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Document Abstract:	Based on the SELCAT work packages WP1, WP2, WP3 and WP4 this document provides an overview of the project results.

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Executive Summary

The SELCAT (Safer European Level Crossing Appraisal and Technology) Coordination Action was launched on September 1st, 2006. Its main objective was to collect and disseminate knowledge related to level crossing risk appraisal, technology and methodology.

The level crossing risk appraisal addresses, in particular, methods for safety performance monitoring thus enabling the evaluation of the main operational risks of different kinds of rail/road crossings. It was based on an overview of related EU and national funded projects dealing with safety performance monitoring. The information collected in the context of the level crossing appraisal aspect of the project led to the development of suitable approaches for comparison of operational risks between countries involved in SELCAT as well as between different level crossing types. The scope of the comparison has been extended to the legislative framework related to level crossings in the countries involved, covering both the rail and road sectors.

A key objective of the SELCAT project was the requirement to provide a study of advanced technologies which could then be used in practice for the reduction of existing risk. As a first step an overview of the relevant advanced technologies was produced. A generic functional model of the level crossing system was then developed to allow a structured classification of the level crossing technologies on one hand and for investigation of their potential for risk reduction on the other. Advanced technologies were evaluated in relation to their capability of implementing additional functions of level crossing protection systems or to extend existing systems. Further activities focused on the evaluation of results of a specific case study on obstacle detection and on the integration of this technology into railway operational processes. At the same time measures for promoting the human awareness of safety at level crossings were investigated. These were based on the psychological aspects of human behaviour on the approaches to level crossings.

Technological solutions offering optimum performance are supported by the application of special evaluation methodologies which take into account all relevant factors such as costs, performance or technological safety requirements. The activities related to level crossing methodology were collated and analysed in conjunction with the different approaches used around the world for level crossing risk evaluation including methods of risk comparison. These took into consideration any relevant country-specific characteristics. As a result a generic level crossing risk model was developed and suitable level crossing risk scaling factors recommended. The efficiency of the measures studied was investigated in the context of the methodology of the cost-benefit analysis. The use of such an analysis was demonstrated taking examples of two technologies.

Based on the project results, recommendations were formulated both for future activities and research (eg in the context of FP7) and for possible standardisation proposals aimed at harmonising the assessment and management of level crossing risk.

The crucial prerequisite for the collection of relevant information in the form of documents or statistics was the design and development of a knowledge based level crossing web portal. Its ontology-based implementation features provided for an effective and easily accessible knowledge management system. Its functionality provides a tool for international level crossing safety performance monitoring in accordance with the Railway Safety Directive.

All this work was accompanied by dissemination activities informing the public about the project's achievements, involving experts outside the consortium in the project work. This included the organisation of public SELCAT workshops and special sessions at leading conferences in parallel with the development of a draft information campaign for road vehicle drivers.

With the current projected levels of growth of both road and rail traffic, the project identified that the risk potential at the road/rail interface will also grow and whilst grade separation should be the long term aspiration, it is only a matter of time before the key players (road, rail, enforcement, EC, state governments…) must come together to address more immediate risk control options in a joined up way.

To contribute to the development of this the SELCAT consortium agreed that development of a cross-sector strategy for level crossing risk in Europe is necessary. Such a strategy would facilitate a greater understanding of the roles and responsibilities and the risks that the various actors are required to manage and how these can be brought together to the mutual advantage of all the key players.

This report contains a detailed overview of the activities and achievements of the SELCAT coordination action.

1 Summary of Achievements

The SELCAT coordination action aims at establishing a knowledge platform for raising the awareness of and the effective reduction of risk at the road/rail interface. The consortium was composed of leading groups from the level crossing operational and research domains. During the project duration the following main achievements were recorded:

- Creation of a widely accessible SELCAT level crossing web portal populated with more than 200 level crossing related documents and country specific statistics covering more than 10.000 level crossing accidents related to 70 national specific level crossing types
- Structured overview of nine European and 70 national funded projects dealing with level crossing risk appraisal and safety performance monitoring in the rail and road sectors in relation to level crossings
- Comparison of the existing level crossing risk made, based on national accident statistics of 13 countries
- Results of analysis of level crossing related legislation involving eight SELCAT member countries
- Development of a generic functional level crossing model allowing the investigation of operational and safety impacts related to the introduction of new technologies
- A structured overview of 40 projects dealing with the application of advanced level crossing technology for level crossing risk reduction
- Recommendations on the promotion of awareness of level crossing users and organisations based on the identification of mutual information gaps
- Proposal for a future level crossing safety system involving advanced technology of radio communication and train positioning
- Overview and classification of worldwide approaches of level crossing risk evaluation methods
- Results of analysing the appropriate scaling factors applicable for the comparison of level crossing accident statistics
- Implementing scaling factors into the SELCAT level crossing web portal to allow for the comparison of individual and societal level crossing accident risk (in accordance with the European Rail Safety Directive) applicable for level crossing safety performance monitoring
- Overview of cost benefit analysis methodologies including exemplar application on obstacle detection technology
- Preparation and publication of a proposed European Strategy for the reduction of risk at the road/Rail interface

All issues required the collection of a very considerable corpus of information from different countries with differing rail/road crossing protection philosophies. In order to establish a common communication language a harmonised information structure has been adopted and used during the project. This was also implemented in the SELCAT web portal.

The achievements outlined have been documented in form of project deliverables accessible directly on the afore-mentioned web portal (www.levelcrossing.net).

2 Detailed overview of the project activities

2.1 Introduction

The ‘SELCAT’ (Safer European Level Crossing Appraisal and Technology) Coordination Action responded to the call of the 6th Framework Programme of the European Commission in the area of ‘Sustainable Surface Transport Coordination Actions’, to meet the objective of ‘Increasing road, rail and waterborne safety and avoiding traffic congestion’. It aimed to contribute actively to the reduction of level crossing accidents by the:

- collection, analysis and dissemination of existing research results and the stimulation of new knowledge exchange in the area of safety at the road/rail interface,
- creation of circumstances whereby European partners, in the rail and road sectors, can make a significant contribution to the reduction of accidents, injuries and fatalities at level crossings,
- understanding and codifying of existing and planned research,
- comparison and harmonisation of data sources,
- exploration of new technologies and harnessing appraisal techniques to optimise these.

The SELCAT consortium, led by the Institute for Traffic Safety and Automation Engineering of the Technical University of Braunschweig, Germany, integrated 25 partners from 14 countries from Europe, Asia and Africa (see Figure 1). Among them were universities, research institutes, road and railway organisations as well as railway infrastructure managers. The SELCAT consortium collaborated closely with the European Railway Agency (ERA).

Fig. 1: Countries involved in the SELCAT project

The activities of SELCAT were designed to lead directly to the improvement and expansion of inter-modal collaboration between the road and rail sectors. The information collection, exchange and comparison was facilitated by the creation of a 'Level Crossing Web portal'. This resulted in an effective and accessible Level Crossing Knowledge Management System (KMS) to facilitate the broad dissemination of safety and level crossing related research activities investigated by SELCAT.

2.2 Project structure

All the coordination activities of SELCAT were focused on an increase in awareness of safety at the road/rail interface addressing all possible influencing factors. The first factor was learning from the current 'state of the art', including an overview of the present status of level crossing accidents statistics and research completed during FP5 and FP6, which is relevant to the areas of rail and road transport safety (WP1). The second influencing factor was an examination of advanced technologies that could be applied to reduce the number of level crossing accidents (WP2). The third critical factor was the need to understand how well-aligned expenditure on level crossing upgrades is to operational risk evaluation, system safety, performance and cost-benefit analysis overall (WP3).

Figure 2 shows the relationship between the work packages (WP).

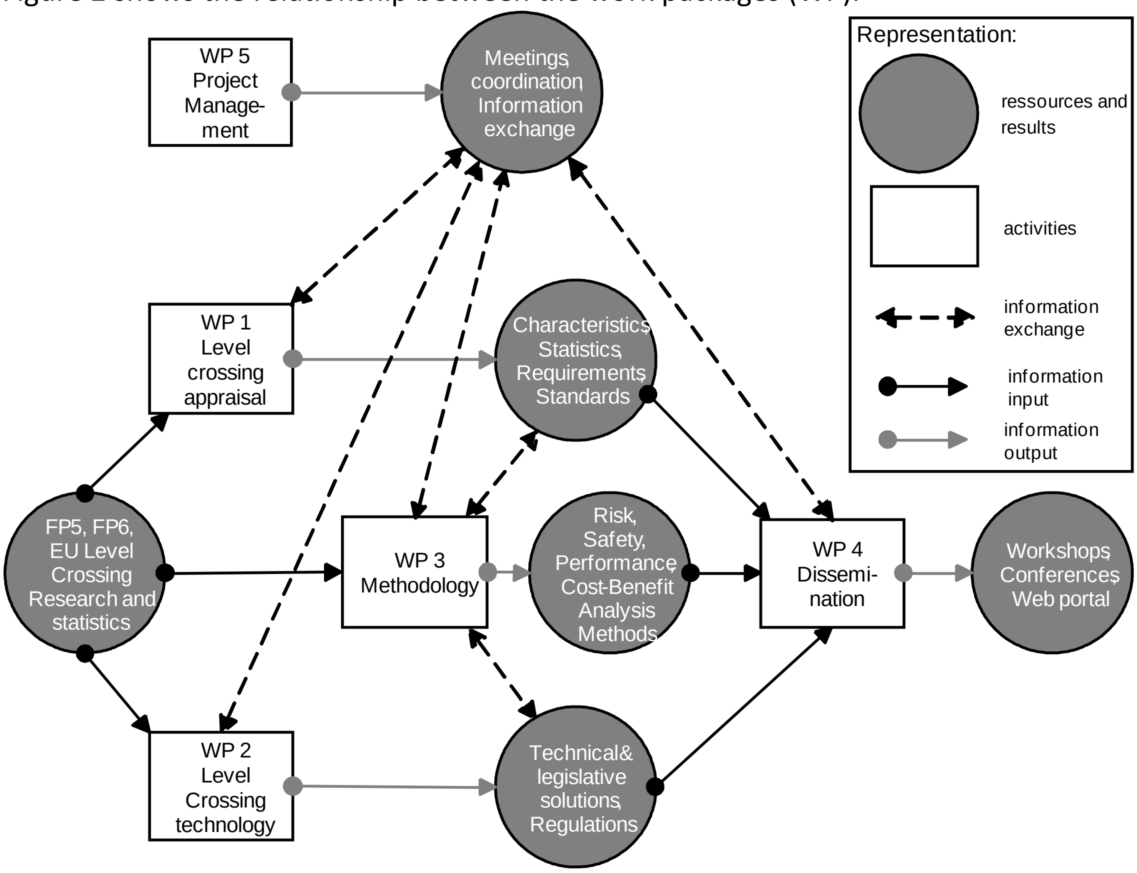

Fig. 2. SELCAT project work structure

A detailed evaluation of level crossing operational risk could only be based on the national statistics coming from the different SELCAT partners. The application of existing European statistics (eg EUROSTAT) has been shown as unusable as they do not possess the required level of detailed information. The same problem occurred when most official national statistics sources were analysed.

Any kind of statistics collection and comparison required harmonisation of their sources. Therefore one of the challenges facing SELCAT has been the need to design a universal platform allowing the integration of statistics from different partners related to different national specific level crossing types. The chosen approach took level crossing functionality as the basic structural element.

Structuring the level crossing functionality was based on a generic approach. A Level Crossing (LC) was generally seen as an intersection between railway and road traffic flows (basic dynamic or functional LC aspects) where unsafe physical interactions must be prevented by the operational functions of the level crossing safety system (whether static or physical LC aspects). In order to describe the static LC aspects, the generic approach identified four basic operational functions (to detect, to inform, to warn and to protect) on both traffic approaches (see figure 3). The basic functions were further refined eg the function ‘to warn’ was further split according to its general realisation process (audible, visual, physical).

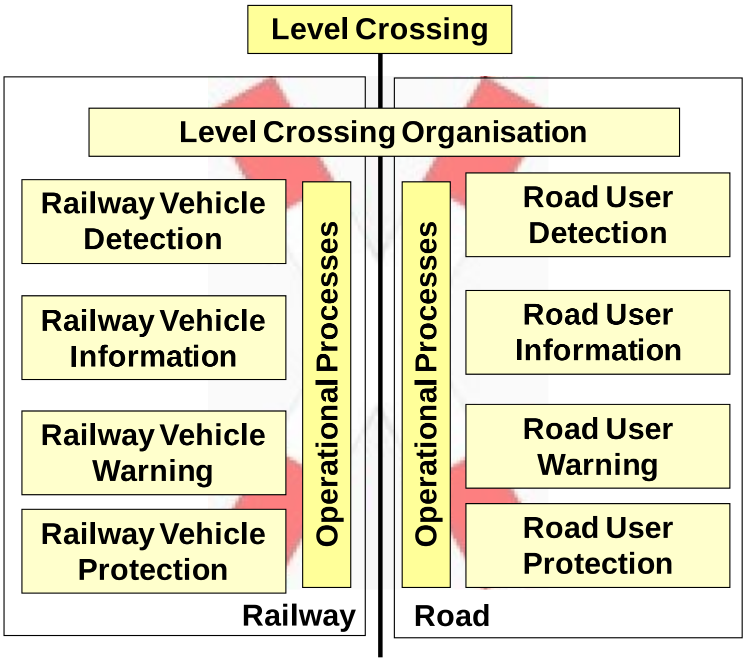

Fig. 3. Functional decomposition of a level crossing system

The dynamic aspects of the level crossing were covered by the definition of the operational condition of the traffic flows. The temporal aspects of the safety procedure of a level crossing could be integrated in this way. Beside the static and dynamic aspects, a major part of the domain knowledge concerned the organisational aspects that also include design and construction laws and standards.

2.3 WP1: Level crossing appraisal

The goal of WP1, led by the International Union of Railways (UIC), was to provide an overview of existing and planned European level crossing research, the actual risk at level crossings, and a summary of the existing and relevant legislative backgrounds. Level crossing risk appraisal procedures address, in particular, methods of safety performance monitoring, and thus enable the evaluation of the main operational risks of different kinds of railway crossings. All the relevant information has been collected by the use of the SELCAT Knowledge Management System, based on a generic functional structure. A further refinement of the basic structure of static operational aspects was then undertaken to make the different approaches more specific (see Figure 4). The final refinement level is produced by a particular technological solution given by the level crossing type and the method of operation (automatic, manual).

The SELCAT KMS interface allowed the project partners to specify all national level crossing types using a predefined functional structure. In this way the common specification language, necessary for future risk analysis, was guaranteed.

Beside the interactive search, it was possible to define general level crossing types (basic types) on a more abstract level of functional definition. In the case of the abstract level crossing type, the user has to indicate the relevance of functions for his analysis (existing, not existing or irrelevant functions). Such abstract (metadata) level crossing types can be used for searches of groups of related particular types from different countries. As an example of such abstract level crossing types, the categories now being used by the European Railway Agency have been included.

The KMS allows each defined level crossing type to be linked to its related accident statistics. In particular it is possible to collected statistics on:

- the accident severity (fatalities, serious and minor injuries),
- the kind of accident (car, bus, bicycle, pedestrian, etc), and
- the accident causes (external, internal, technical, human factors).

Accident statistics for each reference year can be refined specifying the kind of transport and accident causes. Figure 4 shows an example of such a refinement of accident statistics for Automatic Half Barrier (AHB) level crossings in one of the member countries for the year 2004.

add/change statistic data @ Safer European Level Crossing Appraisal and Technology -Netscape

Statistics for *Safety Management Information System (SMIS)*

LC types:	AHB
Year:	2004

Means of transport

	accidents	fatalities	serious injuries	light injuries
all:	7	9	10	28
cars:	3	8	10	27
buses:	0	0	0	0
heavy vehicles:	0	0	0	0
cyclists:	1	0	0	1
motorcyclists:	0	0	0	0
pedestrians:	1	1	0	0
agriculture vehicles:	0	0	0	0
animals:	2	0	0	0

Accident causes

	accidents	fatalities	serious injuries	light injuries
technical causes railside:	1	0	0	1
technical causes roadside:	0	0	0	0
human causes railside:	0	0	0	0
human causes roadside:	4	9	10	27
others:	2	0	0	0

print | Close | delete statistic data

Fig. 4. Example of level crossing accident statistics entered into the KMS (source: RSSB, UK)

The first analysis of operational level crossing risk was carried out based on the abstract level crossing types defined by the European Railway Agency for the purpose of defining Common Safety Indicators [8]. The principal differentiation defines an active level crossing as a level crossing where the crossing users are protected from, or warned of, the approaching train by the activation of devices when it is unsafe for the user to traverse the crossing. In the case of Automatic active level crossings (A.1), these devices are activated by the approaching train. Manual active level crossings (A.2) are activated by humans, where there is no interlocked railway signal to control train movements. In the case of passive level crossings (B), there is no form of warning system and/or protection system showing when it is unsafe for the user to traverse the crossing.

For the chosen normalisation, the typical number of vehicle interactions on level crossings has been estimated based on the volumes of rail and road traffic (road vehicle and train kilometres $V_{RoadVkm}$, V_{Tkm}) moving on networks of particular lengths (rail L_{RailN} and road L_{RoadN} networks) and given a particular number of level crossings (of different types). These considerations have led to the country specific scaling factor given by:

$$sfi_{LCtypeCountry} = \frac{V_{Tkm} V_{RoadVkm} N_{LCtype}}{L_{RailN} L_{RoadN}}$$

The comparison of level crossing operational risk of the EU countries analysed using this scaling is shown in Figure 5. It is immediately apparent that the operational risk of level crossings in Eastern European countries represented is significantly greater than the risk in Member States from Western Europe.

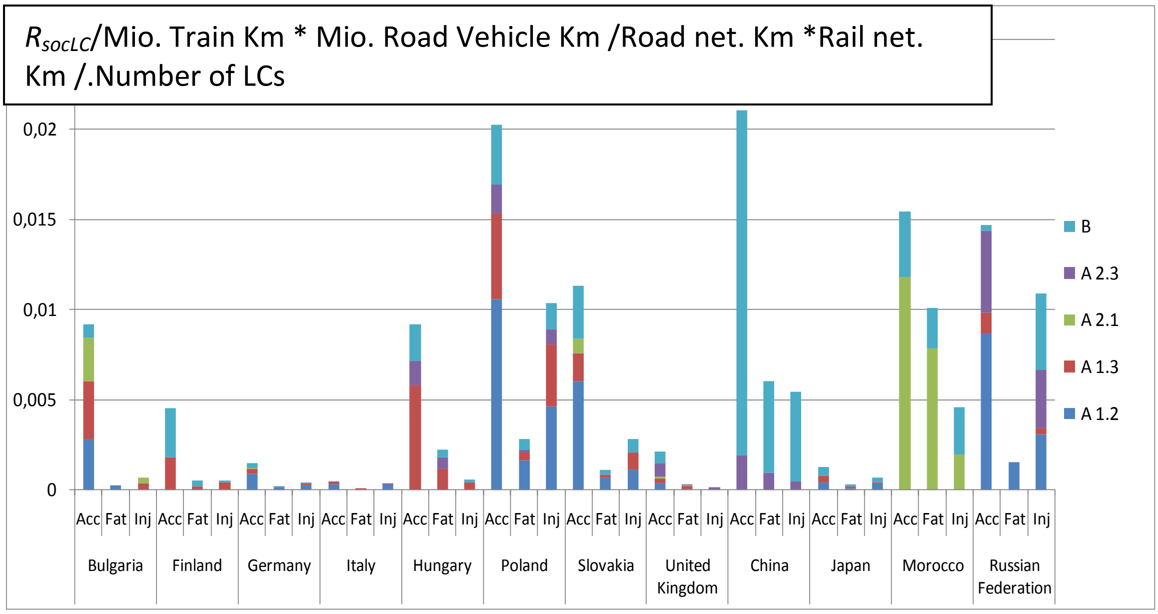

Fig. 5. Comparison of accident statistics scaled by vehicle interactions

According to the results of work package 3, dealing with the methodology of risk evaluation and comparison, the use of level crossing type populations is appropriate for the scaling of level crossing accident statistics. Results of such a comparison are shown in figure 6.

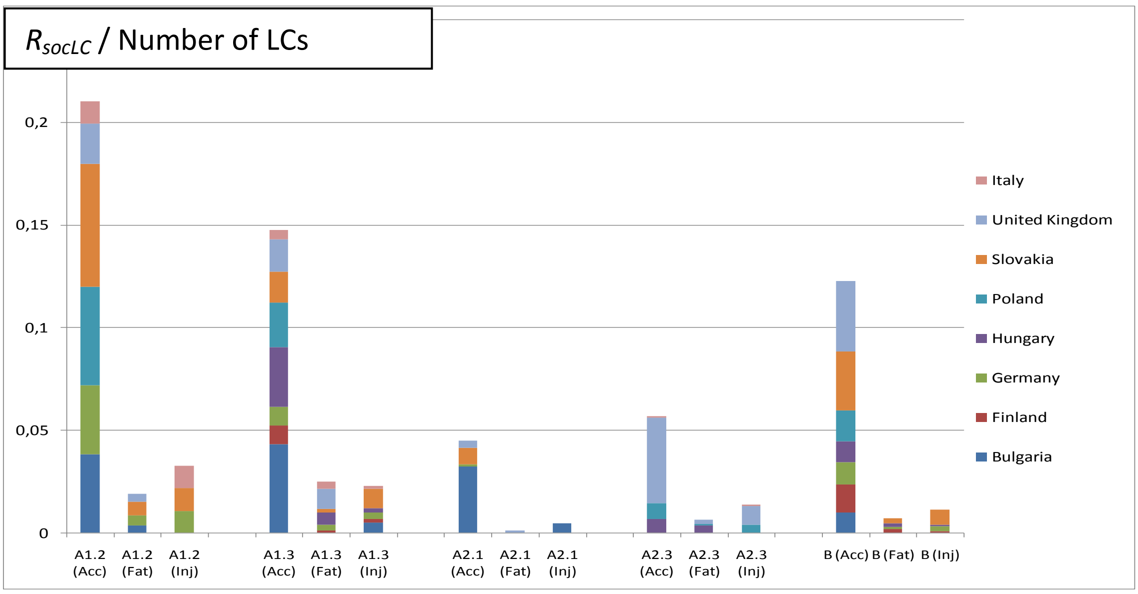

Fig. 6. Comparison of accident statistics at different types of level crossings scaled by level crossing type population (EU).

Figure 6 reveals that by studying the accident statistics of the participating European countries, automatic level crossings with warning lights but without barriers are associated with the highest operational risk.

Beside the comparison of operational risk, SELCAT also provided a legislative overview of level crossing operation as well as on national and/or railway company specific rules for equipment with technical warning and protection devices.

Information concerning the relevant legislative framework (general national law, national traffic laws and regulations, railway laws and regulations, road laws and regulations, standards and guidelines for railway companies) was collected. Secondly, information on relevant speeds, times and rates for level crossings defined by the given laws and regulations was gathered. On the basis of the collected information data the responsibilities for level crossing accidents was compared.

The only existing legislative basis found at an international level, from the road sector, is the Vienna Convention on Road Signs and Signals[1]. This is an international treaty designed to increase road safety and aid international road traffic by standardising the road signs, traffic lights, and road markings in use internationally.

Although the Vienna convention has been successfully implemented in the road sector, as can be observed throughout Europe, the level of harmonisation relating to level crossing signage in the 40 years since the convention was published, has been limited. The main reason for this development is probably the fact that level crossing signage has not being seen as an important issue by the road sector. The principal responsibility for the installation of technical level crossing equipment by railway organisations has led to independent developments of the signage in the various European countries. Typical examples are the different forms and colours of the St. Andrews cross signs or the use of amber-red steady warning light in some European countries which are not in line with the Convention's articles. Based on this inequality, the SELCAT consortium recommends revision of this convention to take into account the actual situation applying to level crossing legislation in the different Member states.

2.4 WP2: Level crossing technology

The main goal of WP2, led by the French National Institute for Transport and Safety Research (INRETS), was to analyse the relevant national and European projects that have identified new technologies for the improvement of level crossing safety. The aim of this work package was to provide a study of particular technological solutions to reduce the numbers of accidents at level crossings.

The first task of WP2 was to provide a suitable generic functional model of a level crossing, which could be refined according to the particular implementation technology in use. The model is to be used predominantly for defining interfaces between existing and potential technologies for operational risk reduction. The model consists of a hierarchical structure of functions, and a series of flow diagrams showing their mutual dynamic dependencies. Figure 7 shows the function hierarchy at the general level, which is the basis for type-specific functional refinements.

[1] Convention on road signs and signals done at Vienna on 8 November 1968, Economic Commission for Europe, Inland Transport Committee, 1968, http://www.unece.org/trans/conventn/signalse.pdf

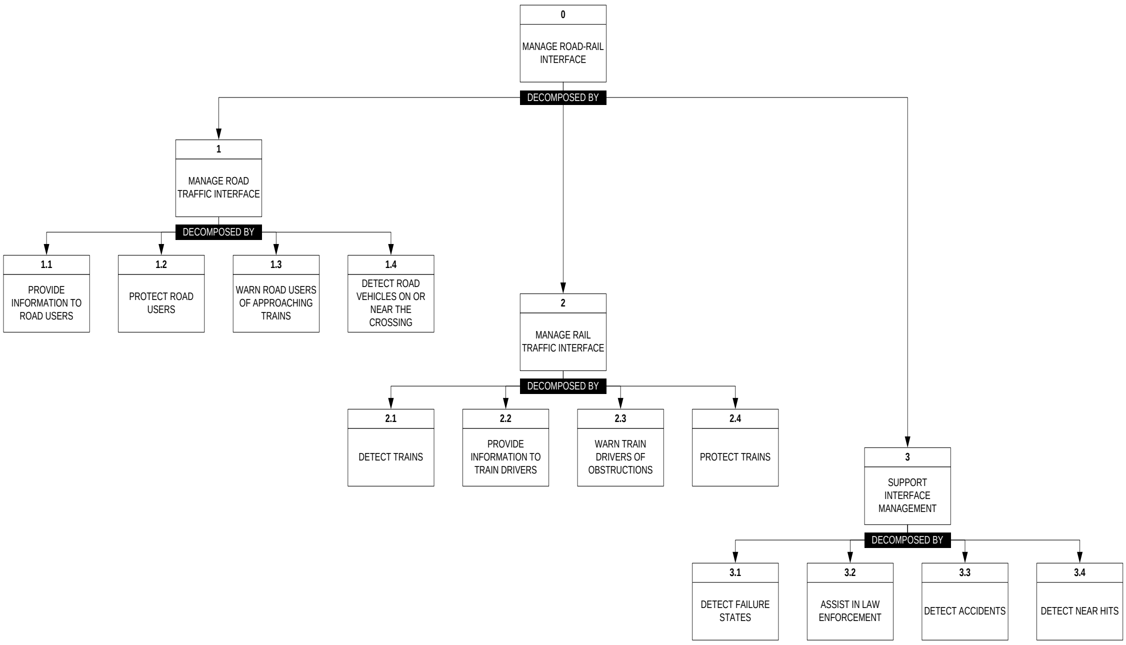

Figure 7 Upper layers of generic functional model of level crossing

The modelling process is extended by an example showing the application of the generic functional modelling for the investigation of impact of introducing a new function (obstacle detection) to an existing level crossing safety system. In another example it was demonstrated how a functional model implemented by a formal description language can be used for level crossing risk analysis and the definition of safety and availability requirements in the components of a technological solution.

The technological basis for the study was an analysis of the results of the projects funded by the 5th and 6th Framework programmes of the European Commission. This focused on projects dealing with advanced technologies for ground transport applications. Special interest was paid to safety critical application systems with man-machine interfaces and low-cost implementation requirements. After analysing the available FP5 and FP6 information, only two projects related to the objectives of the SELCAT work package could be identified.

In addition to the investigation of technologies considered by European funded projects, the survey was extended to cover activities carried out at the national level. Two questionnaires were designed and sent to all SELCAT partners as well as to third parties. In total information on 40 national projects were collected, and in the main most of these projects originated from non-European countries. The information on projects was documented in the form of a matrix of technologies in short project descriptions available also in the knowledge management system in the SELCAT web portal allowing the use of search functions based on representative keywords. The figure 7 the overview matrix, which classifies the projects according to the particular level crossing functions investigated, is shown.

Figure 8 Overview matrix indicating level crossing functions focused on national technological projects

Obstacle detection was also the subject of deeper investigations in the context of a technological case study. The solution investigated was based on video analysis technology use of which is currently possible at relatively low purchase costs. How this technology can be integrated into the railway operation process was also considered. The proposal also contained information about further advanced technologies making use of satellite positioning systems and radio transmission of information. Figure 8 shows one operational situation demonstrating the application of this technology.

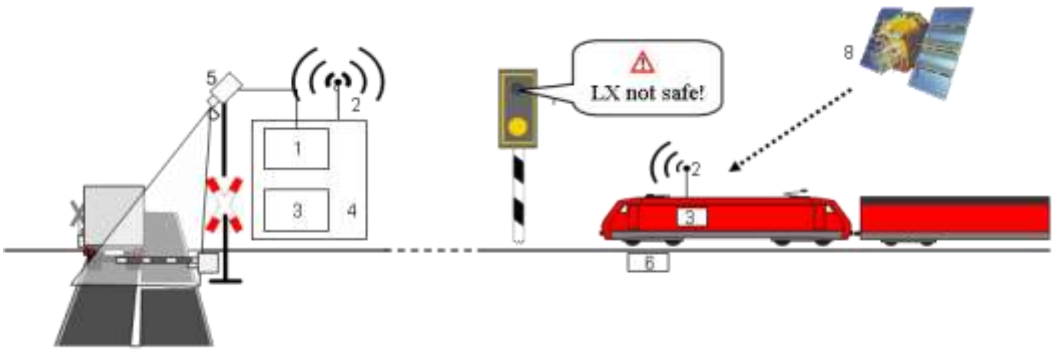

Figure 9 Possible integration of advanced technology into railway operation process

A further task had the objective of extending the study by providing a set of recommendations to suggest how to increase users' human awareness and compliance with the level crossing safety system. As a basis for the recommendations all interfaces between the human players at the level crossing (road user, supervisor and train driver) and the level crossing safety system were identified (Fig. 10). A thorough analysis of the interfaces identified (based on the theory of situation awareness) allowed the identification of the impact of the potential technologies and the creation of recommendations on how the technology should be implemented in order to produce the highest efficiency levels. In addition, the recommendations were generalised in terms of human factor oriented principles applicable to the design of information and communication technologies for level crossing systems.

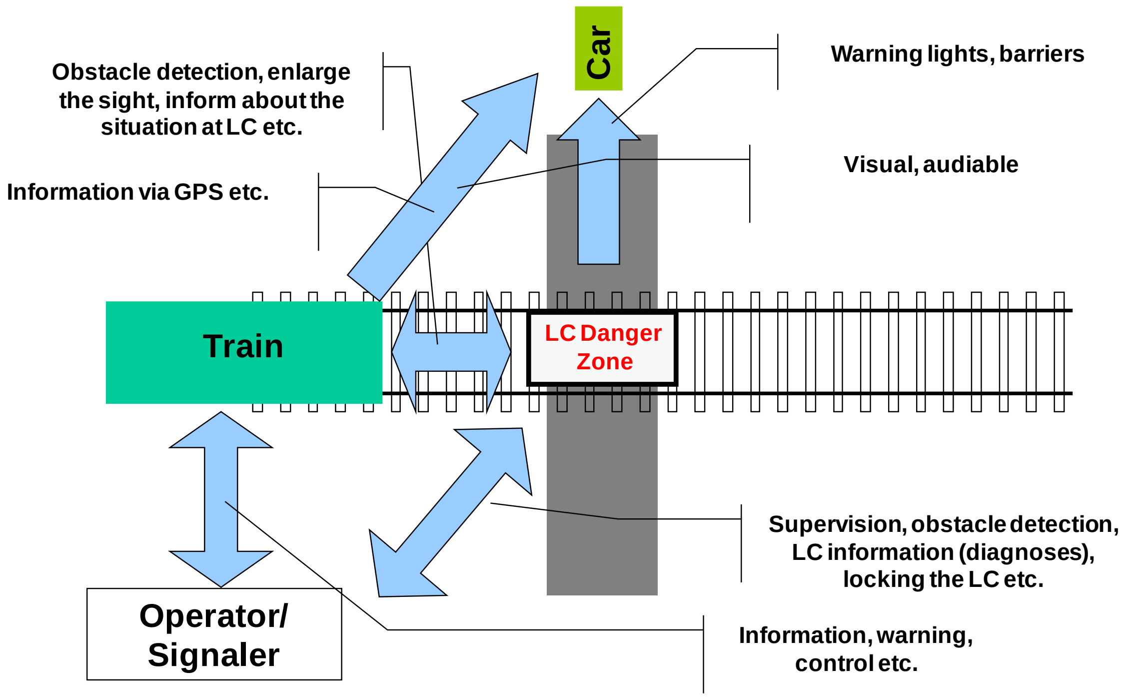

Figure 10. The basic actors and interfaces on a level crossing

2.5 WP3: Level crossing methodology

The objective of WP3 was to identify the different types of modelling techniques that could be used to analyse level crossing risk (including their dependence on manufacturing and operational costs). The main output expected from such modelling techniques is the ability to identify the key activities required to reduce level crossing risk and costs, as well as to define the necessary system architecture for level crossing protection systems. Different countries have different types and numbers of crossings; different degrees of level crossing safety risk; different traffic volumes; and varying cultures, including attitudes to risk and road and rail safety. Accordingly they have different approaches, practices and legislative frameworks for managing risk. Twenty three approaches to level crossing modelling and assessment have been identified across twelve countries [9].

These approaches have been categorised according to the four main types of algorithm used:

Parameter Gate	**PG**	Approaches using simple parameters as decision guides for the selection of appropriate levels of protection. These are not 'models' as such since there is no prediction of risk
Simple Weighted Factor	**SWF**	Building on PG, these models provide some indication of the relative risk contribution of each parameter using simply defined weightings
Complex Weighted Factor	**CWF**	A more complicated derivation of weightings for parameters is used than SWF
Statistically Driven Approach	**SDA**	In contrast to other approaches, these models are based on statistical techniques to determine weightings (often empirical power relationships) for parameters

Table 1: Main types of algorithm used for categorization of level crossing risk modelling

The approaches based on statistically driven approaches have been identified as most suitable. Their application, however, is conditioned not only on whether the statistics are available, but also on the creation of a risk evaluation tool suitable for assessing the impact of different operational aspects. Based on the findings obtained by the analysis of the national approaches to level crossing risk modelling, a proposal for a level crossing risk model was developed. The model considers generic causes and consequences of level crossing accidents.

As an example the Automatic Half Barrier (AHB) crossing was chosen. This type of crossing was selected as it has wide application across Europe and it also presents a wide range of accident causes. On this basis a generic model prototype was developed which can be adopted at any particular site specific AHB crossing. This risk model can be used for an assessment of the site-specific risk at level crossings and quantifying the benefits from possible level crossing safety improvements. Within the model the causes of accidents are separated into four types: deliberate misuse by road users (see figure 11), road user accidental misuse, equipment failures and signaller/crossing keeper error. Within each type a full range of specific causes are assessed.

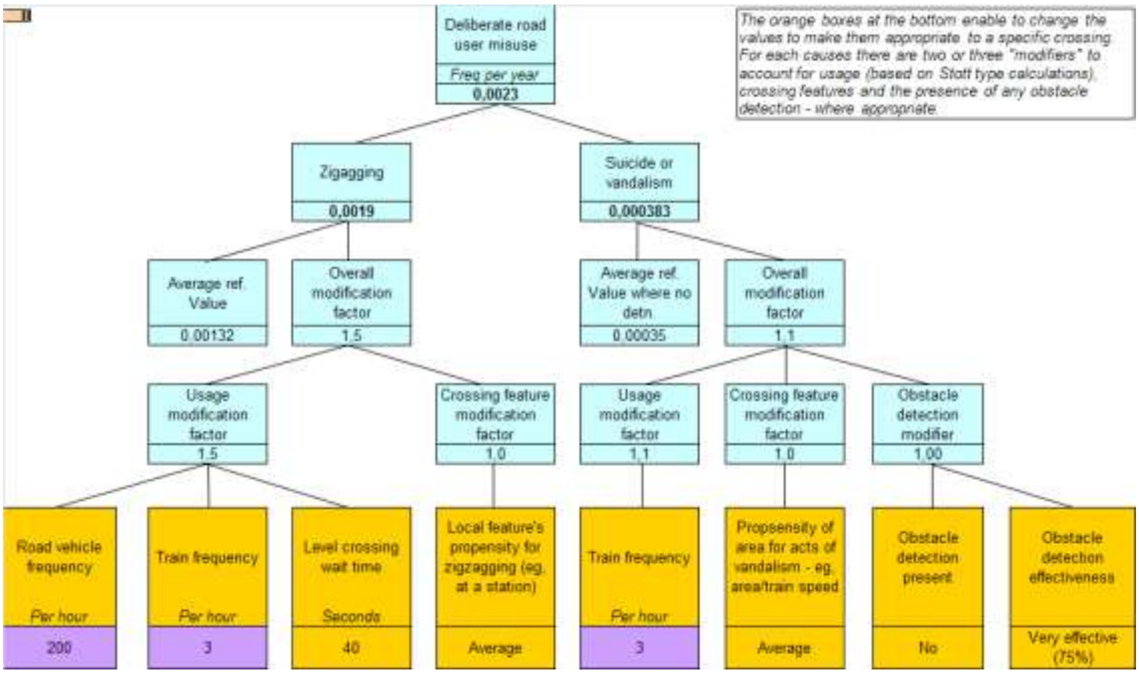

Figure 11 Risk frequencies modelling on example of deliberate road user misuse

There are three components to the model, one section that assesses the cause and frequency of trains striking road vehicles at level crossings, another which investigates how an event may escalate, eg, whether there is a subsequent derailment, collision or fire and finally a section that estimates the number and severity of injures to both train occupants and road users (see figure 12).

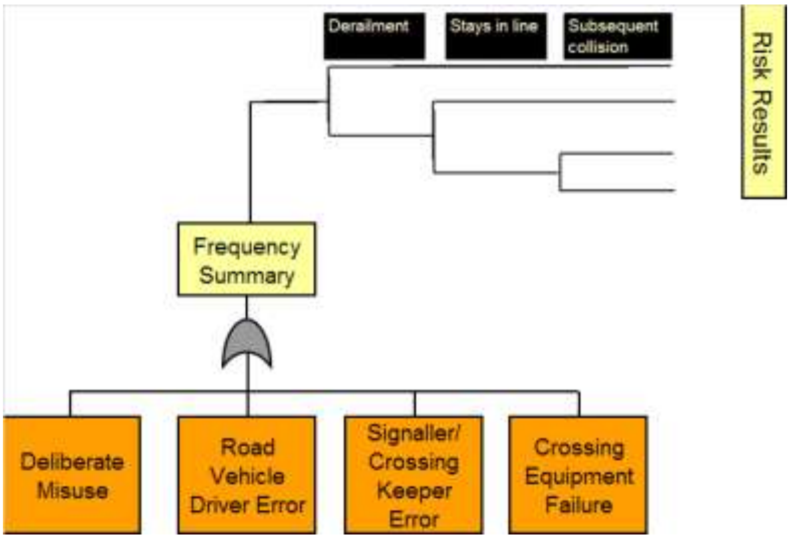

Figure 12 Illustration of the three main elements of the SELCAT level crossing risk model

It is recognised that level crossings of the same type but at different locations can present widely different levels of safety risk due to the local features of the crossing.

Such features include the type and frequency of traffic, the number of passengers on the trains, the train speed and details of the approach to the crossing. Hence the model has been developed so that the user can enter details of a specific level crossing and ensure that the risk estimate reflects the specific crossing under consideration.

The model draws on a wide range of sources of data, including prior research and existing UK and overseas risk models. In order for the model to be utilised by a particular member state, it would need to be customised to reflect the member state's operating experience and ensure that a range of underlying assumptions reviewed and verified. The model has been developed in form of an MS Excel file and is flexible for any adoption or extension. Guidelines allow the users to apply and quantify the model basing on their specific operating conditions.

As a part of level crossing risk modelling the methods for the comparison of level crossing accident statistics have been investigated. The investigation concerned measures of the individual and social risk required for safety performance monitoring by the Railway Safety Directive of the European Parliament. This focussed on the scaling factors which would allow non discriminatory comparisons of the level crossing safety performance of member states. The activity was carried out in collaboration with the European Railways Agency taking into account the recently published Recommendations on the common safety methods for calculation, assessment and enforcement to be used in the framework of the 1^{st} set of common safety targets (ERA REC 01/01-2008/SAF). Results of this work have been applied to the statistics collected as part of WP1.

The last task of WP3 was to investigate the applicability of the methods for Cost-Benefit Analysis for level crossing design and improvements concerning the introduction of advanced technologies. The task was initiated by an overview of methods dealing with efficiency evaluation. The main parts of cost-benefit analysis were identified: the analysis of the quantitative risk, economic analysis and social analysis. To demonstrate the use of the methodology, the example of automatic half barrier crossing has been, again, applied.

Extending the typical AHB crossing by the implementation of obstacle detection and traffic rule enforcement cameras has been investigated to understand the improvement in terms of cost-benefit. In the context of this practical application, led by TUBS, the potential of the use of formal modelling has been demonstrated. The formal model of the level crossing which was developed took into consideration the dynamic processes at the level crossing involving the behaviour of the train, of the road vehicle also, as well as of the level crossing safety system including the obstacle detection process. Applying the formal model, and the impact of the obstacle detection system's reliability to the level of accident risk can be investigated as shown on fig 13.

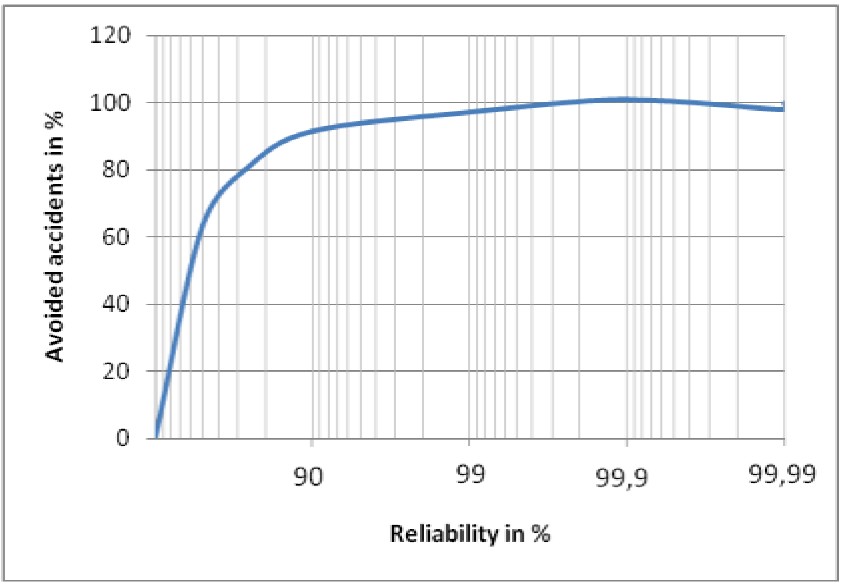

Figure 13 Relative proportion of avoided accidents to reliability of obstacle detection

2.6 WP4: Results dissemination

The goal of WP4 was to ensure the public dissemination of the SELCAT results. Along with the launching of a level crossing web portal, theme specific workshops and special sessions at theme-related conferences were organised. Further means of disseminating the SELCAT results was preparation of a prototype campaign for car drivers and other road users.

The SELCAT web portal has been continuously used for collection of level crossing related knowledge. In total more than 200 documents have been uploaded and classified by the members of the SELCAT consortium. Also the definition of more than 70 national level crossing types and 7 basic types were provided for. These have been then populated by level crossing accident statistics covering more than 2500 accidents from 13 countries involved in the project.

The documents and accident statistics are accessible just in the restricted area of the web portal. The agreed procedures for the increase in the number of web portal users should provide an expected benefit by making the project results available to a wider public. It is also planned to include all the SELCAT deliverables once they have been accepted by the European Commission.

During the SELCAT project three theme specific workshops were organised (May 2007 – Lille, November 2007 – Marrakech, June 2008 – Paris). The last workshop presented the draft final project results, and was organised in conjunction with the 10th International Level Crossing Safety and Trespass Prevention Symposium, (in Paris, from June 25-28, 2008) and gathered 90 participants from 25 countries from Europe, America, Australia, Asia and Africa. All presentations, together with related abstracts, and a report on the workshop discussions can be found in the public area of the SELCAT web portal.

Other international events were used to highlight the SELCAT work including the International Rail Safety Conference, Goa, India in October 2007, the plenary meeting of the European Transport Safety Council, Bern, Switzerland September 2008, the International Rail Symposium, Istanbul, Turkey in October 2008.

As a further dissemination product a campaign was produced to inform road vehicle users about relevant SELCAT results. With this aim seven level crossing related articles were published in the public web area of the ADAC (General German Automobile Club) [1]. Furthermore the articles have been provided to 30 partner clubs of ADAC which are actively operating in Europe. The articles have been disseminated in German and English.

Basing on the results of WP1 it was realised that there is a big variation of country specific highway rules concerning the level crossings of European member states. Their differences have even safety relevant characteristics (eg differences in the expected behaviour of vehicle drivers should there be a safety system failure). Therefore it was decided to produce a leaflet containing all the relevant information (fig.14). The leaflet will be made available after juridical consultation on national liabilities issues.

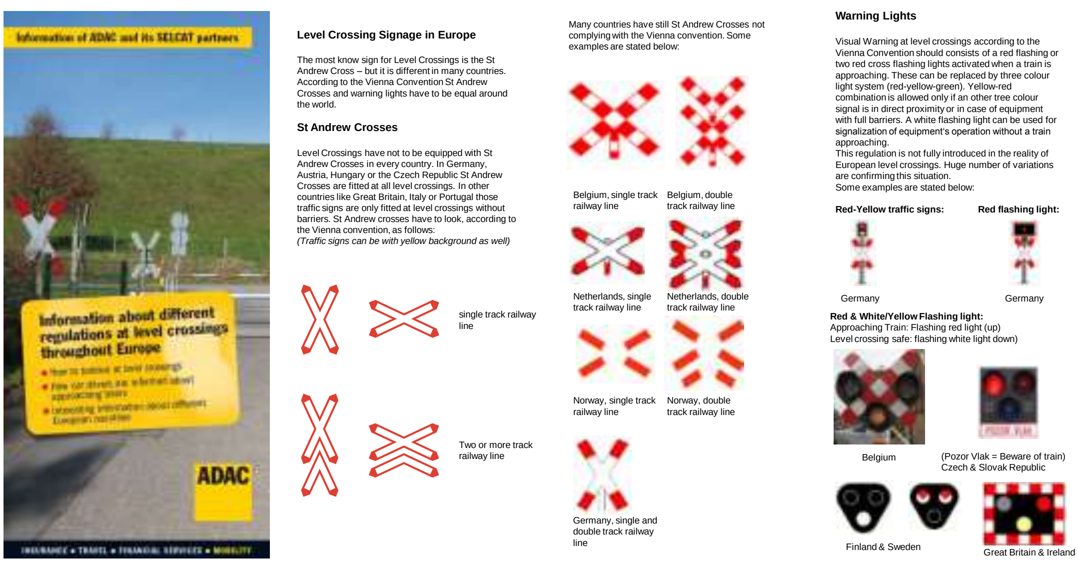

Figure 14 Leaflet proposal with information on European level crossing road side legislative

2.7 Transfer activities

From an analysis of the results of the SELCAT coordination action the following activities beyond the specific work packages have been carried out:

2.7.1 Recommendations for Framework Programme 7

Based on the conclusions drawn from the SELCAT project work packages WP1 (D1), WP2 (D2), and WP3 (D3 and D4) including the discussions at the three SELCAT public workshops (D6, D7 and D8), recommendations for further actions intended to improve safety at level crossings have been formulated. The recommendations have been developed around two major ideas: (i) use of advanced technological solutions designed to minimise the impact of human factors as the main cause of accidents at level crossings and (ii) a joint rail and road sector strategy to control and reduce risks at level crossings. The overarching conclusion was to conceptualise the different approaches within a joint strategy (see also section 2.7.3).

2.7.2 Recommendations for standardisation

Evaluating results and recommendations from the work packages has identified two areas with the potential for standardisation in the future.

The first item is based on the evaluation of level crossing legislation (WP1) during which it was realized that there are significant differences in road driver responsibilities between the member states. In particular the legislation of Eastern European countries requires the full personal responsibility of the road vehicle driver for their safe passage at level crossings. This applies even where that the level crossing is equipped with a safety system (such as warning lights or barriers). On the other hand in the majority of Western European countries the road vehicle driver can rely fully on the function of the safety system (where provided) and therefore does not need to be aware of an approaching train if this system is not activated (where the warning lights are not activated or the barriers are open). Following the tendency in some Western European countries (such as France, Germany or the United Kingdom) it is recommended that there is no need to provide a St. Andrew cross sign at such level crossings, because there is no need of any increased awareness of the road vehicle driver. In the countries, where this awareness is required despite the existence of the safety system, the St. Andrew cross should be further used on all level crossings types.

The second item concerns the evaluation of the level crossing risk. In order to provide similar safety conditions at all European level crossings it is sensible to harmonise risk assessment methodologies. Based on the conclusion that the statistically oriented risk modelling identified by SELCAT is the best risk assessment methodology, this should be widely adopted. Careful attention should be paid to the common set of information collected about level crossing operational conditions and on accidents which have occurred in the past. Such a list of relevant information could be the source of future European standards concerning the monitoring of level crossing safety performance.

2.7.3 European Road Rail Interface Strategy

With the current projected levels of growth of both road and rail traffic, the risk potential at the road/rail interface will also continue to grow and whilst grade separation should be the long term aspiration, it is only a matter of time before the key players (road, rail, enforcement, EC, state governments…) must come together to address the risk control options in a joined-up way.

To contribute to the development of this it is believed that development of a cross-sector strategy for level crossing risk in Europe is necessary. Such a strategy would facilitate a greater understanding of the roles and responsibilities of all parties and the risks that the various actors are required to manage and how these can be brought together for mutual advantage.

This concept takes forward the idea that the only real way to develop this is through a partnership approach between the rail sector, state governments and the EC, road authorities, the enforcement and regulatory agencies including police forces.

This is a model that as been successfully exploited at national level in, amongst other countries Australia, Canada, Sweden, the United Kingdom and the USA, and considered to be the way that momentum around this problem area can be generated at European level.

Development of such a partnership would:

- ✓ Enable a ‘European Road/Rail Interface Strategy’ to be created and implemented
- ✓ Be stakeholder led but with a strong input from the rail sector
    - o Stakeholders would manage those aspects best suited to their competencies
    - o The expertise of each stakeholder could be drawn upon as necessary, allowing the development and delivery of better programme(s)
- ✓ Engage road authorities and a range of other key players in all jurisdictions
- ✓ Be under the patronage of the European Commission

SELCAT’s analysis of the operational level crossing risk in the countries involved in the project shows that this risk can not be neglected and that new approaches to its reduction should be the object of further activities. In particular it is recommended to:

- Encourage society to recognise the bi-modality of the road/rail interface and work closely with the road and rail sectors and governmental agencies to help reduce risk levels at level crossings.
- Foster the continued development of joint research into safety at level crossings from both interfaces, building on the work of SELCAT and the European Level Crossing Research Forum.
- Promote the development of links with law enforcement agencies to cultivate a systematic approach to code of the route violations.
- Address road user behaviour through the introduction of measures which increase (education, campaigns, etc.) at the European level.
- Seek to harmonise the legislative background applicable to level crossings (signage, operational rules, responsibilities, maintenance, etc.)
- Propose a range of risk assessment techniques so as to support a harmonised definition of safety requirements for level crossing technologies
- Seek to develop guidance on managing safety at level crossings that is appropriate to the road and rail sectors and reflects current good practice.
- Highlight the need to systematically collect LC accident data through reporting and evaluation processes.

- Ensure that any improvements proposed are targeted at those level crossings with the highest safety risk and the greatest opportunity for improvement.
- Develop links with the work of those agencies, authorities and other bodies whose actions and decisions affect the use of level crossings. Influence their work so as to support their collaboration with rail companies in reducing risk at level crossings. (Road vehicle manufacturers, GPS developers, etc).
- Develop links with areas such as the insurance sector. The cost of accidents at level crossings caused by road users has a serious impact on rail company insurance premiums. Improvement programmes that demonstrate significant risk reduction and jointly developed with the insurance sector should make the risk of occurrence (and therefore payments) much lower. The sector could well stand to gain in reduced insurance premiums to reflect this state.
- Evaluate proposals for the technological research and development for the reduction of risk at level crossings.

The SELCAT proposal for the establishment of a Road/Rail Interface Strategy for Europe has been documented in a separate document [15].

3 Conclusions

The SELCAT consortium was created to study the background of level crossing accidents and the potential for the effective reduction of operational risks for road and rail transport and their users. Level crossing safety is one of the challenges for improving safety in both sectors. The approach chosen is comprehensive in the sense that it includes aspects ranging from sensing and actuation, to reasoning, learning and reflection.

Addressing safety methods, safety targets and indicators in connection with cost benefit analysis, SELCAT is also harmonising with the aims of the work programme of the European Railway Agency (ERA). Overall, the coordinating activities of SELCAT will contribute to the practical implementation of the Safety Directive of the European Parliament, which prescribes a wide range of new duties for the various stakeholders in railway transport.

One of the direct results of recent activities is the passing of a resolution in February 2008 for the development of a Road/Rail Interface Strategy for Europe. The motivation, idea, role, core elements of the strategy and benefits of the establishment have been outlined with the aim to carry on with the enhancement of level crossing safety after the conclusion of SELCAT.

4 Recommendations

The presented achievements and the conclusions lead to the following project recommendations many of which have been taken on board in the proposed European Road/Rail Interface Strategy:

Level crossing appraisal:

- The scaling factor for establishing the level of risk at a given level crossing should take into account road traffic parameters as well as rail related country specific characteristics. This is especially important when comparing level crossing risk between different countries.
- Few of the level crossing accidents analysed demonstrated a decreasing trend; in several cases an increasing trend has been identified. The human factor element should be incorporated into the investigation together with any technological effects.
- It is considered that there could be significant benefits from reviewing and where applicable standardising LC legislation and signage, but further research should be jointly undertaken between road and rail communities.
- In order to achieve a better appraisal of risk at level crossings a first step should be the systematic collection of road traffic data including buses, heavy vehicles, cyclists, motorcyclists, pedestrians, agriculture vehicles.
- The Vienna convention on Road Signs and Signals was a milestone legislative document dealing with standardisation of road traffic signs on level crossings and should be reviewed. Other than this, only UIC activities (UIC Leaflet 760; 761

and 762) have aimed to achieve legislative harmonisation of traffic and operational rules but these are also not mandatory.

- No level crossings of types A 1.1 and A.2.2 (as defined by the ERA) were identified by SELCAT partners. It is suggested that the ERA should reconsider its definitions.

Level crossing technologies:

- The analysis of existing and new level crossing technologies showed strong dominance of nationally funded research of member states leading to a wide variety of technological level crossing solutions. In order to facilitate market liberalisation an increased involvement of the European Commission is seen as essential.
- Generic functional modelling represents a good basis for the investigation of any impact of new technologies or organisational rules to be introduced in level crossing operation. It is able to describe mutual interactions between the railway and road traffic including the relevant human aspects. Therefore it should be used at the start of any design of new level crossing technology.
- The high cost safety requirements for level crossing safety systems in many countries results in high costs which limit the number of actively protected level crossings. The application of low cost technologies accompanied by a quantitative risk analysis could result in a significant reduction in accident risk by promoting the conversion of more passive level crossings.
- Existing regulations often prevent the adoption of new technological solutions designed to reduce risk, because such regulations are based on the existing types of level crossing equipment. In order to obtain the benefit of new technologies, regulations need to be less prescriptive and more flexible and function-oriented.
- Advanced technologies such as video analysis, multiple sensing or wireless communications, possess high potential for the reduction of level crossing equipment costs. European Commission support for further research on the specific application of such technologies would have a strong catalytic effect on the dynamics of these developments and it would therefore have a potentially positive impact on accident statistics.
- Development of any new technological solutions should be based on an in-depth analysis of the impact of human awareness and the behaviour of road users.

Level Crossing Methodologies:

- Level crossing risk is dependant on a large number of influencing factors. For this reason statistically driven approaches provide the highest precision and objectiveness in the risk modelling process and should be used as a common safety method in the area of level crossings.
- Comparable safety on European level crossings can be achieved only by the use of single risk modelling approach. The chosen approach must be generic

enough to be applicable to all member states. The example described by SELCAT represents a good basis for further development.

- Each basic type of level crossing should have its own separate category in such a risk model. The models should be an object of future standardisation
- The applicability of the generic risk model should be guaranteed by standardisation of the information data sets necessary for the model population and application. The data presented in this report as well as in the recommendations for standardisation of the SELCAT project [D14] represent a basis for this activity.
- Collection of the relevant information for risk modelling and assessment should be supported by the use of a common level crossing information system. The currently available accident statistics database included in the SELCAT knowledge management system represents a prototype of such a information system and should be developed further.
- The most realistic comparison of the societal risk among countries appears to be based on scaling by average traffic interactions. This scaling considers the main relevant factors from the railway perspective as well as from the road side influencing the level crossing accident occurrence. Such kinds of scaled risk values should be applied to the setting of common safety targets for the societal risk in accordance with the Railway Safety Directive.
- Confirmation of the quality and accuracy of road sector data is needed in order to make final recommendation for the adoption of scaling factors of the common safety targets. Until this will is achieved only data from the railway sector should be applied.
- A further task remains to decide how the value of the common safety target should be defined. The proposal of the European Railway Agency gives a very good basis for this aim, and practical proof of its consequences should be one of the next research steps.

Campaign for road vehicle drivers:

- Traffic laws at level crossings are not widely understood so car drivers need educating about them
- Road user behaviour has to be addressed by educational campaigns at the European level
- There is a need for the collection of accident data in a standardised form through common reporting and evaluation systems
- An European level crossing accident information and knowledge management system should be set up
- Improvements at level crossings should be targeted at those level crossings with the highest safety risk and the greatest opportunity for improvement

- There is a case for the configuration of all level crossings to the latest standards
- There should be regular revisions to the technical protection at crossings and the position of traffic signs as well as sight triangles where applicable
- There is a need to promote the development of links with law enforcement agencies to cultivate a systematic approach to reduce offences

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