



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

# 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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# Contents

## **Human factors vision in SAFER-LC (FFE)**

- 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)**

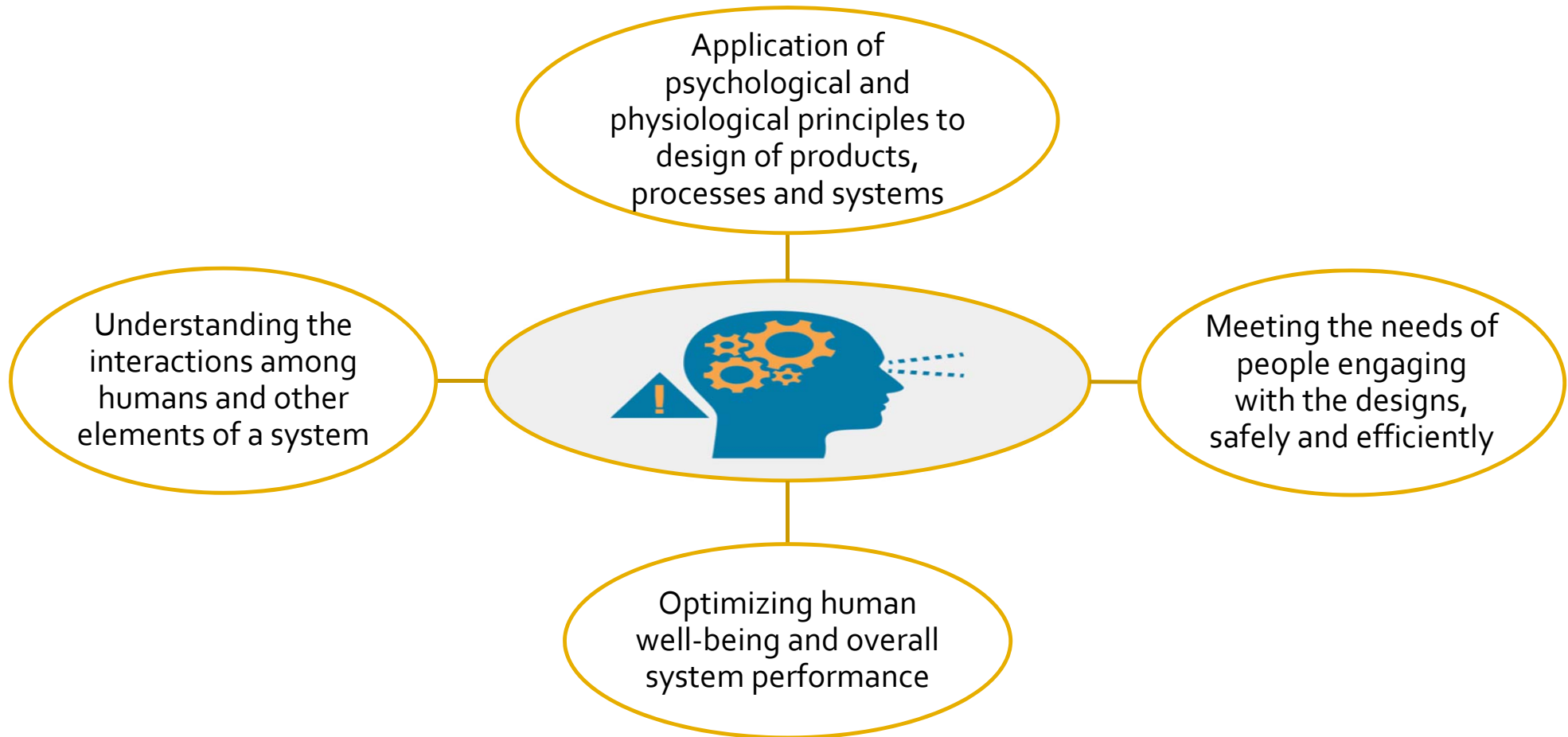




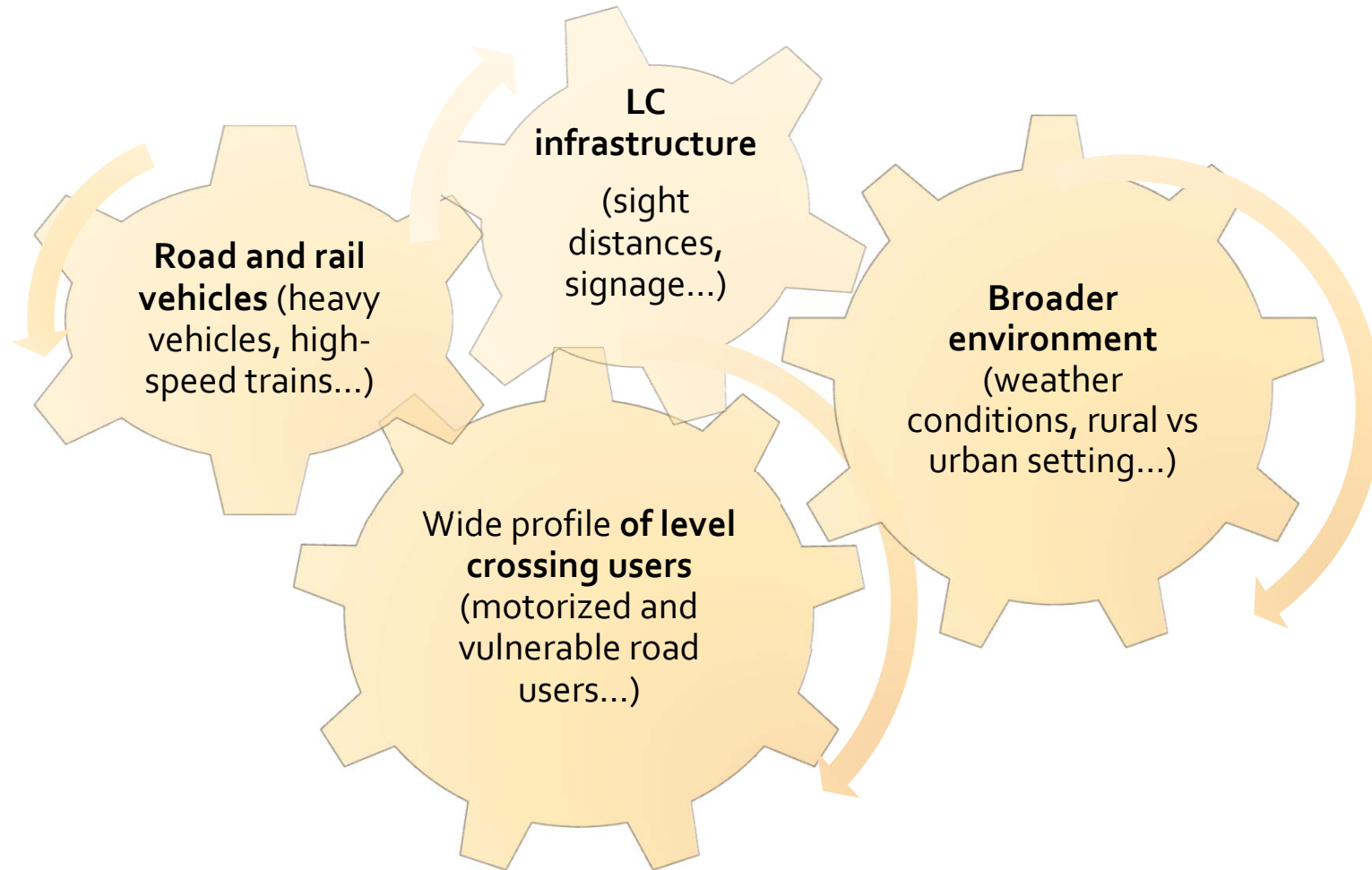
“Human factors must be identified as a major issue in improving level crossing safety. (...) Human factors which cause or contribute to accidents must be put at the heart of actions for improving safety at level crossings.”

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

# Human factors: key concepts



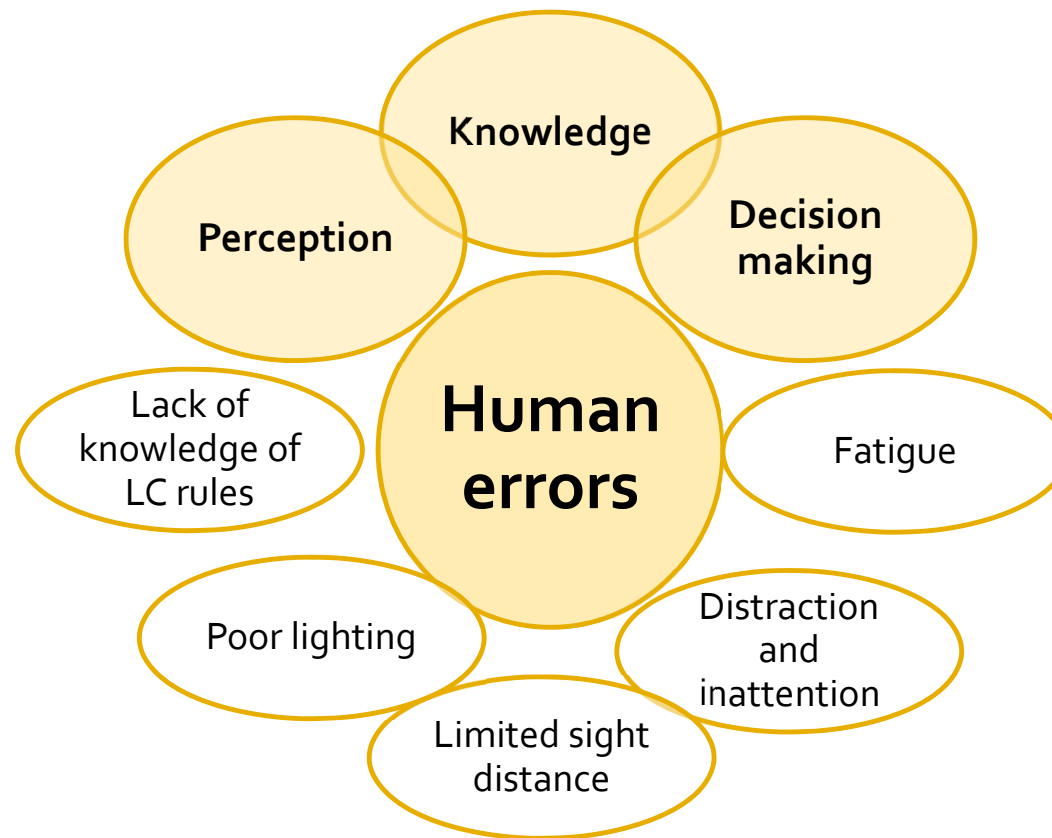
# Level crossings as a complex system



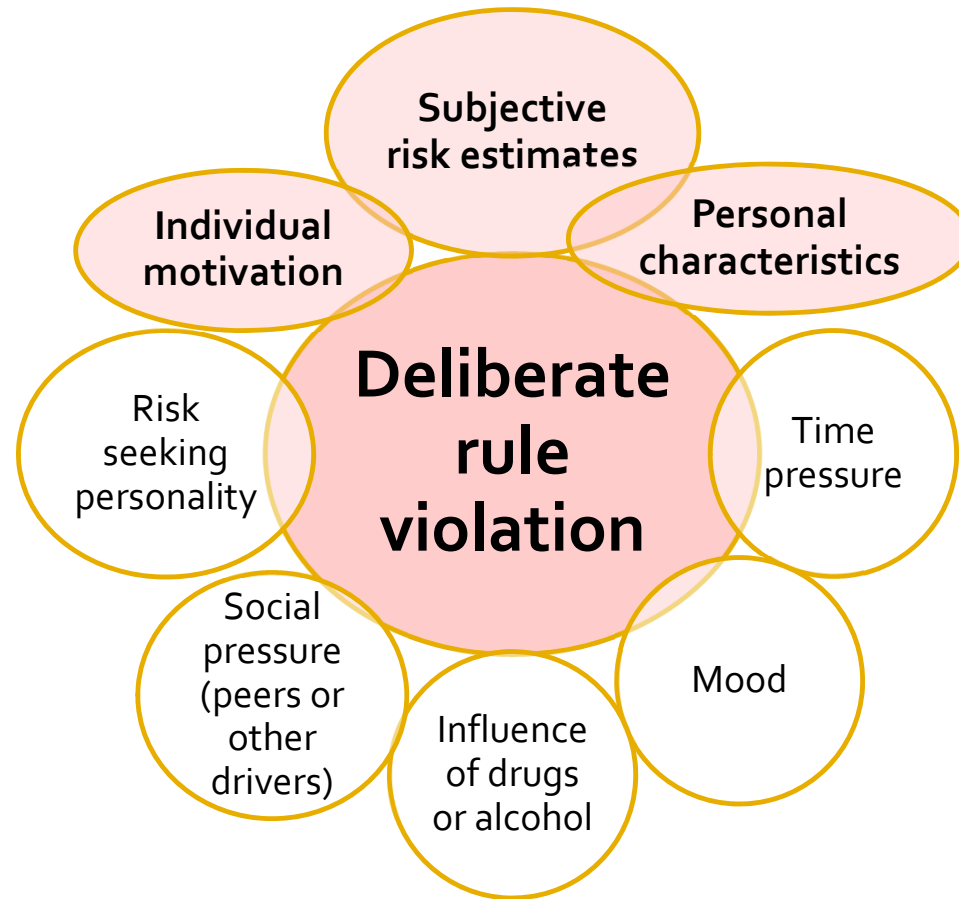
“...it is commonly asserted that a **significant majority of level-crossing accidents are caused by misuse of level crossings by road users.**” (European Union Agency for Railways, 2017)



# Human behaviour = unpredictable variable



# Human behaviour = unpredictable variable





“...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)

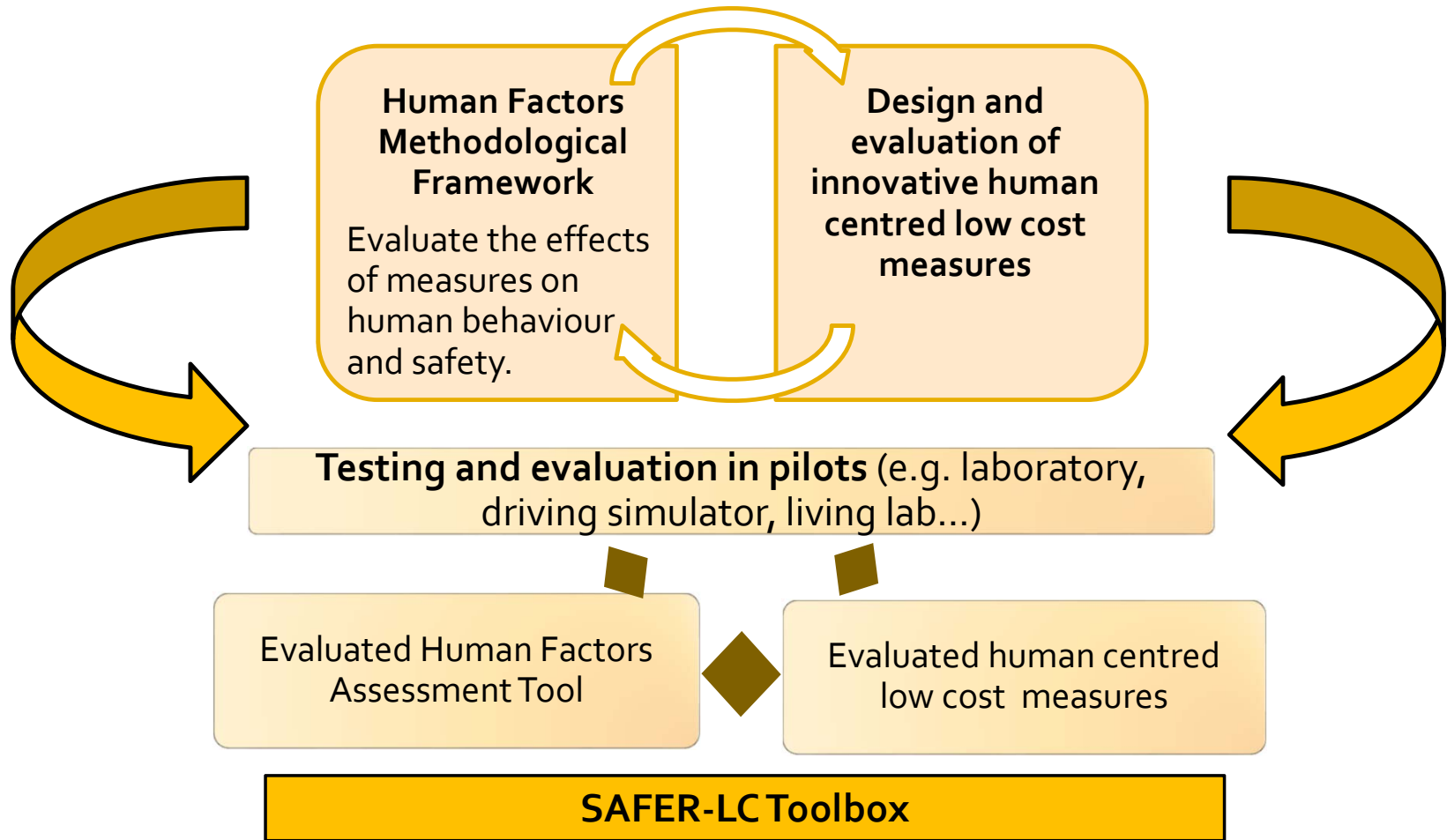


# Approach to Human Factors in SAFER-LC

- ▲ 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**.



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

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



**Table of content**

<b>1. Introduction</b> .....	<b>9</b>
1.1. Objectives of SAFER-LC project .....	9
1.2. General description of Task 2.2.....	9
1.3. Interactions with other tasks and evolution within the project.....	10
1.4. Purpose and structure of the document.....	12
<b>2. Theoretical background</b> .....	<b>13</b>
2.1. Sociotechnical Systems Theory.....	14
2.1.1. Focus on level crossing environments.....	14
2.1.2. Focus on vulnerable road users.....	17
2.1.3. Cognitive Work Analysis.....	18
2.2. Human cognition and behaviour theory.....	20
2.2.1. Errors and violations.....	20
2.2.2. Models of human information processing.....	23
2.2.3. Models of attention.....	25
2.2.4. Skill-related Human Factors models and hierarchical behavioural models.....	27
2.2.5. Risk theories and models of risky decision-making.....	31
2.2.6. Synthesis of the reviewed models and theories.....	33
2.3. Analytical tools and empirical approaches driven from related research projects.....	37
2.3.1. EU project RESTRAIL.....	37
2.3.2. Evaluation framework of Silla et al. (2015).....	39
2.3.3. Ex-ante assessment method of Kulmala (2010).....	39
2.3.4. Main inputs from related previous assessment studies.....	41
2.4. Key Safety Indicators identified in SAFER-LC Task 2.1.....	43
<b>3. Criteria selected for the Human Factors assessment tool</b> .....	<b>46</b>
3.1. Selected sets of criteria and the indicators behind them.....	46
3.2. Quantification of the sets of criteria.....	51
<b>4. The Human Factors assessment tool for testing</b> .....	<b>54</b>
<b>5. Application guide for testing</b> .....	<b>62</b>
5.1. Measurement scales and scoring system.....	62
5.2. Classification Criteria Checklist: Example applied to speed bumps.....	63
5.3. Assessment Sheets for behavioural safety effects: Example applied to speed bumps.....	64
5.1. Assessment Sheet for the user experience and social perception: Example applied to speed bumps.....	71
<b>6. Discussion and Conclusions</b> .....	<b>73</b>
6.1. Steps towards socio-economic assessment of safety measures.....	74
6.2. Future validation of the Human Factors framework.....	76
<b>7. References</b> .....	<b>77</b>
<b>Annex A: Human Factors Assessment Tool (version to print for pilot tests)</b> .....	<b>83</b>

Deliverable D2.2 – Human Factor methodological framework and application guide for testing Page 6 of 90  
(interim report) – 24/07/2018

▲ Deliverable D2.2

▲ Download:

[http://safer-lc.eu/IMG/pdf/saferlc\\_20180724\\_d22\\_vo4\\_uic\\_hf\\_methodological\\_framework.pdf](http://safer-lc.eu/IMG/pdf/saferlc_20180724_d22_vo4_uic_hf_methodological_framework.pdf)

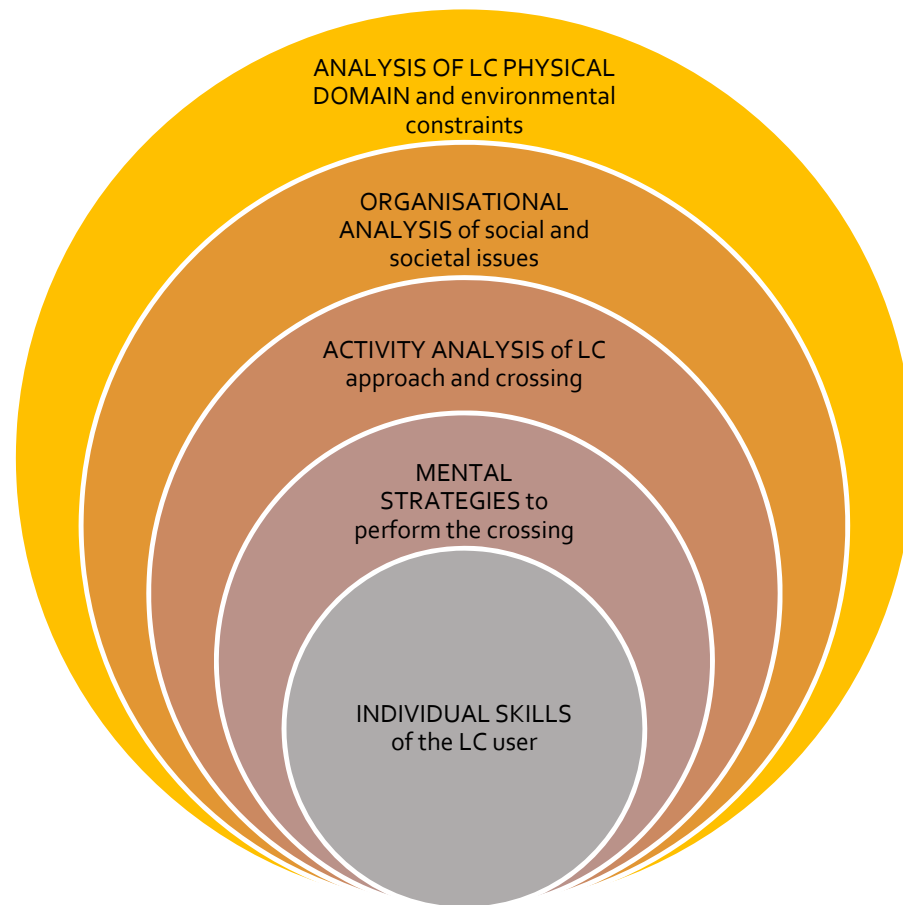
▲ Chapters 2-3: Theory



▲ Chapters 4-5: Application



# 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

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

## Criteria to assess the behavioural safety effects

- Detectability
- 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)

# 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

Factor	Brief description
Applicability to different LCs	Specify the types and characteristics of LCs where the measure can be implemented
Feasibility under different environmental conditions	



## 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).....

### Time of the day

- Daylight
- Darkness
- Dusk
- 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							
Factor	Definition	(0) Un-acceptable	(1)	(2)	(3)	(4)	(5) Excellent
Acceptance	The estimated level acceptance by the public (e.g. road users, people living near the LC)	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input checked="" type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>
	Reasoning behind the score (indicate the findings or assumptions the score has been based on):  <u>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</u>						
Acceptance	The estimated level acceptance by relevant stakeholders (e.g. the railway operator, railway infrastructure manager, train drivers, authority or Government)	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input checked="" type="checkbox"/>	5 <input type="checkbox"/>
	Reasoning behind the score (indicate the findings or assumptions the score has been based on):  <u>Endorsed by the railway stakeholders; strongly supported by the municipality which has an active local policy of traffic calming measures</u>						

# Maturity scales with descriptions and examples (scoring 0–5)



## Criteria to assess the behavioural safety effects

- Detectability
- Identification
- Rule knowledge
- Decision-making
- Behavioural execution



Criterion	Brief description
Detectability	The measure can help the LC user detect relevant visual and auditory stimuli, therefore increasing the detectability of the LC or the approaching train

*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

*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	
Score	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)
	2	<i>Reasoning behind the score / Assumption on the short and long-term change in road user behaviour</i> <u>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</u>

## 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

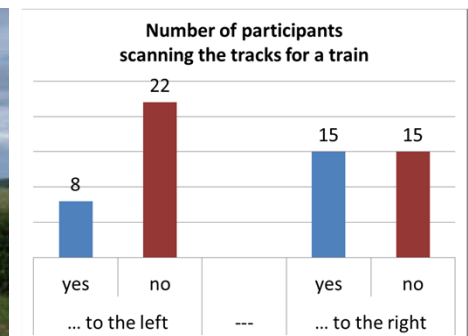


## Active LC with half-barriers / light protection

- ▲ 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

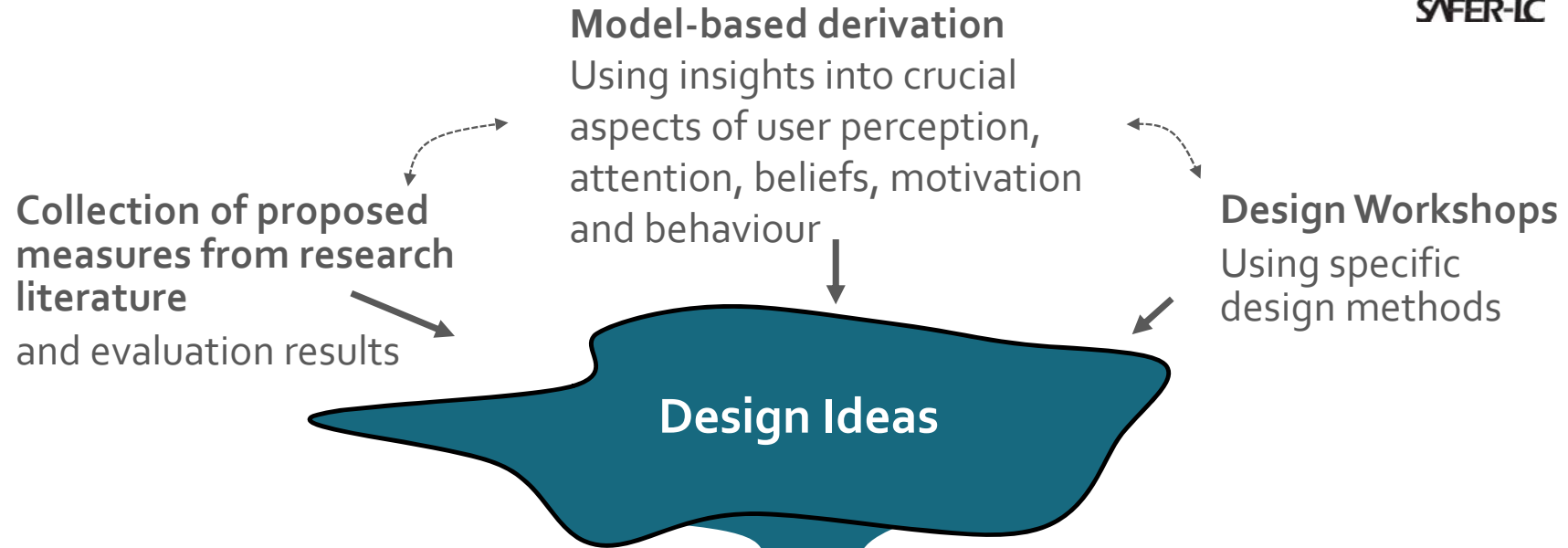
- ▲ Insufficient visual scanning of tracks for train
- ▲ Insufficient adaption of approach speed to scanning needs



# Working Approach



## Collection



## Selection

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



# 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



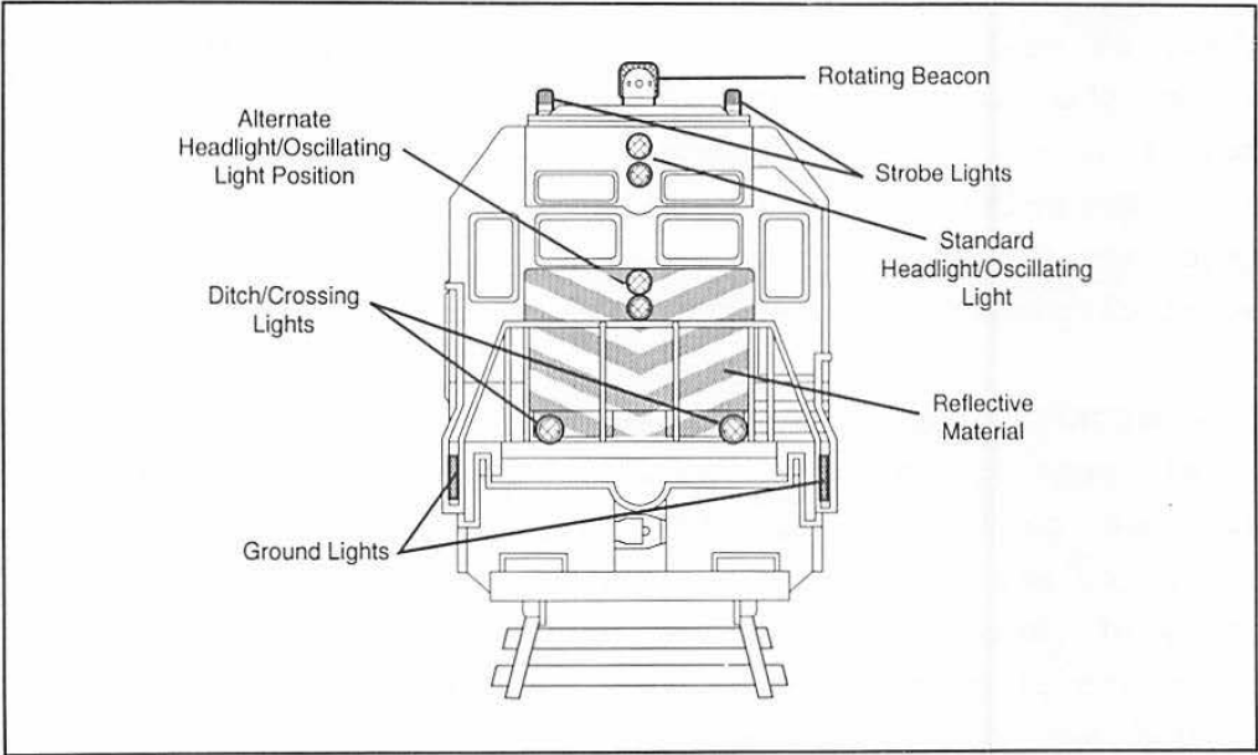
Perceiving the level crossing 

1. Enhance the visibility of the crossing



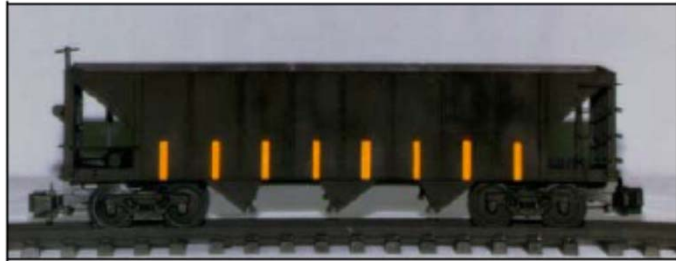


# Measures to enhance LC safety



Perceiving the level crossing 

## 2. Enhance the visibility of the train

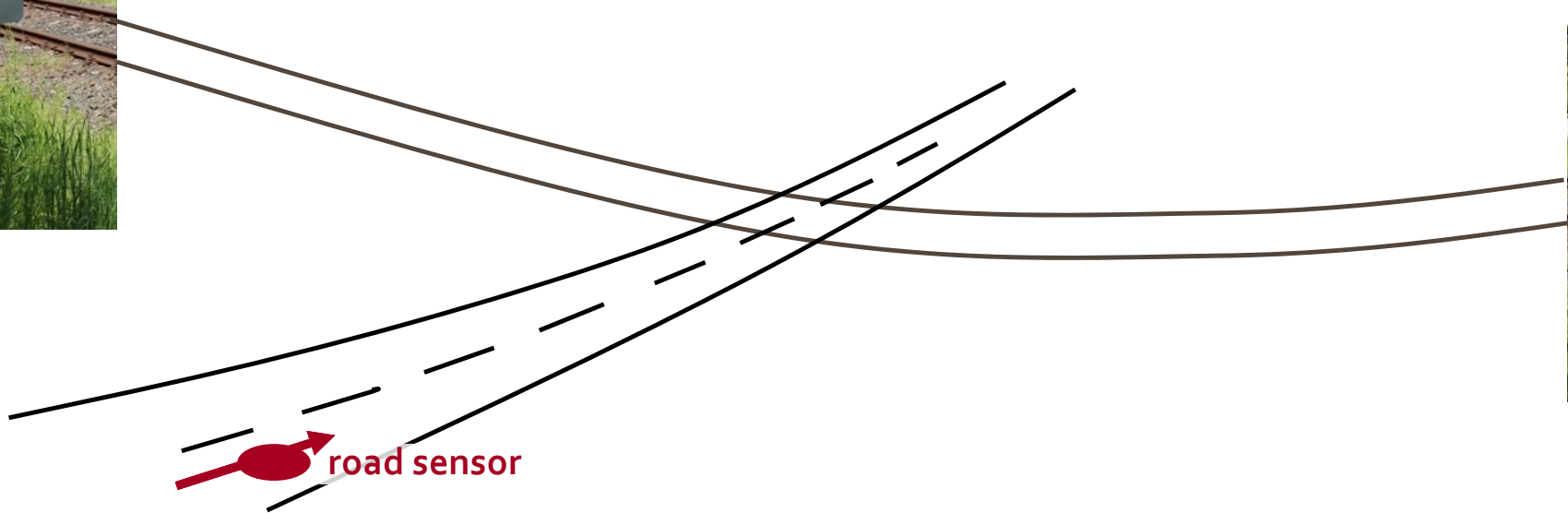


# Measures to enhance LC safety



Perceiving the level crossing 

3. Make road users look where they are supposed to look



# Measures to enhance LC safety



Retrieving relevant knowledge from long-term memory



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.



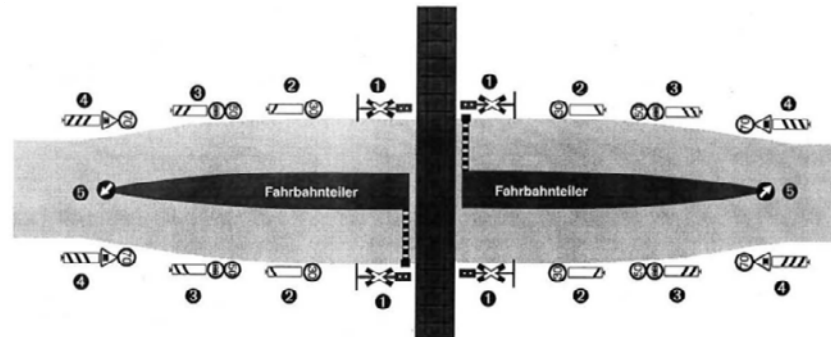
# Measures to enhance LC safety



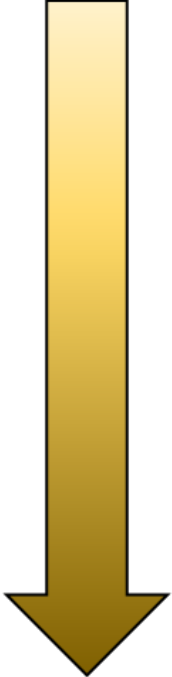
Choosing and executing appropriate actions











1. Create barriers
2. Violations should be difficult
3. Demotivate road users from breaking the law



# Outlook: Pilots and evaluation

	SAFER-LC Testsites
<p><b>Simulation</b></p>  <p><b>Real World</b></p>	<b>DLR - Simulators</b>
	<b>RWTH – Aachen test site (mock-up LC + rail vehicle)</b>
	<b>CEREMA Test Site Rouen for monitoring and remote maintenance</b>
	<b>DLR – AIM Mobile Traffic Acquisition</b>
	<b>TRAINOSE + CERTH – Thessaloniki Living Lab</b>
	<b>INTADER level crossings</b>

# 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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