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Professional paper

On the acquisition, correct analysis and dissemination of knowledge about safety problems as an important managerial tool to improve the functional reliability of transport systems

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Abstract – **No doubt that safety is the most important and difficult to achieve characteristic of whatever transport system. In this field of the technical exploitation, significant measures are being made not only by the relevant government structures but also individual transport undertakings (infrastructure manager and transport operators). On a different note, it should be admitted that without creation, processing, correct analysis and dissemination of knowledge regarding operating safety problems even the best intentions for safety improvement would probably be in vain. The present paper discusses the necessity to design and also the specifics to govern a technological system (within the technical exploitation of a transport undertaking) for the usage of information concerning factors influencing operating safety and on this base for improvement of reliability of undertaking performance.**

Keywords – ***Transport, Operating reliability (safety), Knowledge management***

I. INTRODUCTION

The successful management of transport technological systems (transport companies) requires reliable information, proper assessment and correct analysis of events and phenomena that occur during the course of technical operation. In particular, when making decision on operational reliability (safety) issues, the essential requirement is the availability of information (knowledge) on the risks to the transport process. The more complete this knowledge is, the more relevant the decisions and actions made are.

Historically, transport managers have always relied on "sufficient professional experience and knowledge" for this type of industry when assessing the risks associated with the functioning of technical facilities and most notably how they are used by operating personnel. In other words, thanks to its long history and its specific features, the transport industry has generally been unquestionably successful in maintaining meaningful "basic knowledge" about safety in volume and content.

Over recent decades, however, there has been a significant increase of the usage of new technical and technological solutions used for specific purposes in the transport industry. These technical and technological solutions (systems) are very complex. This complexity is continuously increasing, pushing managers to better understand of how the respective system behaves and what its influence over transport service quality is. It should be admitted that the lack of sufficient and specific knowledge of systems' safe behaviors necessitates the development of new forecasting techniques, most of which are based on the risk concept and management principles.

Of course, there is a wide variety of scenarios under which transport accidents (incidents) could occur. However, their common characteristic is the element of surprise when they arise. This element of surprise clearly shows that in a very large percentage of accidents there is a "lack of preparedness" of the respective transport company with respect to the potential risks to the operational process.

Therefore, a proper understanding of the nature of risks, their elements, management principles and specificities of decision-making process in this field is essential for achieving an acceptable level of the operating reliability (safety) within the transport undertakings.

The present paper discusses the necessity to establish, the essence and basic elements of safety knowledge (and its management) in the field of transport process management.

II. FACTORS FOR SUSTAINABLE FUNCTIONING AND DEVELOPMENT OF THE TRANSPORT SYSTEMS

Transport service quality

Even a not so thorough review of literature shows that there are a great number of definitions for quality used in many industrial fields (e.g. [5], [9], [11], [12], [13]) but few in the area of the transport services, no matter that this term is often used in papers, research reports, operating rules and regulations. Considering the specific of transport service and with adaptation of the definition of quality stated in [1], the quality of transport service could be defined as: *a complex feature of a given transport technological system (e.g. some kind of transport company) to perform its functions connected with the transportation of passengers and goods properly and with the observation of certain pre-determined operating standards, designed in compliance with specific criteria and operational indicators (characteristics of the system).*

The definition given above suggests the following basic properties of service quality regarding a transport enterprise: **Duration of transportation** (speed of conveyance of goods or passengers), **Convenience** (existence of ergonomic travel

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conditions for passengers in the transport means, facilities for loading and unloading cargoes, etc.), **Culture** (ethical and polite relation to customers of a transport undertaking), **Cargo protection** (prevention from damage to the cargo during the transport process), **Reliability** (ability of the transport technological system (transport undertaking) to perform its required functions under stated conditions within a specified period of time.

For its part, **Reliability** has three main features: **Punctuality** (timely arrival/departure of transport means at/from transport rout points), **Regularity** (reliable implementation of each single transport route), **Safety** (ability of the transport technological system to prevent accidents (incidents) from occurring during the transport process

The transport company - a cybernetic type of business system functioning within system safety environment

Continuous improvement of a given activity (including the transportation process and ensuring its reliability and safety) is an organizational belief (culture) that the effectiveness of the technological processes performed in the organization can and should always be in the focus of company management in order to respond to customers' demands. Continuous improvement is usually interpreted as a repetitive four-step management strategy, known as the PDCA cycle (*Plan-Do-Check-Act* - [2], [9]) and "relies" on active and positive involvement (attitude, desire and action) of the operating staff to identify problems related to the functioning of a company. Such a participation is possible and only happens when the employees have sufficient knowledge on the specificity of the company, potential problems and possible ways to remedy them. Having this knowledge and developing their creativity, they will be able to improve their activity, and hence the business process of enterprise. There are many different types of failure causes of the operation of transport technological systems (enterprises), but what unites them is their principle predictability (and preventability). Avoiding failures is possible only when there is sufficient knowledge regarding the influencing factors, the potential hazards and concomitant risks (referred to as safety knowledge). All this means that knowledge is a very important tool for a reasonable balance between the business goals (the implementation of the transport service) and the compliance with safety requirements.

To understand the role of safety knowledge within the improvement cycle of a transport undertaking it is necessary to define the basic features of its performance, and no doubt that reliability and safety (as its property) are the most important of them. Therefore, it is of great use to consider the transport company as: *business system that is designed and organized to generate useful and intended outputs (conveyance of goods and people) which are realized within a specific and changeable operating environment characterized by substantial potential for occurring of adverse (risky) outputs (accidents and incidents).* The definitions above mean that the transport company could be reckoned as a cybernetic type of system requiring the appliance of some management approaches and tools (e.g. organizational acquisition of knowledge) to control the quality of transport service (in other words, measures to control the influence of incidents as adverse outputs of the business process over the quality). The relationship between the two basic functional elements of a transport undertaking considered as a cybernetic system, namely: Operating process management system (OPMS) and Safety management system (SMS), including the role of knowledge as a unifier of business and safety objectives, is depicted in Figure 1.

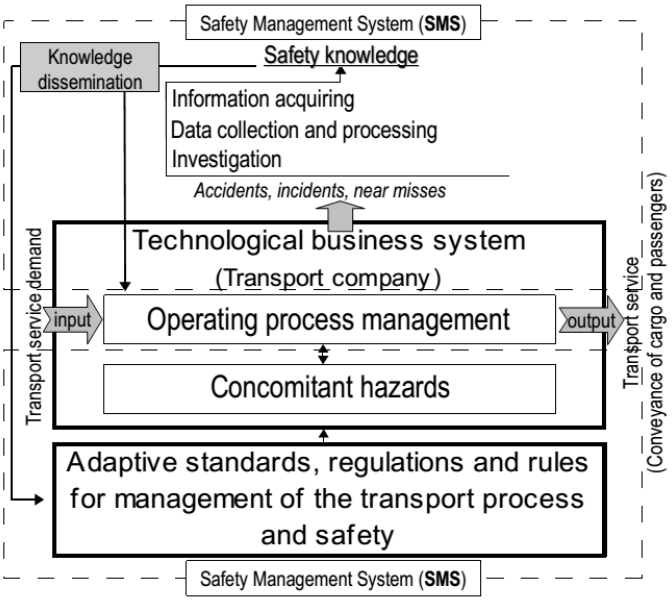

Fig.1. The transport company as a cybernetic type system

Role and contribution of the human-operator in achieving reliable transport process

Every human activity is connected with a set of "potential hazards" with respect to its normal realization. Even the minor hazard poses risk to people and could seriously disrupt the performance quality of the system concerned, which would have serious financial and social consequences. In full, this also applies to transport (all modes of transport), from the proper functioning of which the normal daily life of society as a whole depends. Achieving that requires a continuous process of "decision making to prevent adverse events (incidents, accidents) from occurring", which means risk (safety) management in order to provide a qualitative transport service. In a broader sense, risk management can be defined as a process of identifying, evaluating, and implementing measures to prevent or reduce the impact of potentially possible hazards to the technical exploitation. Of course, the absolute elimination of the risk of accidents is not possible, but it must be reduced to an acceptable level on the basis of practically possible measures. The definition and proper implementation of the latter requires the availability of general information and specific knowledge possessed by the operating personnel (operating managers) about the type and purpose (functions) of the system, its structure (subsystems and individual elements), its life cycle (specifics of its functioning), approaches and tools for analyzing its behavior, factors influencing its reliable (safe) performance, the development process, etc.

III. ESSENCE OF SAFETY KNOWLEDGE

Attributes of safety knowledge

There is a specific type of contradiction (sometimes very obvious) within our modern, information - based and high technological world. On the one hand, the citizens of modern society live and work using lots of contemporary information devices, scientific approaches to decide problems, invent new technologies and construct more and more complex man - machine systems. The practical realization of this requires the presence of a certain type of knowledge and skills, depending on the respective activity being performed. All this applies to all spheres of society, including transport. Ordinary people and professionals get and expand their knowledge through specific education, planned or accidental observation, gathering and processing of information, logical consideration, etc. Not to say that, the access to information is becoming easier than never before thanks to computers and Internet network.

On the other hand, and based on the experience gained from everyday life or technical exploitation of a given technological system, it could be said that the considerable advantage of the new technologies is often not enough for the society as a whole or for the single individual. If we look at the specific features of transport (but not only there) we will see that, regardless of the availability and use of modern technical systems and technologies, there are lots of cases of wrong decision making. Usually it happens due to the lack of uncertainty assessment regarding the respective information. As a result, many serious transport accidents happened because the transport companies ignored the possibility to gain very valuable knowledge from non-desirable operating situations occurred in the course of technological process (technical failures, human errors, organizational deficiency, etc.).

As for safety knowledge, the existing operational experience connected with the transport safety management allows the next definition to be given: *it is familiarity and understanding of specific activities and concomitant risks associated with the transport process, including operating data, facts, information, descriptions, or human skills, which is acquired by experience or education. Safety knowledge primarily encompasses understanding of written operating rules, hazard information, process technology information, and requirements for safe usage of equipment.*

As can be seen from this definition, safety knowledge is inextricably linked to two other categories (knowledge elements) - data and information, which in many cases are used equivalently to knowledge but according their role within safety management process they have different essence and meaning. Data consists of facts which usually represent raw numbers and as a whole give just a general vision with respect to the safety level of investigated process. The number of accidents occurred within a given operating period is an example of data. Information involves processing of data for obtaining a more appropriate understanding of the trends of change regarding a specific process under investigation. The probability of occurrence of an investigated cause for transport accident (of a concrete type) is a good example for information.

Data, information and overall knowledge regarding the safety of the transport process (or its individual elements) can be acquired through:

-Special tests of specific transport technical systems during their design, development, or initial exploitation;

-Specific events (incidents, accidents, near-miss events, etc.) within the real operating process;

-Analytical models simulating actual operation.

Figure 2 shows the relationship between safety knowledge (its attributes) and process of decision making.

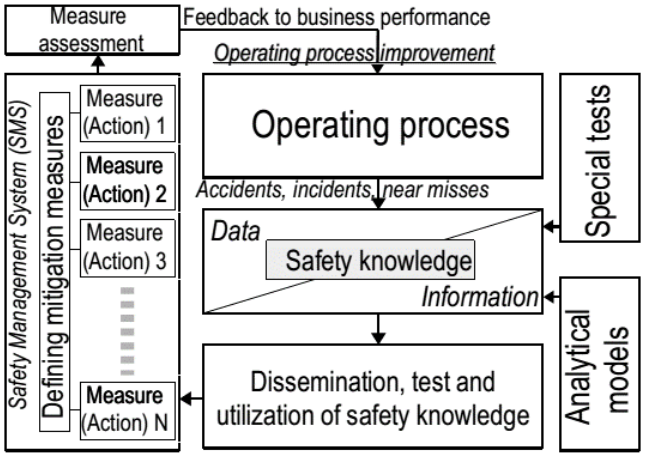

Fig.2. Relationship between safety knowledge and decision making for operating process improvement

Knowledge collection

There is no doubt that of the three ways of obtaining data, information and appropriate safety knowledge (described above) the second is the most plausible one - known as *Incident learning* approach.

Incident learning concept is a result of the combination of two competing and complementary theories, namely: *Normal accidents theory* and *High reliability theory*.

Normal accidents theory is a consequence of the understanding that any system is designed, operated, and maintained by people who are essentially not perfect in their actions. Therefore, the system itself is not perfect and when there are changes in the system itself or in its surrounding work environment, it is perfectly normal for the system to adapt to these changes incorrectly (for one or another reason). As a consequence - mishaps occur - [6], [7], [10].

High-reliability theory says that while mishaps as a whole may be reckoned as normal to occur, serious ones could be prevented by defining and implementing certain practices. One of them is the organizational approach to design, develop and manage a normative system (internal for the respective transport company) for acquisition of knowledge on the basis of investigation of past incidents (acquisition of safety knowledge) - [4], [8], [14], [15], [16], [17].

But at the same time, there is a large number of examples showing that many serious accidents happened due to the fact that at least one of the organizations involved in the mishap has disregarded the warning of prior similar unwanted events and failed to adequately acquire or accurately analyze the knowledge regarding the causal factors and consequences of the event. When it comes to safety analysis and management,

it should be emphasized that in most transport accidents, one specific and common feature is observed - the inability of the organization (that caused the respective disaster) to effectively acquire, synthesize, disseminate (towards the interested people within its structure) and to most adequately use the information relating to past incidents. In this way, the opportunity to take appropriate measures to control hazards and reduce concomitant risks is missed. The fact that, by their nature, transport accidents are stochastic events and their accurate prediction is impossible, does not in any way mean that they should not be investigated very accurately aiming at taking certain measures to prevent them from occurring in the future.

The next conceptual framework allows the achievement of a successful accident investigation process:

-Each individual transport accident (incident) is unique in nature and should not be hastened to associate with similar one that has occurred in the past.

-The investigation is conducted in order to discover facts, not guilt and responsibility, because the latter are a source of "defensive reactions" and "bias".

-The investigation of accidents should always be reckoned as a very serious activity and as an important part of the overall safety management system, aimed at:

-identifying and describing in an appropriate manner the actual course of events in the accident scenario;

-identification of the causes of the accident (root, direct and contributing ones);

- provision of sufficient information on the basis of which accident prevention measures can be proposed and implemented;

-providing evidence for subsequent search for guilt and responsibility.

-The investigation should be carried out by a team of experts with a diverse range of theoretical knowledge and practical experience.

-Due to the fact that in most cases accidents are related to the implementation of several heterogeneous events (occurring in different systems, subsystems and their elements), the investigation must compulsorily use a system approach, with a certain desire for detailed analysis.

-The investigation should be carried out in stages and each stage should have clearly defined objectives and scope (limits) for the problem under consideration.

-The investigation must be carried out by the usage of appropriate scientific approaches and methods in order to achieve:

-identification of the potential information gaps (lack of facts that need to be further identified) about the events in the accident scenario;

-identification and description of the sequence of occurrence of the individual events and phenomena (causes of the accident).

IV. Conclusion

The main purpose of this article is to discuss and analyze the role and influence of safety knowledge on the reliable operation of the transport enterprises. It cannot be argued that this important problem is sometimes underestimated in the field of technical operation of transport. The statistics shows that more than 80 percent of transport accidents occurred due to human ignorance to act appropriately during the implementation of a specific activity within the operating process. There are two reasons for that. Either the respective human-operator does not have enough knowledge and skills on how to act or he/she has knowledge but apply it in a wrong manner. In both cases, the consequences can be extremely fatal.

Therefore, within the framework of safety management systems, each transport undertaking must provide a mechanism for obtaining, analyzing and disseminating information on current safety issues. It must ensure that managers and employees have sufficient knowledge at all times about the safety situation in the enterprise and all related activities, e.g. the results acquired after an incident investigation should be made known to all interested parties.

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