Road safety Engineering
22 February 2012 | Sofia

Road Restraint Systems
EN1317 Application Tools

Joseph MARRA – ArcelorMittal Liege
Member of ERF Road Safety Working Group
Overview

Road safety context

EN1317 Application Tools
Road safety context

The problem on EU25 roads:

- 42,000 persons killed/year
- 1,213,300 persons injured/year
The problem on EU25 roads:

- Estimated social costs = €200bn/years = 2% EU GDP

Europe asked to halve road fatalities < 2010 (white book)
The solutions:

- Are described in the well-known “Haddon Matrix”

<table>
<thead>
<tr>
<th>Haddon Matrix</th>
<th>Driver</th>
<th>Car</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td>![Driver image]</td>
<td>![Car image]</td>
<td>![Road image]</td>
</tr>
<tr>
<td><strong>During</strong></td>
<td>![Driver image]</td>
<td>![Car image]</td>
<td>![Road image]</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td>![Hospital image]</td>
<td>![Car image]</td>
<td>![Call image]</td>
</tr>
</tbody>
</table>
Road safety context

The driver:

- Inform and educate the drivers
- Strengthen radar controls, police presence, …
- Education on reflexes in case of danger
- Decrease time to arrive on accident place
- Increase the emergency call possibilities
The car:

- Impose regular car inspections
- Inform the driver on the car’s level of safety
- Increase energy absorption possibilities
- Impose use of seatbelts, airbags, …
- Help cars communicate with emergency
Road safety context

The infrastructure:

- Make clear and visible signs
- Facilitate the driver choices
- Make safe road designs
- Provide the safest road restraint systems
- Make infrastructure interact with drivers
- Make speed the emergency calls easier

...
Road safety context

The infrastructure – situation before EN1317:

– Imposition of the type of safety barriers to be used:

– Imposition of materials & designs:

\[\text{Commodity steel S235JR} \]
\[\text{Post-galvanized products} \]
\[\text{Few controls on performances and tolerances} \]

\(\Rightarrow\) No possible innovation on design or material
Road safety context

The infrastructure – situation before EN1317:

– Conclusions:

➔ Implementation of new Standard based on performance: EN1317
Road safety context

The infrastructure – situation with EN1317:

Prescriptive standards...

Performance standards
### Road safety context

**OLD infrastructure (before EN1317):**

<table>
<thead>
<tr>
<th></th>
<th>Hard shock</th>
<th>Soft shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(F &gt;&gt;&gt;&gt;)</td>
<td>(F &lt;&lt;&lt;)</td>
</tr>
<tr>
<td>Low displacements</td>
<td>OLD RIGID SYSTEMS</td>
<td><strong>Ideal:</strong> Technically difficult</td>
</tr>
<tr>
<td>(d &lt;&lt;&lt;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High displacements</td>
<td><strong>Worse:</strong> All disadvantages</td>
<td></td>
</tr>
<tr>
<td>(d &gt;&gt;&gt;)</td>
<td></td>
<td>OLD DEFORMABLE SYSTEMS</td>
</tr>
</tbody>
</table>

2/28/2012
Sofia, Bulgaria
### Road safety context

#### NEW infrastructure (with EN1317):

<table>
<thead>
<tr>
<th>Low displacements (d &lt;&lt;&lt;)</th>
<th>High displacements (d &gt;&gt;&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hard shock</strong> (F &gt;&gt;&gt;&gt;)</td>
<td><strong>Worse</strong>: All disadvantages</td>
</tr>
<tr>
<td><strong>Soft shock</strong> (F &lt;&lt;&lt;)</td>
<td></td>
</tr>
</tbody>
</table>

- **OLD RIGID SYSTEMS**
- **Ideal**: Technically difficult
- **OLD DEFORMABLE SYSTEMS**

*Optimum*:  
- $d \uparrow$ to soften the shock
- $d \downarrow$ to increase resistance
Road safety context

A lot of **NEW SAFER products** according to EN1317:

- **Central** (H2-H3-H4a-H4b)
- **Lateral** (H2-H3-H4a-H4b)
- **Bridges** (H2-H3-H4a-H4b)
Road safety context

Common bad image of steel safety barriers:

- Old steel solutions
  ~ N2, ASI A, W8
  No heavy vehicles retained
  & huge reparation needed

Common bad image of concrete safety barriers:

- Old concrete solutions
  ~ H2, ASI C, W1
  Too high risks for the road users
  (severity & stability)
Road safety context

New steel safety barriers with less deformation keeping safety:

- New steel solutions
  \( \sim H4, ASI A, W2^* \)
  
  *Truck can be retained & 5 times less reparation*

New concrete barriers accepting some deformation for higher safety:

- New concrete solutions
  \( \sim H4, ASI B, W1^* \)
  
  *Lower risks for road users*

* \( W \) of the H4b system for an impact of a H2 level (to be compared to the previous \( W \)*)
Overview

Road safety context

EN1317 Application Tools
Example: How EN1317 could influence National Regulations?

National regulations imposing material & design safety levels of EN1317

OLD regulations

NEW regulations

ASI A preferred to B
ASI C forbidden
1st criteria: CONTAINMENT LEVEL (heavy vehicles safety)

**RS Working Group activities**

**Belgium regulation:**

<table>
<thead>
<tr>
<th>Danger level</th>
<th>Speed (km/h)</th>
<th>Traffic (Cars)</th>
<th>Road exit</th>
<th>Daily (trucks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very dangerous</td>
<td>&gt; 50</td>
<td>/</td>
<td>Yes</td>
<td>&gt;3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>&lt;3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;3000</td>
</tr>
<tr>
<td>Medium dangerous</td>
<td>&gt; 100</td>
<td>/</td>
<td>/</td>
<td>&gt;10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,000&lt;10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70&lt;100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
</tbody>
</table>

**German regulation (main topics):**

<table>
<thead>
<tr>
<th>Danger level</th>
<th>Speed (km/h)</th>
<th>Traffic (Cars)</th>
<th>Road exit</th>
<th>Daily (trucks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very dangerous</td>
<td>&gt; 50</td>
<td>/</td>
<td>Yes</td>
<td>&gt;3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>&lt;3000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;3000</td>
</tr>
<tr>
<td>Medium dangerous</td>
<td>&gt; 100</td>
<td>/</td>
<td>/</td>
<td>&gt;10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,000&lt;10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70&lt;100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;1,000</td>
</tr>
</tbody>
</table>

**French regulation:**

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>Side</th>
<th>Middle</th>
</tr>
</thead>
<tbody>
<tr>
<td>v &lt; 90 km/h</td>
<td>N1</td>
<td>N2</td>
</tr>
<tr>
<td>v &gt; 90 km/h</td>
<td>N2</td>
<td>N2:H2</td>
</tr>
</tbody>
</table>

**Italian regulation:**

<table>
<thead>
<tr>
<th>Road type</th>
<th>Traffic type</th>
<th>Middle barriers</th>
<th>Side barriers</th>
<th>DZ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways &amp; high speed secondary roads</td>
<td>I</td>
<td>H2</td>
<td>H1</td>
<td>H2</td>
</tr>
<tr>
<td>Low speed SR &amp; high speed urban roads</td>
<td>II</td>
<td>H2</td>
<td>H1</td>
<td>H2</td>
</tr>
<tr>
<td>Low speed urban roads and local roads</td>
<td>III</td>
<td>H2</td>
<td>H1</td>
<td>H2</td>
</tr>
</tbody>
</table>
EN1317 Application Tools

Austria
- Side Barrier: H2
- Central Barrier: H2
- Bridge Barrier: H3

Belgium
- Side Barrier: H2
- Central Barrier: H2
- Bridge Barrier: H4b

Denmark
- Side Barrier: H1
- Central Barrier: H2
- Bridge Barrier: H3

Finland
- Side Barrier: N2
- Central Barrier: N2
- Bridge Barrier: H2

France
- Side Barrier: N2
- Central Barrier: H1
- Bridge Barrier: N2
EN1317 Application Tools

<table>
<thead>
<tr>
<th>Country</th>
<th>Side Barrier</th>
<th>Central Barrier</th>
<th>Bridge Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>H2</td>
<td>H2</td>
<td>H4</td>
</tr>
<tr>
<td>Ireland</td>
<td>N2</td>
<td>H2</td>
<td>H2</td>
</tr>
<tr>
<td>Italy</td>
<td>H2</td>
<td>H3</td>
<td>H4b</td>
</tr>
<tr>
<td>Netherland</td>
<td>H2</td>
<td>H2</td>
<td>H2</td>
</tr>
<tr>
<td>Spain</td>
<td>H1</td>
<td>H2</td>
<td>H3</td>
</tr>
</tbody>
</table>
Example 1: Use of EN1317 in ITALY (~ 2005)

- *H* safety barriers with ASI A only *(safe for small AND heavy vehicles)*

Example 2: Use of EN1317 in BELGIUM (~ 2005)

- EN1317 not yet used or with *low performances requirements*
EN1317 Application Tools

Things are moving since EN1317 application in Belgium

Figure 1 – New system (H4) replacing the old prescriptive one in Belgium (Black spot)
Why differences of National Codes between countries?

- Difference of landscape
- Difference of road design
- Difference of road culture

Holland with large flat landscape  Italy with hills and mountains
2nd criteria: The ASI level (light vehicles safety)
Generally: ASI A preferred to B, ASI C forbidden
EN1317 Application Tools

National Regulations new role:

THE THREE STEPS OF VRS TECHNICAL HARMONIZATION

A. PERFORMANCE CLASSES: Containment levels, Crash-Test methods and Acceptance criteria
   - EN 1317, parts 1, 2, 3 and 4 (ENV)
   - Already EN (1990-2001)
   - Currently under revision parts 1 & 2

B. PRODUCT CONFORMITY: Factory Production Control and CE marking
   - EN 1317, part 5
   - Under Formal Vote - Publication within 2007

C. VRS DEPLOYMENT: Recommendations and Criteria for VRS implementation, Roadside Safety Audits
   - NO EN
   - National Regulations

Standard EN1317 = reference

Application Tool = helping tool

National regulations
EN1317 Application Tools

The EN1317 Application Tools aim to:

– link EN1317 criteria to understandable physical concepts
– help increase safety by using EN1317 criteria
– avoid making mistakes by a wrong use of EN1317
– give safety advice when making new roads
– give safety advice when replacing old systems

The EN1317 Application Tools don’t aim to:

– choose the level of safety

⇒ The final decision is for the Road Authorities.
The Application Tools: Example for containment level

Table of the transversal energy

<table>
<thead>
<tr>
<th>E (kJ)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law V ≤ 120 km/h if M ≥ 7.5t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Law V ≤ 90 km/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Law M ≤ 44t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transversal Energy
The Application Tools: Example for containment level

Containment levels according to the table

<table>
<thead>
<tr>
<th>Law V ≤ 120 km/h</th>
<th>Law V ≤ 90 km/h if M ≥ 7.5t</th>
<th>Law M ≤ 44t</th>
</tr>
</thead>
<tbody>
<tr>
<td>725kJ</td>
<td>572kJ</td>
<td>H4b</td>
</tr>
<tr>
<td>572kJ</td>
<td>462kJ</td>
<td>H4a</td>
</tr>
<tr>
<td>462kJ</td>
<td>287kJ</td>
<td>H3</td>
</tr>
<tr>
<td>287kJ</td>
<td>127kJ</td>
<td>H2</td>
</tr>
<tr>
<td>127kJ</td>
<td>82kJ</td>
<td>H1</td>
</tr>
<tr>
<td>82kJ</td>
<td>43kJ</td>
<td>N2</td>
</tr>
<tr>
<td>43kJ</td>
<td></td>
<td>N1</td>
</tr>
</tbody>
</table>
EN1317 Application Tools

The Application Tools: Example for containment level

If I want to stop a 40 tons truck at 90 km/h \(\rightarrow H4b\)
The Application Tools: Example for containment level

If I want to stop a 13 tons bus at 90 km/h → H3
How to choose the ASI and the Working Width?

Guardrails performance:
- Containment level (i)
- ASI (j)

Verification of the working width (w)

Sufficient place:
- Fin

Insufficient place:
- Change of place of the obstacle or adaptation of the safety device?
- New w

Possible
- i → i+1

Not possible
- j → j+1

Possible
- End

<table>
<thead>
<tr>
<th>CL</th>
<th>N1</th>
<th>N2</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4a</th>
<th>H4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>ASI</td>
<td>A</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASI C forbidden
EN1317 Application Tools

The infrastructure – situation with EN1317:

– EN1317 Road Restraint Systems are LCM

\( LCM = \text{Low Cost Measures} = \text{High Benefit/Cost ratio} \)
EN1317 Application Tools

The infrastructure – situation with EN1317:

– EN1317 Road Restraint Systems are LCM

(LCM = Low Cost Measures = High Benefit/Cost ratio)
Thank you for your attention!

Joseph MARRA
ArcelorMittal Liege

Joseph.Marra@ArcelorMittal.com