SAFER-LC Workshop WS 3
Presentation and Evaluation of the SAFER-LC Toolbox
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Human Factor at Level Crossings: Towards a design for self-explaining and forgiving infrastructure

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A dedicated human factors work package which aims to enhance the safety performance of level crossing infrastructures from a human factors perspective, making them more self-explaining and forgiving, designed to take into account the needs of different road and rail users, and especially issues related to vulnerable users.
“Human factors must be identified as a major issue in improving level crossing safety. (...) Human factors which cause or contribute to accidents must be put at the heart of actions for improving safety at level crossings.”


“...it is commonly asserted that a significant majority of level-crossing accidents are caused by misuse of level crossings by road users.” (European Union Agency for Railways, 2017)
Analysis into human factors at level crossings: literature & expert consultation

Human Factors Methodological Framework
Evaluate the effects of measures on human behaviour and safety.

Design and evaluation of innovative human centred low cost measures

Testing and evaluation in pilots (e.g. laboratory, driving simulator, living lab...)

Evaluated Human Factors Assessment Tool
Evaluated human centred low cost measures

SAFER-LC Toolbox
Human Factor Methodological Framework (T.2.2)

Objectives:

▲ Develop a methodological framework to analyse and evaluate safety measures (technological and non-technological) from the LC user perspective.

▲ The framework is based on a set of evaluation criteria for self-explaining and forgiving LC design (assignment of a score rating).

▲ Key safety indicators concerning human errors and violations were identified in task 2.1.

▲ Accompanied by an evaluation research tool and implementation guide.
Criteria selected for the HF Assessment Tool (HFAT)

**Classification criteria**
- Applicability to different LCs
- Feasibility under different environmental conditions
- Applicability to different types of users
- Adaptability to individual characteristics and conditions of users
- Intended effect mechanism

**Criteria to assess the behavioural safety effects**
- Detectability and identification
- Rule knowledge
- Decision-making
- Behavioural execution

**Criteria to assess the user experience and social perception**
- Acceptance
- Reliability (Trust)
- Usability (Level of self-explaining nature)

Estimation of **short-term** safety effects on road user behaviour (direct, immediate reactions)

Estimation of **long-term** safety effects on road user behaviour (learning processes and behavioural adaptation)
**HFAT – classification criteria checklist**

**Classification criteria**
- Applicability to different LCs
- Feasibility under different environmental conditions
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**CLASSIFICATION CRITERIA**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brief description</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability to different LCs</td>
<td>Specify the types and characteristics of LCs where the measure can be implemented</td>
<td></td>
</tr>
<tr>
<td>Feasibility under different environmental conditions</td>
<td>Specify the environmental circumstances in which the measure aims to be most effective and which may affect the perception or the behavioural adaptation of road users</td>
<td></td>
</tr>
</tbody>
</table>

**Indicator**
(Tick all the cases that the measure applies to)
- Type of LCs
  - Passive LCs without any warning devices
  - Active (manual)
  - Active LCs with half barriers
  - Active LCs with full barriers
  - Active LCs with skirts for pedestrians
  - Active LCs with light and sound warning
  - Active LCs with other warning devices
  - Active LCs with traffic lights
- Characteristics of LCs
  - LCs with low vehicle traffic
  - LCs with high vehicle traffic
  - LCs with paved road
  - LCs with gravel road
  - LCs with availability of electricity
  - LCs with low usage / not used at all
  - LCs with sharp / wide crossing angle
  - Other (specify) ........................................

**Estimation of short-term safety effects on road user behaviour**
(direct, immediate reactions)

**Estimation of long-term safety effects on road user behaviour**
(learning processes and behavioural adaptation)
HFAT – behavioural safety effects forms

Classification criteria
- Applicability to different LCs
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Criteria to assess the behavioural safety effects
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Estimation of short-term safety effects on road user behaviour (direct, immediate reactions)

Estimation of long-term safety effects on road user behaviour (learning processes and behavioural adaptation)

Write down brief descriptions of the expected and/or observed changes in road user’s detection of the LC or train as a result of the measure (including any numerical findings from pilot tests or literature to support the estimated behavioural changes)

<table>
<thead>
<tr>
<th>Period</th>
<th>Evidence from literature (Short-term)</th>
<th>Evidence from literature (Long-term)</th>
<th>Evidence from pilot test (Short-term)</th>
<th>Evidence from pilot test (Long-term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before / Without the</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>measure</td>
<td></td>
<td></td>
<td>Some drivers did not direct gaze</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>towards LC warning signs</td>
<td></td>
</tr>
<tr>
<td>After / With the</td>
<td>N/A</td>
<td>N/A</td>
<td>Most drivers directed gaze towards</td>
<td></td>
</tr>
<tr>
<td>measure</td>
<td></td>
<td></td>
<td>LC warning signs</td>
<td></td>
</tr>
</tbody>
</table>

Estimation of short-term safety effects on road user behaviour

Estimation of long-term safety effects on road user behaviour

Answer the following question by choosing one score between 0 and 5 or the answer ‘N’. Make the choice based on the descriptions you gathered above.

Question: To what extent does the measure facilitate the detection of the LC or train while the user is approaching the LC?

Answer modalities

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
</tr>
<tr>
<td>1</td>
<td>Reasoning behind the score / Assumption on the short and long-term change in road user behaviour</td>
</tr>
<tr>
<td>2</td>
<td>Slowing down MRUs and cyclists will facilitate the detection of relevant visual and auditory stimuli such as LC signage and warnings (i.e., signs that might have been missed if travelling at speed) which alert the user to the LC and approaching train</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>LC users can easily detect the LC or the approaching train with sufficient time to stop or to cross safely (and continue to do so in the long term)</td>
</tr>
</tbody>
</table>

Score: 2
HFAT – User experience and social perception rating

**Classification criteria**
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**Criteria to assess the behavioural safety effects**
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**Estimation of short-term safety effects on road user behaviour**
(direct, immediate reactions)

**Estimation of long-term safety effects on road user behaviour**
(learning processes and behavioural adaptation)
Design and evaluation of human-centered low-cost measures for LC safety (Task.2.3)

**Design**
- Collection
  - Measures from literature
- Selection
- Design Workshop
  - Models of road user behavior

**Evaluation**
- Pilot tests
  - Simulation
  - Field
- Human Factors Assessment
  - HFA Tool

Detailed Classification
- short-term
- Behavioural safety effects
- long-term
- User experience and social perception
Key results - design phase

▲ Collection of 89 LC safety measures:

▲ 36 for passive LCs
   ▲ Laser illumination, blinking peripheral lights drawing driver attention, light markings in the road to highlight the waiting line, speed bumps on approach to the LC, on-road flashing markers, road swiveling, LC attention device, colored marking of the danger zone, …

▲ 29 for active LCs with barriers (full, half, light protection)
   ▲ Adapting the timing of LC closure to the speed of the passing train, camera-based enforcement (prosecution of violations), additional display “Two Trains”, second chance zone, sound warning, lane separation in front of half barriers, increasing the length of the barrier, …

▲ 24 for all kinds of LCs
   ▲ Proximity message via connected device, improving train visibility using lights, extended “no stop” zone, routing avoiding LCs by satnav intelligence, countdown to train arrival, LED enhanced traffic signs, warning sign to avoid blocking back, …
Key results – evaluation phase

▲ Human Factors Assessment of 13 measures:

For passive LCs
▲ Blinking amber light with train symbol
▲ Funnel effect pylons
▲ Message “<- Is a train coming? ->” written on road
▲ Peripheral blinking lights
▲ Rumble strips
▲ Sign “<- Is a train coming? ->”
▲ Speed bump and flashing posts

For active LCs with barriers
▲ In-vehicle proximity warning (1)
▲ Rings upstream of the LC
▲ Traffic light

For all kinds of LCs
▲ Blinking Lights for Locomotive front
▲ Coloured road markings on approach to LC
▲ In-vehicle proximity warning (2)

Common human factors metric, based on results from the research literature and 5 SAFER-LC pilot tests:
▲ Two driving simulator environments (SNCF, DLR)
▲ Real railway environment & user questionnaire (VTT)
▲ Two real road traffic environments with LCs (CERTH-HIT & TRAINOSE, DLR)
### Behavioral Safety Effects Assessment

<table>
<thead>
<tr>
<th>Measure</th>
<th>Detection &amp; Identification</th>
<th>Rule Knowledge</th>
<th>Decision-Making</th>
<th>Behavioral Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinking lights for locomotive front</td>
<td>Short</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Coloured road markings on approach to LC</td>
<td>Short</td>
<td>3</td>
<td>3</td>
<td>NA</td>
</tr>
<tr>
<td>In-vehicle proximity warning (1)</td>
<td>Short</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>In-vehicle proximity warning (2)</td>
<td>Short</td>
<td>5</td>
<td>4</td>
<td>NA</td>
</tr>
<tr>
<td>Rings upstream of the LC</td>
<td>Short</td>
<td>3</td>
<td>2</td>
<td>NA</td>
</tr>
<tr>
<td>Traffic light</td>
<td>Short</td>
<td>4</td>
<td>3</td>
<td>NA</td>
</tr>
<tr>
<td>Blinking amber light with train symbol</td>
<td>Short</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Funnel effect pylons</td>
<td>Short</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Message “Is a train coming?” on road</td>
<td>Short</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Peripheral blinking lights</td>
<td>Short</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>Short</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sign Look for train</td>
<td>Short</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Speed bumps and flashing posts</td>
<td>Short</td>
<td>4</td>
<td>3</td>
<td>NA</td>
</tr>
</tbody>
</table>
Conclusions

The resulting assessments describe the suitability of measures in their defined application context.

Measures assessed to most facilitate safe road user behavior:

▲ For all LCs: blinking lights for the locomotive front, in-vehicle proximity warnings
▲ For passive LCs: peripheral blinking lights at the LC
▲ The scores for the two measures involving blinking lights are supported by multiple studies including the pilot tests; the score for the in-vehicle proximity warnings is more tentative with the only evidence available by now coming from the pilot test.
▲ On a theoretical basis, for in-vehicle proximity warnings, some habituation effects can be expected in the long term, because, to be effective, the measure requires a voluntary effort of the driver to initiate the recommended behavior. The autonomous capture of visual attention by flickering stimuli in the periphery of the visual field, as used in the blinking train and the peripheral blinking lights, is a hard-wired feature of the nervous system that is unlikely to be subject to considerable habituation effects

HFAT added value:
▲ HFAT mainly useful for research purposes and not policy-making in itself
▲ Is the HFAT useful for rail stakeholders in future safety evaluations? HFAT useful for road and rail local stakeholders to analyse and understand one measure in one particular LC context (comparison of the results across measures very difficult)
Recommendations

Policy vision:

▲ Consider low-cost solutions both in technical and human factors terms (i.e. all important aspects covered through checklists)

▲ Solutions that help the infrastructure become more self-explaining and forgiving should consider all aspects of information processing, e.g. perception, memory, action execution...

Long-term trials of human-centered low-cost measures in real traffic environments should be promoted and facilitated

▲ E.g. trials initiated by municipalities, road-/rail infrastructure managers

The HFAT should be used as a checklist to support the consideration of human factors aspects in the evaluation of LC safety measures.
Potential for further development of the work

Transfer of results into the SAFER-LC Toolbox
- Measures collected
- Specifications for use
- Overview of empirical evidence

Revision of the Human Factors Assessment Tool (HFAT) based on feedback from the evaluation
- Evaluate reliability of the scores, e.g. further specification of defined aspects in the instruction part
- Inclusion of specific behavioral descriptions of target effects on behavior within the stages of information processing
- Further specification of the method to integrate the results
- Psychometric validation of the HFAT
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## Key results – evaluation phase

### Acceptance Assessment

<table>
<thead>
<tr>
<th>Measure</th>
<th>Scores and reasoning by sub category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acceptance by public</td>
</tr>
<tr>
<td>Blinking lights for locomotive front</td>
<td>3</td>
</tr>
<tr>
<td>Coloured road markings</td>
<td>3,5</td>
</tr>
<tr>
<td>In-vehicle proximity warning (1)</td>
<td>4</td>
</tr>
<tr>
<td>In-vehicle proximity warning (2)</td>
<td>4</td>
</tr>
<tr>
<td>Rings upstream of the LC</td>
<td>4</td>
</tr>
<tr>
<td>Traffic lights</td>
<td>4</td>
</tr>
<tr>
<td>Blinking amber light with train symbol</td>
<td>4</td>
</tr>
<tr>
<td>Funnel effect pylons</td>
<td>0</td>
</tr>
<tr>
<td>Message &quot;Is a train coming?&quot; on road</td>
<td>4</td>
</tr>
<tr>
<td>Peripheral blinking lights</td>
<td>4</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>3</td>
</tr>
<tr>
<td>Sign Look for train</td>
<td>4</td>
</tr>
<tr>
<td>Speed bumps and flashing posts</td>
<td>2,5</td>
</tr>
</tbody>
</table>