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INFLUENCE OF THE HUMAN FACTOR ON ENSURING THE STABILITY AND RELIABILITY OF TRANSPORT AND LOGISTICS SYSTEMS DURING THE RUSSIAN-UKRAINIAN WAR

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Summary

Introduction. *The development of society and scientific and technological progress strengthens the role of the human factor in ensuring the stability and reliability of transport and logistics systems. Moreover, the number of determinants that negatively affect the state of the human factor and the level of acceptable risk in the transport sector is currently growing in the martial law in Ukraine.* ***Purpose.*** *The purpose of the article is to identify the nature and components of the human factor and the peculiarities of its action in the transport and logistics system in peacetime and wartime.* ***Methods.*** *The following set of scientific methods was used in the study of human factor: analysis of scientific and technical literature and regulatory framework, dialectical method, structural analysis, systemic and synergetic approaches, general logical methods and scenario approach.* ***Results.*** *The article determines the human factor that can negatively affect the functioning of the transport and logistics system or increase the risk of adverse conditions. The components of the human factor were identified, and a set of practical tasks to be solved by the transport and logistics company for human factor management was analyzed. It has been proven that in peacetime the minimization of human impact on the transport and logistics system can be achieved through the creation and implementation of a safety management system, including anthropometric driver training, and process automation such as modern Transport Management System (TMS) to help the driver and monitor the environment in order to identify hazards in advance and prevent them.* ***Scientific novelty.*** *Risk factors associated with the action of the human factor on transport, which increase the occurrence of adverse events during the war in Ukraine, have been determined.* ***Practical significance.*** *Measures to establish a human factor risk management system for a transport and logistics company in wartime were proposed.*

Key words: *human factor, transport and logistics system, transport, human factor risk management system, transport management system.*

ВПЛИВ ЛЮДСЬКОГО ФАКТОРУ НА ЗАБЕЗПЕЧЕННЯ СТАБІЛЬНОСТІ ТА НАДІЙНОСТІ ТРАНСПОРТНО-ЛОГІСТИЧНИХ СИСТЕМ ПІД ЧАС РОСІЙСЬКО-УКРАЇНСЬКОЇ ВІЙНИ

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Анотація

Вступ. *Розвиток суспільства та науково-технічний прогрес посилюють роль людського фактора в забезпеченні стабільності та надійності транспортно-логістичних систем. Водночас, в умовах воєнного стану в Україні зростає кількість детермінант, які негативно впливають на стан людського фактору та рівень прийнятного ризику в транспортній сфері.* ***Мета.*** *Метою статті є виявлення сутності та складових людського фактора та особливостей його дії в транспортно-логістичній системі в мирний та воєнний час.* ***Методи.*** *При дослідженні людського фактору використовувався наступний комплекс наукових методів: аналіз науково-технічної літератури та нормативної бази, діалектичний метод, структурний аналіз, системний та синергетичний підходи, загальнологічні методи та сценарний підхід.* ***Результати.*** *У статті досліджено сутність людського фактору, який може негативно впливати на функціонування транспортно-логістичної системи або підвищувати ризики настання несприятливих подій. Також визначено складові людського фактору, проаналізовано комплекс практичних завдань, які має вирішувати транспортно-логістична компанія щодо управління людським фактором. Доведено, що у мирний час мінімізація впливу людського фактору на транспортно-логістичну систему може бути досягнута завдяки створенню та впровадженню системи управління безпекою, зокрема облаштування робочого місця водія із врахуванням вимог антропометрії, та автоматизації процесу, наприклад використання сучасних TMS для допомоги водію і моніторингу навколишнього середовища з метою завчасного виявлення небезпеки та її попередження.* ***Наукова новизна.*** *Визначено фактори ризику, пов'язані з дією людського фактора на транспорт, які збільшують виникнення несприятливих подій під час війни в Україні.* ***Практичне значення.*** *Запропоновано заходи щодо створення системи управління ризиками, пов'язаних із дією людського фактору, для транспортно-логістичної компанії в умовах воєнного часу.*

Ключові слова: *людський фактор, транспортно-логістична система, транспорт, система управління ризиками людського фактора, система управління транспортом.*

Introduction. The development of society and scientific and technological progress strengthens the role of the human factor in ensuring the stability and reliability of transport and logistics systems. With the transition to a post-industrial society, the complexity and automation of the transport and logistics system, increased traffic in the 70s of the twentieth century, the role of the human factor began to grow significantly in the man-made sphere and accounted for 80 % of rail transport events. So far, 3/4 of all man-made emergencies have been due to technical reasons. Somewhat different statistics in the aviation industry: if in the twentieth century 50 % of accidents were due to the human factor, and the rest of the reasons were related to the technical condition of the aircraft, at the beginning of the XXI century this ratio is 90:10 [1]. Regarding maritime transport, according to maritime statistics, 60 % of accidents worldwide are associated with the human factor [2]. According to studies [3; 4], the largest number of accidents occurs due to erroneous human actions, the complexity of technology and its growth, the emergence of unexplored technical failures and violations. At the same time, in order to prevent accidents, human capabilities increase due to improved education, advanced training, exchange of experience, increased stress resistance and the level of industrial culture, etc.

Statemant of the problem. The complexity of the issue lies in the fact that it is in the sphere of interest of several scientific aspects (psychology, medicine, economics, technical sciences and legal sciences, etc.) and concerns the study of relationships in the system "human-machine-environment" and its safety. Currently, the issue of the impact of martial law on this system is being raised, especially in areas close to war zones.

Analysis of recent research and publications. Issues of human relationships and ensuring the stability and reliability of transport and logistics systems, the causes of occupational risks, the role of the human factor in the emergence of man-made hazards, the degree of influence of this factor on the mechanism of the accident, and the methods of their quantification were studied [1; 2; 5; 6].

The scientific works consider the research issue in the sectoral aspect and in the context of risk management development. Thus, in [2] the set of factors determining the performance of certain actions by members of maritime transport crews, and their impact on the erroneous actions of staff are identified.

Analytical review of the human factor as a basis for safety of railway transport is studied in [7]. In particular, the authors note that the achievement of reliability and safety of railway transport should be ensured by a system of strict control over the human factor, development of psychosocial assessment of workers and the need for periodic psychophysiological studies of train safety.

In [8] it is determined that the issue of the impact of the "human factor" on the occurrence of railway accidents is diverse and structurally complex. In addition, it is noted that nowadays the most common causes of railway accidents are psychological characteristics and physiological capabilities of human.

The influence of human factors on the safety of motor vehicles in the transport process is studied in [9]. The author emphasizes that this factor is the least studied and most difficult in the safety of the motor vehicle process. Moreover, publications on the human factor often address technical issues of vehicle safety.

The study of the importance of the human factor in the context of ensuring the stability and reliability of transport and logistics systems covers a wide range of relevant scientific aspects. At the same time, despite the in-depth analysis of the research question, the number of factors that negatively affect the state of the human factor and the level of acceptable risk in the transport sector is currently growing in the martial law in Ukraine.

Formulation of the purpose of the article. The purpose of the article is to identify the nature and components of the human factor and the peculiarities of its action in the transport and logistics system in peacetime and wartime.

Research methodology. The following set of scientific methods was used in the study: analysis of scientific and technical literature and regulatory framework for the organization of drivers' work; dialectical method – to reveal the nature of the human factor and the peculiarities of its action in the transport and logistics system; structural analysis – to determine the components of the human factor, the structure and causes of accidents and hazards in the transport sector in military conditions; systemic and synergetic approaches – to determine a number of priority tasks for the development of the human factor in order to ensure the stability and reliability of transport and logistics systems; general logical methods and scenario approach – to improve the conceptual basis of risk management related to the human factor in transport and logistics systems in peacetime and during the Russian-Ukrainian war.

The main material of the article. The term "human factor" began to be used in the late nineteenth century to analyze the causes of accidents and disasters in rail transport and aviation. German psychologist Hugo Münsterberg introduced a concept of "personal factor" in his scientific works in the early twentieth century. "Personal factor" meant the erroneous actions of man while flying. Nowadays, the "personal factor" is understood as the individual influence of a person (personality) on failure (event), and the concept of "human factor" is defined as the impact of all possible participants involved in a particular process (technical systems with which man interacts) on this event. There is no single definition of the term "human factor" in state regulations and standards, but it is used in various interpretations in the field of safety, technology, management, military affairs, etc. [5].

Nowadays, the term "human factor" is mainly used in two senses: 1) to characterize the interaction of a complex system "Human – Technology" as the cause (determinant, factor) of a phenomenon, often negative (traffic accident, plane crash, etc.); 2) as an integrated set and an indicator of the qualitative characteristics of the human component of the combat potential of military formations [6].

Let's analyze the approaches to the definition of the concept of "human factor" existing in the scientific literature (Table 1).

The above definitions reveal the content of the human factor as a whole. In this paper, we analyze the human factor as a holistic system of activities aimed at changing, developing and improving the functioning of the transport and logistics system, as a set of basic qualities and competencies of the employee (professional, physiological, moral and psychological, etc.), his/her conscious or unconscious actions/inaction that can affect/affected the normal functioning of the transport and logistics system, and that appear to increase the risk of accidents or catastrophes.

Table 1

Overview of definitions of the "human factor" in the scientific literature

№	Author	Definitions
1	Zagumenna, N.	a set of basic social qualities of human that have historically developed in society (values, moral principles, norms of behavior, life plans, level of knowledge and awareness, the nature of work and social skills, attitudes and ideas about personally important elements of social life: social justice, human rights and freedom, civic duty [10].
2	Bochkovsky, A.	– certain human characteristics that may cause (or have caused) a violation of the normal process of interaction between the elements of the ergatic system [5]; – conscious or unconscious actions or inaction of a person (group of people) that involve a risk of occurrence (led to the occurrence) of a dangerous event [11].
3	Sobkova, N.	manifestation of the whole set of personal qualities of human, which affect his work activity. This concept indicates the crucial role of man in the process of organization, production and control [12].
4	Meister, D.	a term that describes a person's ability to make erroneous or illogical decisions in specific situations [13].
5	Panasyuk, I., Mykytenko, L., Danilevich, N.	factor associated with various human roles in solving management problems and should be taken into account by scientists in developing tools for solving such problems (models, methods, mathematical apparatus, methodologies, computer tools, etc.) [14].

Source: developed by the authors based on the analysis [5; 10; 11; 12; 13; 14]

In the field of transport there is a direct interaction of human (drivers and service personnel) and machines (vehicles), which is influenced by both internal and external determinants. In particular, the human factor depends on: social and legal working conditions (current ILO legal norms, national employment policy and ensuring safe working conditions, the policy of an individual transport and logistics company, the terms of the contract with each individual employee); working conditions in the workplace, type of work, relationships with other employees; the state of health and well-being of the employee, the living conditions and the organization of rest; professional knowledge and skills, level of education and training of the employee; state of the transport system and infrastructure, technological development of the transport industry; environmental influences, which include in particular the culture and behavior of traffic participants.

Transport and logistics systems are socio-technical systems such as "Human – Vehicle – Environment" (see Fig. 1).

The human factor has the following components: professional skills and competencies, moral and psychological characteristics, values, cognitive skills of the employee. Human factors is concerned with cognitive processes, such as attention, memory load, distraction, workload, management of interruption, problem solving, computation, judgment, and decision-making.

In order to ensure the development of the human factor, the stability and reliability of transport and logistics systems, it is necessary to solve a set of practical tasks. In particular, first of all it is necessary to pay special attention to: 1) selection of personnel, constant monitoring by the company of the state of employee's health, efficiency

and reliability of drivers in terms of well-being, attentiveness, stability of mental state and confidence, ability to react quickly in extreme conditions; 2) development of employees' abilities; their certification and promotion, systematic training; 3) use of employees in positions that correspond to their level of qualification; 4) stimulation and encouragement of employees; 5) availability and accessibility for the driver of the necessary information coming from the road, the environment and the vehicle, as well as the ability to perceive and understand the information by the driver; 6) ability to anticipate changes in the road situation to prevent danger; 7) functional state of a person, which is characterized by the efficiency of its activities, the ability to perform certain work, working capacity and professional longevity of human; 8) infallibility of human actions, willingness to work at any time, the ability to perform actions in a timely manner.

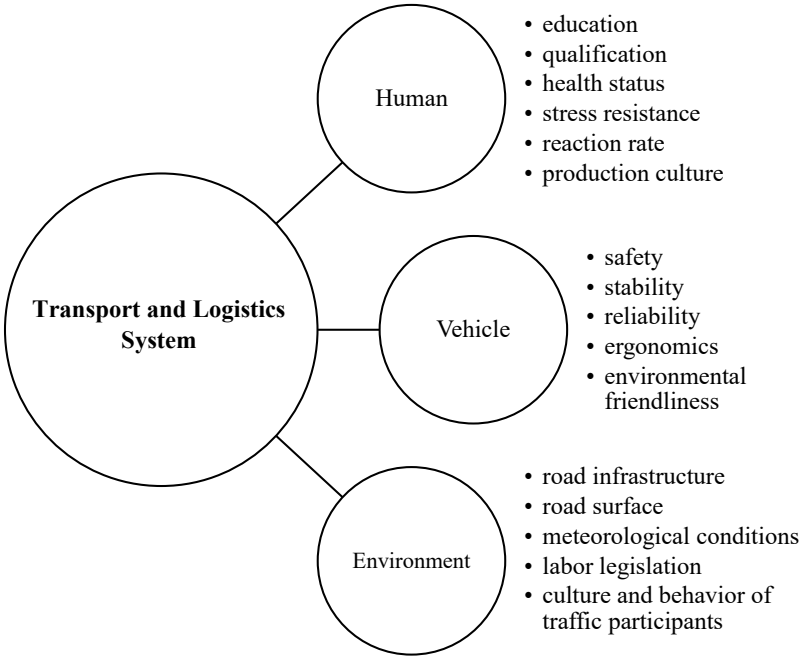

Fig. 1. Components of the transport and logistics system
Source: author's development

Minimizing the impact of the human factor on the transport and logistics system can be achieved through the creation and implementation of a safety management system and mitigation of risks on transport. For example, in peacetime, one of the ways to improve transport safety is the impact on physical ergonomics and anthropometric factors that affect employee productivity and workflow. The human factor is related to the location of the driver's workspace, including the location, size and characteristics of tools such as lighting, vehicle control panel, monitors and other equipment. Anthropometry is especially concerned with understanding human physical change and its impact on productivity. Vehicles and equipment in them must meet the road environment, the needs of road users and the task of safe and comfortable transportation.

Another way to increase transport safety by reducing or eliminating human error is the introduction of automation. These are both vehicle management automation systems and transportation software, so-called "Transport management system (TMS)".

Automated driver assistance systems for driving are represented by adaptive cruise control and lane-keeping assistance. Such systems are designed to increase the safety of the driver and passengers, the safety of goods during transportation. Full automation also includes environmental monitoring and detection of special driving conditions (eg traffic jams).

Modern TMS meet the following requirements: create realistic routes that can be performed by drivers, and allow drivers to change routes in real time according to changes in traffic; reflect the time of arrival of the vehicle at each destination; allow company to automatically monitor drivers on the routes (location of the truck, engine performance, truck mileage, etc.); calculate the efficiency of the truck fleet that will be involved in the transportation process (when ordering, it is necessary to specify the size of the order, volume and weight characteristics of the cargo, load capacity and body volume of the truck to be submitted for loading).

TMS allows company to save fuel and lubricants by 30 %, to reduce truck mileage by 35 %, to reduce time for planning of routes in 2.5 times, to increase loading of vehicles by 20 %. At the same time, the introduction of navigation systems allows for an objective assessment of the working result of drivers and dispatchers. This eliminates the grounds for potential conflicts in labour collectives, related to the evaluation of work performed, unreasonable provision of more "favorable" conditions and transport tasks, etc. After the implementation of the system, each participant in the transportation process at any time can receive information about the results of his/her work. This completely eliminates the possibility of influencing this process of subjective factors. It is dangerous to over-trust the automated systems in situations that tend to be strange, unpredictable, and hazardous.

Among the risk factors that increase the occurrence of adverse events, accidents, road accidents, damage to cargo can be identified: poor employee training (in particular, non-compliance with the level of employee training to modern technologies and automated systems); increasing workload; employee fatigue; unsatisfactory technical condition of the vehicle; external force majeure factors.

One of such challenges is the full-scale Russian invasion of Ukraine, which complicates the impact of environmental factors, changes the tasks facing the driver. The factor of danger, threat to human life as a result of direct military action in the occupied territories, artillery shelling of vehicles on the line of contact, missile strikes throughout Ukraine come to the fore.

In military conditions, it should be noted the increase in risks associated with: injuries and deaths of participants in the transport and logistics system (drivers, passengers); partial or complete damage to the vehicle during artillery shelling or missile strikes; damage to the transported goods; lack of communication between the driver and the control center due to the destruction of telecommunications infrastructure, lack of mobile communications; the destruction of transport infrastructure (as of April 11, 2022, the total infrastructure damage caused to Ukraine by the russian invasion is estimated at $ 119 billion, and the total amount of direct documented infrastructure

damage reached $ 80.4 billion. Almost 8,000 km of roads, dozens of railway stations, airports were damaged, seaports were blocked, supply chain failures were observed).

During the war, some cities and territories where hostilities are taking place were blocked, which significantly complicates the work of transport and logistics companies. Massive rocket attacks and artillery shelling destroyed a significant number of oil depots and fuel depots, leading to fuel shortages in May 2022. Some transport and logistics companies have stopped working altogether.

Due to constant stress, employees' fatigue increases, their ability to act in extreme situations decreases sharply, which increases the risk of accidents. In particular, on May 3, 2022, 26 people died in an accident involving three vehicles (bus, fuel truck and car) in the village Sitne, Dubna district, Rivne region. The accident was caused by the driver of a car, who was overtaking and drove into the oncoming lane, where he collided with a fuel truck [15]. After this terrible tragedy, the Government of Ukraine decided to resume the operation of video surveillance cameras on the roads of Ukraine.

In conditions when the airspace over Ukraine is closed, seaports are blocked, railway tracks and power lines are destroyed, the main cargo flows are transported by road. Road transport is involved in the transportation of weapons and equipment for the Armed Forces of Ukraine, humanitarian goods and medicines for the population. Evacuation of the population from the combat zones of the russian-occupied territories of Ukraine is also carried out by road. At the beginning of the active hostilities on February 24, 2022, "green" corridors for the delivery of food and priority humanitarian aid to Ukraine were literally formed manually, which significantly increased the burden on both the transport and logistics companies and drivers. It should be noted that during the war, some drivers were mobilized to the Armed Forces of Ukraine or Territorial Defense, some went with their families to safe western regions of the country, some simply refused to go to work if their routes were in places of direct hostilities. This has greatly increased the workload of those workers who remained to work.

As a result, more and more EU countries are easing the work and rest regime for drivers transporting humanitarian goods to Ukraine. This is a deviation from the provisions of EU Regulation 561/2006 on the hours of work and rest of trucks' drivers (Table 2). The first countries to introduce easing were Poland, Belgium and Germany [16]. They were followed by Austria, Denmark, France and Hungary. For example, Austria has allowed the movement of humanitarian goods on its territory on weekends and holidays.

Table 2

Changes in the time of work and rest of trucks' drivers in the EU during the transportation of humanitarian goods in wartime

Indicator	Regulation (EC) No 561/2006 [17]	Changes in legislations due to the Russian-Ukrainian war [16]
The daily driving time shall not exceed	9 hours	11 hours
The weekly driving time shall not exceed	56 hours	60 hours
The total accumulated driving time during any two consecutive weeks shall not exceed	90 hours	96 hours
A driver shall take an uninterrupted break of not less than 45 minutes after a driving period of	four and a half hours	five and a half hours

Source: developed by the authors based on [16, 17]

At the same time, it should be noted that such changes increase the burden on drivers, which increases the risk of accidents. Improper understanding of the situation, making wrong decisions, dangerous actions are the main causes of accidents. Functional reliability of the driver is a decisive factor in ensuring the stability and reliability of the transport and logistics system. Military action reduces the time needed to get out of an emergency. There is a psychophysiological barrier (fear or lack thereof) when the driver is unable to ensure quality performance of professional duties. Errors can be caused by lack of information and physical and psychological condition of the driver. Limited resources and lack of time to make decisions is complicated by the experience of high responsibility for his actions (saving someone's life, delivery of essential goods).

During the war, the main burden of making decisions on the carriage of goods and passengers fell directly on the driver, but the responsibility – on the transport and logistics company. Therefore, it is important for the company to develop and implement an effective system of risk management related to the human factor, and the implementation of a scenario-based measures to prevent and neutralize the risks associated with the human factor (see Fig. 2).

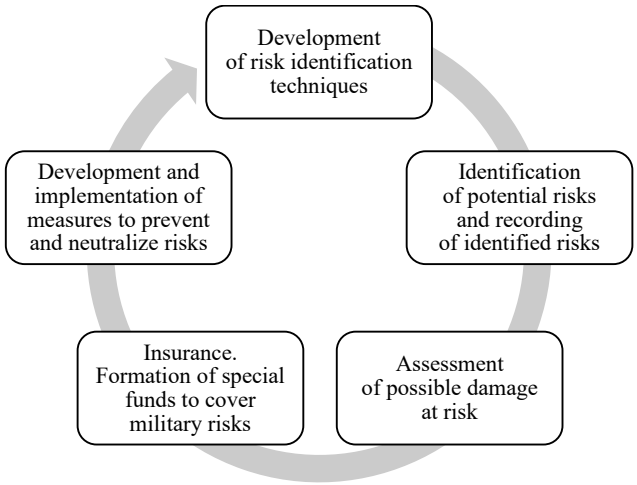

Fig. 2. Risk management system, related to the action of the human factor in transport and logistics systems

Source: developed by the authors based on [18]

Conclusions. In the conditions of military economy and uncertainty the role of the human factor in ensuring stable and reliable functioning of the transport and logistics system is growing. Based on the analysis of scientific approaches and concepts to the definition of the concept of "human factor", we have identified it as a holistic system of activities aimed at changing, developing and improving the functioning of the transport and logistics system, as a set of basic qualities and competencies of the employee (professional, physiological, moral and psychological, etc.), his/her conscious or unconscious actions/inaction that can affect/affected the normal functioning of the transport and logistics system, and that appear to increase the risk of accidents or

catastrophes. Due to its complexity and versatility, the human factor depends on socio-legal conditions, working and leisure conditions of the employee, his/her professional knowledge and skills, level of preparedness, state of transport system and infrastructure, environment, culture and behavior. The work of the transport and logistics system is interpreted from the standpoint of three components: human, vehicle (machine) and the environment. The human factor has the following components: professional skills and competencies, moral and psychological characteristics, values, cognitive skills of the employee. We have identified a number of important tasks that need to be addressed as a matter of priority for the development of the human factor, ensuring the stability and reliability of transport and logistics systems, in particular: selection of personnel, constant monitoring by the company of the state of employee's health, efficiency and reliability of drivers; development of employees' abilities; availability and accessibility for the driver of the necessary information coming from the road, the environment and the vehicle, as well as the ability to perceive and understand the information by the driver etc.

In the process of research, we came to the conclusion that minimizing the impact of the human factor on the transport and logistics system can be achieved through the creation and implementation of a safety management system and mitigation of risks on transport. For example, in peacetime, one of the ways to improve transport safety is the impact on physical ergonomics and anthropometric factors that affect employee productivity and workflow. The another way is the introduction of automation (vehicle management automation systems and transportation software). During the war, priorities change due to the increased risks associated with injury and death of participants in the transport and logistics system; partial or complete damage to cargo due to missile strikes and shelling, destruction of transport infrastructure. The safety factor comes to the fore, including saving the lives of workers and passengers, saving cargo and finding new logistical safe routes, through the closure of traditional sea and air routes. The main cargo flows are transported by road. Transport and logistics companies face new challenges during the war, in particular due to staff reductions as a result of hostilities. The workload of the remaining staff is growing significantly. This leads to their exhaustion, fatigue and an increase in the number of road accidents and accidents, injuries and deaths of transport participants. Realizing the need to organize transport corridors to help Ukraine, most EU countries have weakened the work and rest regime for drivers transporting humanitarian goods to Ukraine. The paper proposes a scheme for the development and implementation of an effective system for managing the risks associated with the human factor, and the implementation of a scenario-based measures to prevent and neutralize the risks associated with the human factor.

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