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RAMS MANAGEMENT OF A RAILWAY SYSTEM

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Abstract**:** *This paper makes the overview how to achieve necessary safety and availability and how to manage risk of a railway system in terms of the European standards EN 50126 in the new railway lines and renewal railway lines. This standard defines RAMS in terms of reliability, availability, maintainability and safety of railway applications and their interaction. It also defines a systematic process for specifying requirements for RAMS and demonstrating that these requirements are achieved and managed. Although the standard mainly addresses RAMS of technical (sub) systems and components, some of its contents are very useful within a common process of risk management.*
Key words**:** *RAMS, Safety, Availability, CSM, Railway*

INTRODUCTION

The European Standard EN 50126 provides for common understanding between all railway players of a consistent approach to the management of reliability, availability, maintainability and safety (RAMS) of a railway system, sub-system and their components. The RAMS of a system can be characterized as a qualitative and quantitative indicator of the degree that the system or the sub-system and the components comprising that system can be relied upon to function as specified and to be both available and safe. The goal of a railway system is to achieve a defined level of rail traffic safely in a given time. Railway RAMS describes the confidence with which the system can guarantee the achievement of this goal.

Safety and availability are inter-linked in the sense that a weakness in either, or mismanagement of conflicts between safety and availability requirements, may prevent achievement of a dependable system.

Basically one railway system consists of track, structures and earthworks, traction supply and overhead contact system, stations and signalling and telecommunication equipments. These systems are critical to the safe operation of the railway. As well as loss of availability, poor design, installation or maintenance potentially leading to a safety risk either through a failure that is directly hazardous or because failure leads to adoption of a degraded mode of operation where other hazards may arise. Hence to a large extent the provision of a reliable, available and maintainable system also ensures safety. There are however some situations where the mismanagement of conflicts between safety and availability requirements may prevent achievement of a dependable or safe system. Hence all the RAMS elements are interlinked, and it is appropriate to manage them together, as shown in the Figure 1.

Attainment of in-service safety and availability targets can only be achieved by meeting all reliability and maintainability requirements and controlling the ongoing, long-term, maintenance and operational activities and the system environment. Technical concepts of safety are based on knowledge of:

• all possible hazards in the system, under all types of operation;

• the characteristic of each hazard in terms of the severity of its consequences;
• safety-related failures in terms of:
  - all system failure modes that could lead to a hazard;
  - the probability of occurrence of each safety-related system failure mode;
  - sequence and/or coincidence of events, failures, operational states, environment condition, etc., in the application, that may result in an accident (i.e. a hazard resulting in an accident);
  - the probability of occurrence of each of the events, failures, operational states, environment condition, etc., in the application;

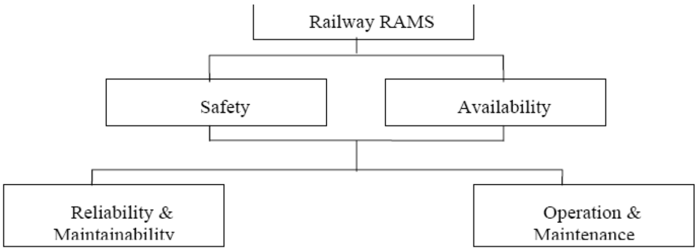

Fig. 1. Railway RAMS

• maintainability of safety-related parts of the system in terms of:
  - the ease of performing maintenance on those aspects or parts of the system or its components that are associated with a hazard or with a safety-related failure mode;
  - probability of errors occurring during maintenance actions on those safety-related parts of the system;
  - time for restoring the system to a safe state;
• system operation and maintenance of safety-related parts of the system in terms of:
  - human factor influence on the effective maintenance of all safety-related parts of the system and safe operation of the system;
  - tools, facilities and procedures for effective maintenance of the safety-related parts of the system and for safe operation;
  - effective control and measures for dealing with hazards and mitigating their consequences.

The balance between the RAMS performance of a system and the costs of development and ownership of the system is well reflected by lifecycle costs. The system lifecycle is a sequence of phases, each containing tasks, covering the total life of a system, from initial concept through to decommissioning and disposal. The lifecycle provides a structure for planning, managing, controlling and monitoring all aspects of a system, including RAMS, as the system progresses through the phases, in order to deliver the right product at the right price within the agreed time scales and safety level.

DESCRIPTION OF ASSET AND SUBSYSTEMS

Basically, while disregarding the necessity of safe operation, every railway system only consist of railway vehicles, railway infrastructure, signaling and telecommunication equipments and the necessary power supply. In order to enable train movements form a starting point to its destination also speed control and direction control are required (Figure 2).

A railway system can be described as:

• The means of transportation where combinations of coaches and/or wagons are moved by locomotives over and guided by rails;
• The totality of the sub-systems for structural and operational areas, as defined in Directives 96/48/EC and 2001/16/EC, as well as the management and operation of the whole system.

The railway system can be defined in a *functional and structural manner*.

A *functional description* takes the functions within the system as points of reference. A distinction can be made in logistical functions (i.e. shunting, boarding and transport) and technical functions (i.e. signalling and control, energy supply, guiding).

When it comes to the *structure of the railway system*, distinction can be made in:

• *Context*-It is important to define the boundaries of the railway system with its environment.

• *Organization* -Which parties are involved, what is their role and what are their responsibilities and competencies?
• *Operations* -The operational structure refers to the operational process and the position of the players that make the system work.
• *Techniques/Technology* -The technical infrastructure refers to the hardware and to the physical means of production.

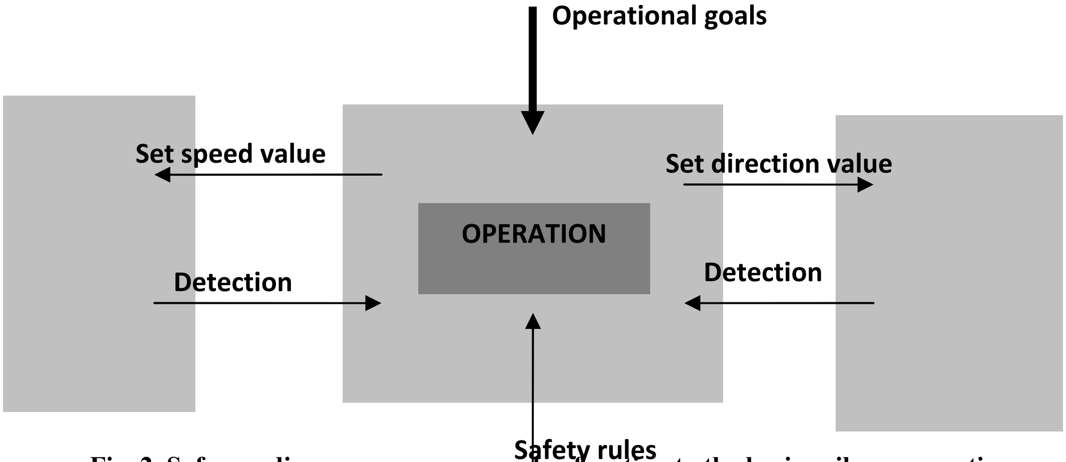

Fig. 2. Safeguarding process as an overlay function to the basic railway operation

A railway system can also be divided into partial systems, sub-systems and components. Each 'level' demands a separate approach in risk identification and risk control. In order to apply most suitable methods and to obtain most reliable results these levels should be taken into account during the whole process of risk (based) management. A combination of the functional and structural division of a (generic) railway system is visualised in the Figure 3.

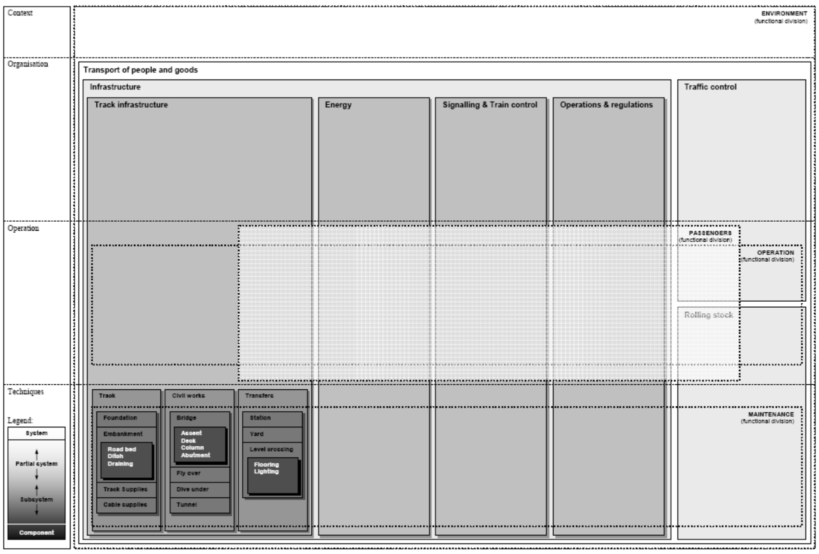

Fig. 3. Functional and structural division of a generic railway system

The railway system is embedded within its physical environment. This means that interactions with the environment are possible. For instance, it is possible that trains collide with road traffic at level crossings. Level crossings are places where there is an interaction between road and railway traffic.
The physical environment can also interfere with the railway system and vice versa. A good system description, as well as the description of the system boundaries and the possible interaction of the system with its environment, are essential for the identification of hazards and risks.
It is a recommendation *to develop a reference model* for the description of the railway system in which the elements named are developed further. Within this model links have to be made with the TSIs for technical (sub) systems and operations.

Within the organisational system the stakeholders and their responsibilities as well as their contribution in the management of the risks emerging from the hazards identified and the sources of these hazards have to be identified. The system model must conform to the relevant European directives for the railways.

LIFECYCLE RAMS ACTIVITIES

The aims of the RAMS management process on generic railway system are to obtain:

- A level of safety as good as reasonably practicable for the asset in line with other European Railway Network;
- An average daily availability target;
- A high level of asset condition compliant with the standards and norms;
- All maintenance activities which have an impact on the availability of the infrastructure.

According EN 50126 the lifecycle is shown in the table 1.

Table 1. RAMS lifecycle

CONCEPT	• Definition of the system	•
RISK ANALYSIS	• Perform RAM Related Risk Analysis	• Perform System Hazard & Safety Risk Analysis • Set-Up Hazard Log • Perform Risk Assessment
SYSTEM REQUIREMENTS	• Specify System RAM Requirements (Overall) • Define RAM Acceptance Criteria (Overall) • Define Systems Functional Structure • Establish RAM Programme • Establish RAM Management	• Specify System Safety Requirements (Overall) • Define Safety Acceptance Criteria (Overall) • Define Safety Related Functional Requirements • Establish Safety Management

APPORTIONMENT OF SYSTEM REQUIREMENTS	• Apportion System RAM Requirements
	  • Specify Sub-System & Component RAM Requirements
	  • Define Sub-System & Component RAM Acceptance Criteria
		• Apportion System Safety Targets & Requirements
		  • Specify Sub-System & Component Safety Requirements
		  • Define Sub-System & Component Safety Acceptance Criteria
		• Update System Safety Plan

DESIGN AND IMPLEMENTATION	• Implement RAM Programme by Review, Analysis, Testing and Data Assessment covering:
	  • Reliability & Availability
	  • Maintenance & Maintainability
	  • Optimal Maintenance Policy
	  • Logistic Support
	• Undertake Programme Control, covering:
	  • RAM Programme Management
	  • Control of Sub-Contractors & Suppliers
		• Implement Safety Plan by Review, Analysis, Testing and Data Assessment, addressing:
		• Hazard Log
		• Hazard Analysis & Risk Assessment
		• Justify Safety Related Design Decisions
		• Undertake Programme Control, covering:
		  • Safety Management
		  • Control of Sub-Contractors & Suppliers
		• Prepare Generic Product Safety Case
		• Prepare (if appropriate) Generic Application Safety Case

MANUFACTURING	• Perform Environmental Stress Screening • Perform RAM Improvement Testing • Commence Failure Reporting and Corrective Action System (FRACAS)	• Implement Safety Plan by Review, Analysis, Testing & Data Assessment • Use Hazard Log
INSTALLATION	• Start Maintainer Training • Establish Spare Parts and Tool Provision	• Establish Installation Programme • Implement Installation Programme
SYSTEM VALIDATION (INCLUDING SAFETY ACCEPTANCE AND COMMISSIONING	• Perform RAM Demonstration	• Establish Commissioning Programme • Implement Commissioning Programme • Prepare Application Specific Safety Case
SYSTEM ACCEPTANCE	• Assess RAM Demonstration	• Assess Application Specific Safety Case

OPERATION AND MAINTENANCE	• On Going Procurement of Spare Parts & Tools • Perform On Going Reliability Centred Maintenance, Logistic Support	• Undertake On Going Safety Centred Maintenance • Perform On Going Safety Performance Monitoring and Hazard Log Maintenance
PERFORMANCE MONITORING	• Collect Analyse, Evaluate and Use Performance & RAM Statistics	• Collect, Analyse, Evaluate and Use Performance & Safety Statistics
MODIFICATION AND RETROFIT	• Consider RAM Implications for Modification & Retrofit	• Consider Safety Implications for Modification & Retrofit
HANDBACK	• No activity for RAM	• Establish Safety Plan • Perform Hazard Analysis & Risk Assessment • Implement Safety Plan

CONCLUSION

Risk management can be approached from different angles. It can be regarded as the way the top management of an organization meets its responsibilities for safety. On the other hand it can be considered as the process which demonstrates that a railway system meets its overall requirements for safety, the Common Safety Targets.
From a management perspective the instrument to use is the Safety Management System (SMS). From a demonstration of safety perspective it is essential that the process, the proof and the evidence for demonstrating safety meets all requirements as laid down in the Common Safety Methods.
When a railway system is designed and built according to the applicable standards and prescribed specifications the most important phase in its life cycle starts - the operational or exploitation phase. In this phase the level of safety has to be maintained and safeguarded. For the technical level this implies that the systems and sub-systems have to be maintained according to the formal standards for maintenance. In some cases, on the basis of the behaviour of the systems, sub-systems and "lessons learned", modifications have to be performed. The level of safety and ALARP are the leading principles.
With regard to the operational level, the quality of procedures, the competencies of staff and the quality of supervision are the managerial issues.
On the organizational or managerial level an oversight of the performance of the railway system with regard to safety has to be monitored and safeguarded as far as the specific organization is responsible. The essential tool for this purpose is a SMS. The common requirements for this SMS are part of the European Safety Directive.

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[3] Commission Regulation (EC) N°352/2009 of 24 April 2009 on the adoption of a common safety method on risk evaluation and assessment as referred to in Article 6(3)(a) of Directive 2004/49/EC of the European Parliament and of the Council

УПРАВЛЕНИЕ НА RAMS НА ЖЕЛЕЗОПЪТНА СИСТЕМА

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Ключови думи: *RAMS, Safety, Availability, CSM, Railway*

***Резюме*: *В тази статия се прави анализ на постигането на необходимата безопасност и готовност и как се управлява риска на железопътна система в смисъла на Европейския стандарт EN 50126 за нови и модернизирани железопътни линии. Този стандарт дефинира изискванията за RAMS – надеждност, готовност, ремонтопригодност и безопасност на железопътните приложения и тяхното взаимодействие. Той също дефинира систематично процесите за специфициране на изискванията за RAMS и демонстриране, че тези изисквания са достижими и управляеми. Въпреки, че този стандарт основно е насочен към RAMS на технически системи (подсистеми) и компоненти, неговото съдържание е полезно и в рамките на общите процеси по управление на риска.*