MANAGERIAL WAYS FOR AVOIDANCE OF CRISIS OF SAFETY MANAGEMENT IN RAILWAYS

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ABSTRACT
Safety Management Systems (SMSs) of railway undertakings are based on system-based approach that stresses the interactive nature and interdependence of external and internal factors influencing the operational process. A well organized and properly functioning SMS is supposed to secure high level of operational safety. But sometimes, due to lots of causes the SMS of a railway undertaking may fail (operates in an improper way) as a result of which a crisis of safety management can arise. The present paper discusses the possibilities for introduction of managerial and scientific approaches into safety management in railways.

Key words:
Safety management, safety management systems, expert evaluations

ABSTRAKT
Systémy riadenia bezpečnosti (SMS) železničných spoločností sú založené na systémovom prístupe, ktorý zdôrazňuje interaktívnu povahu a vzájomné prepojenie vnútorných a vonkajších faktorov ovplyvňujúcich prevádzkové procesy. Dobre organizovaný SMS by mal zaručiť vysokú bezpečnosť prevádzkových procesov. Z mnohých príčin však môže niekedy SMS železničnej spoločnosti zlyhať (pracovať nesprávnym spôsobom), v dôsledku čoho môže vniknúť kríza riadenia bezpečnosti. Článok sa zaoberá možnosťami zavedenia manažérskych a vedeckých prístupov do riadenia bezpečnosti na železniciach.

Kľúčové slová:
Riadenie bezpečnosti, systémy riadenia bezpečnosti, expertné odhady

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1 INTRODUCTION

Perhaps, safety is the most frequently used word within all organizational levels, operating bodies and structure as a whole of any railway operator (railway carrier or infrastructure manager). In many cases this term is used primarily descriptively without intentional emphasis on a special issue. But in two specific cases, safety becomes a key problems whose correct solution requires right attitude and understanding, namely: the initial design and establishment of Safety Management System (necessary for railway undertaking licensing and obtaining of safety certificate in line with respective State Railway Agency requirements) and incident/accident occurrence (leading to the necessity for reconsidering SMS for eventual deficiencies).

Both cases are relating to the next very important practical issue of whether there is any discrepancy between safety awareness, knowledge and responsibility of every member of undertaking's operating staff and company's system safety as a whole. The presence of such a discrepancy is irrefutable evidence that company's management does not pool resources (human, technical, organizational, financial, etc.) and conditions to make safety key company's strategy, i.e. the company does not make enough efforts to:

- involve all individuals (operating staff, managers, etc.) in the process of definition, assessment and mitigation of the risks regarding potential operating hazards;
- define safety as a basic requirement within all stages of transportation process, levels of operating management (technology, organization and monitoring of transport process) and exploitation units which is of great importance for railway undertaking performability;
- consider safety as a main and complex attribute of the railway undertaking which depends on many influencing factors (each with its specific characteristics);
- involve applicable approaches and methods to disclose safety issues.

The achievement of a safe transportation process is a very important task. The railway experience categorically shows that in case of even minor incident all subsystems of given railway undertaking disorganize their performance, i.e. there is crisis not only in operating process but in company's management (including safety management) as a whole.

In order to prevent operating and safety management crisis from occurring it is needed to involve managerial ways in company's management. The present paper discusses the possibilities for introduction of the method of expert evaluation into safety management in railways.

2 ESSENCE OF EXPERT EVALUATION METHOD AND ITS FEASIBILITY FOR ANALYSIS OF SAFETY MANAGEMENT SYSTEM OF RAILWAY UNDERTAKINGS

The method of expert evaluation is well known and often used analytical methodology within decision-making in variety of industries. This method is based on the team work of some experts having significant expertise about particular problem which is under question. The decision-making fulfilled within this method is primarily based on the following steps:

- very clear definition of the problem which is to be analysed;
- creation of a questionnaire with content and structure corresponding to the defined problem;
- implementation of a poll for questionnaires answering;
- analysis of poll results.

The method of expert evaluation has been used in a study of SMS functioning of a Bulgarian railway carrier after occurrence of several incidents. The main purpose of study was to discover those factors having the most significant impact on the ongoing safety level – in such a way, the most appropriate mitigation measures would be defined.

In implementation of the study, a team of $m = 6$ experts (consisting of four managers working in the field of undertaking's technical exploitation and two external experts with rich expertise in the area of railway operating safety) has been created. The expert team devised a poll encompassing $n = 9$ questions describing the influence of certain causal factors (technical, technological, managerial, human, etc.) on operating safety (respectively on SMS functioning), namely:

- rolling-stock reliability;
- permanent way reliability (marshalling tracks, sidings, loading/unloading tracks, etc.)
- technology and organization of train movement;
- technology and organization of shunting operations;
- operating staff reliability (skills, education, safety culture, etc.);
- degree of correspondence of the written rules and regulations to the requirements of operating safety;
- influence of operating environment (e.g. influence from other railway undertakings);
- risk assessment and management (defining and registering of hazards, assessment of risks' elements, etc.);
- administrative and technological management of the undertaking (as a whole or within the individual organizational units).

Expert	Questions (factors under evaluation)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	*2*	*1*	*2*	*2*	*3*	*4*	*1*	*4*	*4*
2	*1*	*1*	*3*	*2*	*4*	*4*	*1*	*4*	*4*
3	*1*	*1*	*2*	*2*	*3*	*4*	*2*	*4*	*3*
4	*1*	*2*	*3*	*3*	*4*	*3*	*1*	*4*	*3*
5	*2*	*1*	*2*	*2*	*4*	*4*	*1*	*3*	*4*
6	*2*	*2*	*2*	*2*	*3*	*3*	*1*	*3*	*3*
r_j	9	8	14	13	21	22	7	22	21
$\overline{r_j}$	1.5	1.3333	2.3333	2.1667	3.5	3.6667	1.1667	3.6667	3.5

Tabl.1.Rank matrix of expert evaluations

Regarding the degree of influence of respective factor on operating safety, $k = 4$ opportunities (answers) have been established. The opportunities ranks have been assigned following the next approach:

- rank 1: Insignificant influence;
- rank 2: Minor Influence;
- rank 3: Moderate influence;
- rank 4: Major influence.

Expert evaluations $r_{i,j}$ are shown in table 1.

The processing of results after implementation of the poll (Table 1) follows the next procedure consisting of the following major steps [1], [2]:

●*Calculating of some parameters*

- Total rank of each question $j \to (j = 1,...,9)$ - $r_j = \sum_{i=1}^{m} r_{i,j}$;

- Average rank of each question j - $\overline{r_j} = \frac{r_j}{m}$;

- Coefficient of concordance - $W = \frac{12\sum_{j=1}^{n}(r_j - \overline{r})^2}{N^2(n^3 - n)}$.

The *coefficient of concordance* is a measure of the agreement of experts' opinions and varies on the order of 0 to 1.Value of $W = 1$ means that there is a complete agreement among expert evaluations. Contrary to that, $W = 0$ stands for the lack of agreement among experts. In the course of the study, *coefficient of concordance* $W = 0.82$ has been calculated.

●*Check of the statistical significance of evaluations*

The obtained coefficient of concordance $W = 0.82$ shows a very high level of agreement between expert evaluations. No matter of that, this result should be statistically verified. For this purpose two hypotheses have to be tested:

- *Null hypothesis* (H_0) - disagreement between expert evaluations;

- *Alternative hypothesis* (H_1) - agreement between expert evaluation.

Decision-making regarding the choice of so defined hypothesis is based on the comparison of the computed test statistic $\chi^2_{test} = W(n-1)m$ and theoretical value of χ^2 distribution (given in tables). The latter depends on two parameters: α - level of significance and $df = 2(n-1)$ - degree of freedom.

The rule about the acceptance or rejection of null hypothesis is as follows: *The null hypothesis is rejected if the obtained value* χ^2_{test} *exceeds the theoretical* χ^2 *(* $\chi^2_{test} > \chi^2$ *). Otherwise (* $\chi^2_{test} < \chi^2$ *) the null hypothesis is accepted.*

Within the presented study, practically implemented with purpose to improve SMS functioning of a railway carrier, the next results about parameters mentioned above have been obtained:

- $\chi^2_{test} = W(n-1)m = 39.37$;
- $df = 2(n-1) = 16$;
- $\chi_{\alpha,df} = \chi_{0.05,16} = 26.296$ (taken from table for χ^2 distribution with parameters $df = 16$ and $\alpha = 0.05$).

Since $\chi^2_{test} = 39.37 > \chi^2 = 26.296$ the null hypothesis has been rejected.

3 CONCLUSION

Achieving high level of operational safety in given railway enterprise (no matter if it is railway carrier or infrastructure manager) is a very important task but at the same time extremely difficult. The main reason for that is the fact that railway enterprise is a very complex system consisting of a variety of subsystems. Of course each subsystem has its own characteristics but what unifies them is their imperfection. In other words, such a system could never be designed perfectly and every constituent of it can be subject to failure - technical equipment failures, operating staff faults, imperfection of the written procedures and rules, deficiencies of the managerial system as a whole, etc.

The subsystem failures (and as a result - system failures) entail incidents which are usually considered as normal to occur (it is impossible to absolutely prevent them from occurring). At the same time, serious ones (accident) could and should be prevented and that can be done by implementing certain measures, e.g. enterprise's knowledge of incidents. On this basis and by the usage of appropriate managerial approaches, the risk management regarding incidents and serious accidents becomes not only possible but extremely effective.

The present article shows that the method of expert evaluation is not only applicable in designing and functioning of Safety Management Systems of the railway undertakings but leads to good managerial solutions helping the avoidance of crisis of the technical exploitation.

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Článok recenzovali dvaja nezávislí recenzenti.