The concept of sustainable transportation and unmanned railway technologies: the EAEU experience

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Abstract. The article attempts to critically assess the current regulatory framework in the field of unmanned technologies through the prism of the concept of sustainable transportation in the EAEU. The main trends in the development of unmanned technologies in transportation are identified. Using the example of the Russian railway transportation, the key technical and technological aspects of the operation of unmanned systems, which need a primary mechanism of regulation, are shown. The study shows that the effectiveness of high-level automation technologies directly depends on adequate normative and technical regulation and legal basis for ensuring safety issues and regulating responsibility at the interstate level. The authors consider it advisable to apply a test procedure for the use of unmanned technologies at the initial stage of operation, as well as to create "regulatory sandboxes" before the mass operation of unmanned vehicles. The development of international legal regulation of unmanned transport will become a driver for the realization of Russia's transit potential, especially in the context of de-globalization trends in the world economy and anti-Russian sanctions.

1 Introduction

In the context of deglobalization trends in the world economy caused by international sanctions imposed against Russia, the development of international legal regulation of unmanned transport within the framework of such regional organizations as EAEU, SCO, BRICS contributes to the solution of the problem of realizing the transit potential of Russia on the basis of integration of railway transport into international transport systems [1-3]. The introduction of unmanned technologies will help improve the global competitiveness of Russian railroads and the level of their integration into the global market of transportation and logistics services. According to analysts' forecasts, the cost of an autonomous transportation system can fall by more than 85% to about $10,000 by 2030.

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Information and telecommunications infrastructure that meets the needs of the time and the current technological environment is necessary to ensure the operation of digital services and the timely availability of relevant information about the environment. Also important is the need to develop methodology and practical methods for solving the problems of ensuring safety when using unmanned technologies in transportation.

However, the effective operation of technologies of such a high level of automation requires both the development of detailed technical regulations and a legal framework to ensure safety issues and liability regulation.

2 Materials and methods

The study used open source materials, the official website of the EAEU, statistical data on the results of the development of integration processes in the EAEU. The authors used the methods of analysis, synthesis, systematization and comparison, works of Russian and foreign researchers, laws and subordinate legal acts.

3 Results and discussion

Currently, in Russia, the legal regulation of the use of unmanned technologies in road transport has been significantly developed. Thus, the Decree of the Government of the Russian Federation dated November 26, 2018 N 1415 regulates the experimental procedure for the application of these technologies on the roads of Moscow, the Republic of Tatarstan, St. Petersburg and 10 other subjects of the Russian Federation from 2018 to 2022. A significant achievement of the document is the development of the conceptual apparatus for this area of regulation. Thus, it discloses the concepts of "highly automated vehicle", "automated driving system", "automated control mode".

In the field of railway transportation in Russia, the development and testing of unmanned technologies by NIIAS JSC, a subsidiary of Russian Railways, has been underway for several years. In 2022, Rosstandart approved GOST R 70059-2022 (URL: https://files.stroyinf.ru/Data/777/77713.pdf?ysclid=1fs7beesnk363871680 (date of access 20.06.2023)) for the functional requirements of unmanned commuter train control systems. It provides definitions of terms used in the functioning of unmanned railroad technologies. The document also contains classification of levels of automation of railway transportation control systems (UA0- UA4), and of which only level UA4 implies the use of unmanned technologies. GOST R establishes the basic requirements for the operation of unmanned technologies, indicating that their detailing is agreed with the owner of the infrastructure when designing such systems.

The leading trends in the development of digital technologies for transportation are:
- growth in the development of software (SW) and operating systems (OS) for the operation of unmanned transportation,
- growth in the number of developments in the field of transportation safety management system development.

Over the past five years, Russian Railways Holding Company has been actively working on the development of unmanned locomotives. The key task is to solve the problems of functional safety, which is fully defined by the standards IEC 61508 "Functional safety of safety-related electrical, electronic, programmable electronic systems" (EN50126, EN50128, EN50129), GOST 33435-2015 "Control, monitoring and safety devices for railway rolling stock". In addition, according to the requirements for on-board safety devices, Safety Integrity Level 4 (SIL4) must be ensured.
For this purpose, vision sensors, lidars are used. It is obvious that the operation of unmanned locomotives in difficult weather conditions urgently requires a new approach to the issue of proving the safety of unmanned vehicles.

Thus, in 2019, ISO/PAS 21448 "Road vehicles. Safety of specified functions" (SOTIF). The standard is based on a scenario approach, which studies the behavior of a technical system under different circumstances. The total number of such scenarios is infinite. The main task in the development is to minimize unsafe scenarios of different nature.

In order to implement fully automatic control of railway rolling stock without the presence of the driver in the locomotive cab, it is necessary to form an adequate regulatory framework synchronized with the development of regulatory control in the EAEU logistics space.

JSCo "Russian Railways" has a timetable for work on the regulatory support of the use of unmanned control systems for railway rolling stock. Among the most important requirements for regulatory support of the operation of vehicles in automatic mode on railroads is the updating of the Regulations on the Procedure for the Official Investigation and Accounting of Transport Accidents Involving Harm to the Life or Health of Citizens Unrelated to Railway Transport Operations. The Holding Company is working to approve and put into effect a whole set of regulatory documents governing the operation of unmanned railway vehicles.

According to experts at Russian Railways, unmanned passenger transportation will be a reality in the next few years. A significant step towards the development of unmanned railway transportation was the creation by Russian Space Systems of a platform for controlling unmanned trains via GLONASS.
A new rolling stock - Lastochka - has arrived for certification, which is so automated that it can travel without a driver, carry passengers in automatic mode and react to obstacles. The driver is at a remote control panel, in a specially equipped room where up-to-date information on all trains is accumulated.

A significant step towards the development of unmanned railway transportation was the creation by Russian Space Systems of a platform for controlling unmanned trains via GLONASS. It is planned to launch unmanned electric trains Lastochka on the Moscow Central Ring Road (MCC) in 2024.

In order to realize the project of launching a train with artificial intelligence, the developers replaced a number of complex tasks that were previously handled by the driver with a hardware and software complex. The following systems were implemented for the smooth and accident-free operation of unmanned trains: a system for controlling passenger boarding and disembarkation on the platform, a stationary obstacle detection system, digital vision systems, door locking control, remote power control, cryptographic information protection, and video surveillance.

Several industrial modems are installed in each Lastochka and each locomotive. Since 2018, Russian Railways has deployed its own high-speed network of base stations on a dedicated frequency in the LTE band. In addition to sensors and cameras on the trains themselves, there is also a network of stationary obstacle detection complexes on track bends in the danger zone. Now there is one such complex working on the MCC, the data from which comes first to the data center, then to the train computer. The driver-operator can display any information from any controlled train: video from any camera, readings from sensors located throughout the train.

JSCo "Russian Railways" is implementing onboard technical vision based on an artificial intelligence system at the UA3 level, which optimizes the driver-operator's constant control over the situation on the tracks in front of the train. The system is trained to recognize objects and obstacles to the speed of reaction to the detection of a potentially dangerous object on the track, and reacts faster than a human.

The main challenge in developing vision systems is the lack of standards for defining obstacle detection requirements. This means that some developers can make a measurement in ideal conditions, for example, in a depot with a well-distinguished object, while others can make a measurement on a test site in foggy conditions. Therefore, standards are being developed in Russia to regulate testing in automatic and remote modes.

At the same time, it should be noted that before the mass operation of unmanned technologies begins, it is necessary to first of all make a preliminary assessment of the economic feasibility of introducing such systems in railway transportation. For this purpose, it is necessary to take into account not the capabilities of modern unmanned technologies, but first of all, those functional changes in the management of transportation processes, which will optimize the business models applied today on the railroad, and how much the cost of transportation will be reduced when using unmanned transport.

It should be noted that various Industry 4.0 technologies are used to support the operation of the unmanned train system [4,5]. Thus, during the movement, the vehicle must accumulate and process information about the speed and direction of other vehicles and stationary objects for efficient operation. For this purpose, Internet of Things (IoT) and Big data technologies are used. Of course, algorithms of artificial intelligence technologies are embedded in the autonomous system for ensuring train traffic.

The development of railway transport in the conditions of digitalization and transition to a new technological mode should take place within the framework of the application of those achievements of science and technology that increase its competitiveness. Therefore, for the effective functioning of such technologies, it is necessary not just to supplement the existing
lacunas in the legislation, but to create a comprehensive legal regulation of the use and functioning of Industry 4.0 technologies.

Harmonization of technical documentation within the EAEU appears to be of paramount importance, as digitalization of the transport and logistics industry is one of the leading trends and the main way to improve its efficiency and reduce the share of logistics costs in the price of foreign trade operations. Thus, the Strategy for the Development of Railway Transportation until 2030 states: "In order to implement the direction on the introduction of highly automated and unmanned vehicles, it is assumed to finalize the existing legal framework regulating their operation at the level of the United Nations and its working bodies, as well as at the level of the Eurasian Economic Union and the legislation of the Russian Federation".

However, currently within the EAEU there is Technical Regulation of the Customs Union (TR CU) 003/2011 [6], which does not actually regulate the issues of ensuring infrastructure safety on railway transportation with the use of unmanned technologies. TR CU 001/2011[7], which establishes requirements for ensuring the safety of locomotives, motorized rolling stock and its cars, locomotive traction passenger cars, freight cars, as well as special railroad rolling stock, does not contain regulation of technical requirements for unmanned technologies implemented on the railroad. The same gaps are inherent in TR CU - 002 - 2011, which regulates the safety of high-speed rail transport.

At the same time, the need to develop special rules to regulate the issues of compensation for damage to others by the owner of unmanned technologies in railway transportation seems to be unnecessary. Article 1079 of the Civil Code of the Russian Federation regulates the issues of compensation for damage caused by a source of increased danger, which may include unmanned technologies in transportation. The issues of certification of manufacturers of software and server software for unmanned technologies, requirements to the safety check of their operation, etc., are subject to detailed regulation at the EAEU level.

In 2022, new Rules for the Technical Operation of Railroads of the Russian Federation (RTO) [8] were adopted, which regulate certain issues of unmanned technology application. The new edition, however, contains only one article concerning the operation of unmanned trains.

Thus, Article 162 of the PTE provides for the possibility of operating locomotives and motor-car rolling stock using unmanned technologies (in automatic and/or remote mode). At the same time, it is stated that their operation is allowed on non-public railroad tracks (i.e., for example, on the infrastructure of private companies) in accordance with local acts of the infrastructure owner. Thus, the use of unmanned technologies on public railroads is not yet regulated. At the same time, it should be noted that the term "unmanned technologies" is not used in the PTE, which seems to be its disadvantage, since the terminology should reflect both the current achievements of science and technology and the terminology adopted for their designation.

The PTE further states that locomotives and motor-car rolling stock, in which autonomous control systems are used, must, on the one hand, meet the requirements of TR TS 001/2011, and on the other hand - the requirements of local acts of rolling stock owners. Thus, there are actually no unified requirements for the use of this kind of technology.

At the same time, in PTE the responsibility for reliable operation of automatic and (or) remote control systems is borne by the developer and manufacturer of these systems. This provision seems to be inconsistent with the norms of the Civil Code of the Russian Federation, because in case of causing harm to a third party, for example, a physical person, the victim has the right to make a claim for compensation for damage to the owner of the source of increased danger. And the latter will be able to claim against developers and manufacturers of autonomous and (or) remote control systems by way of recourse.
At present, the main document regulating cross-border railway communication within the EAEU is the Procedure for regulating access to railway transportation services, including the basics of tariff policy. This document defines the rules of access of the carrier to the infrastructure of another EAEU member, the procedure for interaction between the infrastructure operator and the carrier, their rights and obligations and the basic terms of the contract between them. At the same time, the issues of the possibility of operating locomotives with remote and (or) autonomous control, as well as other issues of technical operation are practically not addressed in them. The existing unified system of technical regulations within the EAEU allows unifying technical requirements for the operation of railway infrastructure, locomotives and rolling stock. However, it should be noted that the CU TRs adopted back in 2011 do not regulate the possibility of using Industry 4.0 technologies in railway transportation to the extent required for the introduction of unmanned technologies.

4 Conclusion

Thus, taking into account the process of integration of transport systems of the EAEU states for the effective introduction of unmanned technologies in the railway ecosystem of the member states, it is necessary to finalize and unify the CU TRs regulating this area. Prior to the creation of a regulatory field for the mass operation of unmanned technologies, "regulatory sandboxes" should first be created that focus not on the evaluation of individual operational performance indicators, but on a whole set of performance indicators for railroads as a whole.

It also seems appropriate to use the experience of regulating the operation of unmanned transport by establishing a test procedure for the use of unmanned technologies in railway transport for a certain period of time.

In the context of intensification of regional cooperation within, for example, the EAEU and the Asia-Pacific region, and deglobalization processes taking place at the global level, the development of legislation on drone technologies, cybersecurity standards, and electronic document management should be carried out at the transnational level. The unification of national legislations should be aimed at solving the following tasks:

- preventing the possibility of interception and spoofing of unmanned train control signals,
- creation of a system of constant information exchange with the control service (dispatching service),
- creating and ensuring safe operation of secure communication channels for data reception and transmission,
- regulation of the procedure for obtaining the necessary permits and certificates to operate not only in the Russian Federation, but also in the EAEU and China,
- Developing a system of standards and subsidizing the costs of testing unmanned technologies.

It seems that in the medium term, unmanned technologies in transportation will become one of the leading drivers of sustainable development.

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