SAFER-LC

SAFER LEVEL CROSSING BY INTEGRATING AND OPTIMIZING ROAD-RAIL INFRASTRUCTURE MANAGEMENT AND DESIGN

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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Approach to Human Factors in SAFER-LC

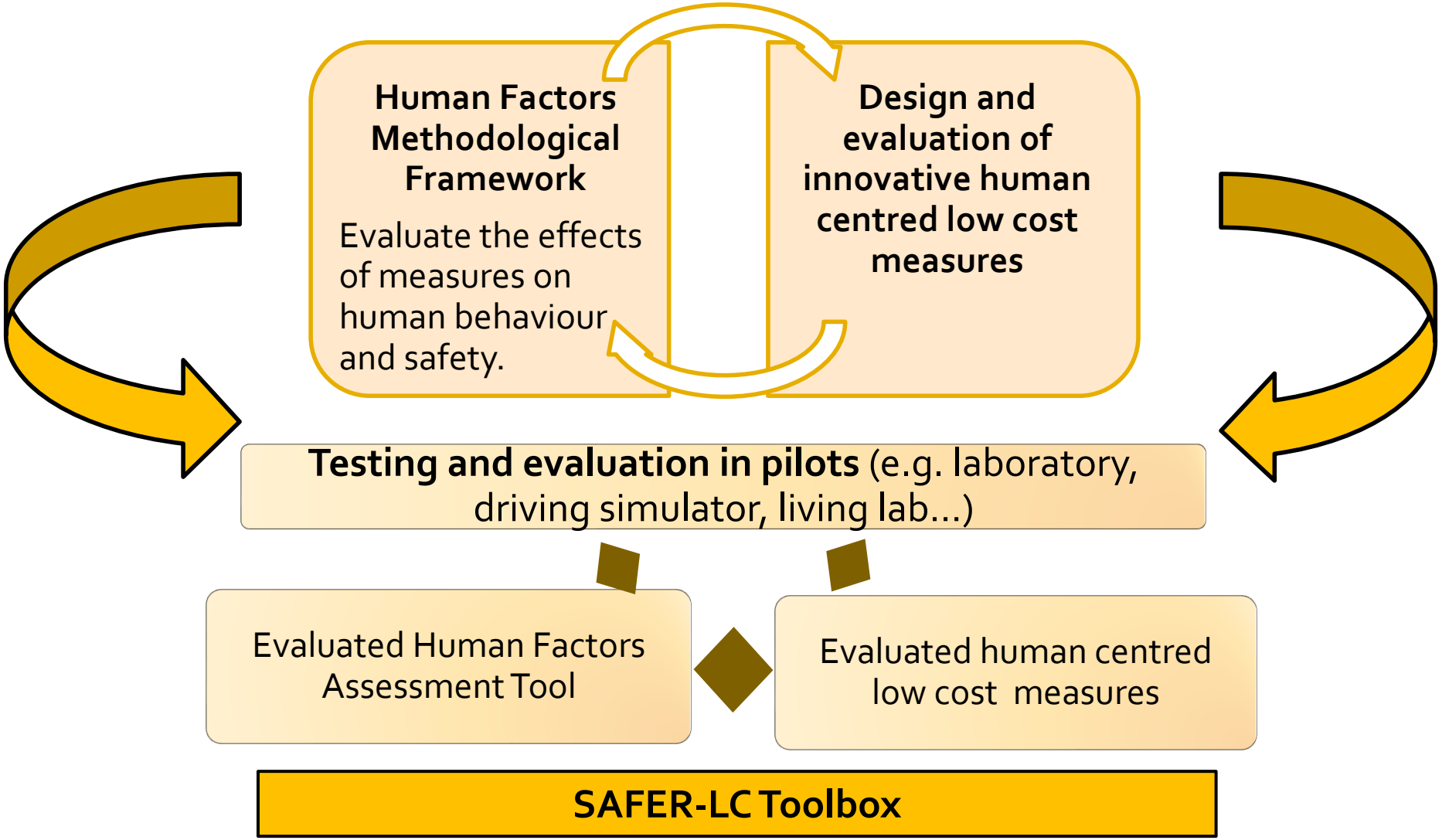
- A **dedicated human factors work package** which aims to enhance the safety performance of level crossing infrastructures from a human factors perspective, making them more **self-explaining and forgiving**, designed to take into account the needs of different road and rail users, and especially issues related to **vulnerable users**.

"Human factors 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."

(United Nations Economic Commission for Europe [UNECE] Group of Experts on Improving Safety at Level Crossings, 2017)

"…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 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 user
- Adaptation to individual characteristics and conditions of users
- Intended effect mechanism

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

Criteria to assess the behavioural safety effects

- Detectability and identification
- Rule knowledge
- Decision-making
- Behavioural execution

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

Criteria to assess the user experience and social perception

- Acceptance
- Reliability (Trust)
- Usability (Level of self-explaining nature)

HFAT – classification criteria checklist

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

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

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)

CLASSIFICATION CRITERIA		
Factor	**Brief description**	**Indicator** *(Tick all the cases that the measure applies to)*
Applicability to different LCs	*Specify the types and characteristics of LCs where the measure can be implemented*	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).....
Feasibility under different environmental conditions	*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*	Time of the day ☐ Daylight ☐ Darkness ☐ Dusk ☐ Dawn ☐ Peak traffic hours Weather conditions ☐ Rain ☐ Snowfall

HFAT – behavioural safety effects forms

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

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

Criteria to assess the behavioural safety effects

- Detectability and identification
- Rule knowledge
- Decision-making
- Behavioural execution

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Criteria to assess the user experience and social perception

- Acceptance
- Reliability (Trust)
- Usability (Level of self-explaining nature)

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)

Period	Evidence from literature		Evidence from pilot test	
	Short-term	Long-term	Short-term	Long-term
Before / Without the measure	N/A	N/A	Some drivers did not direct gaze towards LC warning signs	N/A
After / With the measure	N/A	N/A	Most drivers directed gaze towards LC warning signs	N/A

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	N	The LC user's visual or auditory perception can be impeded/distracted by this measure
	0	This measure has no intended influence on the visual or auditory perception of the LC user
	1	
	2	
	3	
	4	
	5	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)
Score	**2**	*Reasoning behind the score / Assumption on the short and long-term change in road user behaviour* 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

HFAT – User experience and social perception rating

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

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

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)

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

Factor	Definition	(0) Un-acceptable	(1)	(2)	(3)	(4)	(5) Excellent
Accep-tance	The estimated level of acceptance by the public (e.g. road users, people living near the LC)	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
		Reasoning behind the score (indicate the findings or assumptions the score has been based on):					
	The estimated level of acceptance by relevant stakeholders (e.g. the railway operator, rail infrastructure manager, train drivers, authorities or Government)	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
		Reasoning behind the score (indicate the findings or assumptions the score has been based on):					
		0	1	2	3	4	5

Design and evaluation of human-centered low-cost measures for LC safety (Task.2.3)

Design

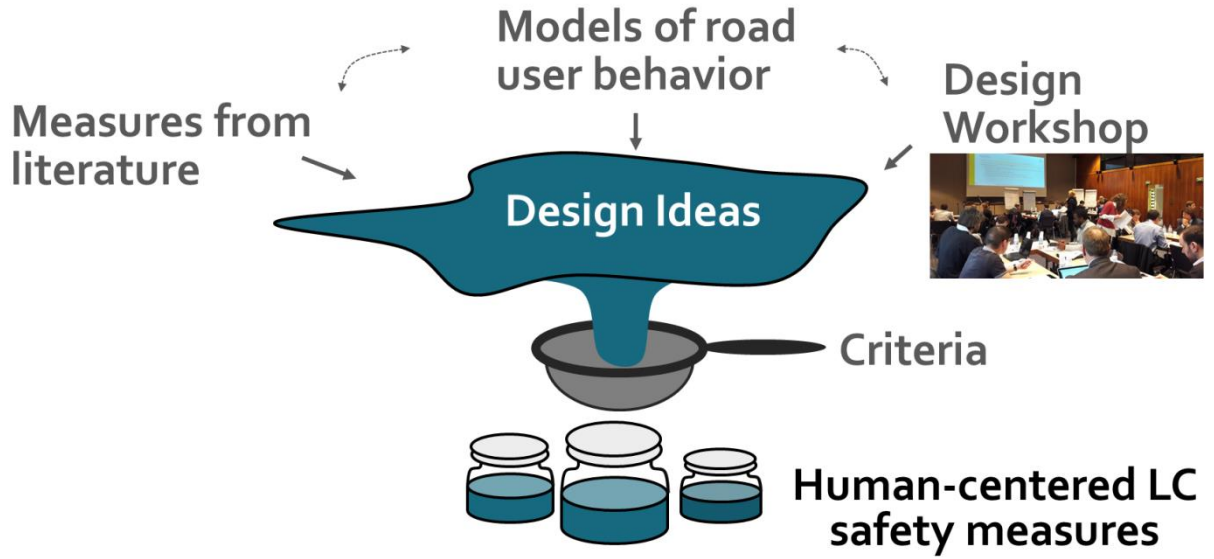
Collection

Selection

Evaluation

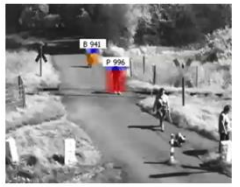
Pilot tests

Human Factors Assessment

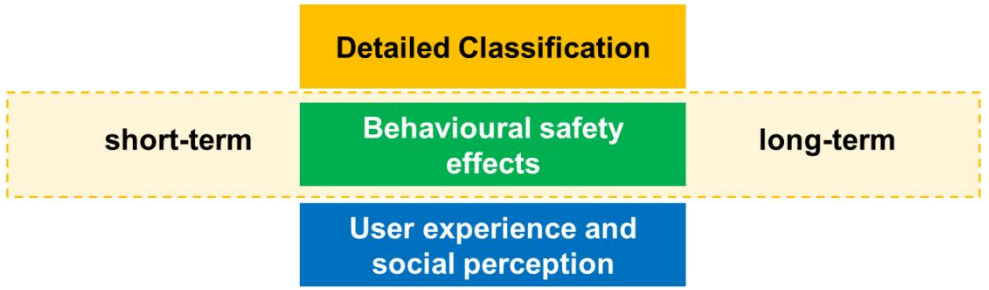


Simulation

Field

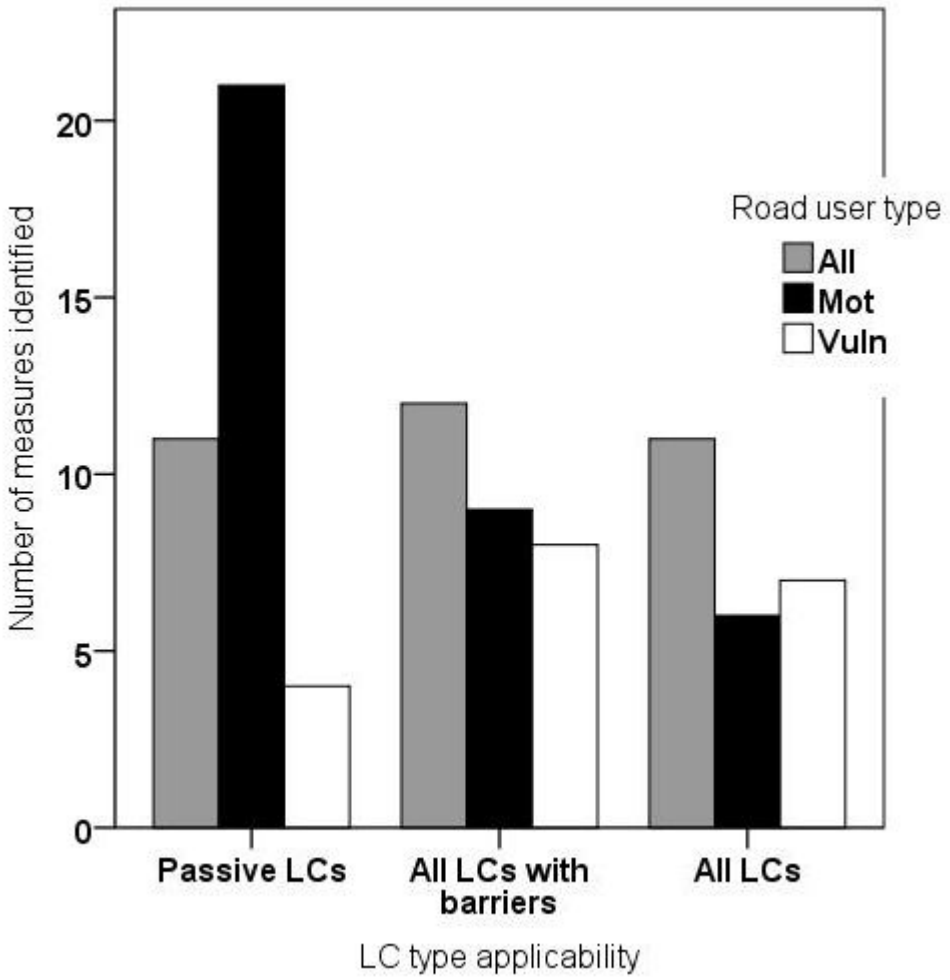


HFA Tool



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, …*



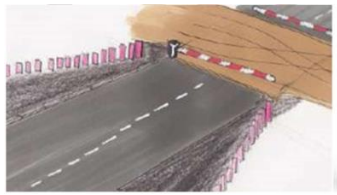
Key results – evaluation phase

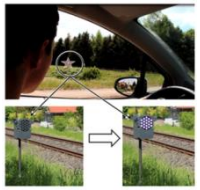
Human Factors Assessment of 13 measures:

For passive LCs

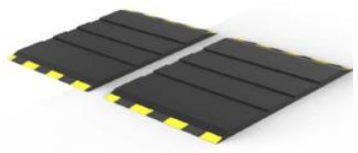
- *Blinking amber light with train symbol*
- *Funnel effect pylons*
- *Message "<- Is a train coming? ->" written on road*
- *Peripheral blinking lights*
- *Rumble strips*
- *Sign "<- Is a train coming? ->"*
- *Speed bump and flashing posts*











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)*

Key results – evaluation phase

Behavioral Safety Effects Assessment

Measure	Time-scale	Detection & Identification					Rule Knowledge					Decision-Making					Behavioral Execution				
		Score	Lit.		Pilot		Score	Lit.		Pilot		Score	Lit.		Pilot		Score	Lit.		Pilot	
			base	test	base	test		base	test	base	test		base	test	base	test		base	test	base	test
Blinking lights for locomotive front	Short	5	X	X	X	X	4	X	X		X	4	X	X	X	X	2		X	X	X
	Long																				
Coloured road markings on approach to LC	Short	3				X	3				X	NA					NA				
	Long																				
In-vehicle proximity warning (1)	Short	5				X	1				X	4				X	1				X
	Long				X					X					X					X	
In-vehicle proximity warning (2)	Short	5				X	4				X	NA					NA				
	Long																				
Rings upstream of the LC	Short	3				X	2				X	NA					NA				
	Long																				
Traffic light	Short	4				X	3				X	NA					NA				
	Long																				
Blinking amber light with train symbol	Short	3				X	3			X	X	2			X	X	1			X	X
	Long																				
Funnel effect pylons	Short	0				X	0				X	NA					NA				
	Long																				
Message "Is a train coming?" on road	Short	1				X	2			X	X	1			X	X	1			X	X
	Long																				
Peripheral blinking lights	Short	4	X	X	X	X	4	X	X		X	4	X		X	X	3	X	X		X
	Long																				
Rumble strips	Short	2	X	X	X	X	2	X	X		X	2	X	X	X	X	3	X	X	X	X
	Long		X	X										X							
Sign Look for train	Short	3		X	X	X	4		X		X	4		X	X	X	2		X	X	X
	Long																				
Speed bumps and flashing posts	Short	4				X	3				X	NA					NA				
	Long																				

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

Contacts

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Key results – evaluation phase

Acceptance Assessment

Measure	Scores and reasoning by sub category				
	Acceptance			Reliability	Usability
	Acceptance by public	Acceptance by stakeholders	Integration potential	User Trust	Level of self-explaining nature
Blinking lights for locomotive front	3	3	3	4	*4*
Coloured road markings	3,5	2	2	1	*1*
In-vehicle proximity warning (1)	4	5	4	4	*4*
In-vehicle proximity warning (2)	4	4	4	3	*3*
Rings upstream of the LC	4	1	1	2	*2*
Traffic lights	4	2	2	4	*4*
Blinking amber light with train symbol	4	4	4	3	*3*
Funnel effect pylons	0	0	0	0	*0*
Message "Is a train coming?" on road	4	4	4	4	*4*
Peripheral blinking lights	4	4	4	3	*4*
Rumble strips	3	4	4	4	*2*
Sign Look for train	4	4	4	4	*4*
Speed bumps and flashing posts	2,5	3	3	3	*3*