 2003/102/EC phase 1

- craniocerebral injury (CCI) 1st degree caused by 3rd third of the bonnet
  \[ \text{tested area } \rightarrow \text{AIS}^*=1 \]
- multiple abrasions of left forearm caused by ground impact
  \[ \text{non tested area } \rightarrow \text{AIS}=1 \]
- contusion of pelvis caused by bonnet leading edge
  \[ \text{non tested area } \rightarrow \text{AIS}=1 \]
- fracture of tibia caused by bumper
  \[ \text{tested area } \rightarrow \text{AIS}^*=1 \]

\[ \text{MAIS}^*=1 \]


assumption on injury level

All injuries due to tested areas will be shifted down by one AIS level
representation of effect of primary safety measure BAS – case-by-case method

current situation without BAS

- initial speed \( V_0 \)
- mean braking deceleration \( BV \)
- collision point
- braking distance pre collision \( S \)

GIDAS dataset
- dry asphalt
  \[ V_0 = 46 \pm 5 \, \text{km/h} \]
  \[ S = 7,4 \, \text{m} \]
  \[ BV = 7,8 \, \text{m/s}^2 \]
  \[ VK = 25 \pm 5 \, \text{km/h} \]

activation of BAS if mean braking deceleration \( BV \geq 6 \, \text{m/s}^2 \) → 47% of all cases

predicted situation with BAS

- initial speed \( V_0 \)
- mean braking deceleration \( BVBAS \)
- collision point
- braking distance pre collision \( S \)

BAS activated:

recalculation of collision speed using the ceiling of mean deceleration based on forensic literature (e.g. Danner and Halm 8,8 m/s² for dry asphalt)

\[ V_{KBAS} = \sqrt{V_0^2 - 2 \cdot BVBAS \cdot S} \]

Therefore:

\[ V_{KBAS} = 21 \pm 5 \, \text{km/h} \]
Savings in seriously and fatally injured pedestrians with implementation of EU Directive 2003/102/EC current phase 2 in comparison to the implementation of EU Directive 2003/102/EC phase 1 and Brake Assist System

**current situation**

- **MAIS2+ = 45%** for EU Directive 2003/102/EC phase 1
- **MAIS2+EEVC = 34%** for EU Directive 2003/102/EC phase 2

**EU Directive 2003/102/EC phase 2**

- **VK = 25 km/h**
- **MAIS2+ = 34%**

**EU Directive 2003/102/EC phase 1 + BAS**

- **VKBAS = 21 km/h**
- **MAIS2+ phase 1+BAS = 30%**

In sum over all 712 casualties, this method predict the number of at least serious injured pedestrians!

\[
\sum_{i=1}^{712} MAIS2^+ = 377
\]

Savings of 70 at least seriously injured pedestrians!

\[
\sum_{i=1}^{712} MAIS2^+_{\text{phase2}} = 307
\]

Saving of 81 at least seriously injured pedestrians!

\[
\sum_{i=1}^{712} MAIS2^+_{\text{phase1+BAS}} = 296
\]

56 impacts were completely prevented (VKBAS = 0 km/h)
### Overall results of Equal Effectiveness Study On Pedestrian Protection

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Seriously injured (n=531)</td>
<td>12.4%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Fatalities (n=48)</td>
<td>8.3%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Number of collisions avoided in regarded accidents (n=712)</td>
<td>0</td>
<td>56</td>
</tr>
</tbody>
</table>

**Conclusions:**

It is shown that the combination of EU Directive 2003/102/EC phase 1 and primary safety measure BAS is at least as effective as implementation of EU Directive 2003/102/EC current phase 2 in reducing pedestrian injuries and fatalities when hit by passenger cars.

Even 56 impacts could completely be prevented with implementation of BAS.

In addition there is enhanced protection for other pedestrian impacts than addressed by EU Directive 2003/102/EC current phase 2 test proposals (e.g. side impacts, overrun) and beyond it, there are positive effects for all real world crashes where BAS was activated.

16.04.2004 L Hannawald, F Kauer

chart 9