LET'S DISCUSS RAILWAY VEHICLE MAINTENANCE

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TEXT DIVISION.

The architecture of the railway system is complex. It is composed of technical, structural, and functional sub-systems, and involves a multitude of stakeholders with specific roles and responsibilities. The European railway legislation requires those stakeholders to be organised and to communicate and cooperate to enable a safe operation and maintenance of the railway system. The achievement of those objectives requires sound management and transfer of knowledge, and systematic communication of safety relevant information between the railway stakeholders.

All parties involved in the maintenance process of vehicles, such as railway undertakings, infrastructure managers, vehicle keepers, entities in charge of maintenance, as well as manufacturers of vehicles, shall exchange information relevant to maintenance.

To take it forward, it is crucial to strengthen the exchange of safety relevant information between the different railway stakeholders. The Agency developed and implemented some tools as the Safety Alerts IT tool (SAIT), or a framework related to the obligation for entities in charge of maintenance to provide a list of safety critical components, that could already improve this exchange of information between railway stakeholders.

OBJECTIVE

This paper aims to present the state of arts of developments having the potential for improving the communication between railway actors, their collaboration and finally the inter-organisational knowledge management for the maintenance of railway vehicles.

This article will focus on the framework related to Safety Critical Components and a system for exchanging safety information on maintenance (SAIT).

INTRODUCTION

The European railway environment is changing. The European railway network has been impacted by major changes. Its access has been redefined by regulations that guarantee the safety and interoperability of the entire railway system.

The maintenance management system for vehicles is a strategic issue for all market players.

In this perspective, the following regulations are imposed on all railway vehicles operated on the European railway system:

- EU Directive 2016/798 defines the common principles for the management, regulation and control of railway safety.
- EU implementing regulation 2019/779 establishes the terms of a certification system for the entities in charge of rolling stock maintenance.

However, the need for stronger communication and collaboration has also been highlighted as key factor for success.

ARCHITECTURE OF THE RAILWAY SYSTEM

The architecture of the railway system is, however, quite complex, and the safe operation and the safe traffic management are highly dependent on the following:

(a) the safety of the contributing technical sub-systems, and;

(b) the safe organisation and correct sharing of roles and responsibilities between the various stakeholders defined in the European railway legislation.

The construction of any new equipment composed of multiple smaller parts, or the integration of a new or a modified element into an existing system, is a common development activity. Regardless of the level at which such development takes place, safe integration is necessary at every level to ensure the safe achievement of the expected functionality and to demonstrate that the change does not create unintended, adverse and unacceptable effects on the safety of the overall system.

The European legislation on the railway market opening, and the subsequent restructuring of the European railway sector, have changed significantly the organisation and the sharing of roles and responsibilities between the (new) railway actors (see Figure 1 here below): national safety authority (NSA - usually including the activities of the former safety homologation department of the state railway company), separation between the infrastructure manager(s) and the railway undertaking(s), the introduction of entities in charge of maintenance, manufacturers, service providers, contracting entities, etc. The

responsibility for the safe operation and safe traffic management of the former railway system of a country, and the proper control of the associated risks, is no more restricted to a single railway actor. The infrastructure manager and all railway undertakings operating on its network are sharing, each one for its part of the system, that responsibility. Consequently, in addition to the need of managing own safety risks, the infrastructure manager and the railway undertakings operating on its network have to communicate and collaborate between themselves and with the other stakeholders to address their shared safety risks (figure 1) This implies more communication and more collaboration.

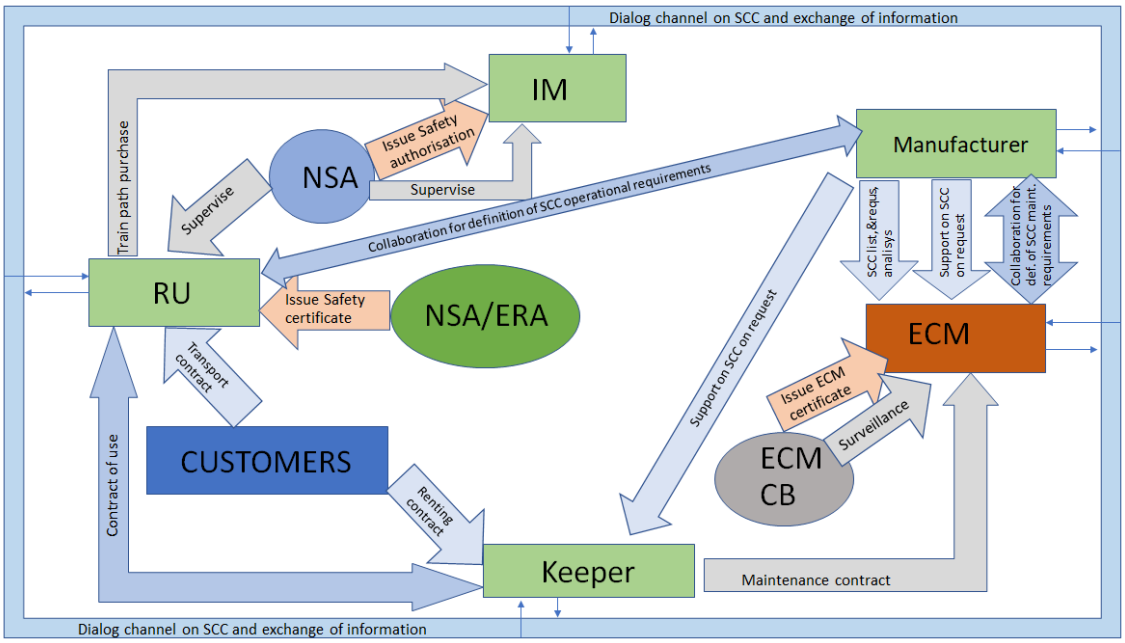

Figure 1: As illustration, different railway stakeholders and the communication links for Safety Critical Components

Legal obligations for cooperation between the railway stakeholders:

Article 4(1) of the Safety Directive (EU) 2016/798 requires explicitly "…that railway safety is generally maintained and, where reasonably practicable, continuously improved" during and after the market opening. To achieve that goal, the infrastructure manager and railway undertakings are required to apply a "system-based approach" and "… where appropriate …" to cooperate "… with each other", involving all other railway actors who have a potential impact on the safe operation of the railway system (e.g., manufacturers of vehicles).

Article 4(1)(d)(i) requires that "railway undertakings and infrastructure managers shall implement the necessary risk control measures…", identified by the application of Commission Implementing Regulation (EU) 402/2013 on the CSM for risk assessment, "…where appropriate in cooperation with each other and with other actors";

Article 4(4) requires that "without prejudice to the responsibilities of railway undertakings and infrastructure managers …, entities in charge of maintenance and all

other actors having a potential impact on the safe operation of the Union rail system, including manufacturers, maintenance suppliers, keepers, service providers, contracting entities, carriers, consignors, consignees, loaders, unloaders, fillers and unfillers, shall":

- Article 4(4)(a): "implement the necessary risk control measures, where appropriate in cooperation with other actors";
- Article 4(4)(b): "ensure that subsystems, accessories, equipment and services supplied by them comply with specified requirements and conditions for use so that they can be safely operated by the railway undertaking and/or the infrastructure manager concerned".

Very often, there is a mix of roles: for instance, a railway undertaking encompassing the role of ECM complies in addition to its duties and responsibilities of Railway undertaking with the requirements of annex II of the ECM regulation 2019/779.

ECM CONCEPT

Before being operated on the network, Directive 2016/798/EU requires that each vehicle must be assigned an entity in charge of maintenance (ECM) responsible for ensuring that the vehicle is in a safe state of running. The ECM must be registered in the vehicle register in accordance with Directive 2016/797/EU.

The role of the ECM can be performed by any competent entity able to manage the maintenance process of railway vehicles systematically. The ECM is allocated to a specific vehicle or group of vehicles and must be registered in the vehicle register in accordance with Directive 2016/797/EU.

In the case of freight wagons and other vehicles where the ECM is not a railway undertaking or infrastructure manager maintaining vehicles exclusively for its own operations, the ECM must be certified by an accredited or recognised body or by a national safety authority. The certification system must provide evidence that the ECM has an established maintenance system to ensure the safe running of the relevant vehicles. Regulation (EU) 2019/779 also introduces a new system for the management of safety-critical components.

An appropriately designed and thoroughly implemented railway vehicle maintenance process constitutes one of the key factors influencing the safety of the rail sector. Requirements in this area have been developed over an extensive period individually by particular countries. However, creating a uniform European railway area has necessitated harmonising the approach to the railway vehicle maintenance process in the whole European Union. The process primarily included the rules of freight wagon maintenance. However, since June 2022, it has been extended to cover other types of railway vehicles.

The EU legislative bodies introduced the entity in charge of maintenance, to facilitate a transparent allocation of responsibility for the maintenance of vehicles, which so far has often been dispersed between various categories of entities active in the rail transport sector, i.e. the railway undertaking, keeper or the company carrying out repairs.

The entity in charge of maintenance has to ensure that the vehicles for which it is responsible can be operated safely on the railway network. The instrument enabling the achievement of this goal is the Maintenance Management System, i.e. a set of procedures

and instructions to be implemented by the entity to minimise the risks associated with maintenance activities.

The ECM is responsible for coordinating and monitoring all maintenance activities with a vehicle or fleet of vehicles, including developing a maintenance file (file including maintenance plans and technical instructions, configuration files of the vehicles, records of delivered maintenance) , the fleet maintenance management and the maintenance delivery. These three functions can be outsourced, in whole or in part. Regardless of the outsourcing arrangements in place, the ECM is always responsible for the outcome of the maintenance activities and must establish a system to monitor the performance of those activities.

MAINTENANCE ACTIVITIES IS CRUCIAL IN THE RAILWAY SYSTEM, FEEDBACK FROM VIAREGGIO

Concerning the need to regulate the maintenance activities (certification of ECMs), this need has been boosted by the VIAREGGIO accident.

The Viareggio derailment was the derailment of a freight train and subsequent fire which occurred on 29 June 2009 in a railway station in Viareggio, Lucca, a city in Central Italy's Tuscany region. Thirty-two people were killed, and a further twenty-six were injured.

The official conclusions of the commissions of inquiry stated that the probable cause of this accident is attributable to the structural failure of an axle of the carriage of the first tank wagon derailed.

It was also obvious that the sharing of safety responsibilities, communication and collaboration in maintenance was poorly understood and implemented within the railway sector

To facilitate the communication and collaboration between the different stakeholders, the Agency developed and implemented a framework for the management of safety critical components and a system of exchange of information.

SAFETY CRITICAL COMPONENTS, A WAY TO IMPROVE THE COMMUNICATION

In 2016, the 4th railway package introduced some coordinated text related to the term “safety critical components” (SCCs). EU railway legislation did not clearly define which component could be characterised as safety critical. In 2016, the Agency conducted several informal and formal consultations to define the state of play in the area. In general terms, the only output of the consultation undertaken was that:

- no list defined which components of the railway system are safety critical, even if EU legislation stated safety critical components include but are not limited to “*components involved in train movements”*
- it was evident that there was no real clear definition or common understanding of safety critical components in the EU legislation
- there was no criteria stated in the EU legislation for defining and evaluating the criticality

As a result, later in 2019, both the TSI Loc&Pas and WAG revision introduced the SCCs definition and some other SCCs requirements and the new ECM Regulation (Regulation

(EU) 2019/779) introduced some ECM management requirements for the SCCs of all vehicles.

Safety critical components are defined as "*the components for which a single failure has a credible potential to lead directly to a serious accident defined as follows:*

- *any train collision or derailment of trains resulting in the death of at least one person or serious injuries to five or more persons or extensive damage to rolling stock, the infrastructure or the environment; and*
- *any other accident with the same consequences which has an obvious impact on railway safety regulation or the management of safety*

'Extensive damage' means damage that can be immediately assessed by the investigating body to cost at least EUR 2 million in total".

As the criticality of a component depends on the design of the technical system in which it is incorporated and therefore of the design of the vehicle, the legislation stated that the initial identification of safety critical components should start at the design process level and the definition of manufacturing processes.

As the design process is normally activated for new vehicle and when existing vehicle is renewed/upgraded or simply modified, the designers/manufacturers or, generally, the entity managing the change (holder of the vehicle type authorisation or other) should then have a process to identify the safety critical components in conformity with the above definition.

This process should include a systematic risk based analysis of all components using the current methods offered by standards or using the annex I of the Commission Regulation 402/2013 (Common Safety Method on Risk Evaluation and Assessment) and, when applicable, the relevant provisions related to the (safety) requirements capture in the Implementing Regulation establishing practical arrangements for the railway vehicle authorisation and railway vehicle type authorisation process pursuant to Directive (EU) 2016/797 of the European Parliament and of the Council. The questions of the identification process could also be summarized in the following flowchart:

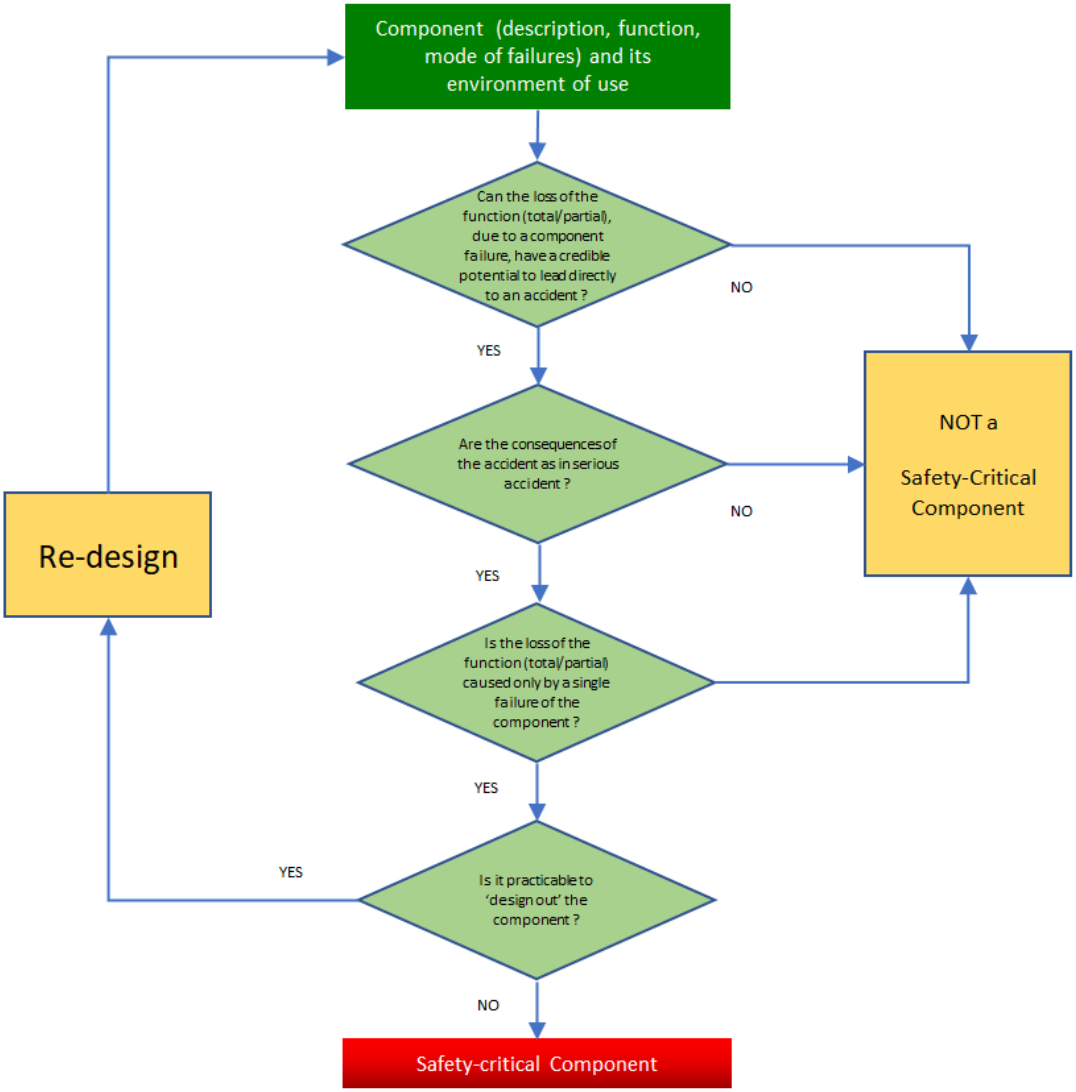

Figure 2: SCCs identification process

In the design and manufacturing of new or modified vehicles, the designers/manufacturers of the vehicles, as well as any designers/manufacturers of the incorporated technical systems and components, should collaborate.

To ensure the level of safety of the railway system, it is crucial that the designers/manufacturers identify the control measures associated with the identified safety critical components and communicate to RUs and ECMs those exported constraints related to maintenance and operations.

For the subsystem 'rolling stock', this communication should be performed by means of the documentation to be provided in accordance with TSIs and Regulation EU 2018/545. The designers/manufacturers should explain/justify in the provided documentation the potential to lead directly to a serious accident due to the single failures of the identified safety critical component.

The whole SCCs documentation packet (SCCs list, methods used and analysis performed, operation and maintenance requirements) is the core of the SCCs management during the vehicle service.

In addition, after different consultations in the railway sector, it was highlighted that the documentation provided by designers/manufacturers could be enormously improved together with a common understanding on the methods used for identifying SCCs. The Agency has been sensitive to this aspect, considering that documentation improvements can support the collaboration between RUs, ECMs and designers/manufacturers. To this end, the Agency proposed to set up a specific Task Force composed of railway sector experts under the umbrella of the Joint Network Secretariat and in collaboration with the CEN TC 256 WG 48 to draft a methodology helping the sector to define these safety critical components.

This chance was catched by CEN TC 256 WG 48 for preparing a Technical Report on SCCs. The document CEN TR17696, prepared in 2020, was released officially in October 2021. This document provides for a common understanding of all the SCCs requirements specifying them for each railway stakeholder involved (ECM, RU/Keeper, Manufacturer/Entity managing the change) and promotes practical arrangements for SCCs identification and management.

The CEN TR 17696 supports classical methods of risk-based analysis (Event Tree Analysis, Fault Tree Analysis, FMECA, HazOp, Cause-Consequence Diagram) together with the CSM on Risk Evaluation and Assessments (Regulation 402/2013).

The steps to identify SCCs are the following:

- identification of components within the structure of the vehicle using EN 15380 series through a breakdown structure (product or functional structure);
- analysis of criticality of components through a risk-based analysis;
- application of the steps as in Fig. 2.

Next step is to arrange operation and maintenance requirements, including traceability requirements.

The SCCs requirements, supporting a safe operation and maintenance, are normally developed as a result of the risk analysis with the scope to control the risk of accidents due to the failure of a SCC during the service of the vehicle.

The legislation states the following SCCs requirements to be derived:

- the SCC operational and operational traceability requirements;
- the SCC servicing, maintenance and maintenance traceability requirements.

The operational and operational traceability requirements are developed in collaboration between Manufacturer/Entity managing the change and Railway Undertaking/Keeper.

The servicing, maintenance and servicing/maintenance traceability requirements are developed in collaboration between the Manufacturer/Entity managing the change and the ECM.

Generally, the risk analysis provides for a wide range of information (function, failure mode, cause, detectability, criticality, scenario, probability of failure, etc…) and, based on this information, tips and indications on measures, barriers, mitigations, restrictions, protections, recommendations can be directly derived as in the following examples:

- operational restrictions (speed limit, max duration/cycle of use, day operation, distance, stops, journeys) and operational rules (manuals, handbooks and guide for use);

- maintenance measures (frequency, visual/instrumental check, condition-based maintenance, periodic inspections, planned substitution, overhaul...).

Operational and maintenance traceability requirements are the recording of certain operational and maintenance activities/data relating to the relevant SCC such as, as an example:

- operational: date, time, distance run, number of journeys and stops, speed, track line profile,…
- maintenance: activity performed, operator, competence, tools

The final step is to collect all the documentation and insert it in the technical file (as defined in the TSIs):

- SCCs list;
- Methods, analysis, principles used for SCCs identification and derivation of its requirements.

During the vehicle service, ECM and RU need to activate a specific monitoring process on SCCs and its requirements and exchange information.

Specifically, related to the exchange of information, ECM is called to:

- where necessary, address a support request to the Manufacturer, when it is identified, directly or via the Keeper, for technical and engineering support about SCCs and their safe integration;
- inform Manufacturer, the holder of the vehicle type authorisation and the holder of the vehicle authorisation, when it becomes aware of evidence that a new SCC is identified;
- inform the rail sector and the rail supply industry about new or unexpected safety relevant findings, when the related risks are relevant for more actors and are likely to be poorly controlled, using the SAIT;
- exchange information on SCCs and exceptional maintenance findings with RUs, IMs, Keepers, Manufacturers, holders of vehicles authorisations and holders of the type authorisation of vehicles, subsystems or components.

The whole SCC management process is showed in the following Fig. 3.

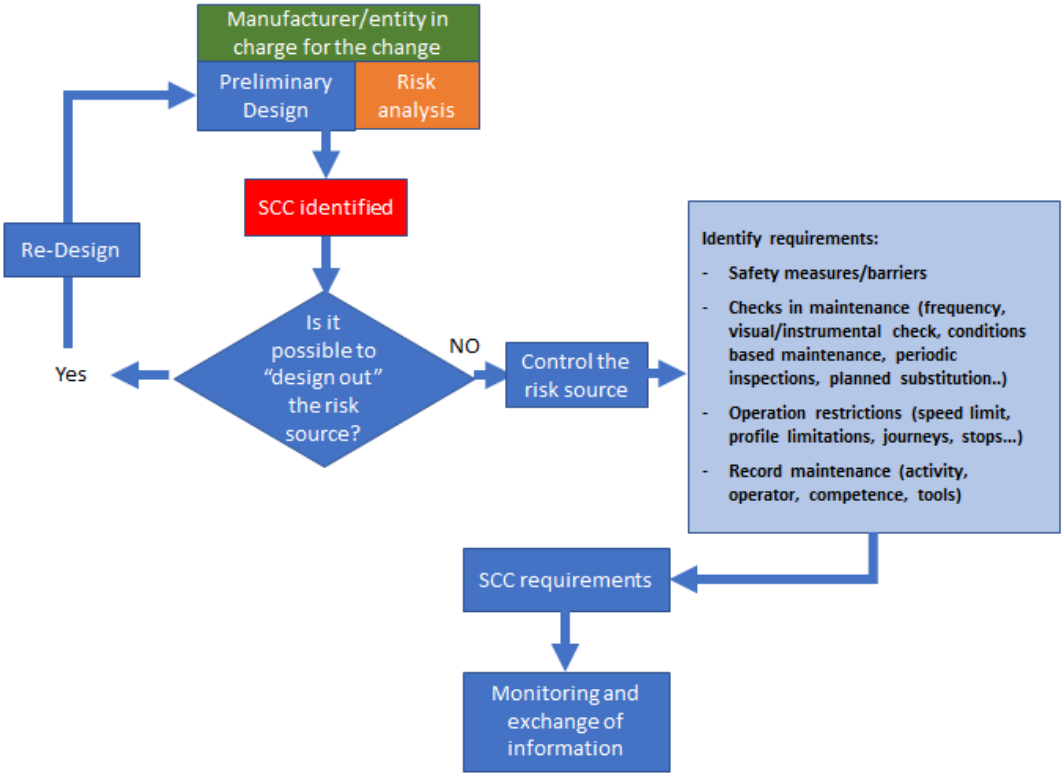

Figure 3: SCCs management process

THE SAFETY ALERTS IT (SAIT) TOOL, ANOTHER WAY TO IMPROVE COMMUNICATION

The Safety Alerts IT tool is a platform developed by the Agency in the frame of the Directive (EU) 2016/798 to support the urgent reporting and sharing of unknown or poorly understood information about hazards and their consequences.

SAIT is a secure website which grants registered users the ability to share information quickly about safety risks relating to defects of technical equipment between some European railway players.

SAIT is managed by the Agency, which is responsible for its security and availability to the public, for its user management and user support. The Agency is also tasked to ensure that SAIT is aligned with the regulatory framework, supporting the exchange of information among the different railway players.

To date the SAIT numbers more than 600 contributors and it has a dynamic evolution in terms of user account requests. The SAIT users are men and women working for railway undertakings, infrastructure managers, entities in charge of maintenance, manufacturers, maintenance suppliers, keepers, service providers, carriers, loaders, fillers and unfillers.

Other bodies, such as National Safety Authorities and National Investigation Bodies are sharing information using another tool the Safety Information System hosted by the Agency.

An effective reporting culture is an essential component of a positive European rail safety culture, the current use of different reporting tools by the industry and authorities marks the current situation which still requires work to be done.

The goal of the European Union Agency for Railways is to have one single reporting tool accessible to actors and authorities, and we are working with national authorities and rail players to develop the necessary safety and regulatory maturity to make that possible. This means building a system in which railway industry report promptly and transparently defects and malfunctions of technical equipment and the authorities and other bodies do not provide any unilateral regulatory responses in case of single occurrences.

By providing operational railway professionals with a platform for sharing and assessing potential safety risks, users of the SAIT can gather important information to prevent accidents in their network. Additionally, the SAIT helps to manage and prevent equipment failures, reducing costs related to repairs and replacements. While in other transport sectors, such as aviation or automotive, safety managers are more prone to exchange knowledge/data/information and learn from each other. By launching the SAIT, the European Union Agency for Railways has provided a solution to a clear gap within the EU framework for railways, as previously there was no formal communication channel for operational players to share vital information regarding critical equipment failure. This is an important innovation because the rail sector is using the same or similar equipment all over Europe and the world, and because EU legislation includes new requirements on safety information sharing.

Professionals from the European rail sector may apply for access to the SAIT, for which they will have to undergo a simple validation process to ensure that only actual operational staff gain access to the tool. After this, users will be able to post and receive safety alert notifications. Users of the tool can filter safety alert notifications based on their interests. The safety alerts include the location of the failure or event, the equipment or systems involved, how the defective technical equipment was maintained and operated, and how the specific defect was discovered. The users can upload supporting documents, including photos. A comment section will allow the community of users to share information about any safety measures taken to prevent similar occurrences, as well as building up a picture of the risk level associated with the failure.

The success of a tool is dependent mainly on the level of engagement of railway stakeholders in Europe. It provides a unique opportunity for rail companies to comply with the new legislative requirements in Article 4 of the Railway Safety Directive to report risks of safety failures to other involved actors, as well as existing EU regulations for safety monitoring, and governing certified entities in charge of maintenance.

Concerning risks detectable during the maintenance activities, ECMs shall report on defects having the potential to flag the presence of an urgent high risk to the railway system in accordance with the application of the CSMs for monitoring processes set out in Commission Regulation 1078/2012/EU provided that:

- The defects relate to a failure of, or a damage to, a rail vehicle, or a component or a system thereof, which prevents or impairs its intended function and could cause an accident or incident.
- The defect, hazard, event or information is novel or unexpected and therefore the related risks are likely to be poorly controlled, especially for a hazard which did not seem to be controlled by a maintenance activity and potentially might lead

to an accident. “Potential serious & potential imminent danger to railway operation” shall be indicated in SAIT if impacting the:

- Interface vehicle/infrastructure
- Design of the vehicle
- Maintenance plan

CONCLUSION

An harmonised and effective reporting process at EU level is in progress. The European Union Agency for Railway has created the basis for boosting the exchange of information within the railway sector. The Agency believes that an effective supporting IT tool (SAIT) and a process to identify safety critical components will enable to fill a clear gap in the European safety practice.

It not only provides operational players with the chance to learn from each other and thereby avoid potential safety risks, but it also plays a crucial role in building the necessary trust between all railway stakeholders, which is vital for building a common approach to safety culture for European railways.

Keywords: Railway, maintenance, knowledge management, inter-organisational learning, knowledge transfer, know-how, communication.