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The Control of Road Infrastructure Safety Management Procedures

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Abstract Road infrastructure is one of the pillars of the road safety management system. In order to improve road safety, it is necessary to introduce and implement road safety checks both before and after the road construction process. In the period prior to the construction of a road, it is the planning and design of the road that should be monitored, while following the construction of a road, the initial phases of the use of the road should be monitored, as should the continued use of the road as a maintained highway. There are two aspects to the monitoring and evaluation of the introduction and implementation of road safety control procedures: firstly, measuring the success of the introduction of each individual road safety control procedures in practice and secondly, measuring the overall success of the implementation of those road safety control procedures. To measure the success of the introduction and implementation of road safety procedures, the performances of the systems to be measured need to be defined and the standards for measuring performance set. In order to monitor road safety, a cyclical iterative procedure has been designed for the introduction and implementation of road safety procedures during each stage of the road life cycle, enabling the achievement of the central aim, that of road safety. Developed modern road procedures can be transferred, as good practice, to other countries, especially to those that are undeveloped or developing and thus contribute to the improvement of traffic safety in those countries and the establishment of an integrated global approach to road safety control.

Keywords Control, Road infrastructure safety management, Procedures, Monitoring, Evaluating

1. Introduction

Reducing public risk identified in relation to global road traffic, in the period 2007–2013 [1], shows that improvements in road safety are possible and that most often they are the result of the better management of the road safety system [2].

In order to further reduce public risk in road traffic, the Global Plan for the Decade of Action for Road Safety 2011–2020 [3], recommends that activities at the national level be implemented in five categories or "pillars": building road safety management capacity; improving the safety of the road infrastructure and broader transport networks; further developing the safety of vehicles; raising the level of road user behaviour; and improving post-crash response systems.

Road infrastructure is thus the second identified pillar of the national road safety management system, which, if well designed and properly maintained [4], can contribute to the achievement of national targets related to the reduction of instances of road accidents and also of fatal or severe injuries to people in road traffic accidents.

The introduction of a road infrastructure assessment and a targeted improvement of the safety planning, design, construction and exploitation of roads [3], can contribute to improving the overall safety and quality of the road infrastructure so as to prevent unsafe road traffic events. The development of road safety procedures is of great importance when assessing the safety of road infrastructure.

The concept of road safety monitoring originated in the United Kingdom, which in 1990 issued a handbook of road safety measures [5]. Since then, several countries have introduced mandatory road safety control procedures, whether analyzing road safety on existing roads, renovating existing roads or building new roads [6-8]. For the purpose of road safety control, the European Union (EU) has adopted a directive on the safety procedures across the Trans–European Transport Network (TEN–T) [9], as a set of rules of the profession, which can also be used for any state road infrastructure which is not part of the trans–European road network. The Directive requires the introduction and implementation of procedures relating to the safety of trans–European roads, regardless of whether the roads are only in the design phase, are being built, or are already in use. The following road control procedures are covered by

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the Directive:

- Road Safety Impact Assessment (RSIA),
- Road Safety Audit (RSA),
- Road Safety Inspection (RSI),
- Risk Mapping (RM),
- Network Safety Management (NSM),
- Black Spot Management (BSM) and
- In Depth Study (IDS).

Within the framework of the RiPCORD–iSEREST [10] and SEROES [11] projects, the above-mentioned procedures were developed and best practices for their application were recommended. National and international organizations prepared manuals and professional guidelines to address the aforementioned road safety control procedures [5, 12-16].

Good practice globally shows that road safety in developing and underdeveloped countries can be improved by accepting the best practices of developed countries as the starting point for the development of indigenous national practice [3]. From this perspective, trans–European road safety procedures represent good practice for underdeveloped countries and developing countries, in which the introduction of modern road safety control procedures is envisaged as key to reducing the number of deaths on the roads. In this context, two decisive questions can be raised: first, which of the trans–European road safety procedures (RSIA, RSA, RSI, RM, NSM, BSM and/or IDS) should be used in the national practice of underdeveloped and developing countries for periods before and after the construction of roads and the different stages within these periods and second, how should we conduct the monitoring and evaluation of the introduction and implementation of modern national road safety control procedures? The monitoring and evaluation of the introduction and implementation of modern national road safety control procedures is a twofold process with two elements to address: firstly, how to measure the success of the introduction of the road safety control procedures in practice and secondly, how to measure the success of the implementation of those road safety control procedures. In terms of the measurement of success in these two areas, the question could be raised as to which performances of the systems of introduction and implementation should be measured and what the standards to measure them should be, as well as, finally, how to design a procedure for the introduction and implementation of road safety control procedures which will ensure the achievement of the goal of safe road traffic. This paper provides possible solutions to the questions of the monitoring, evaluation and process of the introduction and implementation of modern national road safety control procedures.

2. Road Infrastructure Safety Management

Road Infrastructure Safety Management (RISM) is a set of procedures aimed at ensuring the safety of road infrastructure [9]. RISM refers to the entire road infrastructure life–cycle: planning, design, the beginning of use and the process of use [9, 17-19, 4, 20]. To begin with, this implies both proactive and reactive approaches to road infrastructure management to improve traffic safety [21, 4]. Secondly, RISM enables the monitoring of changes in the behaviour of road users, especially those related to security: driving speed, the use of seat belts, the use of a helmet by cyclists, driver fatigue and so on [17, 18]. Thirdly, RISM refers to a set of procedures that help road management in deciding on interventions to improve road safety [20]. Fourthly, RISM encourages the development of the national institutional capacity for road safety [2, 22], initiates the normative and operational processes required for road safety [23], develops the profession of road safety auditors [24, 25], and also develops tools and procedures for road safety monitoring [10, 26, 18, 27-29]. Finally, RISM has established a common framework and a common approach in the way of thinking about and addressing road safety management, outlining a minimum set of mandatory road safety management rules [23, 4, 30] and the exchange of good practice in road safety management [23].

Nevertheless, RISM is not interconnected either with tunnel safety management [31-33], which is an integral part of the route of the road, or with the Intelligent Transportation System (ITS) [23], on which modern phase road safety management is based [34-37], and respecting safety procedures in designing and constructing roads does not guarantee safe traffic, because people are the weakest component of the traffic safety system [38].

Recent studies on the implementation of road safety procedures [23, 39, 4, 33, 30, 24], have shown that there are areas for the potential improvement of road safety procedures and that an integrated Pan–European approach is desirable [40].

3. Road Safety Procedures

3.1. The Determination of Procedures for the Periods and Stages of Road Safety Monitoring

Road safety monitoring is performed in two periods:

- before road construction and
- after road construction

The period prior to road constraction includes two stages:

- road planning and
- road design.

The period after road construction encompasses a further two stages:

- the beginning of the use of the road after construction and
- the use of the road with maintenance.

In the period prior to the construction of the road, at the stage of road planning, the RSIA procedure is used to

monitor the Feasibility Study.

In the period prior to road construction, at the stage of road design, the RSA procedure is used to monitor the Preliminary Design and the Detailed Design of the road.

In the period after the construction of the road, during the stage of the beginning of the use of the road after construction, the RSA and RSI procedures are applied to monitor the constructed road, the BSM procedure is used to monitor specific dangerous spots on the constructed road, and the IDS procedure is applied to monitor events on the constructed road.

In the period following the construciton of the road, during the stage of the use of the road with maintenance, the NSM procedure is applied to monitor the road network, the RSI and RM procesures are used to monitor the road/route in use, the BSM procedure is used for specific spot checks on the road in use, and the IDS procedure is used to follow events on the road.

The process for determining road safety procedures is shown in Figure 1.

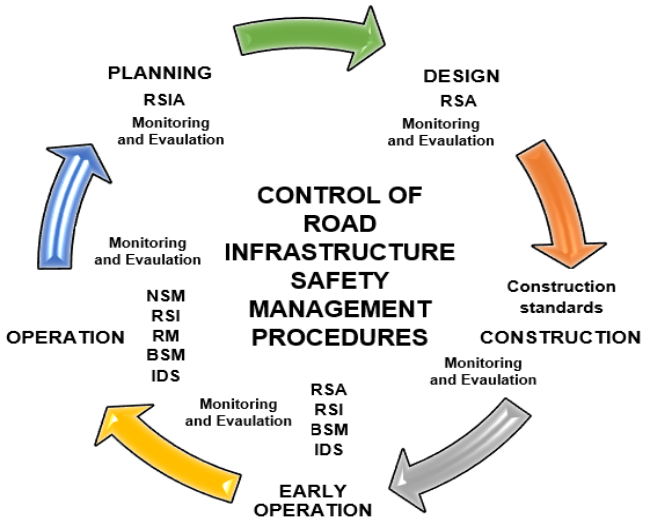

Figure 1. Control of road infrastructure safety management procedures

3.2. The Introduction of Road Safety Procedures

EU Member States were obliged to introduce and implement procedures related to Trans–European road safety by 2010 [9]. Outside of the TEN–T procedures, most EU Member States have developed national legislation [30].

In 2009, the Road Safety Audit manual was published in Australia [41], while in 2010 in the USA the Highway Safety Manual (HSM) manual was published, which was developed as a comprehensive tool for integrating security in planning, designing, using and managing road infrastructure [42].

However, in underdeveloped and developing countries, the road safety control has not been developed, although the analysis of the traffic safety trend at the WHO region level, in the period 2007–2010–2013 (Figures 2 and 3), shows that there is a strong correlation between the risk of fatality in road traffic and the level of development of the countries (R^2 = 0.77–0.92–0.87), where this risk is greatest in the regions of underdeveloped and developing countries, and the smallest in the regions of developed countries, where the trend of traffic safety improvement is stable, especially in the region of Europe (R^2 = 0.92), in which the road safety control is mandatory by implementing the prescribed procedures. On the other hand, developed modern road procedures can, as good practice, be transferred to other countries, especially to those that are not developed or developing and thus enable these countries to control road safety. In addition, the introduction of road safety procedures is, as a rule, prescribed by national legislation [43], and the procedures are implemented according to relevant guidelines, which determine: activities, tasks, competencies and dynamics [44].

4. The Monitoring and Evaluation of the Introduction of Road Safety Procedures

4.1. The Performances of the System for the Introduction of Road Safety Procedures in Practice

The performances of the system for the introduction of road safety procedures refers to the procedures themeselves which are introduced in practice. It could be all or some of procedures of traffic control of the trans–European roads: RSIA, RSA, RSI, RM, NSM, BSM, IDS, which should be used in the national practice of underdeveloped and developing countries for periods before and after road construction, and for the different stages within these periods.

4.2. The Standards for the Successful Implementation of Road Safety Procedures in Practice

For the purposes of monitoring and evaluating the introduction of road safety procedures into practice, the following performance standards should be set:

- the creation of a multi–sectoral partnership of road managers, planners and designers, road construction contractors, independent road safety auditors, governments and scientific and professional organizations in the field of road safety,
- the development and promotion of road safety procedures,
- the development and promotion of guidelines and standards for the introduction and implementation of road safety controls,
- the number of licensed independent road safety auditors and the ratio between the number of auditors and the number of kilometres of the road network,
- the number and percentage of licensed independent road safety auditors who participated in seminars and other forms of vocational training,
- the ratio of licensed independent supervisors to road safety auditors and their percentage ratio in relation to the number of kilometres of the road network,

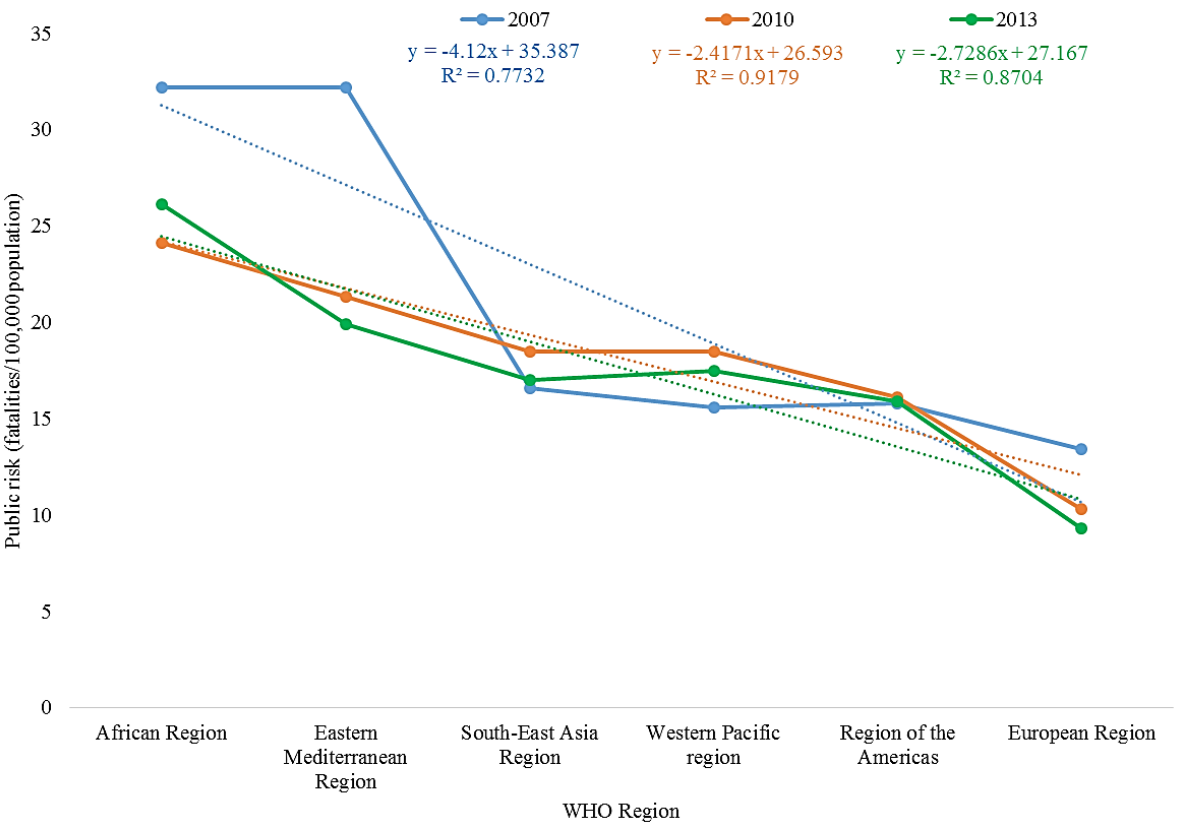

Figure 2. Trend in the public risk at the level of the WHO regions

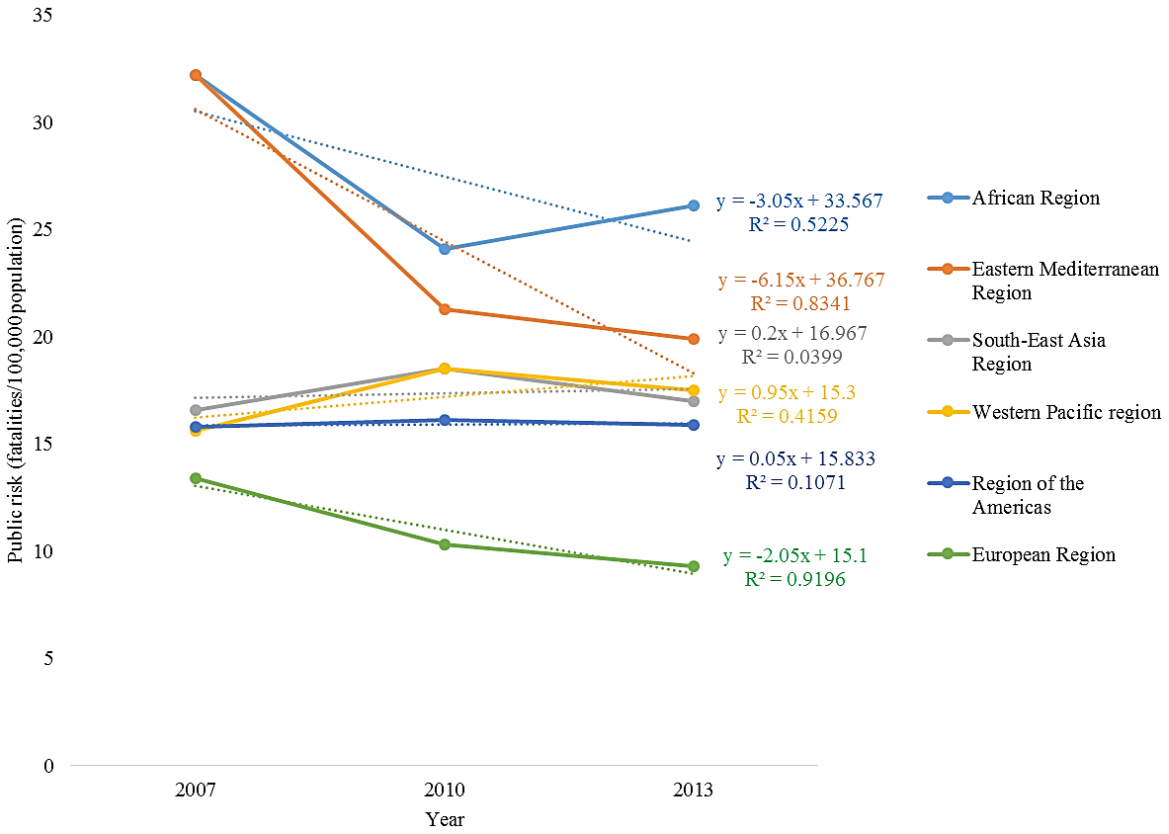

Figure 3. Changes in the public risk at the WHO regions

- the number and percentage of Road Feasibility Studies for which RSIA was performed,
- the number and percentage of Preliminary and Detailed designs for which RSA was conducted,
- promoting demonstration projects for the improvement of road safety,
- the number and percentage of kilometres of roads which began to be used after construction for which RSA and RSI were executed,
- the number of spots and the percentage of kilometres on roads whose use began after construction for which BSM was conducted,
- the number and percentage of events on the roads whose use began after construction for which IDS was carried out,
- the number and percentage of kilometres of roads in use for which NSM was conducted,
- the number and percentage of kilometres of roads in use for which RSI was conducted,
- the number and percentage of kilometres of roads in use for which RM was conducted,
- the number and percentage of kilometres of roads in use for which BSM was conducted,
- the number and percentage of events on the roads in use for which the IDS was implemented and
- the improvement of road records.

5. The Monitoring and Evaluation of the Implementation of Road Safety Procedures

5.1. The Performance of the Implementation System of Road Safety Procedures

During the implementation of road safety procedures, the following performance features of the road safety system should be measured:

- responsibility for road safety,
- setting goals for road safety,
- adapting roads to human capabilities and the vulnerability of people,
- the implementation of efficient technical measures on the roads,
- the application of new technologies in the construction of roads,
- promoting research on road safety and
- financing road safety programmes.

5.2. The Standards for the Successful Implementation of Road Safety Procedures

For the purposes of the monitoring and evaluation of the implementation of road safety procedures, the following performance standards must be set:

- establishing the responsibilities of road safety managers and designers for road safety and reporting on road safety trends,
- setting ambitious, but achievable goals for improving road safety and the minimum levels of safety on roads,
- the promotion of the “secured system” approach, “self-explanatory road design”, “forgiving roads”, speed control and so on,
- the development of guidelines and standards for the design, construction, maintenance and supervision of roads,
- monitoring the execution and provision of works on roads,
- the publication of the results of research on the road safety,
- the allocation of 10% of the budget for the construction and renovation of roads for road safety improvement programmes and the monitoring of the results of that investment.

6. Discussion

Roads are investment objects intended for traffic. A road life–cycle consists of the following phases: planning, design, construction, the beginning of use and use. Road safety is a top-level requirement, the fulfilment of which is a precondition for their use. Road safety management is organized at each stage of the road life cycle. Road safety can be viewed as a process that ends with a control phase. On the other hand, road safety management takes place in a cyclical phase repetition, and the control process ends one management cycle only to begin another. In doing so, the outcome of the control phase determines the pace of the new cycle, keeping it the same or changing it: by accelerating or slowing the pace of change from one phase to another, by increasing or decreasing the pace of activities in certain phases or by shortening the cycle itself, by omitting certain phases, or repeating a certain phase. Checking is carried out through implementing a set of defined procedures. In addition, it is necessary to monitor the control phase. To achieve this, the introduction of modern procedures into the practice of road safety control is also monitored (Figure 4). This checking involves a process which takes places at two levels:

- monitoring and
- evaluation.

Monitoring refers to data collection, and evaluation involves analysing the collected data on the activities related to the phase of introducing modern procedures in the practice of road safety control. When during the evaluation it is determined that the implementation of the activities on the introduction of modern procedures in the practice of road safety control is insufficiently effective, the process of the control of this stage in the life cycle of the road is repeated until the set standards for the successful implementation of road safety procedures are fulfilled in practice (Figure 4). This enables the complete and high–quality implementation of modern road safety procedures. Following this, we have the phase of the monitoring and evaluation of the

implementation of modern road safety procedures, in which the monitoring of data that are collected on the predefined performance of the road safety system is conducted, and by evaluation, the analysis of the collected data, using the established performance standards, the effectiveness of the implementation of modern road safety procedures is assessed. When that evaluation determines a failure to meet the standards of road safety system performance, the road safety management process at that stage of the life cycle of the road is repeated until the set standards for road safety performance are complied with. This process of control is cyclically carried out for each stage in the life cycle of the road and has a unique goal: safe road traffic. The effectiveness of this process is determined by evaluating the safety objectives for the road before its construction, and then at the beginning of use, thus achieving safe traffic on the road in use. Thus, the activities of road safety control improve the performance of the traffic safety system.

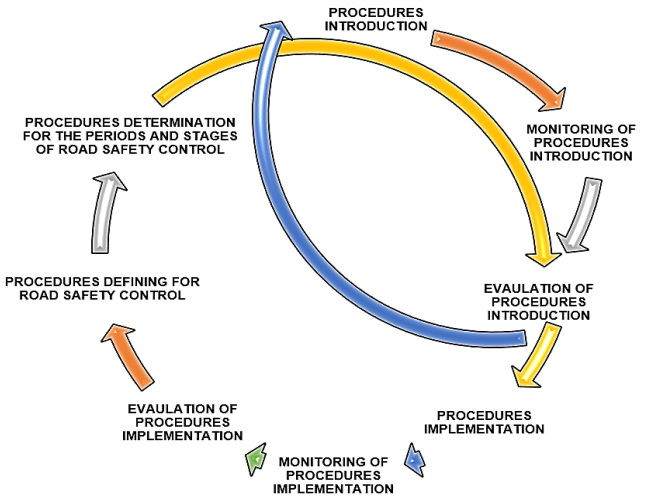

Figure 4. Control of the introduction and implementation of road safety procedures

7. Conclusions

Road safety management is organized at each stage of the road life cycle: the planning, design, construction, beginning of use and the use of the road. It can be viewed as a process that ends with a control phase, by implementing a set of defined procedures. Thus, the monitoring and evaluation of the introduction and implementation of road safety procedures should reflect two key elements: first, measuring the success of putting into practice the procedures for road safety control and second, measuring the success of the implementation of the road safety control procedures themselves. To measure the success of the introduction and implementation of road safety procedures, the performances of the systems to be measured have been defined and the standards for measuring their performance set.

In order to control road safety, a cyclical iterative procedure has been designed to introduce and implement procedures for road safety at each stage in the life cycle of the road, until the achievement of the overall goal for safe road traffic.

Road safety appears to be an area for potential improvement in road safety management which can greatly contribute to the achievement of national road safety improvement goals, if the full and high–quality implementation of modern road safety procedures is ensured. In order to achieve this, it is necessary, firstly, to repat the proces of introducing road safety procedures into practice until the set standards of performance are met, which can be achieved by the monitoring and evaluation of the introduction of road safety procedures in the control procedures. Developed modern road procedures can, as good practice, be transferred to other countries, especially to those that are undeveloped or developing and thus contribute to the improvement of traffic safety in those countries and the establishment of an integrated global approach to road safety control.

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