SAFER-LC Mid-term Conference
Madrid, 10th October 2018

Human Factor at Level Crossings: Towards a design for self-explaining and forgiving infrastructure

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| ➢ Rationale and approach |
| Analyzing the effect of countermeasures on human behaviour and safety (UIC) |
| ➢ Application of a Human Factor Methodological Framework |
| Human centered low cost measures (DLR) |
| ➢ From design to evaluation |
| Discussion (All) |
“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.”
Human factors: key concepts

- Application of psychological and physiological principles to design of products, processes and systems
- Meeting the needs of people engaging with the designs, safely and efficiently
- Optimizing human well-being and overall system performance
- Understanding the interactions among humans and other elements of a system

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Level crossings as a complex system

**LC infrastructure**
(sight distances, signage...)

**Road and rail vehicles** (heavy vehicles, high-speed trains...)

**Wide profile of level crossing users**
(motorized and vulnerable road users...)

**Broader environment**
(weather conditions, rural vs urban setting...)

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“...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)
Human behaviour = unpredictable variable

- Knowledge
- Decision making
- Perception
- Human errors
  - Lack of knowledge of LC rules
  - Fatigue
  - Distraction and inattention
  - Poor lighting
  - Limited sight distance
  - Perceived

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Human behaviour = unpredictable variable

- Deliberate rule violation
- Subjective risk estimates
- Personal characteristics
- Individual motivation
- Risk seeking personality
- Social pressure (peers or other drivers)
- Influence of drugs or alcohol
- Time pressure
- Mood

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“...better understanding of the root causes and human factors of this misuse could support improved management of this significant railway risk.” (European Union Agency for Railways, 2017)
Approach to Human Factors in SAFER-LC

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 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

Analysis into human factors at level crossings: literature & expert consultation
Analyzing the effect of countermeasures on human behaviour and safety

Human Factors Methodological Framework

- Theoretical & conceptual foundations
- HF Assessment Tool & Application Guide

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Human Factors Methodological Framework and application guide for testing (interim report)

Deliverable D2.2

Download:

Chapters 2-3: Theory

Chapters 4-5: Application

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Adaptation of Cognitive Work Analysis (CWA) approach

For each level there are sets of criteria which apply

The levels help to:

- establish the context and identify the purpose of the new measure (intended effect mechanism)
- estimate the measure effectiveness from a LC user perspective
Criteria selected for the Human Factors Assessment Tool

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

**Criteria to assess the behavioural safety effects**
- Detectability
- 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)

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## Checklist where no quantitative score is assigned

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

### CLASSIFICATION CRITERIA

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brief description</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>
</tr>
<tr>
<td>Feasibility under environmental conditions</td>
<td></td>
</tr>
</tbody>
</table>

### Indicator

*(Tick all the cases that the measure applies to)*

#### Type of LCs
- [x] 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
- [x] LCs with low vehicle traffic
- [x] LCs with high vehicle traffic
- [x] LCs with paved road
- [x] LCs with gravel road
- [x] LCs with availability of electricity
- [ ] LCs with low usage / not used at all
- [ ] LCs with sharp / wide crossing angle
- [ ] Other (specify).................................

#### Time of the day
- [x] Daylight
- [x] Darkness
- [x] Dusk
- [x] Dawn
## Likert-type scale (scoring 0–5) + description

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

### Choose the most appropriate answer by ticking one box for each case

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
<th>(0) Unacceptable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5) Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The estimated level acceptance by the public (e.g., road users, people living near the LC)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Acceptance</td>
<td>Reasoning behind the score (indicate the findings or assumptions the score has been based on):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequent complaints from the drivers living nearby who claim that the speed bumps force them to slow down every time, even when not necessary and that they reduce their driving comfort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The estimated level acceptance by relevant stakeholders (e.g., railway operator, rail infrastructure manager, train drivers, authorities or Government)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Reasoning behind the score (indicate the findings or assumptions the score has been based on):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Endorsed by the railway stakeholders; strongly supported by the municipality which has an active local policy of traffic calming measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maturity scales with descriptions and examples (scoring 0–5)

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

**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</th>
<th>Evidence from pilot test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short-term</td>
<td>Long-term</td>
</tr>
<tr>
<td></td>
<td>Short-term</td>
<td>Long-term</td>
</tr>
</tbody>
</table>

**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?

<table>
<thead>
<tr>
<th>Answer modalities</th>
<th>Score</th>
<th>Reasoning behind the score / Assumption on the short and long-term change in road user behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td></td>
<td>Reasoning behind the score / Assumption on the short and long-term change in road user behaviour</td>
</tr>
<tr>
<td>0</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>The LC user’s visual or auditory perception can be impeded/distracted by this measure</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>This measure has no intended influence on the visual or auditory perception of the LC user</td>
<td></td>
</tr>
</tbody>
</table>

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Human Factors Assessment Tool: Improvement process during the SAFER-LC pilots

△ Applied and evaluated at various test sites

△ Adjusted according to the feedback from the pilot test leaders

△ Enhanced in deliverable D2.5

△ Will form part of the SAFER-LC toolbox
Human-centered low cost measures overview

The Task

▲ Design of hc-lc countermeasures
   ▲ Identify knowledge gaps, new approaches and out of the box ideas concerning LC safety and design
      ... and also existing concepts not implemented yet
   ▲ Conceive and choose promising countermeasures for evaluation (new ones and / or upgrades of existing measures)

▲ Evaluation of hc-lc countermeasures
   ▲ based on human factors criteria
   ▲ using multiple methods (e.g. Simulator tests, behavior studies in real traffic, user interviews)
Challenges with user behaviour

**Active LC with full barriers**
- Circumventing closed barriers (climbing over / below)
- Passing the LC after pre-signaling has begun / while barriers are closing
- Getting caught between the barriers
- Getting stuck on the rails

**Active LC with half-barriers / light protection**
- Circumventing closed half-barriers (swerving around, climbing over / below)
- Passing the LC in spite of active light signals (e.g. flashing red light)
- Passing the LC after pre-signaling has begun / while barriers are closing
- Getting stuck on the rails

**Passive LC**
- Insufficient visual scanning of tracks for train
- Insufficient adaption of approach speed to scanning needs

**Number of participants scanning the tracks for a train**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>to the left</td>
<td>8</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>to the right</td>
<td>22</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

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Working Approach

**Collection**
- Collection of proposed measures from research literature and evaluation results

**Model-based derivation**
Using insights into crucial aspects of user perception, attention, beliefs, motivation and behaviour

**Design Workshops**
Using specific design methods

**Selection**
- Criteria-based selection of measures for evaluation

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Expert Design Workshop Paris

▲ 38 road and rail systems experts
▲ 12 countries
▲ 2 groups per LC type
  ▲ full barrier
  ▲ half-barrier / light protection, passive)
▲ Using design-thinking methods

▲ 95 ideas for countermeasures
▲ Expert ratings for 110 countermeasures on effectiveness, low-cost and innovativeness
Measures to enhance LC safety

1. Enhance the visibility of the crossing

Perceiving the level crossing

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Measures to enhance LC safety

2. Enhance the visibility of the train

Perceiving the level crossing
Measures to enhance LC safety

3. Make road users look where they are supposed to look
Measures to enhance LC safety

1. Make LCs as self-explaining as possible.
2. Use signs and symbols that road users are familiar with.
3. Convey relevant messages via onboard systems.

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Measures to enhance LC safety

1. Create barriers
2. Violations should be difficult
3. Demotivate road users from breaking the law
Outlook: Pilots and evaluation

<table>
<thead>
<tr>
<th>SAFER-LC Testsites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simulation</strong></td>
</tr>
<tr>
<td>DLR - Simulators</td>
</tr>
<tr>
<td>RWTH – Aachen test site (mock-up LC + rail vehicle)</td>
</tr>
<tr>
<td>CEREMA Test Site Rouen for monitoring and remote maintenance</td>
</tr>
<tr>
<td>DLR – AIM Mobile Traffic Acquisition</td>
</tr>
<tr>
<td>TRAINOSE + CERTH – Thessaloniki Living Lab</td>
</tr>
<tr>
<td>INTADER level crossings</td>
</tr>
</tbody>
</table>

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Discussion

▲ Measure classification criteria: Does it offer the scope and level of detail needed for countermeasure keyword search?

▲ Is the Human Factors Assessment Tool useful for rail/road stakeholders in future safety evaluations?

▲ How many measures would you like to see in the SAFER-LC toolbox?
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