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Exploitation Plan - Final version

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Consortium - List of partners

Partner No	Short name	Name	Country
1	UIC	International Union of Railways	France
2	VTT	VTT Technical Research Centre of Finland Ltd	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	Société Nationale des Chemins de Fer Français (France's National Railway company)	France
16	DLR	German Aerospace Center	Germany
17	UTBM	University of Technology of Belfort-Montbéliard	France

Executive summary

This document is a key deliverable of the SAFER-LC project which summarises the beneficiaries' strategy related to the protection and exploitation of the project results during the project's life and afterwards. It is to serve as an on-going, concise work plan for setting out the main aspects of the exploitation. It also establishes suitable actions to make SAFER-LC a success and ensure sustainability of the results for a long period. It also makes sure that the impact of the project outcomes is maximized; the use of results in further research other than those covered by the SAFER-LC action concerned is ensured, the development, creation and marketing of any further products, services or processes and standardisation activities are aware of and constructively use the project results.

This document also makes the bridge with the deliverable of the WP6 D6.3 "Communication and Dissemination Plan", which sets forth the planned dissemination & communication actions during the project's life and later, i.e., strategies and measures to be followed by the SAFER-LC project consortium in order to raise awareness of the safety challenge of rail-road level crossings, and its suggested solutions and availability of the results within the professional community as well as with the general public.

Another objective is to fill in the existing gaps between (a) research and development, (b) practical implementation and utilization of the results, and (c) end users' decision-making. The document, therefore, attempts to provide a systematic but flexible approach, allowing the end-users to adapt their utilization and deployment decisions to their specific corporate and industrial requirements. Industry adoption of the innovative technologies developed by the project is of primary importance as it provides important opportunities for new product development and adoption of novel methods in the road and rail sectors as well. SAFER-LC plans its results to be quickly integrated into the industry development roadmap by several means, including standards and industrial recommendations.

SAFER-LC partners are involved in various expert national or international committees that may influence National and European transport policies in topics related to the development of Cooperative Systems, Intelligent Transportation Systems, Railway Systems etc.. Contribution to policy development (at both National and European level) is therefore an important project activity.

Road and rail transportations are two rather independent modes of transportation operating on distinct and independent technological bases. One main objective of SAFER-LC is to bring the requirement specifications and the enabling multidisciplinary solutions affecting LC safety capable to work in a close symbiosis where interoperability of the safety technologies is a prevailing factor. Liaisons with road and rail transportation sectors, national / market / cultural problems are also taken into consideration.

The final version of this Exploitation Plan provide a cumulative overview of the undertaken activities at the end of the project (M36). A detailed plan for exploitation or use in further research for each project participant is presented.

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TERMS AND ABBREVIATIONS

Abbreviation	Definition
3G/4G	Third/Fourth generation cellular phone technology, e.g., UMTS/LTE
5G	Fifth generation cellular communications technology
ADAS	Advanced Driver Assistance Systems
AVIS	Automatic Vehicle Identification System
API	Application Programming Interface
CAM	Cooperative Awareness Message (C-ITS communication protocol)
Car2X	Car to everything communication
CBTC	Communication Based Train Control
CCTV	Closed Circuit Television
CSMA	Carrier Sense Multiple Access
CTA	Cooperative Traveller Assistance application
C-ITS	Cooperative Intelligent Transportation Systems
DENM	Distributed Environment Notification Message (C-ITS communication protocol)
DSRC	Dedicated short-range communications
EC	European Commission
EDA	Enhanced Driver Awareness
ERA	European Union Agency for Railways
FOV	Field of View
GeoNetworking	Geographic addressing and routing for vehicular communications
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
ICT	Information and Communication Technology
IPv6	Internet Protocol Version 6
IPR	Intellectual Property Rights
ITS	Intelligent Transportation Systems
IVIS	In-Vehicle Information System
LC	(Rail-Road) Level Crossing
LDM	Local Dynamic Map
LTE	Long Term Evolution (aka 4th generation cellular communication)
LOS	Line of Sight
MAC	Medium Access Control (layer)
OBU	On Board Unit

OEM	Original Equipment Manufacturer
P2P	Peer to peer
POC	Proof of concept
RSU	Road Side Unit
SDO	Standard Development Organization
SPaT	Signal Phase and Timing intersection control protocol
TCC	Traffic Control Centre
TCDD	Turkish State Railways (Türkiye Cumhuriyeti Devlet Demiryollari)
TMC	Traffic Management Centre
TRL	Technology Readiness Level
V2I	Vehicle to Infrastructure (communication)
V2V	Vehicle to Vehicle (communication)
V2X	Vehicle to Everything (communication)
WAVE	Wireless Access in Vehicular Environments

1. INTRODUCTION

This document is a key deliverable of the SAFER-LC project which summarises the beneficiaries' strategy related to the protection and exploitation of the project results during the project's life and afterwards. It is to serve as an on-going, concise work plan for setting out the main aspects of the exploitation. It also establishes suitable actions to make SAFER-LC a success and ensure sustainability of the results for a long period. It makes sure that the impact of the project outcomes is maximized; the use of results in further research other than those covered by the SAFER-LC action concerned is ensured, the development, creation and marketing of any further products, services or processes and standardisation activities are aware of and constructively use the project results.

The document is an incrementally advancing (evolutionary) deliverable for the SAFER-LC project which proceeds with the project lifetime. This describes the way how the consortium as a whole but also each individual participant envisions the exploitation of its own involvement and the results what is expected to achieve. As the consortium puts together a balanced team of execution, involving industrial, SME and academic partners, there are – in each case – distinct ways to exploit the project's outcome.

What is reported in the following sections draws-on the initial SAFER-LC exploitation plan sketched by the consortium members.

In Section 3 and 4 we will first explain the general strategy and other approaches that the project consortium has agreed upon.

In Section 5 the updated exploitation strategy is reported on a per partner basis in order to highlight the opportunities and technology and knowledge transfer action envisaged by each partner. Clearly, the exploitation plan for each partner (but also for the consortium as a whole) became more detailed and relevant as the technical work proceeded and the first SAFER-LC results are derived. In this sense, a more detailed description of the considered plans became available during the second and the third year of the project. The recent final version of this Exploitation Plan at the end of the project (M36) will provide a cumulative overview of the undertaken activities and a detailed plan for exploitation or use in further research for each project participant, when the SAFER-LC developments have been completed and the validation results are known.

This document makes the bridge with the WP6 deliverable of SAFER-LC: D6.3 "Communication and Dissemination Plan". This sets forth the planned dissemination & communication activities during the project's life and later, i.e., strategies and measures to be followed by the SAFER-LC project consortium in order to raise awareness of the safety challenge of rail-road level crossings, and its suggested solutions and availability of the results within the professional community as well as with the general public.

Another objective was to fill in the existing gaps between (a) research and development, (b) practical implementation and utilization of the results, and (c) end users' decision-making. The document, therefore, attempts to provide a systematic but flexible approach, allowing the end-users to adapt their utilization and deployment decisions to their specific corporate and industrial requirements.

Road and rail transportations are two rather independent modes of transportation operating on distinct and independent technological basis. Industry adoption of the innovative technologies developed is of primary importance as it provides important opportunities for new product development and adoption of novel methods in the road and rail sectors as well. One main objective of SAFER-LC is to take the diversity and heterogeneity of the required solutions into consideration and bring the requirement specifications and the enabling multidisciplinary solutions affecting LC safety capable to work in a close symbiosis. Interoperability of the safety technologies applied by road and rail technologies is a prevailing factor.

SAFER-LC plans its results to be quickly integrated into the industry development roadmap by several means, including standards and industrial recommendations.

SAFER-LC partners are involved in various expert national or international committees that may influence National and European transport policies in topics related to the development of Cooperative Systems, Intelligent Transportation Systems, Railway Systems etc. Contribution to policy development was therefore an important activity of the project.

Maintaining liaisons with main actors of the road and rail transportation sectors, national / market / cultural problems were also considered.

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2. PROJECT SUMMARY

According to Eurostat 2015, more than six hundred persons are killed in EU-28 at railway level crossing incidents yearly. This represents 35% of all accidental casualties in railway systems.

Reducing hazards and increasing traffic safety at railway crossings involving the traffic of trains, road and rail vehicles is, therefore, a key focus area for the creation of safe and sustainable transportation strategy in Europe.

2.1. The consortium

SAFER-LC partnership incorporates 17 partners from 8 different EU countries, including one associated country, from Western, Northern, South, Central and Eastern Europe. The decidedly trans-European character of the project presents a particular added value since it deals with issues of a common concern at pan-European level, which, in conjunction with the partners' multidisciplinary expertise, creates an efficient form of collaboration where sharing of practices, technology transfer and joint collaboration in the process, methodologies and deliverables results in more effective cooperation and leads to the beginning of a sustainable networking across the European research and educational area.

The consortium consists of a complementary mix of parties and uses and exploits the benefits of an established partnership between enterprises and stakeholders from the railway industry, academic, educational and training institutions, universities and research and development organisations, as well as with civil society authorities who can valorise the results directly and/or indirectly, through subsequent cooperation with industrial partners and rail and road service providers. The various participations of rail-road stakeholders and of the local LC managing authorities or private road owners in pilot projects further enrich the consortium's related knowledge portfolio.

2.2. Scope of the SAFER-LC project

SAFER-LC is a Research and Innovation Action (RIA) Project within the EU's H2020 Framework Programme running from 1st of May 2017 to 30 of April 2020 whose main objective is to answer the call of the number of fatalities and develop methods for LC safety enhancement as discussed in the objectives section in more detail.

The project focuses both on technical solutions, such as smart detection and warning services and advanced infrastructure-to-vehicle communication systems and on human processes to adapt infrastructure design to end-users and to enhance coordination and cooperation between different stakeholders from different transportation modes. The project takes an exemplary approach in this respect when it stresses the need for the rail and road systems to share information and data so that each party can manage disruptions caused by the other in an optimal way: this balance is continuously emphasised.

In the coming automated self-driving cars populated traffic, railway crossings pose an additional safety challenge that cannot be overlooked. The problem is double faced. From the one side an autonomous car's driving strategy that is much better at avoiding accidents than human drivers may

lead to unreasonably over-cautious manoeuvring at level crossings. The approach and passing of railway crossings by autonomous vehicles could result in unnecessary traffic slow down or even end up with complete traffic jams because of the bad visibility of most road-rail level crossings scenarios. The solution is to use the connected car paradigm by extending cars' ability to see beyond line-of-sight and field-of-view with enhanced accuracy.

The scope of the SAFER-LC project is, therefore, broadened from human centric traffic to automated traffic systems.

A series of pilot tests across Europe were rolled out to demonstrate how these new technological and non-technological solutions can be integrated, validate their feasibility and evaluate their performance in a field where technological crossovers and interdependencies are common. The project delivered a bundle of recommended technical specifications (that can be useful also for standardisation), human processes and organisational and legal frameworks for implementation.

SAFER-LC also developed a publicly available toolbox accessible through a user-friendly web interface (http://toolbox.safer-lc.eu/) which integrates the project practical results and solutions in order to help both rail and road stakeholders to improve safety design at level crossings.

2.3. SAFER-LC objectives

The main objective of the project was to develop and test new technologies to improve safety and minimize risks at and around rail-road 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.

Modern vehicles are becoming increasingly capable of establishing connectivity for the exchange of information between vehicles (V2V) and between vehicles and road infrastructure units (V2I) – together referred to as V2X or C2X (Car2X). The so-called 'connected-vehicles' paradigm can bring about an enormous potential for safer transportation.

The safety management at level crossings, however, calls for disruptive new technology and the application of novel detection and communication solutions, capable of extending the cooperative functionality of C2X systems to support the avoidance of dangerous traffic situations in real-time and in rail environment.

Collective perception, for example, is the name of a new technology for the exchange of data from a vehicle's sensors with other vehicles or infrastructure via V2X that enhances the event resolution and perception range of a vehicle that was experienced in the framework of SAFER-LC.

This capability can provide oncoming traffic information beyond line-of-sight and field-of-view with enhanced accuracy which enables better control of both driven and self-driving vehicles. Cooperative perception techniques together with sensor fusion technology provide better situation awareness and improve visibility for both road and rail vehicles resulting in a pre-emptive safety enhancement for rail crossings. Novel methods for information exchange between road and rail vehicles are among the many innovative solutions developed by the project.

Making project achievements for third parties readily available in a searchable and reusable form is a primordial goal of project implementation. The SAFER-LC toolbox that is published at the end of the project serves this purpose.

2.4. Key project results

One core aspect of the project's practical exploitation involves the development of the expert toolbox for relevant actors of the LC safety community. The toolbox summarises the most relevant and practical information collected and produced during the project. The toolbox is easily accessible free of charge since the project final conference, and will continue to be maintained, updated and improved by the International Union of Railways (UIC) even after the end of the project for the benefit of the entire road- and railway-safety communities. We trust that the SAFER-LC toolbox will become another good example of exploitable results from EU-funded projects and will perfectly complete the RESTRAIL toolbox (already acknowledged as a "success tool" by the European Commission).

The aims of the SAFER-LC toolbox are the following:

- to provide 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 SDOs);
- to provide detailed guidance on the implementation of integrated socio-technical solutions to increase safety at LCs;
- consider human factors (perceptive, cognitive, motivational) in the design of LC infrastructures for all levels of the LC ecosystem – for all participants in the system (LC operators, road travellers and train passengers etc).
- to provide a framework for collecting and structuring information in order to feed an accessible and documented database on efficient measures across the road-, rail-, and scientific communities.

The compliance with the above objectives will help to fill the existing gaps between (a) research and development, (b) practical implementation of results, and (c) decision-making. The toolbox provides a systematic but flexible approach, allowing the end-users to adapt it to their specific needs and according to particular national / cultural problems.

At this point, the existing LC research is somewhat separated between the road and the rail sectors, as well as between technical and human factors research. Through this toolbox everything will be integrated and available for the concerned stakeholders and researchers. To our knowledge the SAFER-LC toolbox is the first attempt to provide an evidence-based practical tool for relevant actors of the LC safety community and a structured research framework for technical and human factors / behavioural scientists concerned with the continuous optimisation of integrated and connected socio-technical safety solutions at LCs.

3. PREPARATION FOR EXPLOITATION

3.1. Exploitation strategies

All SAFER-LC partners find real opportunities to leverage the project results in their ongoing and/or future activities whether that be industrial, commercial, research or academic. As SAFER-LC is a RIA action project, the efficient exploitation requires an additional effort by the partners to bring the project results to a level of maturity that can be included in a commercial (or at least close to commercial or prototype) application. The early industrial and academic adoption of the new and effective safety enhancement technologies developed by SAFER-LC may result in direct competitive advantages for the SAFER-LC partners. SAFER-LC, therefore, tries to catalyse this adoption process by bringing various actors together under the umbrella of this research and innovation action by harmonizing needs and requirements generated by the key players of the field, i.e., build a bridge between basic research and industrial adoption and exploitation.

Exploitation strategies applied by the project are varied and they differ in key concepts characterized by the domain of exploitation as it is discussed in the following sections.

Potential users of the results provided by SAFER-LC are road and rail transport operators, city authorities, local state organisations and various traffic service providers. Now that the SAFER-LC termination is imminent the consortium invites selected actors from the interested stakeholders and demonstrate them the key project achievements on the SAFER-LC Final Conference.

3.1.1. Road and rail infrastructure managers

Road and rail modes of transportations are two rather independent operating on rather separate and independent technological basis. One main objective of SAFER-LC is to bring the requirement specifications and the enabling solutions affecting LC safety closer to each other, capable to work in a close symbiosis. Infrastructure owners and operators are to be involved in the planning, design, construction, maintenance, and operation of the road-railway infrastructure. They should establish realistic expectations about the available supporting and enhancing technologies when deploying new LC projects and demonstrations. To fully realize the benefits of novel technological elements (such as the ones developed by SAFER-LC) decision makers, operators and users must understand and be wholly comfortable with the new technological developments.

Road and rail infrastructure operators must know the available cross modal solutions. Infrastructure owners and operators have already expressed interest in more information and guidance on the scope and content of these safety technologies and how to prepare LC deployment and operation. This request will be answered by

- the organization of trainings and workshops focussing on the use of the SAFER-LC toolbox including standardized solutions and technologies (first training on the toolbox held on 22 April 2020 during the project online final conference),
- providing best practices and policy considerations to support stakeholders as they work to better understand SAFER-LC’s achievements, how it may impact their roles and

responsibilities, and how best to integrate the solution approaches into existing and future LC deployments,

- close cooperation with stakeholders to maximise interoperability throughout Europe and take advantage of common international interests by leveraging work across multiple markets, regions and properties.

3.1.2. Industrial and SME's exploitation

Private sector leadership is critical to advancing the development, testing, and commercialization of SAFER-LC results. Consortium members, especially the industrial and SMEs, will rely on the SAFER-LC results to cost-efficiently utilize the safety enhancement techniques developed by the project and seamlessly integrate them in their research prototypes (and/or products). Industrial partners' primary goal is to adopt these safety enhancement technologies on a timely basis.

State organisations involved in the SAFER-LC action play a key role both in industry management and also in academic activities. They work close to the railway transport operators to understand their needs for the handling of potentially dangerous situations occurring at level crossings and inform them about the future possibilities regarding new safety enhancement techniques developed by SAFER-LC.

By broadening the knowledge basis in the field of level crossing safety, the project can start strategic partnerships with railway companies, stakeholders and industrial partners and acquire funding for future collaboration.

SAFER-LC's responsibility in industrial exploitation of its results includes effective dissemination of project results to industrial decision makers, transport infrastructure operators by convincing them about the advantages of the adoption of the results. SAFER-LC's key responsibility is to establish POC pilots operated in real LC sites permitting the public evaluation of the technology elements. Sufficiently exhaustive and successful POC evaluation opens the gate to full-scale industrialization and real technology deployments.

3.1.3. Knowledge and academic exploitation

The academic partners of the consortium will seek to exploit SAFER-LC results during and beyond the project's timeline in the academic area. The expertise gained in SAFER-LC will be used by the partners through scientific publications, offered as expertise in future offerings and consultancy activities, or used when developing future activities. The consortium exercises continued dedication to the production of valuable knowledge and research results in the LC safety enhancement area.

Rail service providers and road authorities (such as TCDD in Turkey) will be informed about the results of accident analysis which is carried out in the very first part of the project. They will also be informed about the developments and innovations the project produces and also its benefits and compatibility with the state of recent practice.

Brainstorming and knowledge sharing during each of the workshops conducted in the project can contribute to creating new projects in the future. Also, abstracts related to the SAFER-LC project may be presented in national and global conferences.

IRU as a key player in European road transport will cooperate with the IRU Academy, the branch of the International Road Transport Union devoted to drivers' training, in order to share with the road freight and passenger transport sectors the knowledge gathered and created by the SAFER-LC project. Training material and activities will be developed in that regard to ensure the relevant tools produced by the consortium are used by the road transport industry on a large scale. IRU will also exploit some of the results produced in SAFER-LC in other projects dealing with cooperative ITS and road safety.

In a direct relationship with SAFER-LC's dissemination activity the project results will be presented to the scientific community in international conferences and be published in scientific journals, covering all focussed theoretical, methodological and technological areas of the project.

A key project objective regarding the knowledge and academic exploitation of the results is to bring the most important SAFER-LC's achievements in higher education programs. Academic institutions will enhance the results using the information and analysis of SAFER-LC achievements in specific courses of education and will employ the results, solutions and methodology in master's degree and PhD thesis programs. Moreover, a continuous exchange of related information and communication will be promoted by universities when organizing meetings, publishing newsletters and presentations, and as such, academic partners will promote the importance of the research in this safety-oriented field of transportation by enhancing professional acceptance and public awareness, continuously.

3.1.4. Collaborative exploitation and IPR management

SAFER-LC is a collaborative research and innovation action project. Collaborative efforts help project participants leverage the strength of working in a team having complementary skills, expertise and knowledges.

Any exploitation activity will be subject to the procedures on ownership of results and transfer of ownership as laid down in the corresponding articles of the SAFER-LC Consortium Agreement.

3.2. Market characterisation of key results

Indications on the market needs and trends must be brought in to SAFER-LC, obviously. It's important to apply research in a practical way and not leave it on the shelf. This means that the research on safety enhancement methodology and technology can be made a success, if the results correspond with the needs of the industry on the one hand, and they are parallel with the most recent technology trends, standards and societal developments of the related field, on the other.

To contribute to market analysis, similar on the shelf products and services can be compared. Also, through the face to face meetings with experts for understanding their expectations for the products and needs of the market can contribute to the market characterisation.

Rail and infrastructure operators involved in the project are the main sources of information about these needs.

The cost/benefit analysis (performed in WP5) provided valuable indications regarding the economic viability of the solution elements developed by SAFER-LC. The analysis inherently covered market

features and resulted to the cost categorisation of the developed solutions. All the SAFER-LC solutions fell into the category of low-cost initial investment (less than 10.000 € per LC) which verifies the initial planning for low-cost safety measures.

In order to exploit on a large scale some of the solutions suggested by the SAFER-LC project, the innovations proposed will have to be interoperable and cost-efficient. Road transport operators will implement solutions only when have clear and reasonable potential benefits.

Human lives are priceless and road safety is an obvious priority of the sector, however, the safety benefit is very difficult to characterise in general. Moreover, the number of fatalities in level crossings in the road transport sector is relatively low compared to the injuries and deaths occurring as a result of other kinds of traffic.

Due to the ongoing plans in some European countries regarding reactivation of rail lines in rural areas, the development of innovative and cost-effective measures to increase the safety of level crossings, in particular of passive level crossings, is of great relevance. The reactivation of rural level crossings can be made on the price of considerable costs which may hinder traffic projects. The planning and provisioning process of already established technical safety systems for level crossings takes a long time and is very expensive. Especially with an eye on precarious economic situations of many rural municipalities all over Europe, there, definitely, is a demand for innovative low-cost measures to enhance safety at level crossings. As a part of the project SAFER-LC such systems have been invented in WP 2.3 and evaluated in WP 4.3. The market for the distribution of innovative low-cost safety systems is huge, since it comprises all countries with railways and level crossings.

The cost of the developed solutions must therefore be a conscious issue. The favouring price/performance ratio of the technical solutions is a key factor in industrial adoption that paves the way for real deployments in the road-rail transport industry.

3.3. Potential barriers to the exploitation of results

Several factors can be identified as potential barriers to the exploitation of the project results in real conditions

Level crossings represent a very unique type of infrastructure both from rail and road transportation point of view from many reasons. Because of their multimodal nature in design, construction and operation, the nature of their geographical implantation, moreover, the very different social, legal and regulatory frameworks and technical capacities applied by different countries, LC requirements are very difficult to satisfy. All European harmonization and the assurance of technological interoperability of the results applied by LCs are another critical issue.

SAFER-LC will have to overcome the fragmentation of approaches to the different LC situations and deliver results that can be replicated and exported to the different LC situations in different countries. In order to do so, SAFER-LC will include, not only a cost-benefit analysis, but a detailed human factors description so that each solution delivered can be adapted to the different LC situations, no matter the users or environments involved.

Insufficient harmonisation of the rules governing the management and use of level crossings at the European level, or a deficient interoperability between different technical or communication systems

developed to improve safety at level crossing would be significant obstacles to the large-scale implementation of the solutions proposed by the consortium. Other major barriers to the exploitation of the suggested tools would be solutions that do not fully meet the requirements of infrastructure managers and rail and road users, or solutions with implementation costs so high that they would prevent stakeholders to adopt them in real life. That is why the development of each of the solutions has to be preceded by an attentive evaluation of the trade-off between risks reduction and costs, moreover, an attentive market characterisation is ultimately important.

Finally, it has to be noted that the lack of an appropriate communication about the outcome of the project would also limit the use of the results. Market analysis must pre-emptively filter out solutions which are redundant with SAFER-LC development goals in order to avoid double development efforts which may potentially result in attacking the market with a product with similar feature set with already known solutions.

From the academic point of view, an important barrier is the willingness of the solution developers to patent their developments, since this will not allow to publish anything. Regarding raw project objectives, this is not a barrier, since the patent is also a valuable output. In order to better manage these issues, the IPR issue of the project developments should be carefully discussed and agreed between the partners. See Section 3.1.4 Collaborative exploitation and IPR management.

Strict jurisdiction and conservative admission processes for innovative safety systems can be a threat to the impact of the countermeasures of results developed by SAFER-LC.

Another challenge is originated in the rather complex acceptance issue which is characterised by the shared responsibility structure and hierarchy of LC management. Shared responsibility between road and railway management and municipalities can lead to the diffusion of the responsibility for level crossing safety that may cause refusals or delayed decisions.

One of the main barriers, which is the direct consequence of the shared responsibility characterised above, is represented by the lack of cooperation between the road and the rail managers. The difficulties produced by this condition are amplified by the excessive number of stakeholders and, often, the lack of a national and systemic vision about LC safety issues.

Considering that in many European countries the dissemination of the results and solutions proposed by SAFER-LC through a valid exploitation based on scientific papers, conferences with stakeholders, politicians, international and national academic members can provide a decisive inception to reduce the potential barriers.

Further exploitation risks can be identified in the following factors:

- Sensitivity/confidentiality of the data collected during the SAFER-LC project.
- Confidentiality of the solutions developed/tested during the SAFER-LC project.
- Development, implementation and maintenance costs of the developed solutions can be technologically limiting.
- The use and reuse of SAFER-LC collected information affecting privacy.

3.4. Contribution to standardisation

The SAFER-LC project capitalizes on various research approaches and methodologies. Multidisciplinary solutions of safety enhancement techniques, a set of distinct ICT technologies are applied to the LC context to achieve the project goals. They are the intelligent video processing and object recognition systems for detecting various hazardous events which happen in LCs and in their immediate vicinity, the advanced vehicle and infrastructure communication solutions for accessing traffic partners on road and rail in order to share information between one another and interact them in real-time, moreover, the application of various human decision centric low-cost measures characterize the heterogeneous methods and approaches.

A broad stakeholder set was identified to represent researchers, manufacturers, transit agencies, and infrastructure owner-operators, among others.

The SAFER-LC domain knowledge with distinct technology elements must be integrated in a comprehensive set of interoperable solutions in an attempt to satisfy the requirements of the stakeholders and make LC passing manoeuvres for people, road vehicles and trains safe as much as possible. The primary goal of SAFER-LC is, therefore, to produce working solutions in this multimodal transportation field that fulfil the agreed needs and requirements of both road and rail transportation.

The use and integration of (vehicular) communications in this diverse and heterogeneous environment, for instance, to provide railway operators with a means to control and manage the train traffic on their networks and assist road users during LC manoeuvres is a must to make the traffic safe and sustainable in the future. The greatest difficulty arises from the application of the multi- and cross-modal set of innovative solutions and tools, especially ones related to information exchange and communication which are not harmonized with each other.

SAFER-LC objectives can only be achieved through *harmonization* of the applied methods and *standardisation* of the results which are candidate for real industrial use.

Obviously, adherence to standards helps ensure safety, reliability and interoperability in this complex multi-modal situation. Standard compliance increasingly helps in taking-up of the new technologies. Different use and interpretations of terminology regarding LC safety enhancement technologies can be confusing for the public, state and local agencies, and industry. In the interest of supporting consistent terminology, state legislatures may want to use terminology already being developed through voluntary, consensus-based, technical standards.

Historically, standardised solutions and technologies used by road and rail transportation systems have been developed independently and separately from each other. While relying on standardized solutions in such a heterogeneous field of applications is a must, it is not a straightforward task since, sometimes, it depends on contradictory or inconsistent requirement specifications and involves in many cases the agreement of different stakeholders (user communities, administrators, technology providers, road and rail operators etc.) to act in a common strategy.

SAFER-LC's exploitation plan, therefore, relies on a balanced standardization strategy emphasizing important principles for SAFER-LC standardization endeavours. The research, identification and adoption of existing standards which are closely related with SAFER-LC's objectives were

considered whenever it was possible and where it made sense in order to comply with the broad user requirements.

Key activities during the first two project years, therefore, included research, identification and study of existing project related standards and other de facto technical specifications. Existing project specific standards were broadly adopted for project use.

Not industrialized research results of SAFER-LC at least are aware of the existence of standardised solutions and they identify themselves relative to these standards.

SAFER-LC officially propose further development and/or extension of existing standards (through their company delegates in various SDOs[1]) in cases when missing features and/or functionalities are identified with regard to relevant standard documents. This also includes the monitoring of standardization bodies and their working group activities as well as requires the active contributions from delegated members of SAFER-LC in the international standardisation work in the future. In this respect the immediate feedback of validation results of experimental technical solutions to the standard development was crucially important.

Involvement of the standardisation expert Dr. Hans Joachim Fischer from the Advisory Board in this activity was highly beneficial.

A high-level view on the adoption techniques of standards is summarized in SAFER-LC deliverable “D5.2 Standards for communication and data interoperability”.

[1] Commsignia, as active member of ETSI, ISO and IEEE-SA represents SAFER-LC results in the respective technical working groups of standardisation.

4. EXPLOITATION PLAN AND FUTURE DIRECTIONS

4.1. Current actions

Sharing of information and objectives of the SAFER-LC project with national road and railway companies and stakeholders is primordial goal of exploitation preparation, which belong to the recent objectives. SAFER-LC partners having the chance to contact the stakeholders, moreover, other research centres and universities in the national and international context prepare the future collaboration with external partners by exchanging information about innovative and technological measures provided by the project.

The deliverable D5.4 on "Recommendations for policy makers" contains recommendations for national infrastructure building policy and regulations regarding the design of LCs from the infrastructure point of view.

Collection of data and information from different sources, countries, regions and contexts helps conceptualization of the exploitation. One of the plans is to involve road and rail managers proposing their cooperation at all levels of the problem hierarchy to develop policies, low–cost and technological measures and guidelines related to LC safety.

Preparation of development of advanced POC systems and pilots which operate in real conditions is another early objective of the project which, through the effective performance evaluation and demonstration capabilities affects successful exploitation of the project results.

Partners, such as IRU has presented the project to the members of the International Road Transport Union and shared the preliminary results with its internal Commission on Road Safety. Representatives of road freight and passenger transport operators participating in this Commission have been asked to provide input on requirements regarding potential solutions to improve safety at level crossings.

4.2. Short and medium-term actions

The project evaluated the technical solutions through the use of cost-benefit analysis to ensure the solutions can be realistically implemented in real life. To this end, deliverable D5.3 “Business Models for SAFER-LC solutions” categorize particular solution elements *in accord with* various cost types, such as development, implementation, operation and maintenance costs, and set against the benefit of deployment. This may help decision makers in strategic planning in short and medium-term.

Members with privileged access to regarded decision making and representative forums (such as IRU to various International Road Transport Union related groups and associations) cooperate and promote the adoption and use of the proposed innovative solutions suitable for road and rail transport operators.

Convincing road and railway infrastructure operators about the benefit of experimenting with and effectively contribute to the demonstration of the innovative new SAFER-LC technology is in focus of the medium-term actions.

Training material and activities were developed in partnership with academic and non-profit research institutions, with the training branch of other profit-oriented organisations and companies to ensure the relevant tools and technologies produced by the consortium are used by the road and rail transport industry in the future.

Presentation of results in national and international conferences and seminars is part of both dissemination and exploitation activities on the long run.

Special attention is payed to the organization of various safety campaigns, demos and participation in other road users' representatives' meetings. One needs to support recommendations on adjustments of the current legal framework to implement the suggested solutions at a harmonized and interoperable Pan-European level. The participation in standardization at various SDOs activity is ongoing. Selected project members delegate supporting experts to particular standard work items and project beneficiaries with active SDO membership will represent SAFER-LC achievements in international harmonization work.

4.3. Long-term actions

Long-term actions are related to post-project exploitation activities when planning future projects and product offerings.

Based on the short and medium-term actions the industrialisation of the project achievements is made with special focus on making the solution elements robust, scalable and on a low price.

Employ the results provided by various SAFER-LC actions to conduct other studies about safety enhancement and risk analysis to analyse other similar situations and prepare forthcoming project actions in the future.

The re-use of the results produced by the SAFER-LC action in future projects, particularly in the fields of cooperative ITS and road safety.

5. EXPLOITATION BY INDIVIDUAL PARTNERS

The defining characteristic of activities regarding exploitation of SAFER-LC results is very much based on the particular scientific or industrial profile and interests of individual partners. The corresponding research and development topics of exploitation are formulated in the partner specific sections in the following.

5.1. UIC

UIC, as the worldwide professional association representing the railway sector and promoting rail transport, has no commercial purposes but has a lot of dissemination capabilities and a very important network of experts from rail infrastructures managers and operators.

The SAFER-LC toolbox which has been developed during the project summarises the most relevant and practical information collected and produced during the project. This toolbox is easily accessible free of charge at the end of the project (now available online at: http://toolbox.safer-lc.eu/), and will continue to be maintained, updated and improved by UIC even after the end of the project for the benefit of the entire road- and railway-safety communities.

The exploitation of the results of SAFER-LC project will be done by UIC at different levels:

- Within the organisation: SAFER-LC knowledge will be integrated in the overall activities of the UIC Security Platform, UIC Safety Platform, UIC European Level Crossing Forum and Rail System Forum. The project findings, results and recommendations will be presented in the relevant meetings of those bodies. Trainings and workshops for railway experts will be organised to promote the toolbox developed within the project. The first toolbox training was organised on 22 April 2020, during the project online final conference with 180 participants from 35 countries.
- Outside the organisation: UIC will promote the results of the project and especially the online SAFER-LC toolbox in related international events where UIC is participating. All the UIC dissemination capabilities will be used, namely, the electronic newsletter (UIC e-News) that reach globally about 5,000 email addresses, the UIC dedicated website, and the UIC network of experts.
- With the help of ERA and especially the EUMedRail project group (Projet euro-méditerranéen du transport ferroviaire), UIC is also promoting the SAFER-LC toolbox outside the EU. A good example is the seminar held in Algeria in February 2020. Following this successful experience, the ERA and UIC agreed to further promote the tool towards in the Mediterranean region and a toolbox training in the French language is now under discussion.

5.2. VTT

In the SAFER-LC project, VTT exploited its expertise on accident data analysis, driver and road user behaviour, risk assessment and safety impact assessment tools, and in-vehicle warning systems for railway level crossings including vehicle positioning, train location determination, arrival estimates and alarms. VTT has a long history on developing both V2X communication and self-driving car technologies. Based on the results of the SAFER-LC project, VTT is looking forward to developing integrated safety solution for the self-driving cars and passive level crossings.

In the case of the application of additional warning lights, the technical feasibility as well as the positive expert ratings and the promising results from the simulator study suggest that it might be worthwhile to test the additional train lights on locomotive in a larger scale real world experiment. Therefore, VTT will be looking for possibilities for a larger scale pilot testing of this system. VTT is involved, for example, in the SmartTram project (https://www.vttresearch.com/en/news-and-ideas/smarttram-ecosystem-brings-attractive-solutions-sustainable-mobility-while-fostering), which is an example on a project where the developed knowledge could be utilised. In Finland there is a plan to digitalise the rail transport (for details see https://digirata.fi/en/towards-digital-and-intelligent-rail-transport/).

The current train control system is becoming obsolete within a decade and it is planned to be replaced with ERTMS level 2 or even ERTMS level 3 implementation. This provides a good opportunity to promote both developed safety solutions. Specifically, the basic requirements for the V2X messaging system between automated vehicles and passive level crossings (i.e. reliable train tracking and communication) will be realised through the digitalisation of rail transport. VTT aims to promote the implementation of this V2X messaging system so that it could be realised simultaneously with the developments related to the digitalisation of railways.

VTT is a large organisation with a wide area of expertise, such as development of the new technology-based solutions and services for vehicles and transport infrastructure. The knowledge gained within the SAFER-LC project will be exploited through increased collaboration between the different teams at VTT's research area on 'Transport and Mobility' and other research teams of VTT.

VTT is heavily involved in transport related research and assists authorities and companies in the various phases of analysis, design, specification, development and evaluation of transport systems and services. The knowledge gained in SAFER-LC will be further exploited in future projects and offerings.

5.3. NTNU

As a research and academic institution, NTNU's main exploitation plan is towards the academic field. New knowledge, newly developed solutions and lessons learned will be used and disseminated to the railway/road educations at various levels. The results will be mainly exploited through integrating and updating the rail/road education module and through publications in scientific journals.

5.4. IFSTTAR

IFSTTAR will take advantage of the technical solutions developed by SAFER-LC to continue developing solutions, particularly in the field of communication. The cost/benefit analysis that will be carried out within WP5 can serve as a basis for future studies regarding railway safety in general.

5.5. FFE

Given the wide reach of FFE´s activities both in the field of R&D as well as providing strategic support and development to the Spanish rail industry, the results of SAFER-LC will be exploited in various ways. On the one hand, the FFE will support its patrons (Spanish Rail Infrastructure Managers, Railway and Metro Operators) and the wider Spanish rail sector in their decision making on investments regarding LC design and associated safety measures and the optimisation of system exploitation. Given the multimodal scope of SAFER-LC, the strategic development support FFE offers will seek to extend beyond rail to also reach stakeholders in the road and intelligent transport system sector. In this framework, various meetings have already been held with key Spanish stakeholders from rail and road (Adif, Renfe, DGT and AESF) with a view to setting up an informal work group to monitor safety issues regarding LC safety in Spain and disseminating SAFER-LC results. A first result of this contact culminated in two organisations delivering presentations at the SAFER-LC mid-term conference and all of them participating as members of the audience; broad participation at the third Stakeholders Workshop, with several representatives of ADIF's Level Crossing Department, various members of the AESF – Spanish Railway Safety Agency, representation of RENFE and of the Spanish Road Technological Platform.

In order to further support stakeholder engagement and promote FFE´s work in the line of LC safety, a SAFER-LC leaflet has produced in Spanish which had a first round of dissemination at the recent SAFER-LC Mid-term Conference and SAFER-LC Website.

On the other hand, SAFER-LC will contribute to the current activities of technical support and studies that FFE performs addressing the whole Spanish railway sector. In this sense, it is especially important to underline that one of the research areas of FFE is dedicated to Safety and Sociology of Transport. Due to its expertise, this group has developed different projects focusing on the human perspective of rail safety, and specifically on LC users from a preventive and educational point of view. As part of its national activity FFE has developed for ADIF (Spanish National Rail Infrastructure Manager) the "YoCruzoseguro" project, with the objective of developing and implementing a prevention and safety awareness program regarding rail in Spain, along with the development of a framework for evaluating and monitoring the impact on end users, enhancing self-explanation of LC in Spain. The in-depth knowledge acquired about LCs in Europe and beyond together with expertise on human factors at LCs, resulting from SAFER-LC, will help improve the projects developed in this area and, therefore, deliver a wider range of solutions on LC safety measures to Spanish decision makers.

5.6. CERTH-HIT

The exploitation plan of the SAFER-LC results at CERTH-HIT will have two major focuses, one short and one long term. The short-term focus is a scientific one: the dissemination of the project results in scientific fora, while the long-term is a more technological one: the inclusion of the alert system at

LCs in the suite of cooperative and traveller information services developed and offered by CERTH-HIT in the Thessaloniki area, as well as to investigate the potential collaboration with TRAINOSE in order to provide estimated time of arrival to the stations.

With regards to the first scope, CERTH-HIT promotes the project results by participating to scientific fora and congresses, technical workshops as well as to other events. Until now the project has been presented in several international conferences (RAILWAYS, EWGT, ITS, ICTR, TRB), and at the time of writing this report, a study paper is under review for the ITSC. The presented studies focus on the multimodal cooperative safety system at LCs and the Estimation of the Time of Arrival using the implementation in Thessaloniki as a case study.

With regards to the second scope, CERTH-HIT hosts and maintains a suite of cooperative and traveller information services which are provided in Thessaloniki in collaboration with other organizations, such as the Region of Central Macedonia and the Municipality of Thessaloniki and the TaxiWay taxi association. This suite also contains the outcomes of various EU funded projects (Mobithess, COMPASS4D, COGISTICS, and C-Mobile) and has been already enriched with the service developed within the SAFER-LC project. Further, a mobile app which will host and offer all the suite's services to the public is currently under development by CERTH-HIT.

5.7. TRAINOSE

TRAINOSE will proceed with a pilot in the second biggest city of Greece, Thessaloniki. The pilot will be implemented in freight, regional and suburban trains. The main idea is the development of a system that will connect the TRAINOSE fleet with a taxi fleet. The taxi drivers will be notified if a train reaches the level crossing point. This solution can help the city of Thessaloniki and TRAINOSE to reduce the accidents in level crossings. Upon a successful validation, the solution is planned to be implemented in all major regions of Greece. The railway network in Greece passes all of the main cities. The developed solution will be extended for the benefit of truck operators, taxi operators, leasing companies and busses which can extensively use this platform solution.

5.8. INTADER

The results of SAFER-LC at INTADER will be exploited in the preparation of scientific presentations, plan future activities and establish new projects. On the other hand, by sharing SAFER-LC results with main Turkish stakeholders and transfer new safety enhancement techniques and other project related knowledge to the industry underlies the application of SAFER-LC results in the practice.

5.9. CEREMA

CEREMA (in the close cooperation with UTBM) develops a smart detection system composed of specialized hardware and software. It is intended to patent the system and the possibility of knowledge transfer will be examined for direct industrial exploitation.

5.10. GLS

GLS is a service integrator with specific competences in transport and ITS solutions. Our first specific action will be to add the SAFER-LC developments into our V2X stack but also in our android app for

vehicles and on our Cooperative ITS platform. As a system integrator, another action will be the integration of the C-ITS development with the smart detection system developed by CEREMA. Concerning exploitation, we will add two elements to our catalogue. The first one being the specific C-ITS SAFER-LC solution which could be of interest to other integrators and the second one being the complete SAFER-LC solution including C-ITS and the smart detection system. As system integrator, the second solution is the one we prefer, and we will propose it to railroad crossing managers. Furthermore, the competence gained by mixing C-ITS and camera detection will permit us to propose additional use cases on intersections like for example pedestrian detection at a traffic light when he crossed during a pedestrian red light.

5.11. RWTH

RWTH is a teaching and research institution. Results from SAFER-LC will be disseminated through journals and conference participations and used in teaching of students and junior researchers. Within the scope of student activities and scientific research assistance, students will be offered the possibility to actively participate in ongoing research projects and gain experience in current scientific topics.

5.12. UNIROMA3

Uniroma3, as an academic organization, covers the key role of the research in the national Italian context. Results from SAFER-LC project will be disseminated also beyond the project's timeline through meetings, papers, courses and conferences involving experts, road and rail managers and academic members of the international and national context.

The results and the methodology applied in the different phases of the project might be used for PhD thesis and scientific papers on in-depth analysis, studies based on the human factors on transport systems' safety issues and impact of low-cost and technological safety measures.

Uniroma3 will promote the dissemination in Italy and in other European countries of SAFER-LC project in terms of solutions, results and recommendations with the aim of creating the condition for the development of the solution proposed in the real market of road and rail operators.

5.13. COMM

Commsignia, being a key supplier of automotive V2X solutions for OEM trials and road and smart city deployment projects will embed newly developed SAFER-LC solutions into its platform solutions offered to the market. These will be emphasized as key, enabling features for road and rail infrastructure operators. Commsignia will focus on the automotive / industrial segment's stakeholders emphasizing the importance of the global use and uptake of cooperative ITS solutions (with the use of V2X technology) to support safety in automated transportation systems. SAFER-LC experiences will help to explore the interaction between autonomous vehicles and other road users, as well as road-rail level crossing infrastructures and identify what information automated vehicles will need in order to negotiate road-rail intersections for safety enhancement. Commsignia developed specific communication scenarios to demonstrate the concept of operations, including system requirements (technology and sensors) for the effective safety enhancement of LC traffic. The

scenarios provide basis to the development of the safety applications which can be integrated in the C-ITS ecosystem as being part of Day 2 and Day 3 solutions.

Commsignia software team will implement selected elements of the various enhancement technologies validated by SAFER-LC for connected and autonomous cars that will be part of the company's standard product offerings. Demonstrative examples and tools will be provided to help third parties and other users to understand and utilize the subjected new safety features. Commsignia contributes to the harmonization activity of rail-road communications systems and intended to give an initial evaluation of novel safety enhancement methods in LCs, such as perception-based event and incident detection, as well as cross-modal information sharing techniques based on C-ITS communication and V2X technology in general, in order to support technology validation and harmonization and facilitate future deployment of these methods in the field of rail systems.

More specifically, the cooperative perception (CP) safety enhancement technology which is recently under development at ETSI and tested in the V2X arena will be extended with rail level crossing specificities and supported with SAFER-LC domain knowledge. SAFER-LC will facilitate real life experimentation with the cooperative perception basic service thus contributing to the validation of the new facility extension of the fundamental Day 1 V2X services.

Based on SAFER-LC technology experiences Commsignia will contribute to the technical specification of the new Urban Rail CBTC communications technology in harmonization with road ITS communications. This item belongs to strategic part of standardisation in various SDO's work program (ETSI, IEEE, ISO, CEN) where Commsignia takes part as contributor.

The company's training and support team will incorporate the required knowledge and materials to aid customers with applying these features in their daily practice. The project will allow Commsignia to continue and extend research on safety enhancement technologies based on cooperative vehicle and infrastructure communication.

By using SAFER-LC knowledge, Commsignia is preparing for the future automated transportation to supporting the safe, reliable, efficient, and cost-effective integration of automation into the broader multimodal surface transportation system in which rail-road interoperability will be a primary condition.

5.14.IRU

IRU Projects is a Belgian non-profit legal entity established to support the road transport industry to reach the goals of sustainable road transport, increased road safety and security. By working closely with the International Road Transport Union and its members present in over 100 countries, the voice of more than 3.5 million companies operating mobility and logistics services, IRU Projects will use its communications channels and its large network of national associations across the globe to make sure road transport professionals are aware of the outcome of the SAFER-LC project. The toolbox gathering all the information produced during the project will be presented to the relevant internal commissions tackling technical and road safety issues. IRU will urge the road transport sector to adopt the proposed innovative solutions suitable to road users. Training material and activities will be developed in partnership with the IRU Academy and its associated training institutes (ATIs) to ensure the tools conceived by the consortium are used in the most efficient manner by road

transport operators on a daily basis. Recommendations on adjustments of the legal framework to implement the suggested solutions will be actively supported by IRU at international and European level, as well as by its members nationally. It will also be in the interest of IRU to promote harmonised measures at all European level crossings. Parts of the outcome of SAFER-LC will be re-used in future projects, especially in those dealing with cooperative ITS and road safety matters. Besides, the close cooperation between IRU Projects and CEDR – The Conference of European Directors of Roads – will also ensure that road infrastructure managers implement and benefit from the results produced during the project life span.

5.15. SNCF

SNCF is interested in research and evaluation of safety enhancement of trains, rail vehicles and other technology related systems and especially methods and technologies connected to the level crossing domain. Depending on the nature of requirements and SAFER-LC proposals, SNCF will carry out tests on rights of way outside the national rail network in order to propose an SIL 4 system, to demonstrate data security and safety satisfying both national and international specification and requirements.

5.16. DLR

Due to the ongoing plans in Germany to reactivate rail lines in rural areas, the development of innovative and cost-effective measures to increase the safety of level crossings, in particular of passive level crossings, is of great relevance. The reactivation of rural level crossings causes considerable costs and hinders traffic projects. The planning and provisioning process of already established technical safety systems for level crossings takes a long time and is very expensive.

Especially with an eye on precarious economic situations of many rural municipalities all over Europe, there definitely is a demand for innovative low-cost measures to enhance safety at level crossings. As a part of the project SAFER-LC, concepts of such systems were collected and newly invented in WP 2.3 and evaluated in WP 4.3. The market for the distribution of innovative low-cost safety systems is huge, since it comprises all countries with railways and level crossings. Promising measures could be patented and be part of future technology transfer projects from science to industry. Based on patents, licenses could be granted to industry partners that generate dues for research partners. These dues could be a basis for further research activities in the field of traffic safety.As an example, the empirical data base concerning the beneficial effects of the peripheral blinking lights (PeriLight), a low-cost LC safety solution developed at the DLR, on road user behaviour could be significantly broadened in the course of the SAFER-LC project. Moreover, the solution could be made known to a professional audience in conferences as well as through materials produced in the project. This greatly increases the chances that the solution will be further tested and employed in rail-road safety practice.

Concerning the academic exploitation, DLR has contributed to the dissemination of the of the SAFER-LC results in various ways. Beyond DLR’s contributions to various SAFER-LC deliverables, the SAFER-LC toolbox and accompanying materials that were distributed in connection with the SAFER-LC Conferences (Mid-Term, Final), they engaged in the publication of results in the framework of conferences (e.g. German Rail Human Factors Workshop, ERTRAC Road Safety Workshop, TRA2020) and journal articles (e.g. Der Eisenbahningenieur). The project was also used

to contribute to university education, with three student works completed in conjunction with the pilot studies done in SAFER-LC. The exploitation of results in the form of journal publications will be continued after the duration of the project, with three articles that are currently in preparation envisaged for submission in practice-oriented (e.g. Der Eisenbahningenieur) as well as academic journals (e.g. Accident Analysis and Prevention, Traffic Research Part F).

Based on the findings and competences generated in SAFER-LC, DLR has been able to further improve its competence and broaden its knowledge base in the field of human factors in transportation systems. The visibility of the project all over Europe has improved the chances to acquire future projects and have an impact on the scientific community.

5.17. UTBM

UTBM develops a smart detection system (with the cooperation of CEREMA) composed of specialized hardware and software. Depending on the actual TRL achieved it is intended to patent the system and the possibility of knowledge transfer will be examined for further industrial exploitation. UTBM develops a video-based risk evaluation system. Industrial transfer should be operated in collaboration with SAFER-LC and/or external partners. Obtained results and capitalized experience should be exploited to extend the approach in other environments like pedestrian crossings, route intersections, etc.

6. CONCLUSIONS

This document was an incrementally advancing deliverable of the SAFER-LC project which evolved with the project lifetime. It describes the way how the consortium as a whole but also each individual participant envisions the exploitation of its own involvement and the results what is expected to achieve. This final Month 36 release of the deliverable is the last of the series of iterative editions of this plan. Each SAFER-LC partner is aware of the importance of the efficient exploitation of the results and have action plans for it.

The execution of the exploitation plans will bring a high potentiality for the developed SAFER-LC solutions, the technological developments introduced during this project and a new environment for safety measures of low cost that can be utilised in areas where traffic is less dense but safety remains the top priority. The solutions were evaluated and thus the effectivity and efficiency of the measures is estimated. The economic evaluation can provide the framework and realistic examples of the cost efficiency for the decision makers. Last but not least, the toolbox provides all the information necessary for relevant stakeholders to get the correct decision, compare similar safety measures and choose the best well-suited one related to the specific circumstances and needs for each specific case.