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Deliverable D5.4

Recommendations for National Policy and regulations regarding the LC from the infrastructure point of view

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Consortium - List of partners

Partner No	Short name	Name	Country
1	UIC	International Union of Railways	France
2	VTT	Teknologian tutkimuskeskus VTT Oy	Finland
3	NTNU	Norwegian University of Science and Technology	Norway
4	IFSTTAR	French institute of science and technology for transport, development and networks	France
5	FFE	Fundación Ferrocarriles Españoles	Spain
6	CERTH-HIT	Centre for Research and Technology Hellas - Hellenic Institute of Transport	Greece
7	TRAINOSE	Trainose Transport – Passenger and Freight Transportation Services SA	Greece
8	INTADER	Intermodal Transportation and Logistics Research Association	Turkey
9	CEREMA	Centre for Studies and Expertise on Risks, Environment, Mobility, and Urban and Country planning	France
10	GLS	NeoGLS	France
11	RWTH	Rheinisch-Westfaelische Technische Hochschule Aachen University	Germany
12	UNIROMA3	University of Roma Tre	Italy
13	COMM	Commsignia Ltd	Hungary
14	IRU	International Road Transport Union - Projects ASBL	Belgium
15	SNCF	SNCF	France
16	DLR	German Aerospace Center	Germany
17	UTBM	University of Technology of Belfort-Montbéliard	France

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1. INTRODUCTION

1.1. Objectives of SAFER-LC project

The main objective of the SAFER-LC project is to improve safety and minimise risks at and around level crossings (LCs) by developing a fully integrated cross-modal set of innovative solutions and tools for the proactive management and new design of level-crossing infrastructure. These tools will enable

i. Road and rail decision makers to achieve better coherence between both modes
ii. Effective ways to detect dangerous situations potentially leading to collisions at LCs as early as possible,
iii. Prevent incidents at level crossing through innovative design and predictive maintenance methods, and
iv. Mitigate the consequences of incidents/disruptions due to accidents or other critical events.

The main output of the SAFER-LC project is a toolbox be accessible through a user-friendly interface. The toolbox integrates all the project results and solutions to help both rail and road stakeholders to improve safety at level crossings.

1.2. Purpose of this deliverable

This deliverable is a guidance document summarising the main infrastructure-related national policy recommendations for LCs that were collected and produced during the SAFER-LC project.

This guidance document presents a synthesis of recommendations on technical specifications and human processes, as well as on organisational and legal frameworks when implementing safety measures at level crossings. This is to meet the requirements of the latest cooperative standards.

This policy-related deliverable is based on prior work conducted by the SAFER-LC consortium mainly in work package 1 (LCs in Europe and beyond: Rail and road safety management requirements) and more recently in work package 5 as part of Task 5.3 (Recommendations and guidelines).

There are three parts to the deliverable:

- The first part of the document provides an overview on level crossing safety in Europe with a focus on the legal, organisational and technical framework as well as main priorities to be addressed.
- The second part of the document focuses on the main challenges for national policy in various EU Member States.
- The third part provides a set of policy options and recommendations for national safety policies identified within the project.

1.3. Abbreviations and terms

Abbreviation	Description
CPS	Collective Perception Service
CSMs	Common safety methods
CSTs	Common safety targets
EN	European standard (Maintained by CEN (European Committee for Standardization)
ETSI	European Telecommunications Standards Institute
ERA	European Union Agency for Railways
EU	European Union
G5	Frequency band (5.9GHz)
GNSS	Global Navigation Satellite System
IEC	International electrotechnical commission
IRU	World's road transport organisation
LC/LCs	Level Crossing / Level Crossings
LTE	Long Term Evolution
PO	Policy Option
SDOs	Standards developing organisations
SDS	Smart Detection System
SIL	Safety Integrity Level
UIC	International Union of Railways
UNECE	United Nations Economic Commission for Europe
VACC	Instrumented vehicle ("Véhicule d'Analyse du Comportement des Conducteurs")
VRU	Vulnerable road user
WP	Work Package

2. LEVEL CROSSING SAFETY IN EUROPE

2.1. Key accident figures

In 2017, there were 108,385 level crossings in the 28 EU Member States (European Union Agency for Railways, 2020). According to the situation in 2014, there were five level crossings per 10 line-km in the EU on average.

In 2017, a total of 466 level crossing accidents occurred in the EU Member States resulting in 298 fatalities and 218 seriously injured persons (European Union Agency for Railways, 2020). Fatalities and serious injuries occurring in level crossing accidents form an important proportion of the total number of victims in accidents occurring on railways (close to 31%, suicides excluded). However, the share of level crossing accidents from all road accidents is only 1% (European Union Agency for Railways, 2018).

2.2. Legal framework

On an international level, a common framework exists in the form of non-mandatory treaties and recommended guidelines produced by international organisations and policy-making bodies such as the United Nations Economic Commission for Europe (UNECE), International Union of Railways (UIC) and the International Road Union (IRU).

On a national level, each country follows a national mandatory legal framework and has its own policy options for LC safety. Based on the results of Task 1.1 (Analysis of level crossing safety in Europe and beyond), the most important safety policy regarding LC safety is the removal of level crossings, followed by the improvement of protective measures at existing level crossings (SAFER-LC consortium, 2017a).

Overall, there is a great level of adherence to the Vienna Conventions on Road Traffic and Road Signs and Signals rather than to UIC leaflets (75% vs. less than 20%). Given the nature of the Vienna Conventions, this indicates a greater level of harmonization with roadside rules than those applied specifically to the operation and management of level crossings.

In some countries, there are specific level crossing safety policies: level crossing removal policy (92% of countries, n=22); level crossing protection policy (67% of countries, n=16); organisational and strategic development policy (30% of countries, n=8); and education and enforcement policy (25% of countries, n=5).

In all countries, responsibility for level crossing safety legislation falls on ministries or government departments responsible for transport, encompassing both road and rail and in many cases also infrastructure.

Concerning level crossing protection decision-making bodies, the responsibility for deciding the form of level crossing protection is generally up to railway infrastructure managers (just over a third of countries) (n=9). Among the remaining countries, the responsibility is distributed between the responsible government ministry (all-encompassing transport) (n=5); decision shared between different agencies (n=5); or is reported to be based on regulation (n=5).

2.3. Organisational framework

Another important policy concerns organisational and strategic development. Organisational recommendations mostly concern international cooperation and strategic partnerships, the design of LC safety, the safe operation of LCs, enforcement, the existence of dedicated government or independent LC safety body and the safety arrangements attached to LCs.

An additional general policy concerns education, generally in the form of campaigns to raise public awareness around safety at level crossings, although such were indicated to already be present in a small number of countries. Increasing public awareness can be achieved through publicity campaigns that encourage changes in attitudes and behaviour and reinforce the need to act. The combination of other countermeasures, particularly enforcement, with communications can yield changes in attitudes towards safety risk over the longer term.

2.4. Technical framework

The railway industry respects national legislation. The technical equipment provided to the railways by the industry such as

- On-board components and sub-assemblies, electrical and electronic systems and equipment, cables.
- Signaling and telecommunication devices.
- Fixed installations.

must comply with SIL (Safety Integrity Level) based on the standard IEC / EN 61508).

Moreover, UIC leaflets give recommendations to UIC members:

- UIC 760: Level crossings: Road signs and signals https://www.shop-etf.com/en/level-crossings-road-signs-and-signals-2311
- UIC 761: Guidance on the automatic operation of level crossings https://www.shop-etf.com/en/guidance-on-the-automatic-operation-of-level-crossings-2317
- UIC 762: Safety measures to be taken at level crossings on lines operated from 120 to 200 km/h https://www.shop-etf.com/en/safety-measures-to-be-taken-at-level-crossings-on-lines-operated-from-120-to-200-km-h-2323

2.5. Main risks at level crossings and priorities

The main risks to level crossings were identified during WP1 with the help of results from the first SAFER-LC workshop, the main findings of tasks 1.1 and 1.2 as well as the results from the past SafeRail project (satellite-based train positioning system: https://business.esa.int/projects/saferail).

Some priorities identified in WP1 are listed below (SAFER-LC consortium, 2018a):

Priorities regarding **human factors and road user behaviour**:

- Attention:
  - Inattentiveness of the road users: Pedestrians/cyclists with headphones or using smartphones, road drivers using smartphones or GPS
  - Failure to observe road signage and rail tracks by road users or pedestrians
- Rule knowledge and understanding: Special focus on the lack of signage or too much signage at LCs and the special needs of impaired people.
- Behaviour: Special focus on excessive speed of road users and deliberate violations at active LCs

Priorities regarding **LC environment design**:

- Design of the LC: Curves before and after the LC, bumps, slopes and high declivity should be avoided: difficult especially for buses and trucks
- Location of the LC: For example, a location too close to a road crossing or at proximity to commercial centres could generate long waiting queue at the LC (and could also cause a so-called blocking back effect)
- Protection of the LC based on a risk evaluation
- Easy access through and around LCs or under the barriers for pedestrians/cyclists

Priorities regarding **railway operations**:

- Vehicle stuck on the level crossing
- Long-time of LC closure
- Failure on rail devices: detection of train, LC control system, etc.

3. CHALLENGES FOR NATIONAL POLICY

Policymakers put great emphasis on informed decision making to ensure that the policies decided upon are backed up by accident data and relevant research findings. While there are hundreds of relevant studies on safety at LCs, there is still a gap between the huge volumes of scientific knowledge on LC safety in Europe and their availability to policymakers. This is also because the studies and operational lessons learned are dispersed across different countries without clear connections between them and without clear transfers of information between relevant sectors (e.g. road and rail, national and local authorities).

The seriousness of the LC issue and associated risks may be compelling, but this does not mean that measures to improve safety at LCs will necessarily be welcomed with open arms. It is not enough to have a well-researched strategy; governments also need to communicate it effectively. Stakeholders should be consulted, including road and rail infrastructure managers, the rail operators, municipalities, the police, the health and education sectors, the insurance industry, and even road users in general. Unfortunately, a main problem observed during the SAFER-LC project is that many railway stakeholders are still think or act in silos and find it difficult to exchange and cooperate with the other key stakeholders.

The main challenges for policy makers identified within the project are presented below (SAFER-LC consortium, 2017a; 2018a). Under each challenge, proposals to overcome them and hence improve level crossing safety are presented:

1. **Strengthen cross-agency work**
   - Work towards creating a shared vision and commitment to level crossing safety between road, rail, local authorities and individual level crossing users based on the identification of common priorities.
   - Approaches could be both top-down (from the authorities towards the users) and bottom-up (from the users towards authorities).

2. **Secure political interest to address investment and long-term support of LC safety programmes**
   - Identify and draw on successful experiences of gaining political commitment to LC safety;
   - Highlight problems to be addressed using critical safety statistics and data.

3. **Define a holistic approach for the risk assessment involving stakeholders from Rail, Road, environment, and authorities responsible for urban planning**
   - Harmonised rail and road data on LC accidents at national and international level
   - Increase cooperation between the organisations conducting in-depth LC accident investigations.
   - Improve risk assessment process for all level crossings involving experts from main stakeholders (Road/rail, private /public).

4. **Address cost and complexity of LC safety improvements, accounting for multiple factors (economic, operational, political, human factors)**
   - Apply data fed risk management models to inform decision-makers regarding safety at specific level crossings
   - Use a hotspot-based approach

5. **Address technical limitations of LC protection, including high costs and complexity of installation and maintenance**
   - Identify examples of low-cost and low-impact safety solutions that have been successfully implemented
   - Pilot human-centred low-cost safety solutions to test new ideas and prototypes

6. **Account for human factors at level crossings to address public acceptance of LC safety measures; LC misuse; design of forgiving infrastructures**
   - Research into human factors at LC;
   - Identify examples of successful community involvement in similar initiatives.

In addition to the points above, some further challenges have been identified alongside the implementation of the SAFER-LC project:

- Governments should implement road safety improvements that consider and aim to reduce risks at LCs. Policy makers must understand and accept that LC accidents occur frequently and their prevention is important even though this is not highlighted by the road safety statistics (only 1% of all road accidents). Therefore, when implemented, road safety policies should also consider LC safety aspects and not focus only on the mainstream problems of road safety (e.g. speeding, drunk driving, etc.).

- Measures related to enforcement (by police, railway staff etc.) are likely to be unpopular with some road users (at LCs or outside them), although an effective communications strategy on the benefits of these actions may reveal substantial support among society in general.

- The large-scale implementation of technological solutions is a very challenging and long-term issue, since their implementation involves research and development activities. Additionally, technological solutions can be costly when implemented at a high number of LCs. While the safety potential of these technological solutions is high, the actual gains from the implementation of new technologies are unknown. For example, these technologies may require some installations in road vehicles that can be expensive and hence could result in resistance from drivers and vehicle manufacturers.

4. POLICY OPTIONS AND RECOMMENDATIONS

4.1. Policy options for safer level crossings

The most important level crossing safety policy across all responding countries is the removal or reduction of LCs (SAFER-LC consortium, 2017a). Table 1 lists the specific policies (PO) related to this action.

Table 1: List of policies related to LC removal or reduction.

PO No	Policy
PO 1	Long term target of zero LCs
PO 2	Encourage closing of crossing by assessment of risk reduction benefit in agreement between the rail and road IMs
PO 3	Contribute towards LC removal/ reduction policy or replacement of LCs with grade separated crossings
PO 4	No LC authorized on sections where the train travels at or above a certain speed (The maximum speed varies from 120 to 160 km/h)

The second most common safety policy is the **improvement of the protection of existing LCs**. The indicated policies related to LC protection are listed in Table 2.

Table 2: List of policies related to LC protection.

PO No	Policy
PO 5	Improvement of the protection of existing LCs, focusing on installing active protection measures at passive LCs.
PO 6	Development of existing protection systems to be more cost-effective and energy efficient.
PO 7	Adoption of a safe systems approach with a focus on forgiving infrastructure rather than a focus on user behaviour and correct usage. For example: • Development of specific protections measures for VRU (pedestrians and cyclists) • Adoption of an information system to assist users in case they become trapped between the barriers.

One third of the countries have a policy to improve LC safety with the help of various **organisational and strategic development** strategies. The indicated policies related to organisational strategic development are listed in **Erreur ! Référence non valide pour un signet.**.

Table 3: Indicated policies related to organisational strategic development.

PO No	Policy
PO 8	Develop evaluation and risk management activities, LC safety strategy and action plans.
PO 9	Promote cross sector working to tackle safety at LCs.

PO 10	Development of common safety targets ('CSTs') and common safety methods ('CSMs') with a view to gradually removing the need for national rules.
PO 11	Systematic LC monitoring: level crossing safety database and inventory; dedicated level crossing e-mail inbox managed by a group of experts; open weekly meetings to discuss level crossing issues with regional stakeholders; integrated and systematic approach to addressing level crossing safety and budget decisions, taking into consideration different factors: infrastructure and operation, legislation, human behaviour.
PO 12	Targeting accident reduction, particularly in identified accident hotspots.
PO 13	Strategy or long-term action plan, and operational planning both on the rail and roadside, setting out the priorities for LC safety.

Just over one fifth of the countries have a policy to **raise public awareness on safety at LCs**. The specific policies related to education and enforcement are listed in Table 4.

Table 4: List of policies related to education and enforcement.

PO No	Policy
PO 14	Raise public awareness around safety at LCs. This takes the form of inclusion within road traffic safety campaigns; public awareness and educational outreach activities through internet and/or paper-based publications (flyers, booklets…) to promote awareness of rules and risks.
PO 15	Increased education and enforcement (Speed limit, other violations, sanctions but also re-education courses)

The indicated policies related to **legal responsibility for LCs across administrative** areas are listed in Table 5.

Table 5: List of policies related to legal responsibilities for LCs across administrative areas.

PO No	Policy
PO 16	Balance the interests of the different parties involved (road, rail, private and public authorities, individual users).
PO 17	Consider the impact of local circumstances that affect the use of the crossing.
PO 18	Consider the number and range of crossing types (including number of user operated crossings), density and length of the national railway network, which are all factors that raise safety concerns and call for an adequate response.

4.2. Organisational Recommendations

This section summarises the organisational aspects related to improving LC safety in terms of roles and responsibilities for the design, operation, and management of LCs and rule enforcement. The analysis included the involved stakeholders and the scope of their responsibilities in addition to the existence of cross agency working and whether there is an independent or specific government body dedicated to promoting safety at LCs. The identified recommendations or policy options for organisational issues are presented in Table 6.

Table 6: List of policy options for organisational issues by topic.

Topic	PO No	Policy
Design of LC safety	PO 19	Rail infrastructure managers hold the greatest responsibility for LC safety design, with sole responsibility or shared responsibility with the road administrator.
	PO 20	Roadside LC elements fall within the domain of the road administrator (particularly the design of road signs), whilst the elements making up the LC itself is the responsibility of the rail administrator.
Safe operation of LCs	PO 21	Various stakeholders are responsible for the management of LC safety, principally the rail infrastructure manager but also the road infrastructure manager, rail operator, police, responsible ministry and national safety agency.
Enforcement of safety at LCs	PO 22	Enforcement of safety is principally performed through the supervision of rail infrastructure activities (by national safety authorities or similar) and the enforcement of roadside user rules (by the police).
Existence of dedicated government or independent LC safety body	PO 23	Encourage the promotion of LC safety by a government body or dedicated independent organisation. In most cases in takes the form of existing government or non-government entities that carry out functions or activities as part of wider road safety or railway safety work.
Safety arrangements attached to LCs	PO 24	Multi-stakeholder working groups with different stakeholders (road and traffic authorities; train and freight operators; local government authorities; police authorities; local safety agencies) to select new measures to improve LC safety.
	PO 25	Use of public education campaigns focused on users of passive LCs.
LC inspections	PO 26	Analyse and diagnose regularly the safety situation at level crossing by different experts (from infrastructure manager, local government authorities and road owner as well as the National Safety Authority)

4.3. Technical Recommendations

The technical recommendations issued by SAFER-LC project mainly relate to the technical solutions developed within the project. **Erreur ! Source du renvoi introuvable.** summarises all standards, realised tests and recommendations in SAFER- LC context (SAFER-LC consortium, 2020a).

Table 7 : List of standards, realised tests and recommendations.

Standards	In SAFER-LC context	Result of tests	Recommendations
LTE & GNSS	Offered as a mobile application. Provides auditory and visual LC proximity warnings to road users' mobile devices (e.g. smartphone or tablet). The estimated time of train arrival is included in the visual warning whenever an incoming train is expected to reach the LC within the next minute. The system was tested in Thessaloniki by more than 600 taxis in road segments located in urban environments with speed limited to 50 km/h or less.	This solution is robust to reasonable positioning inaccuracies and errors of up to a few meters both for the train and road vehicle. The accuracy of GNSS receivers embedded in common tablets is sufficient for the proper operation of this system. The system uses widespread, general purpose devices and technology. It is not fail-safe and warnings are not guaranteed to appear (for instance the users' device might crash or not operate as expected due to other applications or unexpected circumstances). The safety measure could either be considered supplementary to existing ones, or dedicated hardware should be used to ensure it is fail-safe.	It is necessary to investigate and validate that cellular communication is available in the area around the LC. The areas around LCs in which the warnings are triggered should be designed in a case by case approach, in order to consider safe breaking distance and local speed limits (even in events of short delays caused e.g. by slow processing speed of the mobile device) and minimize the frequency of false positive LC detections. To increase the positioning accuracy, it is possible to combine GNSS with other positioning solutions, for instance odometry.
ITS-G5 (IEEE- 802-11 p)	Tested in Aachen pilot site. Share information of LC status, in relation to smart detection system (SDS) the capabilities of which are to detect dangerous situations	Transmission duration is less than milliseconds. The range is about 80 m. Possibility to increase the range with multi-hope schema. Transmission of information in advance increases the safety of drivers.	Cybersecurity will be considered and evaluated.
New Collective Perception Messages	Tested in Aachen pilot site. Range enhancement of detection of approaching trains in LC environments	Detection of unconnected vulnerable road users: can be perceived by other road users' perception sensors. Detection of safety incidents. Increased awareness: Information aggregation about the behavior of other traffic participants in real time increases awareness and the	It was shown that CPS can effectively be used not only in native road environment but in intersection scenarios shared with rail systems.

		safety of drivers.	

5. CONCLUSIONS

Level crossing accidents can result in significant human and economic losses. Therefore, the role of policy makers is to influence all stakeholders in order to facilitate risk reduction at level crossings. Different means ranging from advice to formal enforcement actions can be employed.

This deliverable provides an overview of the most important recommendations for policy makers, to facilitate the use of policy tools as a key enabler to improve level crossing safety within different EU Member States. It is clear that cooperation is needed between the SAFER-LC project partners and policy stakeholders such as the European Agency for Railways (ERA) or the European Road Safety Observatory to ensure that the results of the project can be implemented as widely as possible.

To complement this deliverable, the SAFER-LC Toolbox was developed as a decision-support tool. The toolbox aims to help decision makers increase safety at level crossings through practical recommendations and examples. Moreover, it will enable policymakers and stakeholders to select and implement the most appropriate strategies, measures and cost-effective approaches to reduce accidents of all road user types at LC.

The SAFER-LC toolbox is a free online tool with both practical and scientific aims. On one hand, it is a guide to best practice designed to integrate (in a user-friendly and accessible way) the recommendations, promising interventions and specifications developed during the project. On the other, it is based on empirical evidence collected from the scientific literature, practical case studies, and from the project pilot test results.

The toolbox summarises the most relevant and practical information collected and produced during the SAFER-LC project. It provides an integrated overview of the road and rail safety requirements for the relevant actors of the LC safety community (e.g. road and rail infrastructure managers, train operators, engineers, designers, scientists, decision-makers, policy makers and standards developing organisations) as well as detailed guidance on the implementation of integrated socio-technical solutions to increase safety at LCs.

Link to the online SAFER-LC Toolbox : http://toolbox.safer-lc.eu/

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