Performance Evaluation Model of Railway Operators Safety Management Systems

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Abstract:

The European legal framework and particularly safety directive 2004/49 introduce the necessity for railway operators to have a Safety Management System (SMS) authorised by a National Safety Agency (NSA) during a limited period. A SMS offers a systematic and precise description of the company organisation in terms of safety management. It makes explicit the organisation of all the rules, procedures, methods and technical or human means to reach the safety objectives and mitigate railways activities risks.

The main challenge is to appropriately assess an "organisational" system which heavily involves human factor aspects. Depending on a lot of factors such as, for instance, the size, the operation field or the experience of the applicant, the SMS can vary significantly from one operator to another. A pure conformity check is definitely inadequate to apprehend the safety performances of a SMS, since the assessment has to be considered in a systemic way. Moreover, as every accident could show a failed organisation in the SMS, the SMS also has to be reactive and scalable during its life period.

The authorisation is an a priori check; hence in practice, a future Railways Undertaking (RU) or Infrastructure Manager (IM) could engage a third party which elaborates on an effective and conformed SMS, without any know-how. A NSA must detect this situation. Indeed, this poses a risk that the procedures described in this SMS could not be (appropriately) used in practice.

However, a NSA has also to supervise the SMS in the field, and tools are needed to evaluate safety performance of all stakeholder in a fair and equitable way. Namely, it is crucial to identify what does a NSA need to reach this objective, to have a whole overview of the operator in terms of conformity/respect of the regulation, safety effectiveness, maturity/anticipation capability.

This paper proposes a tool based on a compliance (other called conformity), effectiveness and maturity assessment model. This model is inspired by ISO standards especially concerning the management science domain that qualifies the performances of an organisation.

I. Introduction

According to the "safety" directive (2016/798/EC) [1] (repelling of 2004/49/EC [2]), one of the directives of 4th railway package, the railways operators must describe their SMS and submit it to a NSA to have a safety certificate (for RU) or railway safety authorisation (for IM). After the entry in force of their authorisation (and SMS), the NSA must evaluate the SMS performance during the validity (5 years in France).

The paper proposes a tool (called in the paper "CEM tool") based on a SMS performance model inspired by ISO standards especially the ISO 9000 [3] and European Union Agency for Railways (EUAR) guide [4].

This tool is a result of the RESYGESS (French acronym of Resilience of Safety Management System) project through the collaboration of the French National Safety Authority (EPSF) the Technological Research Institute Railenium and the Laboratory of Industrial and Human Automation control, Mechanical engineering and Computer Science (LAMIH).

II. Objectives

The main objective of RESYGESS is to evaluate the SMS performances and analyse the impact of safety-relating events on the SMS.

In 2014, EPSF developed a performance assessment system for the SMS submitted by applicants called performance matrix [5]. Nowadays, the NSA continually improves its tool, especially, making it usable to in the analysis stage whereas it was initially designed for inspectors to synthetise their audits and inspections conclusions. Eventually, this tool can be shared with the operators to help them in their internal audits, essential requirement in their risk management. For that purpose, the existing tool is enhanced by a new SMS performance based on a three-part work: evaluation of conformity, effectiveness and maturity.

First, the CEM tool must begin the performance evaluation by conformity because this SMS performance indicator is crucial. Indeed, if the conformity criteria are not all satisfied, some reserves can be expressed on authorisation even it could not be agreed. A tool can be useful to help instructors to check the satisfaction of each criterion.

Second, the article 17 of "safety" directive stipulates clearly that the NSAs must ensure that their supervision activities include a checking mean for the well application by RU and IM of their SMS and must monitor SMS effectiveness. So, the proposed tool can determine a level of effectiveness according the results of supervision activities.

Third, EUAR proposes to NSA a guide [4] about a capability model which will allow to make opinions on the proper functioning of a SMS through a maturity level. This guide highlights some SMS properties concerning the operator safety policy, its internal communication about safety issues, its documentation management or other that the CEM tool proposes to check.

Finally, the occurrence of safety related events during operator activities can have an impact to the evaluation of these three performance indicators. The proposed tool can help the instructors/inspectors to review their judgments according to the operator accidentology. Before presenting the tool, some hypothesis particularly concerning the conformity, effectiveness and maturity definitions and the SMS structure considered must be stated.

III.   Definitions and SMS structure considered

a.   Conformity, effectiveness and maturity definition

The conformity (or compliance) is defined by the fulfilment of a need or expectation (*i.e.* a requirement) that is stated, generally implied or mandatory [3]. The effectiveness refers to the fact that planned activities are realized and planned results are achieved [3]. Finally, ISO standards give a definition of the maturity melting efficiency and effectiveness. However, in literature, a definition more suitable to SMS exists coming from quality management in software engineering used in US Department of Defense: the maturity represents the degree at which an organization implements explicitly and in a coherent way processes which are constantly documented, managed, measured, checked and improved [6].

b.   SMS structure considered

To design the CEM tool, it was necessary to fix a SMS structure. EPSF use an application guide which help authorisation applicant to write their SMS but a guide is not mandatory so each operator freely structures it. In addition, EUAR proposes a SMS wheel [7] slightly different than EPSF guide (see Table 1: Differences SMS structure between the EPSF and EURA). Some precautions must be considered with the use of this capability model seeing that the model is based on SMS wheel.

Table 1: Differences SMS structure between the EPSF and EURA guidelines

EPSF SMS structure	EUAR
Leadership	Leadership
Continuous improvement	Planning
Support	Performance evaluation
Operation	Support
	Improvement
	Operation

A comparison between the SMS wheel and the EPSF guide allows to consider that the continuous improvement procedures seen by EPSF integrates the planning, improvement and performance evaluation seen by EURA.

IV.   Tool presentation

The Figure 1: introduces the CEM tool with input, output, reference documents, *etc...*
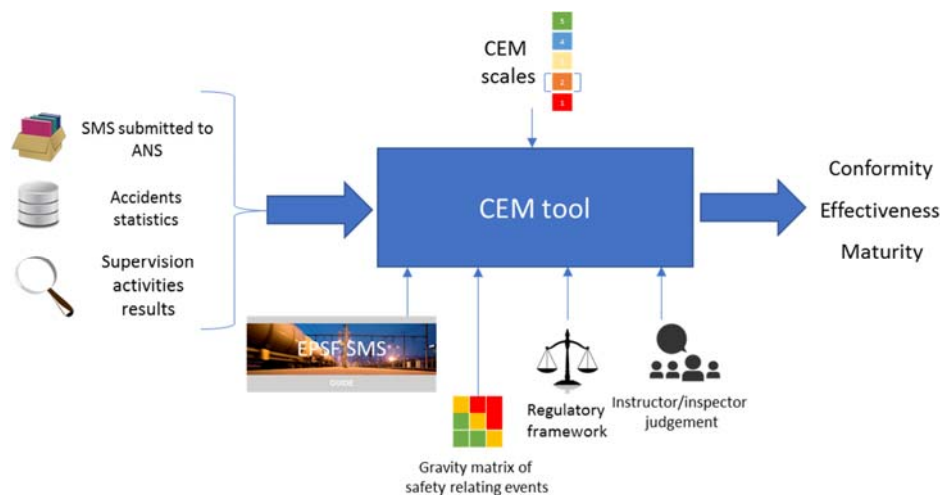

Figure 1: Inputs and outputs of CEM tool

To evaluate conformity, effectiveness and maturity, the CEM tool requires some inputs composed from data collected by EPSF: operator information, supervision, accident statistics.

Name	Operator A	year	Nb cases	Nb audit	Bias not cleared	Bias not cleared / nb audit	Train-km (per 10³)	Nb events	Evt / 10³ km
Authorisation type	Safety certificate	2012	0	0	0	0	9,2	4	0,4347826
Delivery date	01/09/2016	2013	1	1	0	0	94	2	0,0212766
Starting commercial date	13/06/2005	2014	1	1	0	0	192	4	0,0208333
Activity	Freight	2015	1	2	0	0	220	6	0,0272727
Area of activity	All national network	2016	0	3	6	2	220	6	0,0272727

Figure 2: identity card of an operator A with information on the 2012-2016 period

About operator information, it refers to the name, the type of authorisation according the type of railway operator (safety certificate for RU or railway safety authorisation for IM), the authorisation (new or renewal) delivery date, the starting commercial date of the operator, the type of activity (passengers, freight or dangerous goods transport), the activity area (all or a portion of a national network, a border section or a harbour network). Finally, the operator identity card contains a quantification of its activity. According the operator type, a measurement on a five-year period in train-kilometres per year for a RU or kilometre of the railway network for an IM quantifies the operator activities.

During supervision activities, several data are useful for the CEM tool: the number of audits and cases, the type of deviations between submitted SMS and the reality in practice, the number of uncleared biases when the operator does not apply procedures which can deal with the notice bias and the ratio between the last two indicators. EPSF distinguishes four biases from the less to the most critical in terms of safety: weakness point (WP), reserve (Rs), major deviation (MD) and sticking point (SP).

To evaluate the SMS performances in degraded mode operation, the occurrence of safety related events must be considered. Indeed, these events refer to one or several procedures which do not trigger when a dangerous situation occurs. The definition and the nomenclature of safety related events are given by an order in national law. So, the CEM tool considers the following data: the number of this kind of events per year and per train-kilometres and finally their gravity. EPSF uses a 6 levels gravity scale which separate events that <u>could</u> have material or human consequences and events that <u>had</u> consequences.

In addition to these data, the CEM tool needs the list of satisfied criteria (the different criteria are available in Annexe II of 1158/2010 and 1169/2010 Commission Regulation [8] [9] per year and per process for the conformity evaluation. These criteria refer to the presence in SMS of procedures/means/documents during authorisation stage and their well-applying in practice on the validity period. In total, a conformed SMS must satisfy 93 criteria for IM and 80 for RU. These procedures/means/documents must guarantee the achievement of an acceptable safety level.

Next, the answers to questionnaires per year and per process must be given to determine the SMS maturity. Supervision activities include interviews of operator staff which allow to fill the questionnaires.

The CEM tool is designed according the EPSF SMS guide provided to any authorisation applicant to help them to build effectively their SMS. The tool is also based on national and European legal frameworks. In addition, all operator of the rail sector must notify any safety related events which occur during their activities. They fill an events database, used by the tool.

Finally, the CEM tool applies 5 level scale for conformity, effectiveness and maturity using all these data knowing that the level 3 is considered as an acceptable limit for each performance indicators. When data are unavailable in a given year, the last year levels are kept.

The instructors/inspector sensitivity and their judgments must not be removed from SMS performance evaluation. It refers to expert opinions depending on instructor/inspector work experience and their knowledge of the operator. These concepts are complex to apprehend and quantify. So, at any time, they can modify conformity, effectiveness and maturity notation determined by the tool.

In illustrative way, the results for a given SMS operator can be showed in radar plots. It allows to instructors/inspectors to see the global strengths and weaknesses of a SMS (see Figure 3: Rader plots
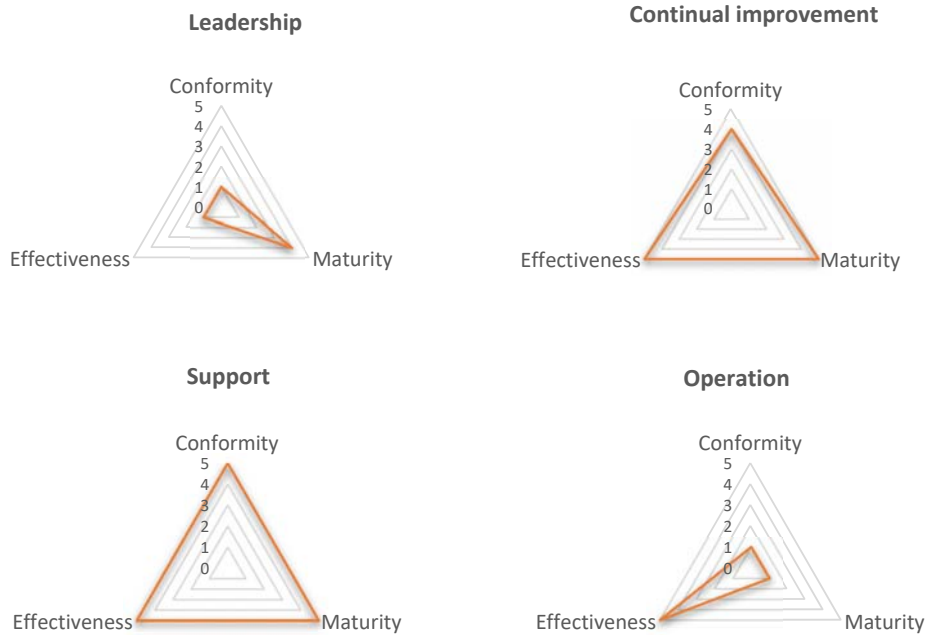

Figure 3: Rader plots for SMS performances for a year

for SMS performances for a year).

To put into service the proposed tool, the following section introduces a brief theoretical example.

V.   Theoretical example

Let's consider an infrastructure manager Y. Having a railway safety authorisation delivered by EPSF in December 2007, it already submitted its SMS to the NSA. Its renewal demand of the authorisation was done on 1st December 2012. Knowing that its validity is 5 years, Y must ask for another renewal demand before end of august 2017 considering a reasonable duration of instruction.

During its instruction, EPSF noticed that the SMS of Y do not include procedures for describing how internal audit findings are used to bring about improvement. Indeed, in the risk management of its activities, Y must ensure a continuous improvement process. According to 1169/2010 regulation, it refers to the criteria "I" (1 out of 93 criteria to satisfy).

The tool determines that the level of the continual improvement conformity is 4 out of 5 because the level 5 referring to 100% of satisfied criteria. However, the renewal is agreed (on 1st December 2017) because 4 is a sufficient level of conformity. The "safety" directive permit to the applicant to have a reasonable (3 months for example) delay to satisfy the remaining criterion.

One year later (2018), EPSF, according to its supervision strategy, plans an audit and notices that some internal audits are not regular. Seeing that it is the same conformity criterion concerned than before, the level of conformity stays at level 4 in 2018. In addition, in maturity part of the evaluation, internal audit is one of property to check. According the EURA guide, internal audits can "1: be rarely realised", "2: exist but not coordinated", "3: be systematic", "4: consider previous audits", "5: compare best practises to achieve objectives". Considering that other property of continual improvement (planning, risk evaluation, monitoring and REX) are 5 out of 5. The average level of maturity of continual improvement process is 4.

In addition, the supervisors in charge of the audit put a reserve about this issue on their list of noticed biases. So, the level of effectiveness (5 by default - a conformed SMS is supposed effective without contradictory information -) is decreased to 4.

In 2020, an unexpected audit on this part of Y's SMS notices that Y rectify the situation about presence of regular internal audits. So, all of indicators are at the level 5.

It is possible that EPSF do not plan supervision activities each year. So, some year cannot be filled in tool. It is assumed that the level is the same than the last year where supervision results are available.

The Figure 4: Results of theoretical example about conformity, effectiveness and maturity evaluation shows the results of the theoretical example introduced above. The absence of safety related event allows instructors/inspectors to keep their conformity, effectiveness and maturity notation.

Process		Conformity evaluation		Maturity	Effectiveness							Nb safety-related events regarding gravity			
		Ratio of satisfied criteria (%)	Conformity out of 5		7 SP	5 MD	3 Rs	1 WP	-1 MP	Cote	Effectiveness out of 5	G3	G4	G5	G6
Continual improvement	2017	96	4	5	0	0	0	0	0	0	5	0	0	0	0
	2018	96	4	4	0	0	0	0	0	1	4	0	0	0	0
	2019	96	4	4	0	0	0	0	0	0	4	0	0	0	0
	2020	100	5	5	0	0	0	0	0	0	5	0	0	0	0
	2021	100	5	5	0	0	0	0	0	0	5	0	0	0	0
	Tendance	98	4,4	4,6	0	0	1	0	0	1	4,6	0	0	0	0

Figure 4: Results of theoretical example about conformity, effectiveness and maturity evaluation

VI.   Conclusions

The paper shows the results of RESYGESS project about an evaluation tool of SMS performances, the CEM tool. It has separated three different aspects of performance: conformity, effectiveness and maturity. The proposed tool is based on existing one used in EPSF, the performance matrix. The CEM tool considering improvement actions identified during the development of performance matrix [5] and permits to express clearly an effectiveness and maturity level. A major enhancement is the extension to authorisation instruction stage in the SMS performance evaluation.

Even if, some actions are automatised (through VBA macro) on the proposed tool in comparison to performance matrix. The tool developed is still an Excel file. A possible improvement suggested in [5] is to develop a software managing existing databases and ensuring the exchange of data in real time.

VII.   Acknowledgements

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