# DESIGNING TOOLS FOR ENHANCED MONITORING OF RAILWAY SAFETY PERFORMANCE OF THE EUROPEAN UNION AND ITS MEMBER STATES


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**SUMMARY**

Current approaches to the evaluation of railway safety performance at national and supra-national level rely heavily on the use of accident and casualties counts. Because of the continuous improvement in safety performance across the European Union and the need to assess safety performance of single Member States, this traditional approach has shown limitations and as alone-standing does no longer enable evidence-based policy making.

The European Railway Agency has been developing a new framework for evaluation and assessment of railway safety at Union and member states levels since 2012. It comprises extended monitoring of safety outcomes and a set of tools for the assessment of the regulatory regime in Member States. The former entails the use of accident precursor data for safety monitoring, while the latter consists of a framework for evaluation of the performance and processes of the key actors in railway safety management at national level (Transport Ministry, National Safety Authority and National Investigation Body).

It is foreseen that the new monitoring framework could be first applied as in 2014 after evaluation of the pilot programme that is underway since summer 2013. The Agency believes that the new approach will bring major benefits to all stakeholders and contribute to further improvements of railway safety in the European Union.

## INTRODUCTION

The levels of railway safety in EU Member States have been traditionally high with some countries even assuming world leadership in railway safety performance. This fact has been broadly recognized and acknowledged by the European policy makers at the time of a gradual introduction of EU legislation aiming at harmonizing safety approaches across the EU. Gradually introduced legislative measures were meant to support the creation of an integrated European Railway Area for the benefit of EU citizens. Notably, the European Railway Safety Directive of 2004 recognized that safety should be at the very least maintained during the restructuring phase, which separate functions of previously integrated railway companies and move the railway sector further from self-regulation to public regulation. Only in addition to that, it stipulated that safety should be further improved, when reasonably practicable, in line with technical and scientific progress, and taking into account the competitiveness of the rail transport mode [1].

The European Railway Agency (the Agency) is a cornerstone of the EU strategy to establish a common railway market in the European Union while preserving a high level of railway safety in its Member States. It was established in 2004 and charged with the task to develop and implement technical specifications for interoperability (TSIs) and to assure a common approach to safety relying on the implementation of safety management systems by railway operators. The Agency further provides advice to the European Commission assuming a function of EU regulator. It also carries out specific technical tasks on its behalf [2].

The monitoring of safety performance in the Union has traditionally been one of the key tasks of the Agency aiming at providing EU policy-makers with a regular feedback on the development of railway safety in a rapidly evolving legislative environment. To enable the monitoring of safety performance, the Railway Safety Directive introduced a series of statistical indicators, so called Common Safety Indicators (CSIs) and a common safety method for the assessment of safety performance vis-à-vis a set of national safety targets, arising from the requirement that the level of safety in Europe must at least be maintained. These national targets and level of risk reflect what the countries have experienced in the recent past, over a period of five years. Thus they do not represent safety targets in senso-stricto, since they do not provide for improvements of safety performance.

Current approach to the evaluation of railway safety performance at national and supra-national (Union) level relies heavily on the use of accident and casualties data (accident outcomes). The Agency has since 2006 actively collected, analysed and evaluated the data that were annually reported as the CSIs and provided inputs to the European Commission by identifying emerging safety issues and areas of increased risk. Yet, the current safety monitoring approach has also shown its limits arising from its reliance on accident and casualty counts that are becoming increasingly scarce. This problem is most visible for small Member states that report only single casualties per year. The delay in accident outcomes data availability is yet another problem further underlining the reactive nature of the current approach.

The number of fatal train collisions and derailments in the Union has seen a continuous and even dramatic fall over past couple of decades, with the current record of less than 10 fatal collisions and derailments per year [3,4], on average (Figure 1). Deriving safety knowledge from these historically used statistics is becoming increasingly meaningless. The use of other data available under the CSIs framework offers somewhat broader possibilities, with an annual number of significant accidents reaching up to 1,000 per year (trespasser and suicide accidents excluded) at the Union level. However, the annual accidents and casualty counts for some smaller Member States are asymptotically reaching zero over a longer term, thus bringing back the issue of data scarcity.

Besides, the reactive nature of the approach and the legal provisions on accident reporting means that the knowledge from data can first be derived with up to one year delay after the end of the reporting period. (In practice, the accident data specified under CSIs are first reported by railway operators to the National Safety Authority (NSA) of each Member State and then forwarded to the Agency for its consolidation at the EU level. This mandatory reporting process is described in the EU legislation which also includes data submission deadlines for reporting entities.) The current provisions allowing producing consolidated safety statistics with important time delay may not be sufficient in current dynamic and complex railway environment, in which a timely response to a safety threat is primordial for preserving safety levels.

In a more general perspective, the current safety monitoring framework has been designed as an ex-post control and not as a steering mechanism, with the view to provide regular (yearly) feedback on the effectiveness of railway safety regulations as implemented by Member States. However, with a shift from rules-based approach to a risk-based safety management system approach, the need for a continuous detailed safety monitoring has become even more apparent. Since the modern management techniques started to penetrate also into the public administration, notably to the NSAs and ERA, the need for integration of measurement tools has appeared also in Member States and EU level. Furthermore, the current regulatory framework in the EU supposes a shared responsibility for safety - between operators, national administration and EU administration. While the national administration may be relatively well

equipped with tools for continuous railway safety monitoring, the monitoring tools available at EU level are limited.

Besides, current monitoring approaches by national and EU regulators continue to rely on traditional analytical approaches, thus failing to exploit all available information for evidence-based policy making. The system approach to railway safety supposes a proactive management of risk at the stage before it starts to manifest as accidents and incidents. It has already been largely adopted by railway operators and the regulators should not stay behind.

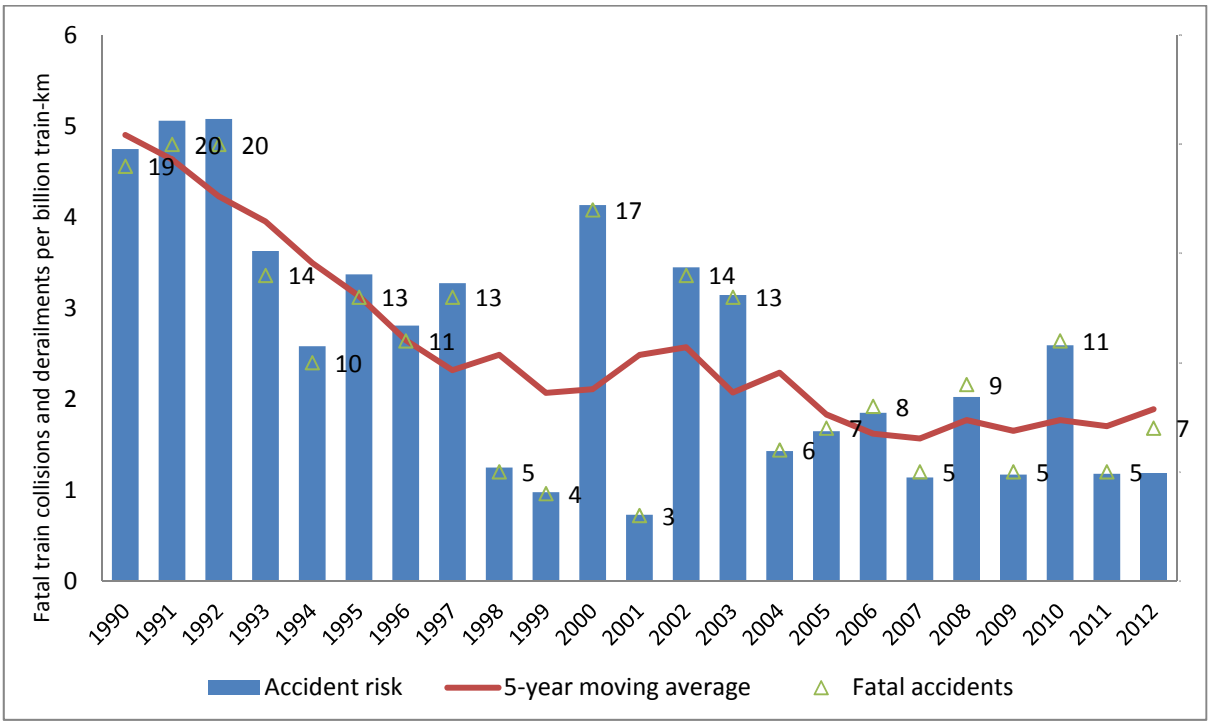


***Figure 1: Fatal train collisions and derailments in the EU since 1990***

To summarize, because of the continuous improvement in safety across the European Union and the need to assess safety performance of single member states, the traditional approach to safety monitoring has come to its limits and does no longer enable efficient data-based policy making. The reliance on scarce accident and casualty counts and the reactive nature emphasized by a delay in data availability are the major obstacles here. The Agency has therefore started in 2012 to revise the current safety monitoring framework with the view to enable a more proactive and efficient monitoring of railway safety in EU Member States. While some of the proposals may need an anchor in the legislation, the success of its adoption and implementation will rely heavily on the support of EU Member States.

## INTRODUCING SAFETY MANAGEMENT SYSTEM FOR EUROPE

A safety management system (SMS) is a pro-active system that identifies the hazards to the activity, assesses the risks those hazards present, and takes action to reduce those risks to acceptable levels. It involves continuous checks to confirm effectiveness of actions and timely identification of new hazards. An SMS is an essential tool for effective risk management by railway undertakings (RUs) and infrastructure managers (IMs), but the concept is eventually applicable also at national (Member States) and supra-national (EU) levels.

The Single European railway area imply a need for an SMS at EU level, since hazards are not always limited geographically and sometimes their identification may only be possible when considering relevant data available across the EU. Drawing from the experience in aviation safety, an SMS for Europe should aim at supporting the efforts by Member States and not replacing them. It should add value to the safety initiatives of Member States, by enabling them to identify risks at an early stage and to share knowledge when determining the measures and actions. Its success depends on the cooperation and contribution of Member States and the railway industry as they have the best knowledge on how to possibly address identified hazards. To allow for the genuine European railway safety management system, several building blocks would have to be introduced:

**National and EU safety plans** are needed to promote leadership by actors and to allow them to strive for commonly agreed goals. Top level goals should be expressed as safety targets, in terms of maximum risk for society and single railway user categories. The safety plans should reflect the existing European railway safety strategy that is roughly outlined in the EC White Paper, while reflecting arising safety problems. It should be translated into the evidence-based safety programmes introducing the actions allowing meeting intermediate targets. The plans should detail responsibility of actors and provide resources related information. An EU railway safety programme should ultimately provide a basis for the preparation of national safety programmes that would drive the actions at the national level. The Member States are also best-placed to identify key problem areas and define plans for addressing them at the national and EU level. The Agency together with the EC should act as a counsellor on the request of a Member State that prepares, or updates its national Programme/Plan.

**Common database of occurrences** in the railway system is seen as a means for extending the risk-based approach by railway operators to national and EU regulators. Any risk analysis at EU level is currently very difficult, if not impossible, due to the absence of detailed accident data, including the causes of accidents and incidents. Larger Member States are in a somewhat better position than smaller ones, as their national databases contain enough similar occurrences to be used for risk analysis.

An appropriate environment will have to be established to ensure that not only serious accidents, but also other occurrences with potentially high impact on safety are reported, collected and available to all railway actors across the EU. Such an environment would enable the integration of information existing at the national level and help to encourage the sharing of information across Europe. By pooling knowledge and resources, the gains in terms of cost-efficiency will be realized in MSs.

**Enhanced safety evaluation** approaches are needed to address the problems identified in the introduction of this paper and to analyse risk regulation regimes in Member States and in the Union. The enhanced safety evaluation and monitoring has three levels: At the top strategic level, the traditional indicators of risk of the railway system are combined with other key performance indicators (KPIs) for assessment of the efficiency, effectiveness and reliability of national railway systems. At the level of safety performance analysis, traditional CSIs are to be used and complemented with a few additional ones targeting the safety of infrastructure and minor occurrences, such as incidents in the railway system. Last, at the level of the regulatory regime and its functioning, a brand new set of elements should be assessed through a set of predefined criteria. The framework for assessment of regulatory regime is presented in the next part of this paper.

## DESIGNING ENHANCED MONITORING FRAMEWORK

Modern management approaches are based on a common belief that one can only improve what can be assessed ("You cannot improve what you cannot measure" or "If you cannot define it, you cannot control it"). At the same time, the issues that are most important, long term, cannot always be measured in advance. These beliefs underline the critical importance of a comprehensive monitoring and evaluation framework as a support tool for evidence-based policy making all the while recognising the limits of the approach, underlining that the creation of such a framework is a long term iterative process.

Monitoring and evaluation of the safety of the railway system at national or supra-national level is a complex task that requires upgrading of traditional outcomes-evaluation techniques and an integration of tools available in modern management approaches. This is essential as the two approaches are complementary and mutually reinforcing. Since the railway safety in the European context is managed at three different levels: At the level of operators, at the level of Member states and at the level of the EU, the monitoring tools must be universal and at the same time proportionate to the target level. It should cover all levels of safety management that can be summarized through the concept of a safety management pyramid [5] in Figure 2. It depicts how the negative consequences of accident outcomes are underpinned by the design of the risk regulation regime. A risk regulation regime can be understood as the complex of institutional geography, rules, practice and animating ideas that are associated with the regulation of a particular risk or hazard [6]. The regulatory regime is thus more than standards, reporting or prioritization; it embraces integration and accountability within relevant organizations [6].

There is certain parallel with the safety management systems of railway operators, which assure risk governance at operational level. These comprise of several functional elements; training and communication should provide awareness, adequate feedback and monitoring should facilitate assessment of the safety performance and the ability to learn and improve the management system [7].

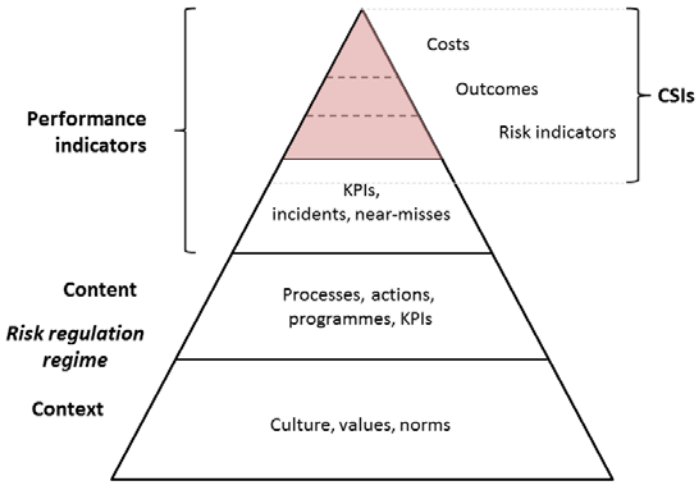


***Figure 2: Pyramid for railway safety management***

Since the (effectiveness of) the risk regulation regime directly impacts safety performance of the system, a holistic evaluation of the railway system includes evaluating the risk regulation regime and its components. The extension of monitoring on the underlying levels of the safety pyramid represents the major novelty for railway safety management.

Management approaches are instructive in designing the framework for risk regulation regime monitoring. The theoretical framework originates from modern management theories that contain a number of approaches to continuous control. The PDSA (Plan, Do, Study, Adjust) cycle known as Stewhart's cycle (Figure 3), is the basic concept of modern quality control systems that have been popularized by Edwards Deming in the mid-1900's. This iterative four-step management method is widely used in business for the control and continuous improvement of processes and products. The concept of PDSA is based on the scientific method, as developed from the work of Francis Bacon in his classic *Novum Organum* [8]. There was certain development in the understanding and design of the PDSA cycle: Steward sought to emphasize the need for an analyst to take action based on the conclusions of the evaluation, while Deming sought to clarify the role of studying the results of the action (sometimes referred as checking). Even a century after its first introduction, the PDSA cycle offers a sound basis for the design of the monitoring framework that focus on all four elements of the cycle, not just the study (check) element.


***Figure 3: Management theories for continuous control and improvement***

The design of the framework for assessment of the regulatory regime for the EU railways, the so-called Regulatory Monitoring Matrix (RMM), stems from the best practices identified across the globe. Notably major modern management and quality approaches have been reviewed by the Agency. As a basis, main ISO standards (in particular the 9000 series for quality management systems, the ISO 14001 for environmental management systems and ISO 19011 on auditing of management systems); the British standard for health and safety management systems (OHSAS 18001) and the acceptable means of compliance performance scheme for aviation developed jointly by the Commission, the Member States, EASA and EUROCONTROL [9] were considered. So were also work done on road safety management [10] and existing knowledge in railways, such as work of Dixit, who proposed a composite safety performance index [11] to better measure safety performance of the Indian railway system. Reasons' work on managing the risk [12] and the work of Health and Safety Commission on human factors provided further useful insights [13].

In addition, in order to better understand the different ways in which a risk regulation regime can function, and to identify best practice in the various elements of such a regime, the Agency commissioned in 2012 a study to review risk regulation regimes across various industries [14]. This work has substantially contributed to defining the criteria for each of the elements in the Matrix.

In developing the Matrix, the Agency considered the national railway systems as complex systems in which institutions and actors interact. The Member States were looked at through business lenses: they were seen as business organisations and it was considered that, in essence, any organisation that wants to control the quality of its outputs firstly needs to identify its goals and set out to direct the organisation towards that goal (steering). It then needs to create a structure that will allow it to reach that goal (organising), followed by ensuring that it has the right people with the right competence to reach the goal (staffing), it then needs to carry out the activities that will result in reaching the goal (performing) and finally measure how effective it is in reaching the goals and whether or not it needs to implement any changes (evaluating). The next step was to identify the relevant sub-elements to these five elements on a national level. The business policy would for example on a Member State level translate to the national transport policy. The leadership aspect on a national level mostly translates to the (Transport) Ministry's governance of the National Safety Authority (NSA), internal governance of the NSA and the NSA's promotion of the safety regulatory framework in relation to the sector (prompting it towards excellence). The Matrix thus looks at performance of key actors of the railway risk regulation regime. The extent to which a certain key actor is being assessed depends on the nature of the sub-element. For example the sub-element of Learning-Accident investigation only concerns performance of the National Investigation Body and does not look at performance in the Ministry or the NSA.

All in all, 26 sub-elements have been identified to the five basic elements which are all vital for functioning of the regulatory regime and delivering the overall purpose of the Railway Safety Directive [1]. The basic elements and sub-elements – and how they relate to the concept of PDSA – are demonstrated in Table 1.

| Elements of control scheme | Elements of RMM | Sub-elements sought |
|---|---|---|
| Planning and organizing | 1. Steering | Goal setting and management |
| | | Leadership |
| | | Board governance |
| | 2. Organizing | Establishment and responsibilities |
| | | Accountability |
| | | Organisational structure |
| | | Communication |
| | | Interface arrangements |
| | | Safety culture management |
| | | Record keeping |
| | 3. Staffing | Worker involvement |
| | | Competence |
| Performing | 4. Performing | Risk-based approach |
| | | Target setting |
| | | Resource management |
| | | Change management |
| | | Control – Supervision and enforcement |
| | | Control – Approval |
| | | Learning – Accident investigation |
| | | Learning – Monitoring |
| | | Promoting the safety regulatory framework |
| Analyzing | 5. Evaluating | Monitoring |
| | | Audit |
| | | Learning from failure/success |
| | | Review |
| Improving | | Corrective action |

***Table 1: Key areas for monitoring and assessment of the regulatory regime (RMM)***

As an example, the reasoning behind the disaggregation of the first element of the Matrix into the three sub-elements can be given as follows. Steering is deemed essential for assuring the leadership, it also includes the management functions. In words of Demig, “the problem is at the top; management is the problem" [15]. Demig insisted that the top-level management had to change to produce significant differences, in a long-term, continuous manner. The leadership of the management and their performance are most relevant in the work of the government, the NSA and national investigation body (NIB). A written safety strategy that contains safety targets underpins the leadership and provides a catalyst for change. Ambitious, achievable and empirically-derived railway safety targets are a key driver for safety improvements, especially when bounded with the plan and programme, outlining how to achieve them, according to the OECD review of ambitious road safety targets [16]. The attitude and dedication of the top management (notably the Ministry) to safety also determines the activity of relevant staff and the availability of resources for safety improvements. The composition of the boards and their governance of the NSA and the NIB respectively refers to the possibility for those key players of the regulatory regime to a) stay independent (no RU or IM should be represented in the board of the NSA/NIB) and to b) carry out their work (the board must fully understand and support the position of the NSA/NIB in the system)..

Evaluation of the performance requires a scale to measure and compare Member States against each other and against themselves as they evolve over the years. In this respect, the Matrix is based on different methods for measuring maturity, in particular ISO 15504 and the Carnegie Mellon’s Maturity Model. Effectiveness within each sub-element is thus measured against a five-step scale, ranging from ad hoc performance in the lower end, over acceptable performance in the middle to excellent performance at the top.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Efficiency of management functions | Ad hoc | Planning/ Initial Implementation | Implementing | Managing & Measuring | Continuous Improvement |
| Maturity levels of processes - ISO 15504 | Purpose achieved | Performance managed | Process established | Process controlled | Process improved |

***Table 2: Performance levels based on two different schemes***

In order to have a common understanding of the particular performance levels and to ensure consistent objective evaluations of performance by each Member State (and indeed, to create a common language to be used in the dialogue with the Member States), the Agency has identified criteria that would be expected to be present on each maturity level for each of the sub-elements. For example, in the sub-element of Leadership you would expect to find among other things on the ad hoc-level that he Ministry does not recognize that the NSA has an important role for the realization of railway safety, while at the level of continuous improvement you would expect to find that the Ministry encourages and supports initiatives from the NSA to optimize railway safety.

The Matrix hereby provides an overview of the approaches and processes used by the key actors such as Ministries, NSAs and NIBs, highlighting problem areas in each Member State. By assembling the monitoring of all Member States into one picture this framework has the potential to identify how far away we are from reaching the overall EU railway safety policy and, more importantly, which areas would need to be targeted in order to finally reach it. This knowledge would be useful in prioritising the Agency's activities and manage its resources more efficiently.

The Matrix also identifies areas where there exists best practice in certain Member States. There already is some sharing of best practices in the NSA and NIB Networks organised by the Agency, but the Matrix would bring a systematic identification of those practices and help to match them against identified problem areas. A systematic guidance from the Agency in this respect could help to bring about an overall performance improvement in the European railway system.

This complex work of designing a model that is capable of assessing the risk regulation regimes of the different Member States started in 2012. The model was presented to the EU Member States in June 2013 and will now be tested on some volunteer Member States in a pilot project. The pilot will evaluate the design and effectiveness of the Regulatory Monitoring Matrix and is expected to produce a final report on its results in June 2014.

## ENHANCED MONITORING OF OUTCOMES

The current EU regulatory framework comes half way in prescribing what types of occurrences must be recorded and reported to regulators. In the framework of CSIs, only significant accidents and six precursors to accidents have to be reported to the NSA and to the Agency acting on behalf of the EU regulator. Only accidents resulting in a fatal or serious injury; or accidents resulting in significant delays and/or damage are reportable as significant railway accidents. Minor accidents and incidents are currently not monitored at EU level (and there are no provisions in place to assure that they are consistently recorded at national level).

This annual reporting allows gathering the figures per type of occurrence and the consequences, so its informative value is limited. The specific datasets are very often not available to feed specific technical and risk-based studies.

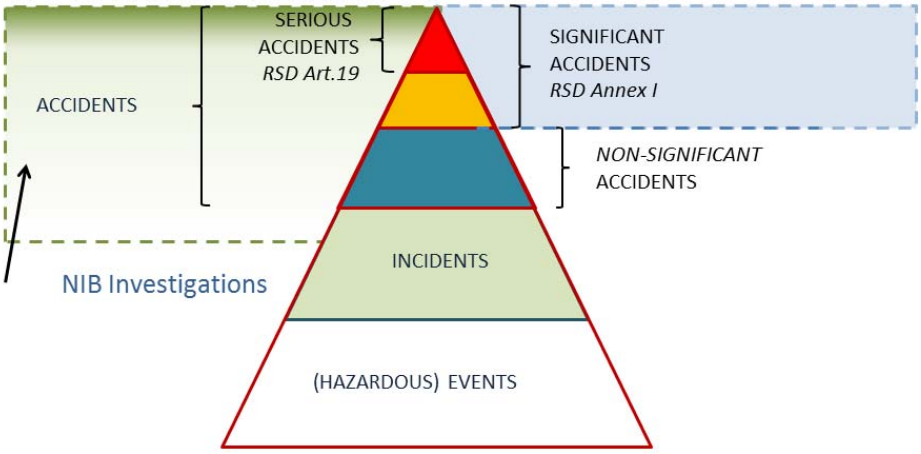


***Figure 4: Hierarchical structure for the current occurrence reporting and monitoring in the EU***

In early 2013, the Agency recommended that the Railway Safety Directive contains provisions for mandatory reporting in railways, similar to the one existing in the aviation. Not only significant, but also other accidents and some incidents should be subject to mandatory reporting. Respecting the principle of proportionality and subsidiarity, the incidents do not need to be reported to EU level, but to the national level.

The Agency has notably recommended a new set of incident indicators, based on the study carried out by a contractor [17] to identify a set of suitable incident indicators for extended common reporting (Table 3). These complement six so called “accident precursor” indicators already defined and reported under CSIs. These are Signal passed at danger, Wrong side signalling failure, Broken rail, Broken wheel, Broken axle and Track buckle.

| Indicator |
|---|
| Unauthorized departure |
| Buffer stop collision |
| Runaway |
| Level crossing protection failure |
| Wrong route setting |

***Table 3: Overview of recommended additional incident indicators***

Whether and when the provision for mandatory occurrence reporting will be introduced in the legislative framework, or will be promoted by the railway industry as a recommended voluntary approach remains to be seen.

## DISCUSSION AND CONCLUSION

In this article, the development of the enhanced framework for safety monitoring in the European Union that is a part of an attempt to introduce an SMS to European and National safety management was presented.

The new approach to safety monitoring combines reactive and proactive safety monitoring approaches. It enlarges the scope by revising the set of monitored outcomes and by introducing five new areas for safety monitoring. For each of the areas, a set of elements is proposed, for which specific evaluation categorical criteria are defined. Like that, objective and consistent evaluation can be carried out for all main actors of the risk regulatory framework. The evaluation method, the so-called Regulatory Monitoring Matrix, will be tested in a pilot project on volunteer Member States, which will be starting in autumn 2013.

The Agency believes that the new framework for railway safety monitoring and evaluation has a potential to largely contribute to more efficient risk governance at Member States level, by allowing to assess areas of the risk regulation regimes that were until now out of scope of measured system properties. This is thanks to a sensitive combination of a traditional linear and modern safety management approaches. Whereas offering a more complex insight into the properties of risk governance at national and supra-national level, the authors humbly recognize that many important properties of the system cannot be directly measured and remains largely unknowable.

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