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Development trends and risks of railroad crossings

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ABSTRACT

The application of new technologies on railroad crossings goes along with many questions, which answering should forego the implementation itself. The paper presents basic problems of crossings and the classification of generic railroad crossings according to the European Railway Agency. Therefore the goal of this paper is to present the current state and prospects in the field of railroad crossings in the light of the present-day situation, whereby the major attention is aimed at two fields – new technologies and overview of risk analysis methods applied worldwide on railroad crossings.

KEYWORDS: railroad level crossing, risk analysis, safety, ERA, research projects

1. Introduction

Recently, on both European and worldwide niveau, there is more attention paid to the issues of level crossings, evaluation of their safety and their technological equipment (including the problems of new intelligent technologies application). This fact may be supported by remarking some events which took place not long ago – first of all the 10th World symposium about level crossings "Level Crossing 2008" in Paris on 24 – 26 June dedicated to safety and prevention issues.

The second important event was the completion of the European project SELCAT – Safer European Level Crossing Appraisal and Technologies which was solved within the scope of the 6th framework program. Its outputs were presented both at the mentioned symposium and at the 3rd public workshop organized on 23 June 2008 – the eve of the symposium. The basic goals of SELCAT project have been already presented e.g. within [2]. The web page of the project is available on [3].

The goal of this paper is to present the current state and prospects in the field of level crossings in the light of both mentioned events, whereby the major attention is aimed at two fields – new potentially applicable technologies and the overview of identified risk analysis methods applied worldwide on level crossings.

2. New technologies on level crossings – the current state of research work

The application of new technologies on level crossings goes along with many questions, which answering should forego the implementation itself. The following belong to the fundamental ones:

- which functions the new technology should realize,
- which requirements it should fulfil,
- what should be the architecture of the new system,
- which interfaces will be there in relation to the existing system,
- how the new technology will conduce to decreasing the risks,
- what will be the costs of the new system, what about the delivery terms etc.,

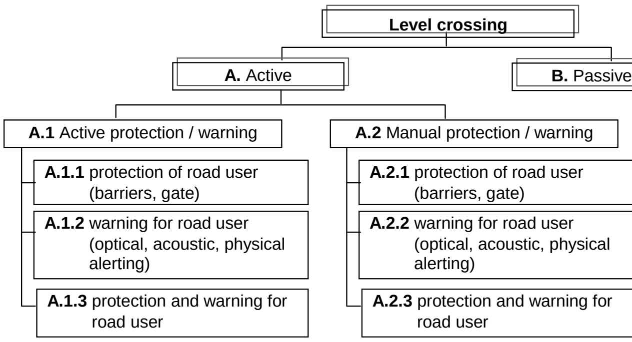

Fig.1. The classification of generic level crossings according to the European Railway Agency

- what will be the service requirements,
- how the existing standards are respected, etc.

The way of determination, which solution is better than another one observing the chosen parameters still remains a fundamental problem. To be able to evaluate the required functions, interfaces, reliability, risks, etc., a conceptual model was accepted within SELCAT project. The model comes from the classification proposal of generic types of level crossings (fig. 1) according to the ERA [4].

The outcomes of existing projects were analysed within working package WP2 of SELCAT project (task 2.1). The analysis was aimed at identifying new technologies, which would improve the safety of level crossings. The developed knowledge management system [3] has helped to collect the information. The result of it consisted of 35 reviewed projects, where 5 of them have been solved in Europe (only 2 financed by the EU), 18 in China, 1 in India, 5 in Russia, 1 in Australia, 1 in North America and 4 in Japan [5].

From the specialization point of view, 13 of analyzed projects dealt with technical solutions (hardware), 5 with software, 2 with methods and the rest with other issues. The most frequent concrete output was a prototype (15), a report (5) or a demonstrator (2).

There were also differences in the availability of information (restriction on group (18) and other participants (1), confidential (6) or public (3) information).

The following belong to the most important projects:

- ECORAIL – EGNOS Controlled Railway Equipment (EU): the project is dealing with the implementation of satellite navigation in the field of railway with the purpose of demonstrating the feasibility and the benefits of GNSS; the possibility of activation of automatic level crossing interlocking plant by a radio link based on an onboard navigation unit utilizing multi-sensor techniques was proved (reducing the need for connection wires, balises, cables etc.); the evaluation of such system operation was demonstrated in Upper Austria, where it was compared with the effectiveness of the existing localizing system (fig. 2),
- SAFETRAIN (EU): the main goal of the project was to decrease the count of fatal and serious injuries in railway accidents by improving the structure design of vehicles; the main objectives comprised: the collection of collision data in 1991-1995 and its analysis, the selection of accidents and their evaluation, numerical simulations (train-to-truck collision on the level crossing), the study of sensitivity and a global analysis,
- Obstacle detection on level crossings (UK): the project realized by RSSB (Rail Safety and Standard Board) was dedicated to an obstacle detection on level crossings with automatic half-barriers as well as with hand-operated barriers with CCTV; the study covered 3 principal fields – the identification of an actual risk and the asset estimation of an obstacle detection from the safety point of view; the identification of feasible solutions of an obstacle detection on the level crossing and their evaluation,
- In-vehicle warning system for railway crossing (FIN): the purpose of this study was a pilot project of warning the drivers inside their cars in advance of train oncoming toward the level crossing,
- CCAS – Controlled Crossing Area System (AUS),
- UZP & UZPu – Adjustable ramp for LC protection (RUS): the goal of the project was to decrease the material damage on hand-operated level crossings by using a mechanical kind of protection in the form of an adjustable hoisting ramp (0.45m above the road level), which, of course, does not limit a car from escaping the danger area in case it gets stuck between the barriers (fig. 3).

The following resulted from the analysis of these and other projects:

- there are no projects, where the operators of railway and road infrastructure would coordinate mutually,
- the safety on level crossings depends on many parameters (interlocking plant, operation conditions, traffic flow, human behaviour etc.),
- it is impossible to propose definitely „the best“ solution,

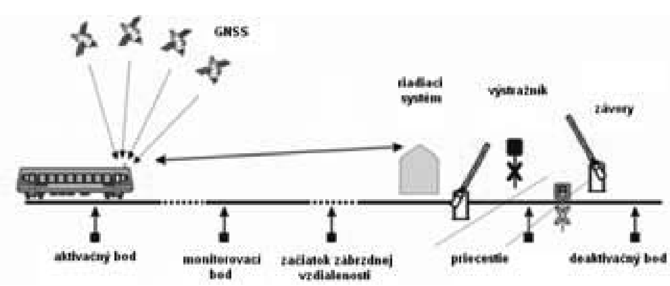

Fig.2. The schema of system within ECORAIL project

Fig.3. Mechanical ramps obstructing the entrance to a level crossing (Russia)

- the attention should be paid especially to country areas with a low traffic intensity (both railway and road traffic) on secondary lines as well as to urban and suburban areas with main lines characterized by high traffic intensity.

A warning system should be preferred for country areas and secondary lines. But there are still some open questions remaining: what kind of system it should be (a fixed installation, onboard warning in the vehicle ...), how to increase the visibility of level crossings and how to involve operators of road and railway to invest their resources in secondary lines.

For urban and suburban areas and main lines a system detecting obstacles should be preferred. However, it relates with many questions too, e.g.:

- which technology to use (camera, radar, laser scanner, inductive loops, ...)?
- which function to realize (reducing the waiting time on level crossing, information transmission to the engineer's cab , fixed installation, ...)?
- what to do after the detection of an obstacle (emergency brake, service brake,...)?
- what will happen if the detection device fails?

It is assumed that the attention of individuals paid to and their becoming aware of the danger situation could be intensified by providing additional information. To reach this, a communicating system defining following is needed:

- what kind of information have the scanners to generate,
- where are the scanners placed,
- where is the information processed,
- who should be the information end-user (voice, image, video, state of operation/system ...).

Four possible communication sides and systems were indentified: train, operating centre, traffic participant and level crossing.

3. Risk analysis methods

Within working package WP3 of SELCAT project a survey was carried out on known methods used for risk analysis of level crossings. Altogether 22 different approaches used in 12 countries worldwide were identified, varying in their complexity and performer's approach (academic organizations, railway research institutions, regulators).

The above mentioned approaches could be classified into four major groups based on different complexity of computational algorithms [8, 9, 10]:

- Utilization of parameters – simple parameters used as hints to choose the safety level (it is not going on methods in the true sense of the word – they do not serve to forecast the risk):
  - › India (Train Vehicle Unit),
  - › Japan (Closed Road Traffic Indicator, Level Crossing Danger Index),
  - › Russia (Rail and Road Intensity Matrix),
  - › Spain (Crossing Criteria),
  - › Sweden (Factors to Determine Crossing Protection),
- Simple weighted factors – based on previous group of methods, but moreover they indicate the relative contribution of every parameter to the total risk by a simple defined system of weights:
  - › Australia (Risk Based Scoring System, Australian Level Crossing Assessment Model),
  - › Northern Ireland (Risk Assessment and Investment Appraisal),
  - › New Zeeland (Product Assessment),
- Complex weighted factors – as compared to previous group of methods, this uses more complex deriving of weights for parameters and algorithms:
  - › Great Britain (All Level Crossing Risk Model, Automatic Level Crossing Model, Event Window Model),
  - › Ireland (Network Risk Model, Level Crossing Prioritisation Tool),
  - › Spain (FMEA),
- Statistical methods – based on statistical techniques of estimating weights (empirical terms) for parameters:
  - › Great Britain (GB Highways),
  - › Australia (RAAILc),
  - › Canada (Collision Prediction Model, GradeX),
  - › New Zeeland (Accident Prediction Model),
  - › USA (Accident and Severity Prediction Formulae, GradeDEC.net).

From the above mentioned classification it results that e.g. the statistical approaches could be found in North America, where there are many level crossings (and accidents) and the available data allow this way their use.

Simpler parametrical approaches could be found e.g. in Asia. In some countries there is the risk modelling based on the application of more advanced techniques (e.g. empirical Bayesian methods, FTA and ETA, human factor analysis).

4. Conclusion

The diversity of signalling systems in a significant way conduces to the operational risk existing on level crossings. According to many installations the harmonization of the signalling technique within the EU appears to be very expensive and therefore difficult to be realized in the near future. The harmonization of operation rules should be the first harmonization step. The safety of operation should be the most important indicator of quality for the legislation dealing with level crossings. The creation of a legislative framework for railway and road transport seems to be an acceptable solution. The survey realized among the countries participating in SELCAT project proved that definitely the harmonization of responsibilities and their assignment has to be done on the European level [6] (e.g. for Central and Eastern Europe it is typical to shift the responsibilities for a safe crossing to the road traffic participant). From the risk analysis point of view, one concrete modelling approach cannot be suitable for several railroads, whereby it does not mean, that more sophisticated algorithms have to provide also more accurate results by themselves. The modelling of risk can be extended to include also the consequences not associated with the safety (e.g. operating and social costs, trade-name reputation and environment). Let apply any model, this should only inform, educate and help; it should never substitute the decision making of management (each time an integrated approach will be needed).

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