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Digital Safety in Railway Transport —Aspects of Management and Technology

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Digital Safety in Railway Transport—Aspects of Management and Technology

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Introduction

In the context of dynamic technological progress and the resulting development of the digital transformation processes of railway enterprises, there is a need to clarify this issue in a broad way to understand cyber security mechanisms as a key challenge for the rail transport sector. Railway enterprises which are responsible for operation and maintenance processes and the safe movement of people and goods must be aware of the increased risks arising from the digitalization of all their areas of operation. Dynamic digital transformation processes include both the elements of the configuration of the business models of railway enterprises and the ontologically separated railway system itself, understood as the railway network and railway vehicles intended for traffic on that network, distinguished by the functional and technical characteristics. Both areas overlap in many cases by creating a complex set of related elements, where railway traffic safety management poses a major challenge to the digitalization of the areas of operation of railway enterprises. Railway enterprises create mechanisms to manage railway traffic safety by introducing management systems based on the concept of the management of the risks occurring in their operation. The division of risk of rail market operators is due to both their place and role in the railway system. The type of activity determines the extent to which the operation of a railway enterprise using a given business model has an impact on the level of railway traffic safety. The digitalization of different areas of rail activity, as a widespread phenomenon induced by both the needs of its own development and legal conditions, should ensure that all processes directly or indirectly linked to its implementation and operation are safe. Due to the high level of innovation in the digital economy, it is difficult to avoid any doubt that the railway system under the conditions of digital transformation will continue to be as safe as before digitalization. Many doubts in this respect arise from the lack of extensive operational experience. Standardized digital safety management mechanisms should therefore be sought, based on the conscious role of the business model of railway enterprises and the embedment of this problem in the context of management, social and technological conditions. The social nature of railway safety stems from strong public pressure to ensure high levels of railway traffic safety. A condition for maintaining trust in rail transport is to invest in the improvement of increasingly better risk control measures built up

not only in the railway system itself, but also in the configuration of increasingly used digital business models of railway enterprises. This problem is considered not only in terms of scientific research, but also its practical application, which makes it a valuable solution for stakeholders in the rail transport sector as well as professionals dealing with management processes geared to different sectoral circumstances. The focus on management, social and technological aspects makes this topic clear from many points of view, which should make readers aware of the importance of digital safety in the rail transport sector and from how many perspectives the methods to improve its management processes can be sought. The interdisciplinarity of this subject means that the scope of critical evaluation of this issue requires an extremely broad view, as shown in this monograph. This work is one of the key results of many years of work by the authors in the field of safety management in rail transport, digital business models and the social aspects of designing digital business models.

The main objective of this scientific discussion is to present, in a multidimensional and holistic way, the mechanisms of digital rail transport safety in management, social and technological terms. The monograph also takes the role of sustainable business model design into account by focusing research and analysis on identifying the role of safety as a social factor. The structure of the book consists of 13 chapters, each of which begins with the introduction and ends with the final conclusions. The work ends with conclusions and empirical-methodical conclusions. Chapter 1 is methodological, describing the scope and methodology of research into digital safety management mechanisms as part of the social business models of railway enterprises. Chapter 2 presents the original models of the authors in terms of different views on the concept of designing and defining safety management mechanisms in rail transport, with an explanation of areas such as the mechanisms of effective safety management in rail transport, the mechanisms of efficient management of railway sidings, the mechanisms of shaping safety culture in rail transport, the mechanisms of ensuring technical compatibility and safe integration in rail transport and the mechanisms of ensuring safe operation of railway vehicles. Such a wide scope of analysis helps to better understand the complex context of the issue of the rail transport sector in the context of the safety criterion. Chapter 3 deals with the clarification of the issue of the digital business models of railway enterprises, with an indication of the social aspect, including the assumptions for sustainable business models and sustainable supply chains in rail transport. All this has been presented in the context of the process of digitalization of rail transport. Of particular importance in this chapter is the reliance on theoretical discussion and the establishment of the leading theory in which research and analysis are embedded, namely the theory of cybernetics, which is the basis for a systemic approach and the starting point for the development of the theory of digitalization. Scientific achievements in this area are extremely helpful in explaining numerous contemporary phenomena pertaining to the analytics of complex digital

technical systems. Chapter 4 deals with the typical sectoral determinants of rail transport in the context of issues relevant to the objective and subject of the book, such as the place and role of railway market operators in terms of sharing responsibility for safety, clarifying the essence of the railway system and its technical, operational and organizational conditions. Issues of technological management were also indicated in terms of improving the performance of the technical railway system and safety criteria, as well as information management in the rail transport chain, and railway traffic safety. Attention was also paid to the assumptions of the operation of control and traffic management systems in terms of safety, the safe operation of railway vehicles and the place and role of railway traffic safety management systems, all of which was important in order to clarify the conditions for the operation of the railway system in terms of railway traffic safety criteria. Chapter 5 introduces readers to the understanding of the digital transformation processes in rail transport, sets the determinants of digital transformation and defines the directions and areas of digital transformation of rail transport. It also draws attention to the assessment of the digital maturity of railway systems in technical, operational and organizational terms and to the migration of responsibility in hybrid, i.e. analog-digital, railway systems. Chapter 6 deals with important issues for digital safety, i.e. it clarifies digital safety in rail transport by highlighting issues such as theoretical assumptions for defining digital safety in rail transport in holistic terms, cybersecurity in rail transport and technical system safety—safety and security aspects, the life cycle of railway systems and the digital safety of technical systems, as well as the identification, design and installation of safety criteria in railway hardware and software solutions. All these issues justify the claim that this problem is difficult and requires extensive knowledge of the rail transport sector. Chapter 7 is devoted to identifying the place and role of processes for creating digital innovation in rail transport. It defines content to understand innovation in the context of rail transport specificity, problems and barriers to the use of innovative solutions in rail transport, technical, operational and organizational innovations and safety in rail transport. This chapter also addresses important issues and problems in testing, verifying and validating innovative digital solutions in the context of safety criteria, and clarifies innovation issues in relation to the exchange of information in railway systems in subjective and objective terms. Chapter 8 aims to identify modern trends and emerging technologies which increase the level of safety in rail transport. They include solutions such as artificial intelligence and its application in improving railway safety, simulations, computer games, videos and virtual reality (VR) and railway traffic safety management, the Internet of Things and interface management in the process of improving railway traffic safety, predictive maintenance of railway infrastructure and railway vehicles in terms of safety, Big Data and its assumptions in shaping digital solutions in rail transport, Industry 4.0 and 5.0 and their assumptions in shaping digital solutions in rail transport, a digital twin as a concept for improving railway traffic safety, and finally digital solutions in rail transport in the field of communication systems in railway traffic control. Chapter 9 is devoted to an important issue, which is currently being reconstructed in relation to the dynamic digital transformation processes of railway enterprises affecting their safety culture, concerning the development of safety culture in rail

transport through the creation and implementation of digital solutions. The chapter indicates that railway enterprises should be understood as organizations that meet the definition of high reliability organizations. The following part of this chapter explains the organizational culture of railway enterprises in relation to digital transformation processes, the determinants of shaping safety culture in railway enterprises towards digital solutions, and a model of shaping safety culture through the digital transformation of railway enterprises, which is important for the content of this chapter. Chapter 10 deals with an important element of safety management in rail transport. This chapter seeks to explain the determinants of railway safety monitoring processes using digital economy solutions. Theoretical and practical assumptions for railway safety monitoring, methods and techniques for monitoring railway safety, digital solutions for monitoring railway safety, the model for digital monitoring of rail transport safety, as well as an important element for ensuring the safety of railway traffic controlled by digital devices, namely data transmission systems as an aspect requiring monitoring due to its role in the data and information safety management system, as well as the control of critical tasks for railway safety have been identified. Chapter 11 presents the findings of the monograph. It outlines the conceptualization and operationalization of the digital safety model for rail transport. The chapter identifies digital technologies supporting the development of a digital safety model for rail transport, safety management methods and tools supporting the development of a safety model for digital rail transport, as well as the safety model for digital rail transport itself. The digital safety model is a coherent set of devices, technical systems and components supporting a safety management system using digital solutions as a basis for maintaining the expected level of safety. The digital safety model is a combination of digital economy solutions embedded in individual components—the functions of the railway system. It is such a set of elements shaping the configuration of the railway system, whose protection against defects, failures, incidents, disasters, and any other irregularities are built on a cybersecurity canvas based on technical, legal-organizational and standard solutions. The twelfth and final chapter presents the original safety triad in the business models of rail transport enterprises, described in terms of management, digitalization and socialization. This chapter presents the results of research and analysis in the form of a description of the conditions of synthesis of the simultaneous implementation of the analog and digital layer of safety management mechanisms in rail transport, a hybrid model of rail transport safety management based on the mechanisms of analog and digital layers, and the conceptualization of the safety triad in the business models of railway transport enterprises. The triad consists of a set of three interconnected elements, namely safety management mechanisms as a set of rules, procedures and methods used to achieve the expected level of railway safety. The second element is the digitalization of processes related to rail transport activities, with a particular focus on digital safety. The final element of this triad is the socialization of the concept of railway safety, which arises from the expectations of stakeholders in terms of intolerance for railway incidents. The book ends with general and empirical and methodical conclusions. A broad review of the literature, the observation of railway enterprises in this area and the concepts and conclusions developed by the authors confirmed the

importance of the issue of digital safety in rail transport in social and technological terms. Digital safety issues are also of particular importance when set against the background of digital business models. This topic is extremely broad, not only in terms of the holistic nature of the safety issue, but in particular the specificity of the operation of the rail transport sector. In this sector, in terms of two key ontologically separable research spaces, namely safety and security, the decision was made to combine them into a single model called Cyber Operational Safety (COS), the assumptions of which should cover all risks arising from the use of computer applications directly related to safety and those that support operational, maintenance and logistics processes in rail transport. The final conclusions of the work on the monograph neatly summarize the above-mentioned issues. The book should inspire other researchers interested in digital safety management mechanisms and socially oriented digital business models.

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