AKADEMIA NAUK STOSOWANYCH
WYŻSZA SZKOŁA ZARZĄDZANIA I ADMINISTRACJI W OPOLU

ACADEMY OF APPLIED SCIENCES
ACADEMY OF MANAGEMENT AND ADMINISTRATION

# LOGISTICS IN CONDITIONS OF UNCERTAINTY

MONOGRAPH

OPOLE-KYIV
2024

**Academy of Applied Sciences**
**Academy of Management and Administration in Opole**

**National University of Life and Environmental Sciences of Ukraine**

**National Aviation University**

# LOGISTICS
# IN CONDITIONS OF UNCERTAINTY

*Monograph*

**Opole-Kyiv**
**2024**

**ISBN 978-83-66567-62-7**

Logistics in conditions of uncertainty. Monograph. Opole: Academy of Applied Sciences Academy of Management and Administration in Opole, 2024; ISBN 978-83-66567-62-7; 290 pp., illus., tabs., bibls.

Together with:

***National University of Life and Environmental Sciences of Ukraine, Kyiv***
***National Aviation University, Kyiv, Ukraine***

Recommended for publication
by the Academic Council of Academy of Applied Sciences
Academy of Management and Administration in Opole
(Protocol No. 5 of May 22, 2024)

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Management and Administration in Opole
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**Publishing House:**
Academy of Applied Sciences Academy
of Management and Administration in Opole,
45-085 Poland, Opole, ul. Niedzialkowskiego 18
tel. 77 402-19-00/01

150 copies

Authors are responsible for content of the materials

ISBN 978-83-66567-62-7

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## INTRODUCTION

The transport and logistics sector is one of the strategically important industries that connects not only the economic space of the country but also largely determines social stability in society and the quality of life of the population. The effective functioning of the main elements of the transport and logical system determines the pace of sustainable development of the industry, the national economy, and, finally, the level of economic security of the country. Competitiveness in the conditions of the modern world, characterized by variability, uncertainty, complexity, and ambiguity and called the VUCA world, is associated with new development opportunities and requires rapid adaptation and flexible behavior of transport and logistics enterprises. Under such conditions, the transport and logistics sector needs changes in the management system based on the use of modern methods and tools, effective forms of integration, a new look at cooperation, and consideration of the interests of stakeholders. Thus, integration processes in the form of the creation of transport and logistics clusters, and holdings provide new opportunities for innovation, effective interaction of enterprises, and increasing their competitiveness. In today's changing and uncertain conditions, only a competitive transport and logistics company capable of innovative development can function successfully. As a result, the ability to develop should be considered as its main competitive advantage, which ensures its strategic competitiveness not only in the logistics sector but also in the country's economy as a whole.

The impact of the domestic and international markets on the country's transport and logistics systems determines the need to achieve competitive advantages through increasing the economic and technological productivity of transport and logistics services in comparison with other countries, restructuring the transport infrastructure, applying new approaches to management decisions, as well as institutional changes in transport policy. The main task of the state and society is to create institutional, economic, legal, organizational, social, environmental, and other conditions for the direction of reforms to ensure a high level of competitiveness of this most important sector

of the economy for countries. Moreover, as the experience of market transformation of the transport sector of the advanced countries of the world shows, the objective prerequisite for technological modernization is, first of all, institutional modernization, which provides formal and informal institutional changes, which, in turn, stimulate technological, organizational and social modernization of the transport and logistics sphere. From these positions, the monograph reveals the development of various areas of transport and logistics spheres of Poland and Ukraine in the current difficult conditions of the war in Ukraine.

The first section of the work covers a group of problems related to military logistics, solving issues of security of the transport system in wartime, analysis of hazards and critical control points in transport systems, and determining mechanisms for the formation of smart decisions in the processes of managing the safety of components of the transport system in the conditions of hostilities.

In the second section of the work, considerable attention is paid to the methodology of humanitarian logistics as a social phenomenon and manifestation of people's attitudes to each other in crises, the social significance of hybridization of humanitarian logistics, the conditions for improving the efficiency of humanitarian logistics and the organization of material and technical support for the affected population.

In the third section of the work, theoretical and methodological approaches to the organization of logistic support for agricultural production, current trends in the development of export-oriented agri-food logistics in Ukraine during the war are studied, the role and prospects for the use of digital technologies in agri-food logistics during the war period are determined.

To solve these problems, the monograph proposes directions for the development of the transport and logistics sphere through the use of adaptive mechanisms based on the speed, flexibility, and efficiency of adaptation, development, and combination of modern marketing concepts and new approaches in the application of marketing communications.

# Part 1

# HUMANITARIAN LOGISTICS AS A SOCIAL MANIFESTATION OF ATTITUDES IN CRISIS SITUATIONS

„The logistician is the most important person in providing immediate help”[1]

Considering the publication of a joint work with colleagues from Ukraine, I decided that my part should refer to the Author's research achievements from the past period, in the context of the work of the Department of Logistics and Marketing of the Academy of Applied Sciences - WSZiA in Opole. The result of these research and studies, especially in the field of logistics, is the significant publication output of the department's employees. The analysis of these studies allowed - taking into account the opinion of, e.g., the Polish Accreditation Committee and the sources of these publications - the identification of selected works that do not constitute only statements of commonly presented content, but are characterized by innovative views. Learning and implementing concepts such as logistics and marketing management, process orientation in the aspect of creating and delivering value, integrated supply chain or humanitarian logistics, in its essence, is particularly characterized by the originality of the proposed program content, the implementation of which in practice creates the opportunity to improve action's efficiency and effectiveness in the practical sphere. The issue of humanitarian logistics is particularly close to the Author and will be the subject of considerations in this part of our joint work.

[1] From M. Przedlacki's statement during the „Logistyka wokół nas 2007” conference, AE Poznań 1.03.07.

## 1.1. Humanitarian logistics – the essence

I am aware that a few years ago, this part of our work would have aroused polemical voices and controversy, especially in relation to those views that were limited to the so-called classic understanding and interpretation of logistics. The provocative question I ask myself at this point is - is it really about another definition of logistics or supply chain, or is it about how many people die every day in the world just because this or that definition is not reflected in the reality? Or maybe it is, but we have devoted too little space and attention to these issues. Specifically, **humanitarian logistics**,[2] logistics with a human face. Presenting the essence of this issue in a global aspect is, as I mentioned at the beginning, the goal of this part of the work. Reader, believe me, this is not populism, it is an inner feeling. If anyone has doubts whether there is such a thing as humanitarian logistics, I would like to ask to carefully study, the work of the various authors mentioned here, whose studies are largely related to crisis management and providing humanitarian aid to those in need in r e a l i t y. This reality, unfortunately, includes great tragedies related, for example, to the ongoing military aggression of Russia against Ukraine or the war in the Gaza Strip, religious conflicts and related crimes against the civilian population of Iraq and Syria in the name of the philosophy of sharia and jihad. Or natural disasters, epidemics and man-made disasters (including terrorist attacks as in Mumbai, Bali or Madrid). Or a combination of different types of disasters - such as tsunamis in the Indian Ocean, marine pollution incidents in third world countries or forest fires in Australia and Spain or floods in Europe. These situations have led to an increase in calls for greater effectiveness of existing European Union and

[2] Humanitarian logistics should not be confused with humanitarian intervention, which focuses on the protection of human rights; check Domagała A., *Interwencja humanitarna w stosunkach międzynarodowych*, Oficyna Wydawnicza Branta, Bydgoszcz-Wrocław 2008, s.24

United Nations capacities to respond to such crises; this is where humanitarian logistics comes in.

I think that humanitarian logistics should be seen as a manifestation of the elusive state of mind of people who are sensitive to the needs of other people. The point is that in response, someone undertakes to provide appropriate help to those in need, understanding it as his or her own interest! Another provocation? No, because this interest, in my opinion, consists in caring for efficiency and effectiveness, but, above all, caring for the subjectivity of other people, and thus also for one's own. This probably helps you look at yourself honestly in the mirror every day with dignity while putting on makeup or shaving. Pathos? Of course not: reality and empathy! Here we can already see a significant difference in relation to the so-called efficiency (in addition to the conceptual-functional and objective-structural) understanding of logistics as a certain orientation and determinant of the increase in efficiency, oriented towards offering customers the desired level and quality of logistics service, while rationalizing the structure of logistics costs and increasing the overall management efficiency. In relation to humanitarian logistics, this premise becomes, as mentioned, less important.

There is also the awareness that every day millions of people around the world fall asleep feeling hungry. Every five seconds a child dies from hunger or starvation-related diseases. Even though our planet produces food in quantities exceeding the needs of the entire population, the most serious obstacles to providing food to those most in need are logistical problems, hence the need to create humanitarian logistics aimed at providing help to people, regardless of political, economic, religious or national factors, regardless of race, gender and age. It should also be financially and politically independent in relation to the areas to which this assistance is provided. Moreover, its goal is not even to restore peace in crisis areas, but above all - and I emphasize once again - to save human lives.

What else can be written about logistics, since so much has already been written and also my achievements in this field are probably noticeable? Perhaps another provocation. Generally speaking, two axioms are accepted in the logistics literature area: firstly, historically, that

logistics was born in the army and secondly, nowadays, that it is a process. However, this is probably not enough to participate comprehensively, responsibly and consciously in contemporary discussions about logistics, which are particularly relevant due to crises (including war). First of all, we must remember to supplement these two axioms with everything - as the real goal of logistics - which involves providing people in need with what they need to survive, even if they live in inaccessible tropical areas, in the Saharan desert or in a war zone. Someone *ex post* will probably notice the process of providing help to those injured in terrorist attacks, wars, disasters or epidemics; which is of course important, but the victims do not wait for it, they cannot even wait for it in situations of extreme danger. Logistics and an integrated supply chain are best verified as **supply chains for life**, best integrated and synergistic. By the way, an interesting thing; namely, it turns out that despite the modern fascination with "supply chain management", you can find materials on the Internet that substantiate the thesis,[3] that logistics is not a chain because it stiffens the functioning of the company, unlike logistics, which is still perceived as a factor that makes the company more dynamic.

Perhaps there has never been such a climate, such a need, so much courage to so clearly present a new approach to logistics - a humanitarian approach. There is also an approach to logistics based on the so-called "interpretive paradigm" According to this approach, logisticians must accept that the logistics system being created cannot be easily identified; because it is more than just their way of seeing reality and there are certainly other views of the world. Therefore, logistics should be taken not as a ready-made solution, but rather as a need for a general consideration of delivery issues; and therefore the delivery of aid through the mentioned supply chain for life. The most interesting thing is that Internet browsers did not find the term "humanitarian logistics" in the Polish version on the Internet until 2009, contrary to analyzes in this area in English or German literature. So it was in the year mentioned above that we introduced humanitarian logistics in Poland, which de facto existed! Paradox, right? I

[3] http://www.insourceaudit.com

also think that we can no longer wait for some concepts to be developed in practice and then, after being taken over by scientists, be passed on to students. This will give students a sense of lower value and wasted time, because when they persistently participate in classes, at the same time, new phenomena and corresponding concepts are being created, which they are missing out on learning. And one more question: why in 2006, in the "Supply Chain Excelence" competition organized for the 10th time by the Logistics Europe magazine - treating this event as a lucky gift of fate, because it is difficult to find a better example illustrating this issue - the best were not those who only govern the processes on a daily basis, nor even those who establish uniform procedures according to which the processes will be created in the future, but those who work to ensure that in the event of any cataclysm in the world, they are delivered to local organizations that organize help for the victims, something as abstract as "clarity, transparency and structure"? In this strange way, they restore - according to the jurors - the attributes of life and enable them to provide real help. This is, among other things, the essence of humanitarian logistics. In such situations, the same laws that should be followed on a daily basis apply, although it is known that everyday life does not require heroism such as in critical situations.

The origins and patterns for humanitarian logistics can certainly be traced to the activities of military logistics services. Military missions (but not only)[4] organized in various parts of the world are one of the important examples of organizing supplies adequate to the needs in difficult, dangerous and often unusual places. Humanitarian logistics, as mentioned, is not only about ensuring the flow of goods in a smooth and economically viable manner. In this case, identifying the client's needs is burdened with additional problems, and the work of a logistics specialist for humanitarian aid involves, among others, on assessing the size of the project, assessing the specificity of assistance or assessing priorities in this area.

Humanitarian logistics differs from other interpretations of the term "logistics" in that its sole purpose is to respond quickly to a crisis situation

[4] An excellent example in this respect is the help of the Polish civilian population for war refugees from Ukraine, especially in the initial period of the war with Russia

in order to save and keep people alive and to prevent or alleviate human suffering wherever necessary, if local authorities and other local actors are unwilling or unable to take action. Local emergency preparedness and capacity are critical to saving lives. Although the rules for providing humanitarian aid are specific compared to other forms of aid, it is necessary to maintain coherence with other policy instruments, especially those related to crisis management and development cooperation. Hence, the scope and nature of humanitarian logistics is - as emphasized - specific due to the need for ad hoc, quick and professional action to meet the basic needs of people in crisis areas, caused by, among others, war, natural disasters, violence, poverty, disease, ethnic cleansing, expulsions or terrorist attacks. Increasingly faster logistics operations are becoming possible thanks to the use of the latest information and communication technologies, thanks to the Internet, data banks and computer networks.[5] Unfortunately, situations are becoming more and more common in which planned aid activities carried out within the framework of humanitarian logistics are met with attacks by an aggressor or opponent. We have seen such examples recently during the war in Ukraine and earlier in the former Yugoslavia, Chad and South Sudan

When in 2009 we organized the first conference in Poland on humanitarian logistics at the Academy of Management and Administration in Opole and published works entitled 'Humanitarian logistics and crisis management' and 'Crisis management and logistics activities' by the Silesian Institute in Opole and the Katowice branch of the Polish Academy of Sciences. and we also published the article 'Humanitarian logistics - essence, conditions of effectiveness and applications in the sphere of civil-military cooperation'[6], it was difficult to expect that the theses contained in these works, as well as the practical solutions presented, would enjoy such great interest in the coming years and would find such important

[5] http://www.swissinfo.ch/ger/archive

[6] Pokusa, T., & Duczmal, M. (red.) *Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy.* Instytut Śląski., 2009 Opole, Pokusa, T., & Duczmal, W. (red*.) Zarządzanie kryzysowe i działania logistyczne – na przykładzie wybranych instytucji.* Instytut Śląski, 2009, Opole, Pokusa, T., & Grzybowski W. *Logistyka humanitarna. Istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno-wojskowej*. 2010, Cz. 1. Logistyka, (2), 29–31.

application. This is particularly due to the development of the areas of logistics use, the increase in its popularity and the need to look for more effective ways of providing humanitarian aid, the systematic increase in international financial outlays for this aid, and the increasing number of aid organizations, but also, unfortunately, a constant upward trend in the number of natural disasters in the world.

A similar approach to this issue is also included in the article 'Logistics of humanitarian operations' [7] published in "Gospodarka Materiałowa i Logistyka". It is also worth emphasizing that the mentioned work 'Humanitarian logistics and crisis management' enjoyed considerable interest among researchers, which is why it is noted, among others, in publications in the field of humanitarian logistics[8]. For example, in his work 'Humanitarian supply chain', J. M. Marcinkowski refers to the thoughts of T. Pokusa, writing that: 'The creation of humanitarian logistics is extremely necessary. Its goal is to provide help to those in need and save their lives, not to restore peace in the crisis area". He also cites the essence

[7] Szołtysek, J. *Logistyka akcji humanitarnych*. Gospodarka Materiałowa i Logistyka 2009, (3), 2–8.

[8] Szołtysek, J. (red.) *Nowe zastosowania logistyki. Przykłady i studia przypadków*. Instytut Logistyki i Magazynowania. 2010, Szołtysek, J. *Typologia obszarów stosowania logistyki – propozycja rozwiązania*,.2010 Gospodarka Materiałowa i Logistyka, (8), 2–6., Łupicka, A. *Wsparcie logistyczne akcji humanitarnych.* Logistyka,2011 (2), 40–42, Łupicka, A. *Logistyka akcji humanitarnych jako jeden z procesów zarządzania ryzykiem w łańcuchu dostaw.* Prace Naukowe UE Wrocław 2011, (234), 257–269. Sienkiewicz-Małyjurek, K. *Logistyka humanitarna – odpowiedź na współczesne zagrożenia*. Ekonomika i Organizacja Przedsiębiorstwa, 2011 (2), 34–44. Sienkiewicz-Małyjurek, K. *Uwarunkowania i bariery w logistycznym wymiarze zarządzania kryzysowego.*2012, Logistyka, (6), 5–8. Sterczewska, I. *Wybrane elementy zarządzania kryzysowego*. 2011, Zeszyt Naukowy Apeiron, (5), 167–180. Nerć-Pełka, A., & Wysocka, A. *Logistyka i transport a wyzwania współczesnej gospodarki.* Zeszyty Naukowe Uniwersytetu Szczecińskiego 2012 (735), 69–82. Ambroziak, S., & Kania, P. *Organizacja logistyki humanitarnej na przykładzie Syrii*. Logistyka 2013, (5), 39–41, Usewicz, T. *Logistyka w działalności wybranych podmiotów niosących pomoc humanitarną*. Gospodarka Materiałowa i Logistyka, 2016, (12, CD), 817–831., Mordzak, K. *Operacje humanitarne.* Cz. II. Wyższa Szkoła Oficerska Wojsk Lądowych we Wrocławiu 2017, Wrocław, Marciniak, D. *Podstawowe problemy wpływające na logistyczne uwarunkowania zarządzania kryzysowego.* Bezpieczeństwo. Teoria i praktyka, 2020, (4), 109–124.

Matwiejczuk, R. *Kompetencje logistyki w tworzeniu przewagi konkurencyjnej przedsiębiorstwa*. 2014,Wydawnictwo Uniwersytetu Opolskiego. Matwiejczuk, R. *Logistyka w zarządzaniu strategicznym.* Polskie Wydawnictwo Ekonomiczne 2021,. Marcinkowski, J. M. *Humanitarny łańcuch dostaw*. Wydawnictwo Uniwersytetu Ekonomicznego 2019, Wrocław,. Witkowski, J. *Dzieje logistyki. Od wspierania przemocy do doskonalenia jakości życia.* Wydawnictwo Uniwersytetu Ekonomicznego 2020, Wrocław.

of humanitarian logistics contained in the cited work and emphasizes the importance of the problem of identifying needs in crisis situations [9] (Marcinkowski, 2019). The publications listed are recommended literature in the process of studying, e.g. the subject Security in logistic chains.

The issue of humanitarian logistics also found significant expression in the Humanitarian Logistics education module launched at the Academy of Management and Administration in Opole - also the first in Poland - which differs from the classical understanding of the concept of "logistics" in that its basic principle is a quick and effective response to crisis situation in order to save and keep people alive.

I have written about the process approach, supply chains and their management, and I am constantly promoting diploma theses in this field. Is it possible to find an alternative and supplement to this approach to logistics, is such an alternative and supplement necessary? Of course, I answer yes twice, remembering, however, that it is necessary to constantly emphasize and refer to the current, valuable and rich theoretical and empirical achievements in this area, also of the Opole environment, including the Academy of Applied Sciences-WSZiA, and its leader, Professor Piotr Blaik. As the Professor writes, "a closer analysis of the concept of logistics allows us to conclude that the definitions formulated by well-known authors differ in terms of the scope of the processes covered by the physical circulation of goods (range and institutional structure), their method of treatment and the interpretation of specific goals, at the same time demonstrating agreement as to the very essence of the problems that constitute their fundamental content[10], such as process orientation in the aspect of creating and delivering value or an integrated supply chain". Today, there is no doubt that humanitarian logistics also fits into this approach, emphasizing people and their needs in crisis situations and beyond. It seems that this is a necessary addition emphasizing man and his needs in crisis situations, a different humanitarian understanding of the integrity of the logistics system according to the principle: **"A man is a man to man".** The starting point for further considerations may be, based on the

[9] Marcinkowski, J. M. *Humanitarny łańcuch dostaw*. Wydawnictwo Uniwersytetu Ekonomicznego, 2019 Wrocław.
[10] P. Blaik, *Logistyka*, *Koncepcja zintegrowanego zarządzania,* PWE, Warszawa 2001, s. 20

rich theoretical achievements, the definition of logistics as "the process of managing the entire supply chain".[11] The supply chain is understood as the activity related to the flow of material (goods) from its original source through all intermediate forms to the form in which it is consumed by the final customer. The supply chain as a process carried out from obtaining raw materials to delivering the finished product to the final recipient probably happens because, as a result of e.g. a natural disaster or an epidemic, someone previously lacked something that had been delivered to them thanks to humanitarian logistics. Hence, in relation to the analyzed problem, it is better to talk about the supply chain for life! But you can also look at this phenomenon slightly differently, going beyond this traditional view. You can also do the opposite: "relocate people to the goods and services they need" and conclusions in this regard can be found in the example of the evacuation through temporary humanitarian corridors of the population of Ukrainian towns and villages affected by the war, the civilian population of the Gaza Strip or, earlier, the population exposed to the effects of Hurricane Katrina in New Orleans. So a person is not at the end of this logistic chain, on the contrary, at the beginning, and this is also humanitarian logistics. Does it fit into the classic logistics formula presented above? This logistics, of course, also includes all classic logistics processes in the implementation of aid projects in crisis and conflict areas. Moreover, it seems that the global ecological and economic crisis that is engulfing us also has a positive side in the sense that if someone has lost access to luxury, perhaps this fact will make them realize that others don't have bread. One can draw an analogy here with the so-called "logistic awareness" which should be developed based on an attitude of mind created through the use of system ideas rather than forced on the basis of expert knowledge about delivery, treated as a system of interacting parts.[12]

Currently, what is the result of theoretical analyses, descriptions or literature studies won't remain in the sphere of ideals and assumptions, because it can be said that today there is a group of people - including our students of ANS-WSZiA - who don't focus their goals on making money, but

[11] D. Bak., *Rozwój i rola logistyki w Wielkiej Brytanii*, PWE, Warszawa 1992, s.35
[12] J. Okulewicz., *Podsumowanie etapu,* www.spedycje.pl/logistyka 11.05.07

on more noble purposes. It is certainly true - although thanks to God we do not experience it - that the world we see is not the world in which all people live. That is why we need those who will help those in need in various forms. I assume that among them there are well-educated and prepared to fulfill their mission graduates of the "humanitarian logistics" specialty of our academy, the Academy of Applied Sciences-WSZiA in Opole.

Humanitarian logistics was until recently a new concept in Polish terminology in relation to the sphere of logistics, although in global publications, as it was emphasized, this issue was expressed already at the beginning of this century.[13] It seems that research in this area still constitutes a significant area of actual and potential investigations and analyzes by scientists and practitioners, e.g. in the area of specifying key conceptual categories and definitions, research problems or practical procedures in the aspect of synergy.

In the first decade of the 21st century, the dynamics of studies appearing on this subject was noticeable [14], and in recent years, we have

[13] L. Gustavsson, *Humanitarian logistics: context and challenges*, Forced Migration Review, 2003, Vol. 18, s.6-8, D.B. Kaatrud, R. Samii, L.N. van Wassenhove, *UN joint logistics centre: a coordinated response to common humanitarian logistics concerns*, Forced Migration Review, Vol. 18, 2003, s.11-14. R. Olorotunba, R. Gray, *Logistics for humanitarian aid: a survey of aid organisations,* Proceedings of the 7th Logistics Research Network Conference, Birmingham, September 2002, R.M. Tomasini, L.N. van Wassenhove, *Pan-American health organization's humanitarian supply management system: de-politicization of the humanitarian supply chain by creating accountability*, Journal of Public Procurement, Vol. 4 No.3, 2004, s..437-49, K. Höfer, *Katastrophenstudiengänge,* [http://studienwahl.suite101.de/article.cfm/katastropstudien] 27 sierpnia 2009.

[14] G. Kovács, K. M. Spens, *Humanitarian logistics in disaster relief operations,* International Journal of Physical Distribution & Logistics Management, Vol.37, No.2, 2007, s.99-114, G. Kovács, K. M. Spens, *Identifying challenges in humanitarian logistics,* International Journal of Physical Distribution & Logistics Management, Vol.39, No.6, 2009, s.506-528, G. Kovács, K. Spens, *Chapter 13: Humanitarian logistics revisite*, w: J.S. Arlbjørn, , A. Halldórsson, M. Jahre, K. Spens, K. (red.), Northern Lights in Logistics & Supply Chain Management, CBS Press, Copenhagen, 2008, s.217-32, Coyne, J. *Humanitarian Logistics: Musing Aloud*, Monday Developments, Vol.24, No.20,2006, s. 12-13, M. Howden, *How Humanitarian Logistics Information Systems Can Improve Humanitarian Supply Chains: A View from the Field,* International ISCRAM Conference – Gothenburg, May 2009, s. 1- 10, W. Hyde, *Applied Humanitarian Logistics,* Humanitarian Logistics Conference,Georgia Institute of Technology, February 19, 2009, s.1-8, E. L. Maspero, H.W. Ittmann, *The Rise of Humanitarian Logistics,* Conference Logistics & Quantitative Methods ,7-11 Jully 2008, Pretoria, s.175-184, , Rickard, J. *Humanitarian Logistics: Musing Aloud*, Monday Developments, Vol.24, No 20, 2006, s. 6-7. R. Oloruntoba, R.Gray, *Customer service in emergency relief chains,* International Journal of Physical Distribution & Logistics Management, Vol.39, No.6, 2009, s.486-505, L.N. van Wassenhove, H. Ford, *Humanitarian Logistics,* Social Innovation Centre, 2008, s.1- 55S. Pettit, A.Beresford, *Critical success factors in the context of humanitarian aid supply chains,* International Journal of Physical

also noticed Polish-language works. [15] Its essence, as emphasized, is not related to maximizing profit and minimizing the costs of running a business, as is accepted in the current understanding of logistics, treated in this case as a tool for shaping processes in a market economy. Globalization and the market economy cannot develop effectively without using moral resources, such as caring for other people, cooperation and helping those in need (perhaps not entirely selflessly). Humanitarian logistics is designed to meets such ideas. Taking action in accordance with its principles by enterprises and governmental and non-governmental organizations proves the farsightedness of those who make decisions about implementing this humanitarian field of logistics into practice. If we allowed part of society to remain in constant poverty, having no chance of getting out of its margins, and their fate was no longer of concern to others, this problem would return with greater force and affect the entire society. Humanitarian logistics therefore shows the "human face" of the economy,

Distribution & Logistics Management, Vol.39, No.6, 2009, s.450-468, R.M. Tomasini, L.N. van Wassenhove, *Humanitarian Logistics* INSEAD*,* Pelgrave Mcmillan, March 2009, s.256

[15] T. Pokusa, *Humanitarian logistics - essence in the light of the specialist literature* w: T. Pokusa, (red. naukowa), Zarządzanie Logistyka – procesy, koncepcje, narzędzia WSZiA Opole 2013 s. 281 – 294, T. Pokusa*, Logistyka humanitarna. Istota, warunki skuteczności i porównanie z ujęciem klasycznym*, w: S. Kauf (red. naukowa), Logistyka i inne koncepcje zarządzania w naukach ekonomicznych, UO, WSZiA Opole 2012, s.149-169T. Pokusa, *Logistyka humanitarna. Nowa "twarz" logistyki w sytuacjach kryzysowych,* w: T. Pokusa, M. Duczmal (red.) Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy, PAN O/Katowice, Opole, 2009, s.9-23, J. Szołtysek, *Logistyka akcji humanitarnych*, Gospodarka Materiałowa i Logistyka 3/2009, s.2-8, P. Michalski, *Logistyka w organizacji projektu ekspedycyjnego*, Logistyka 2008/6, s. J. Szołtysek, S. Twaróg, *Gospodarowanie zasobami krwi jako nowy obszar stosowania logistyki,* Gospodarka Materiałowa i Logistyka, 7/2009 s.12-17, P. Kołodziejczyk, J. Szołtysek, *Epistemologia logistyki społecznej,* Przegląd Organizacji 4/2009, K. Ficoń, *Logistyka kryzysowa. Procedury, Potrzeby, Potencjał,* Bel Studio, Warszawa 2011, T. Pokusa, *Logistyka humanitarna – podstawy teoretyczne i wstępna ocena implementacji,* w: T. Pokusa, W. Potwora, J. Kaczmarek, (red.) Nauka w służbie wartości, WSZiA, Opole 2009, s.324-341. Banaszyk, P., Kauf, S., Szołtysek, J. (2021). *Logistyka jako czynnik dobrostanu.* Polskie Wydawnictwo Ekonomiczne, Marcinkowski, J.M. (2019). *Humanitarny łańcuch dostaw*. Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, Pokusa, T. (2022). *Logistyka humanitarna jako społeczne wyzwanie współczesnych czasów.* Gospodarka Materiałowa i Logistyka, (5), 14–23. https://doi.org/10.33226/1231-2037.2022.5.2, Szołtysek, J. (2022). Identyfikacja wyzwań logistyki we współczesnym świecie. *Gospodarka Materiałowa i Logistyka*, (2), 2–10. https://doi.org/10.33226/1231-2037.2022.2.1,Szołtysek, J., Twaróg, S., Jeż, R. (2018). Logistyka społeczna – kontrowersje wokół jej istoty. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, (505), 56–65., Usewicz, T. (2016). Logistyka w działalności wybranych podmiotów niosących pomoc humanitarną. *Gospodarka Materiałowa i Logistyka*, (12), 817–831, Witkowski, J. (2020). *Dzieje logistyki. Od wspierania przemocy do doskonalenia jakości życia*. Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu.

which is permeated with mechanisms based on market laws. Such actions prove that the proper participants in the global market are flesh and blood people, not machines without a psyche. Humanitarian logistics means a human reflex in the world of the market, because when we help others, we count on reciprocation when we ourselves find ourselves in need. It is built into our nature, although we are not aware of the validity of our emotions that make us reach out to other people. John Forbes Nash [16] stated that the greatest profit and stability that the market strives for comes from mutual cooperation. In turn the competition of wild capitalism leads to the exploitation of man by man. Humanitarian logistics is a manifestation of global solidarity, security that gives a sense of security, which is the basis of social trust, without which the efficient functioning of the market is not possible. Providing help to those in need is acting in accordance with human rights in accordance with the principles of humanitarianism.

A. Schweitzer[17] the author of works on humanitarianism, often included his thoughts on the essence of humanity, which seem to be significantly compatible with the philosophy of humanitarian logistics, constituting, in a sense, an ideological foundation for it. According to him, humanitarianism is "a truly good relationship between man and man." People should act well towards each other not only because of the ethical code, but also because kindness constitutes the essence of man. It is specific to man. Schweitzer believes that humanitarianism requires listening to the heart. Common sense can tell you what is good and possible to do. However, the heart is "a ruler higher than reason." The voice of the heart commands us to do what is most worthy of man (photo 1). A. Schweitzer writes that the ideal of humanitarianism was not known to people, but was formulated thanks to outstanding philosophers and creators of religion. In ancient times, they included: Confucius, Zarathustra, Epicurus, Seneca.

A. Schweitzer finds the deepest words about goodness in Jesus and Saint Paul. Nowadays, humanitarianism also means respect for life in

[16] A beautiful mind - John Forbes Nash - Applied Agnieszkologia, One of the most famous creators of game theory. Online at .http:// pl.walorska.net/index.php?/archives/12 (dostęp 10 styczeń 2024)

[17] Albert Schweitzer (1875 – 1965) is the author of the text entitled "Humanitarianism". http://pl.shvoong.com/social-sciences/1747977-humanitarianyzm (accessed January 12, 2024)

general. A. Schweitzer believes that the idea of humanitarianism won't only be developed, but also expanded to include new features. In his opinion, rejecting the use of nuclear weapons will be a step in the desired direction in terms of humanity's humanitarian attitude. Humanitarian logistics require constant readiness because a crisis is never expected; disasters usually come unexpectedly, surprising and destroying those who are unprepared.


**Photo 1. Distribution of food to those in need in Chad**

Source: Colonel Wojciech Grzybowski's own collection

## 1.2. Humanitarian logistics – definitions

Considerations in the strict sense regarding the definition of humanitarian logistics should begin with presenting this category on the basis of world literature, in this case English and German. In these publications, "humanitarian logistics" can be defined as: "(...) planning, implementation and control of the cost-effective flow and storage of goods and materials, as well as the management of all information related to it, from the point of their origin to the point of consumption, to alleviate human suffering" [18].

[18] Online at :http://www.laa.asn.au/__data/page/757/RAAFReport_Feb08.pdf , Michael Whiting, Humanitarian logistics in disaster relief, February 2008, (dostęp 30 listopada 2023)

A similar definition of humanitarian logistics is presented by A.Thomas, L.Kopczak, namely - it is "the process of planning, introducing and then controlling the cost-effective flow, storage and delivery of various types of goods, as well as the necessary information from the point of their origin to the point consumption, in order to alleviate the suffering of defenseless people"[19]. In a slightly earlier study, A. Thomas defines humanitarian logistics as "the process of planning, implementing and controlling the efficient, rational and cost-effective flow and storage of goods and materials and related information from the starting point to the destination, the aim of which is to meet the expectations of the final beneficiary"[20]. The quoted Author and L. Fritz write that "humanitarian logistics is one of the most important segments in the entire aid chain because, firstly, it determines the effective and quick response to humanitarian program initiatives, and secondly, the preparation of shipment and transport are usually the most expensive activities in providing assistance, and thirdly, it is a treasure trove of information critical for conducting such actions in the future" [21]. Before presenting the definition - marketing logistics - G. Kovacs and K. M. Spens point to pairs of keywords that constitute the basis for their interpretation. These words are: humanitarianism and logistics, humanitarian aid and supply chain, disaster and logistics, disaster and supply chain, recovery and supply chain[22]. The integration of these concepts allowed the Authors to clearly indicate two main streams of humanitarian logistics activities. The first one

[19] A. Thomas, L.R. Kopczak, *From logistics to supply chain management: The path forward in the humanitarian sector*. Fritz Institute, 2005. Online at: http://www.fritzinstitute.org/PDFs/WhitePaper/From Logisticsto.pdf (dostęp 12 grudzień 2023).

[20] A. Thomas, *Humanitarian logistics: Enabling disaster response*. 2003 Online at:http://www.fritzinstitute.org/PDFs/WhitePaper/EnablingDisasterResponse.pdf (dostęp 6 grudnia 2023).

[21] A. Thomas, L.Fritz, *Disaster relief, Inc..,* Harvard Business Review, Vol.84, No 11, 2006, s.115

[22] G. Kovács, K. M. Spens, *Humanitarian logistics in disaster relief operations,* International Journal of Physical Distribution & Logistics Management, Vol.37, No.2, 2007, s.99-114, G. Kovács, K. M. Spens, *Identifying challenges in humanitarian logistics,* International Journal of Physical Distribution & Logistics Management, Vol.39, No.6, 2009, s.506-528, G. Kovács, K. Spens, *Chapter 13: Humanitarian logistics revisite*, w: J.S. Arlbjørn, , A. Halldórsson, M. Jahre, K. Spens, K. (red.), Northern Lights in Logistics & Supply Chain Management, CBS Press, Copenhagen, 2008, s.217-32.

is related to continuous, systematic assistance in relation to at-risk regions, and the second one concerns providing assistance resulting from unexpected, extraordinary disasters.

Ultimately, G. Kovacs and K.M. Spens claim that "humanitarian logistics aims to properly shape the conditions affecting aid supply chains and determine their main attributes such as flow speed, effectiveness, readiness, adequacy and flexibility of delivery."[23] However, L.N.v. Wassenhove describes humanitarian logistics as "the process of planning, implementing and controlling the efficient flow and storage of goods and materials, as well as information, related from the point of origin to the point of consumption, in order to help injured people." [24]

The same author, together with R. Tomasini, in the first compact work on humanitarian logistics, write that "it is a type of logistics that specializes in organizing supplies and storing supplies during natural disasters or complex emergencies in the areas affected by them, especially in relation to people living there." They also write, "let's imagine that logistics was included in the planning of an event like the Olympics. Now imagine planning the same event but not knowing where it will take place, how many spectators will be present, or how many athletes will be competing. The near impossibility of accomplishing this task gives us some insight into the tasks of humanitarian logistics. Logistics flaws and failure to recognize its humanitarian context can result in serious consequences for disaster victims, crossing the thin line between life and death." [25] Due to the fact that the cited work is the only concise publication so far on the subject of humanitarian logistics, published in February 2009 (apart from books with conference materials), I would like to briefly characterize its individual chapters. The book is divided into seven chapters; in the first, the authors deal with the basics of logistics and supply chain management, reviewing logistics issues in humanitarian aid. They also describe the differences and similarities between humanitarian logistics and classical

[23] G. Kovács, K. M. Spens, *Humanitarian logistics in disaster relief operations,* International Journal of Physical Distribution & Logistics Management, Vol.37, No.2, 2007, s.99-114,

[24] L.N. van Wassenhove, *Humanitarian aid Logistics: supply chain management in high gear.* Journal of the Operational Research Society. Vol 57, No 5, 2006, s. 475-489

[25] R.M. Tomasini, L.N. van Wassenhove, H. Ford, *Humanitarian Logistics* INSEAD, Plagrave Mcmillan, 2009, s.4-9

logistics. The second chapter concerns the essence of humanitarianism and its three main principles: humanity, impartiality and neutrality. At the same time, they provide an interesting illustration of the complexity of problems posed by work in humanitarian logistics. Using the example of Bosnia and the decision to suspend all UNHCR activities, despite the massive opposition of the then United Nations Commissioner for Refugees, the authors emphasize that each action must be analyzed and identified separately in order to learn about its nuances and problems.

The third and fourth chapters focused on the problem of preparing and coordinating actions in the fight against natural disasters. They emphasize that logistical preparation is essential and that training should be organized to learn the tools and systems that will provide the organization with the necessary preparedness that will help quickly enter a disaster zone. It is very important that coordination between all interested parties is as efficient as possible, as this ensures the rapid deployment of assistance. The next two chapters concern the process of analyzing and processing information in order to better manage the project so that teams can always be prepared and coordinated. The book draws attention to the similarity of the problems faced by humanitarian organizations as commercial ones, i.e. the reluctance to share information. The final chapter examines corporate involvement in the fight against natural disasters through humanitarian logistics. This chapter discusses, among others: excellent partnerships between specific logistics companies and humanitarian organizations. The value of such cooperation and its extremely positive effect were emphasized.

The term "humanitarian logistics", referred to in German-language publications as "humanitäre Logistik", usually appears in typical multi-page studies devoted to humanitarian aid or logistics. The term "Katastrophenlogistik", i.e. "disaster logistics", also occasionally appears interchangeably in German texts. There is even the expression "Katastrophenmanagement", taken from the issue of business management, which can be translated as disaster management. In the above approaches, "the goal of humanitarian logistics is to provide assistance to people as such, regardless of religious, political, racial, economic or national aspects, regardless of the gender or age of those in

need; it wants to remain financially and politically independent from the regions to which aid is delivered".[26] These studies emphasize that "[...] the scope and nature of humanitarian logistics activities are specific due to the need for ad hoc, quick and professional action in order to meet the basic needs of people in the so-called crisis areas caused by: war, disasters, natural disasters, violence, poverty, diseases, ethnic cleansing, expulsions" and "[...] covers all classic logistic activities focusing on the supply of water, food, medical assistance, providing housing, creating infrastructure etc."[27].

In 2009, a book edited by T. Pokusa and M. Duczmal was published entitled "Humanitarian logistics and crisis management", which presented the first definition of humanitarian logistics in Polish. According to T. Pokusa, it should be considered "in conceptual-functional and objective-structural terms. In the first aspect, humanitarian logistics appears as a concept of managing the flow of goods and services and related information from the moment of their acquisition until the delivery of the finished product and service to those waiting (but not only to those affected) and/or moving people to these goods and services they need, in the sense of planning, organizing, implementing and controlling processes, based on an integrated approach to these activities, in accordance with the basic humanitarian principles, i.e. humanity, neutrality, impartiality and independence. However, from an objective and structural perspective, humanitarian logistics can be treated as an integrated process of the flow of goods, services and information to the injured and/or movements of people in need of help, as well as a specific set of procedures and structural solutions related to the integration and implementation of these activities in the aspect of the above-mentioned humanitarian principles."[28]

[26]K.Höfer,*Katastrophenstudiengänge,*http://studienwahl.suite101.de/article.cfm/katastropstudien] (dostęp 27 sierpnia 2022)

[27] *Schnelle Hilfe in Notlagen – dank ICT* [http://www.swissinfo.ch/ger/archive.html].(dostęp 30 sierpnia 2022)

[28] T. Pokusa, *Logistyka humanitarna. Nowa "twarz" logistyki w sytuacjach kryzysowych,* w: T. Pokusa, M. Duczmal (red.) Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy, PAN O/Katowice, Opole, 2009, s.14

## 1.3. The place of humanitarian logistics in the field of social sciences

Using the typology of logistics fields [29], it seems that, taking into account the unusual area of implementation, **humanitarian logistics** can be placed in the sphere of influence of social logistics and military logistics. (Fig.1). This specificity makes it necessary to ask questions about the essence and definition of humanitarian logistics, its characteristic features, conditions of effectiveness and comparison with the classic business approach to the logistics chain.[30] The answer to these questions results in the need to conduct further research in this area, especially through the prism of supply chain management, social capital and corporate social responsibility.[31] This will also be the subject of further considerations in this work.

One more, very important issue is related to an attempt to answer the obvious question why the issues of humanitarianism, charity, charitable aid, etc. find their place in the broadly understood economic

[29] P. Kołodziejczyk, J. Szołtysek, *Epistemologia logistyki społecznej,* Przegląd Organizacji 4/2009, J. Szołtysek, S. Twaróg, *Gospodarowanie zasobami krwi jako nowy obszar stosowania logistyki,* Gospodarka Materiałowa i Logistyka, 7/2009 s.12-17

[30] In this study, logistics is based on the definition from 1991. British Institute of Logistics, is understood as a supply chain management process, J. Witkowski, *Zarządzanie łańcuchem dostaw,* PWE, Warszawa 2003, s. 17-18. As the author writes, "[...] striving to increase value for customers requires extending the cooperation of chain participants beyond logistics processes and activities." Citing the definition of a supply chain, he emphasizes "[...] that the supply chain understood in this way is a broader concept than the logistic chain", M. Christopher, *Logistyka i zarządzanie łańcuchem dostaw*, PCDL, Warszawa 2000, s.14 -16 emphasizes that "[...] the transition from traditional logistics to the chain approach was evolutionary in nature".

[31] J. Szołtysek, *Logistyka akcji humanitarnych,* Gospodarka Materiałowa i Logistyka, 3/2009 s.4. Social capital is knowledge embedded in social relations and is associated with the trust of organizational members in each other, norms, values and achieving the effect of synergy. Corporate social responsibility is a concept in which a company voluntarily takes into account social interests and environmental protection, check Z. Malara, *Działalność dobroczynna przedsiębiorstwa jako składowa globalnego potencjału antykryzysowego* w: T. Pokusa, M. Duczmal (red.) Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy, PAN O/Katowice, Opole, 2009r s.38-49

issues. The answer, I think, is provided by contemporary literature on the subject [32], as the paradigm is increasingly raised that "the charitable activities of an enterprise may be a source of benefits for it, both material and non-material, and are not inconsistent with similar goals of the state in which it operates"

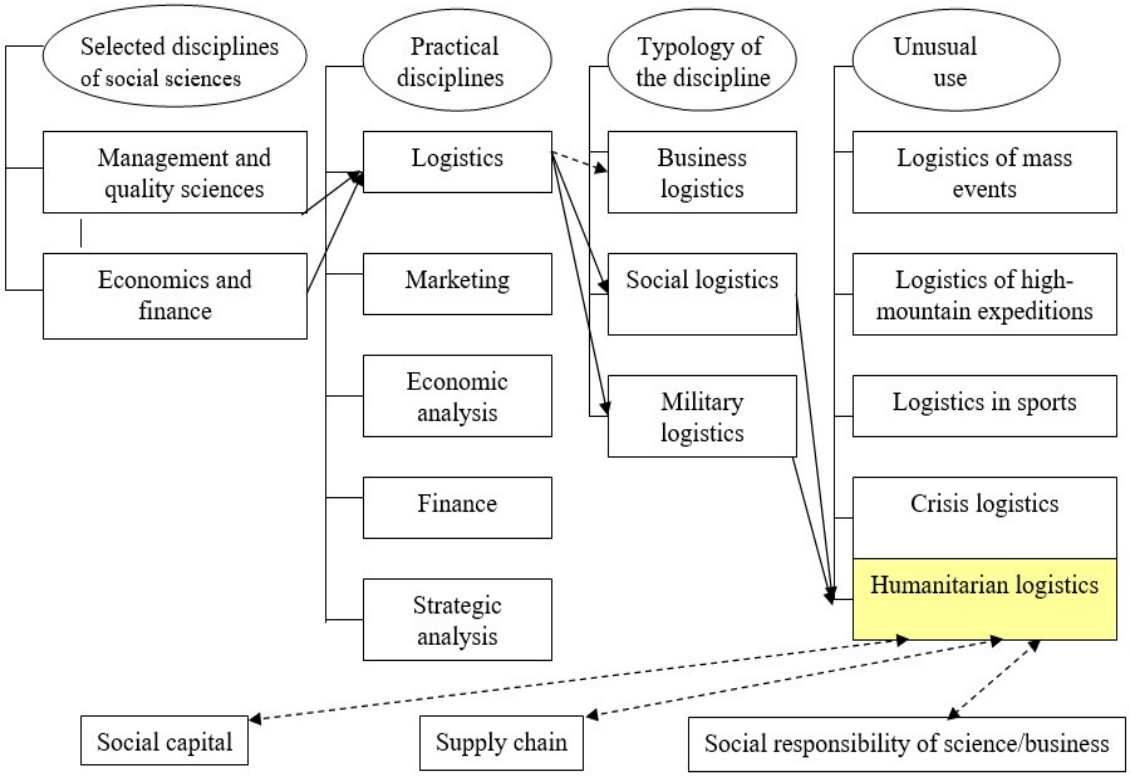



**Fig. 1. The place of humanitarian logistics in the field of social sciences**
Source: Own study

[32]Z. Malara, *Działalność dobroczynna przedsiębiorstwa, jako składowa globalnego potencjału antykryzysowego,*w: T. Pokusa, M. Duczmal (red.) *Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy*, PAN O/Katowice, Opole, 2009, s.38-48, G. Kołodko, *Wędrujący świat,* Prószyński I S-ka, Warszawa 2008, s.139-206, E. Bendyk, *Kooperacja zamiast korporacji*, w: Niezbędnik inteligenta, Polityka, nr 25, 24.06.2006, R. Kapuściński, *Ten inny*, Wydawnictwo Znak, Kraków 2006, J. Mazur, *Ekonomia humanitarna – utopia czy imperatyw?* w: Nowa ekonomia a społeczeństwo, KUL Lublin, 2006, T. Woods, *Moralność i prawa ekonomii na drodze do pojednania*, w: T. Woods, W obronie zdrowego rozsądku, Arwil, Warszawa 2007

It is added that "morality and economic laws have entered the path of reconciliation." Being aware of the controversial nature of these statements, the indicated dilemmas were, among others: noticed by some governments, institutions and non-governmental organizations as well as dynamically operating and forward-thinking transnational enterprises[33]. This is particularly important in relation to the existing, difficult issue of refugees coming to Europe from both Ukraine and other parts of the world.

Logistics draws on the achievements of social sciences, especially the discipline of management and quality science, distinguishing itself to a large extent as a field of practical knowledge, while adapting the achievements of other scientific disciplines, such as marketing, strategic analysis or finance. Most researchers assume that the paradigm of logistics is its flow orientation, i.e. the existence of material (including personal) and information flows, which are shaped in the management process in a way that allows access to products (and places) within the framework of established rules and priorities[34]. Practical disciplines generally do not have separate methodological foundations or their own theories, but - despite their name - they sometimes make a certain contribution to methodology and, to an even greater extent, to theoretical achievements [35]. It should be agreed that each of the practical disciplines has its own conceptual language, categories and definitions and specializes in the study of specific problems that it considers to be its area of interest. Hence, the classic efficiency formula of business logistics, related to achieving a specific level of service while minimizing process costs, can be translated

[33] Z. Malara, Działalność dobroczynna przedsiębiorstwa, jako składowa globalnego potencjału antykryzysowego,w: T. Pokusa, M. Duczmal (red.) Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy, PAN O/Katowice, Opole, 2009, s.38-48. It turns out, for example, that in Third World countries, residents of poor districts pay up to 100 times more expensive than average for drinking water. In the poorest societies, food costs 20-30 percent more than elsewhere in the world. When it comes to financial services, local financiers charge interest of 10-15 percent per day, which amounts to 2,000 percent per year.

[34] Szołtysek, J. Paradygmat logistyki a paradygmaty w logistyce. W: S. Kauf (red.), Logistyka i inne koncepcje zarządzania w naukach ekonomicznych, 2012, (55–64). Wydawnictwo Uniwersytetu Opolskiego.

[35] Ciesielski, M. Nowe problemy z logistyką. Gospodarka Materiałowa i Logistyka, 2009,(10), 2–4.Ciesielski, M. Definicje i zakresy pojęć logistyki oraz sieci dostaw. Gospodarka Materiałowa i Logistyka,2011, (5), 2–4.

into the effectiveness and efficiency of supply chains for life in unique, humanitarian applications, not necessarily typical of business logistics.

In his earlier studies [36] the author - as already indicated - proposes that humanitarian logistics should be considered mainly from a conceptual-functional and objective-structural perspective. Thus, in this first aspect, humanitarian logistics appears as a concept of managing the flow of goods and related information - from the moment of their acquisition until the moment of delivering the finished product to those waiting (but not only to the injured) and/or moving people to the goods they need. , in the sense of the processes of planning, organizing, implementing and controlling, based on the integrated recognition of these activities. However, from an objective and structural perspective, humanitarian logistics can be treated as an integrated process of the flow of goods, services and information to the injured and/or displacement of people in need of help, as well as a specific set of procedures and structural solutions related to the integration and implementation of these activities in the aspect of basic humanitarian principles, i.e. humanitarianism, neutrality, impartiality and independence.

In relation to the above-mentioned essence of social logistics, one can notice "not only the multitude of views and perspectives on this new area of interest of logistics, [...] but also an attempt to create the so-called pure forms of logistics, in fact in such a "pure" form they do not occur in practice, but are certain theoretical patterns"[37] In this context, three "pure" forms of logistics can be distinguished, i.e. business, social and military logistics. Moreover, J. Szołtysek proposes to add a fourth dimension to this triad - the ecology or geographical dimension of the implementation of logistics

[36] Pokusa, T., & Duczmal, M. (red.) Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy. 2009, Instytut Śląski Pokusa, T., & Duczmal, W. (red.) Zarządzanie kryzysowe i działania logistyczne – na przykładzie wybranych instytucji. 2009, Instytut Śląski. Pokusa, T., & Grzybowski W. Logistyka humanitarna. Istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno-wojskowej. Cz. 1. Logistyka,2010, (2), 29–31.Pokusa, T. Logistyka humanitarna – istota, warunki skuteczności i porównanie z ujęciem klasycznym. W: S. Kauf (red.), Logistyka i inne koncepcje zarządzania w naukach ekonomicznych (149–167). Wydawnictwo Uniwersytetu Opolskiego.2012

[37] Szołtysek, J. Logistyka akcji humanitarnych. Gospodarka Materiałowa i Logistyka,2009 (3), 2–8.Szołtysek, J. (red.) Nowe zastosowania logistyki. Przykłady i studia przypadków. 2010, Instytut Logistyki i Magazynowania. Szołtysek, J. Typologia obszarów stosowania logistyki – propozycja rozwiązania. Gospodarka Materiałowa i Logistyka, 2010, (8), 2–6.

processes. The fact that "The formal subject of social logistics research is the degree of satisfaction of identified social needs, implemented through logistic management of material flows (and accompanying information) with a specific social role in order to obtain access to places and goods ensuring its proper functioning and respect for civil rights and human rights, determines the essence and specificity of social logistics and its distinctiveness from other types of logistics[38]. The philosophy of social logistics, and therefore also of humanitarian logistics, is related to the question of why the issues of humanitarianism, charity, charitable aid, etc. find their place in broadly understood economic issues. The answer, as mentioned before, is provided by contemporary literature on the subject. More and more often, as I also emphasized, apart from classic considerations within the social economy, the paradigm is raised that "the charitable activities of an enterprise may be a source of benefits for it, both material and immaterial, and do not contradict similar goals of the state in which it operates" . It is added that "morality and economic laws have entered the path of reconciliation", as logistics managers are increasingly faced with peace of conscience and a sense of justice. [39]

In its essence, humanitarian logistics, apart from particularly noticeable practical activities, e.g. in the conditions of war in Ukraine or the Gaza Strip or the earthquake on the border of Turkey and Syria, is consistent with the goals and tasks of social responsibility of science, including its promotion. Hence the different authors [40] also consider the knowledge of people providing aid and the ways of their communication to be important premises determining the nature and place of humanitarian logistics in the social sphere. The dissemination of science is constantly being

[38] Szołtysek, J., Twaróg, S., & Jeż, R. Logistyka społeczna – kontrowersje wokół jej istoty. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 2018, (505), 56–65.

[39] Malara, Z. (2009). Działalność dobroczynna przedsiębiorstwa jako składowa globalnego potencjału antykryzysowego. W: T. Pokusa, M. Duczmal (red.), Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy. 2009, Instytut Śląski., Woods, T. Moralność i prawa ekonomii na drodze do pojednania. W: T. Woods (red.), 2007, W obronie zdrowego rozsądku. Arwil.

[40] Pokusa, T. Logistyka humanitarna – istota, warunki skuteczności i porównanie z ujęciem klasycznym. W: S. Kauf (Red.), Logistyka i inne koncepcje zarządzania w naukach ekonomicznych 2012, s. 149–167. Wydawnictwo Uniwersytetu Opolskiego, Szołtysek, J., Twaróg, S., Jeż, R. . Logistyka społeczna – kontrowersje wokół jej istoty. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 2018,(505), 56–65.

commercialized, also entering the orbit of social policy.

Above all, first of all, in relation to humanitarian logistics, the civic argument becomes fundamental in the aspect of promoting the social responsibility of science. The development of democracy requires that a sufficient number of citizens, especially young people, understand the problems of science and are able to address them in an appropriate and practical way. Civic participation is an issue that raises many emotions, sometimes fears, but more often hope and positive examples, such as extensive humanitarian aid for people from Ukraine. Its real implementation requires both an open and friendly attitude of the authorities, as well as an active and engaged civic community. Recent years have been a period in which the issue of social participation is gaining importance, and local governments at various levels are trying to build an appropriate model of civic management to meet their needs. In order to talk about management using participatory methods (and not only about elements of civic participation), activity in this field must be a permanent, cyclical process, the central element of which is the dialogue between representatives of local governments and the social side, i.e. citizens and non-governmental organizations and active representative bodies that are representing them. Being scientifically literate helps people make better decisions. The public should participate in the decision-making process on important social issues based on science and technology, and carry out tasks in a specific manner. The example of humanitarian logistics in its social dimension is obvious in this case.

Second, the practical argument matters. Science affects everyone's life. It shapes the reality of everyday life. In order not to get lost in the world created by science, citizens should know its basics - it is a ticket to the modern world. Scientific knowledge determines the effects of behavior and therefore its dissemination changes people's behavior. Understanding science is also important for individuals in their private lives. Personal decisions should be supported by certain underlying knowledge. In relation to humanitarian logistics, we notice the classic feedback between science and practice in its social dimension.

Third, the ethical argument matters. Knowledge of scientific methods shapes a more ethical view of the world. Now, more than ever, due to the

war in Ukraine and other crises, we need global humanitarian response, investment in health, education, ecology, and more resilient systems and services that all can benefit from. By promoting science in the area of humanitarian logistics, young people will learn more about humanitarian crises and understand their impact on people's lives. At the same time, they learn the principles of providing humanitarian aid and are aware of their own impact on the situation of injured people, which we have been constantly observing recently. Therefore logistics and an integrated supply chain are best verified as supply chains for life, best integrated and synergistic[41].

Currently, despite the enormous development of science, its achievements pose threats. Perhaps it sounds paradoxical, because we associate development, including the development of science, with something positive and most people only notice its good sides, and the negatives are usually ignored, which doesn't mean that they are insignificant - nothing could be further from the truth. After all, in the times of artificial intelligence, ubiquitous computer science, the Internet of Things, and extensive research on the Universe, we are unable, on the one hand, to predict various threats, and on the other hand, to control the constant destruction of the natural environment. The paradox lies in the fact that it is due to the progress of science that the nature surrounding us begins to change, and we - so well educated, "moving forward with progress" - are unable to control it. Unfortunately, it is not only nature itself that is the source of crisis situations. The formula that "people brought this fate to others" is still valid, among others through armed conflicts or terrorist attacks.

[41] Pokusa, T. Logistyka humanitarna jako społeczne wyzwanie współczesnych czasów. *Gospodarka Materiałowa i Logistyka*, (5), 2022, 14–23. https://doi.org/10.33226/1231-2037.2022.5.2

## 1.4. The social dimension of humanitarian logistics

"Humanitarian logistics" is a concept that, as mentioned, has been present in Polish scientific terminology regarding the sphere of social management only since 2009. Perhaps until now there has not been the right climate and special need to present the "new face" of logistics so clearly[42]. From a humanitarian perspective, logistics should be understood not only as a ready-made scheme of action, but rather as the need to consider unusual issues of flow, and therefore of delivering aid through "supply chains for life", because, as a rule, humanitarian aid chains differ from the previously recognized supply chains in business. The author wrote more about these problems in the article 'Humanitarian logistics - essence, conditions of effectiveness and comparison with the classical approach'[43].

This phenomenon can also be looked at in a slightly different way, going beyond the traditional understanding of the "supply chain". After all, you can also do the opposite, i.e. move people to the goods and services they need, and an example of such a "reverse" is provided by the fate of refugees from Ukraine, the countries of the Middle East, Asia and Africa, but also the victims of Hurricane Katrina in New Orleans or the tsunami in Indian Ocean. Humanitarian logistics, of course, covers all classic logistics processes in the implementation of aid projects in crisis and conflict areas. Moreover, it seems that images of the war in Ukraine, the Gaza Strip and the noticeable post-pandemic crisis also prompt reflection and perhaps make decision-makers aware of the immensity of other people's tragedy and misery.

Back in 2010, in the work 'New applications of logistics. Examples and case studies' prof. J. Szołtysek wrote in relation to the specific nature of the logistics of humanitarian actions that: "theoretical and reporting studies,

[42] Pokusa, T., & Duczmal, M. (red.) Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy. Instytut Śląski., 2009 Opole s.3-7

[43] Pokusa, T. Logistyka humanitarna – istota, warunki skuteczności i porównanie z ujęciem klasycznym. W: S. Kauf (red.), Logistyka i inne koncepcje zarządzania w naukach ekonomicznych 2012,(149–167). Wydawnictwo Uniwersytetu Opolskiego

mainly by foreign authors, but also a few domestic ones, require methodological ordering and scientific reflection", adding that: "the aim of such procedures is to develop the theory of logistics and improve , organizing and popularizing methods and tools of logistic support for humanitarian aid"[44]. In several published works one can find a proposal of just such a methodological arrangement and, at the same time, a valuable scientific reflection on the discussed issue[45].

Logistics draws on the achievements of social sciences, and, as mentioned before, practical disciplines generally don't have separate methodological foundations or their own theories, but they sometimes make a certain contribution to methodology and to theoretical achievements[46].

[44] Szołtysek, J. (red.) Nowe zastosowania logistyki. Przykłady i studia przypadków. 2010, Instytut Logistyki i Magazynowania. Poznań

[45] Blaik, P. Efektywność logistyki. Aspekt systemowy i zarządczy. Polskie Wydawnictwo Ekonomiczne. 2016, Warszawa, Blaik, P. Logistyka. Koncepcja zintegrowanego zarządzania, wyd. IV zmienione. Polskie Wydawnictwo Ekonomiczne. 2017, Warszawa, Chaberek, M. Ład gospodarczy w gospodarowaniu. Wydawnictwo Uniwersytetu Gdańskiego.2020, Gdańsk, Ciesielski, M. Nowe problemy z logistyką. Gospodarka Materiałowa i Logistyka, 2009, (10), 2–4.Ciesielski, M. Definicje i zakresy pojęć logistyki oraz sieci dostaw. Gospodarka Materiałowa i Logistyka,2011, (5), 2–4., Szołtysek, J. Paradygmat logistyki a paradygmaty w logistyce. W: S. Kauf (red.), 2012, Logistyka i inne koncepcje zarządzania w naukach ekonomicznych (55–64). Wydawnictwo Uniwersytetu Opolskiego. Szołtysek, J. Identyfikacja wyzwań logistyki we współczesnym świecie. Gospodarka Materiałowa i Logistyka, 2022, (2), 2–10., Banaszyk, P., Kauf, S., & Szołtysek, J. Logistyka jako czynnik dobrostanu. Polskie Wydawnictwo Ekonomiczne.2021, Warszawa, Taleb, N. Czarny łabędź. Jak nieprzewidywalne zdarzenia rządzą naszym życiem. Zysk i S-ka 2020, Warszawa, Matwiejczuk, R. . Kompetencje logistyki w tworzeniu przewagi konkurencyjnej przedsiębiorstwa. Wydawnictwo Uniwersytetu Opolskiego. 2014, Opole, Matwiejczuk, R. Logistyka w zarządzaniu strategicznym. Polskie Wydawnictwo Ekonomiczne. 2021, Warszawa. ,Pokusa, T. Logistyka humanitarna jako społeczne wyzwanie współczesnych czasów. Gospodarka Materiałowa i Logistyka, (5), 2022, 14–23. https://doi.org/10.33226/1231-2037.2022.5.2

[46] ., Szołtysek, J. Paradygmat logistyki a paradygmaty w logistyce. W: S. Kauf (red.), 2012, Logistyka i inne koncepcje zarządzania w naukach ekonomicznych (55–64). Wydawnictwo Uniwersytetu Opolskiego, Ciesielski, M. Nowe problemy z logistyką. Gospodarka Materiałowa i Logistyka, 2009, (10), 2–4.

When we organized, previously mentioned, conference on humanitarian logistics[47], it was difficult to expect that the theses contained in these works, as well as the practical solutions presented, would enjoy such great interest and would find such important application. Currently this is particularly due to the recent crisis situations related to refugees on the Polish-Belarusian border or the sheer number of these refugees. The dramatic situation of the population affected by the war in Ukraine and the scale of destruction in this country[48].

So far, there has been no need to clearly present the new approach to logistics - the humanitarian approach. The social need to create humanitarian logistics also concerns the fact that its human dimension results - regardless of political, economic, religious, national and racial reasons - also from gender and age. It should also be financially and politically autonomous in relation to the areas to which assistance is provided. Humanitarian aid is a moral obligation and the most important expression of social solidarity between world citizens and those affected. In a world where natural disasters are becoming more frequent and more severe, and armed conflicts continue to cause suffering for many people, particularly affecting the poorest, all global actors must act together to effectively provide assistance to victims of humanitarian crises and to reduce vulnerability to threats in the future.

[47] Pokusa, T., & Duczmal, M. (red.) Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy. Instytut Śląski., 2009 Opole, Pokusa, T., & Duczmal, W. (red.) Zarządzanie kryzysowe i działania logistyczne – na przykładzie wybranych instytucji. Instytut Śląski, 2009, Opole, Pokusa, T., & Grzybowski W. Logistyka humanitarna. Istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno-wojskowej. 2010, Cz. 1. Logistyka, (2), 29–31.

[48] Pokusa, T. Logistyka humanitarna jako społeczne wyzwanie współczesnych czasów. *Gospodarka Materiałowa i Logistyka*, 2022, (5), 14–23. https://doi.org/10.33226/1231-2037.2022.5.2

**Photo 2. Humanitarian logistics in its social dimension**

Source : https://www.wnp.pl (access 20.01.2024).

Especially recently, from the social point of view, more and more attention is being paid to the principles of providing international aid, its quality and professional operation within the framework of humanitarian logistics. However, these activities today pose many specific problems. Humanitarian crises are becoming more frequent and their consequences are becoming more severe. This is related to armed conflict, climate change, increasing competition for access to energy and natural resources, extreme poverty, weak governance systems and failing states. The civilian population is particularly affected by this. (photo 2). It is also increasingly common for international humanitarian law to be ignored or openly violated. Violation of humanitarian space impedes access to vulnerable populations and adversely affects the safety of humanitarian workers, as evidenced recently by the death of Polish peace support workers during the war in Ukraine and Gaza Strip.

It is time to strengthen global humanitarian response to the current military situation by building a social consensus of the European Union, the US and other global structures on the common values and principles underlying aid efforts. It is also appropriate to consider practical ways of better complementing each other in order to improve the effectiveness of

humanitarian logistics outcomes. The global consensus on humanitarian aid should promote a more coherent, consistent and comprehensive approach to the issue of humanitarian aid, as researchers on this issue write: "this area requires standardization to enable the assessment of the efficiency and effectiveness of humanitarian logistics and the supply chain of, among others, aid organizations"[49].

To sum up, humanitarian logistics should be seen as a concept of managing the flow of goods and services and related information from the moment of their acquisition to the moment of delivering the finished product to those in need of help and/or managing the movement of people to the goods and services they need, in accordance with social humanitarian principles, i.e. humanitarianism, neutrality, impartiality and independence.

The problem posed in the title of the chapter still requires an interpretation of the term "crisis situation", because it is in these crisis circumstances that the social dimension of humanitarian logistics most often manifests itself. The work assumes that a crisis is defined as "a response to suddenly emerging, unforeseen phenomena that pose a threat to. When a crisis occurs, it is necessary to diagnose the crisis situation, understood as a set of external and internal circumstances that influence a given system in such a way that changes begin and continue in it, the result of which may be a qualitatively new system or a new structure and function in the existing system" (http://pl.wikipedia.org/wiki/sytuacja _kryzysowa). Most often, these are special cases of danger that may cause loss of people and material goods, where there is usually a factor of surprise and time pressure. Examples include violent actions of nature, e.g. floods, volcanic eruptions, earthquakes, artificially caused e.g. fires, explosions, epidemic diseases, malnutrition, hunger, terrorism or armed conflicts and warfare.

[49] Shafiq, M., Soratana, K. (2019). Humanitarian logistics and supply chain management: a qualitative study. *LogForum 15*(1), 2019,19–38. https://doi.org/10.17270/J.LOG.2019.325

We usually deal with a situation where a large - and sometimes very large - number of injured people and the extreme conditions in which help is provided to them, make it necessary to use the logistic potential on a mass scale. Humanitarian logistics in its social dimension should therefore focus on the proper management of resources - not only those necessary for everyday life in given conditions, but also technical, information, financial, personal, etc. This involves ensuring specific conditions that must be met, for the humanitarian action to have the desired effect.

## 1.5. The social significance of the hybridization of humanitarian logistics

In the aspect of recent events related especially to the war in Ukraine or the situation in the Gaza Strip or on the Polish-Belarusian border, in terms of the effectiveness of humanitarian logistics activities, its hybridization becomes important. This thesis is based, among others, on the practical experiences of people cooperating with our academy who directly participate or have participated in aid activities. In the adopted approach, a hybrid system is understood as a dynamic system that exhibits both continuous and discrete dynamic properties. Such behavior occurs in many situations, including those related to warfare. Hybridization also applies to logistics activities related to providing humanitarian aid, where there is constant dynamics in the production and processing of materials. We deal with discrete dynamics when reporting needs and providing aid materials. The stability and effectiveness of logistics activities are characterized by their resistance to changes taking place in the supply network, hence hybrid dynamics leads to the proper analysis of this stability and effectiveness. Therefore, in this case we can talk about the "hybridization of humanitarian logistics" as a mixed system, which involves mastering turbulent distribution systems and supply chains in order to reach one or more people in need. It is a partnership of entities created to achieve dynamic, solidary, uncompromising cooperation, as well as a philosophy of action guided by their employees, acting in the spirit of humanitarianism, neutrality and independence. This also applies to technology.

Before a more detailed analysis of the hybridization of humanitarian logistics, it is also necessary to characterize the concept of "hybrid logistics" itself, because it is an innovative approach to supply chain management that integrates elements of traditional physical logistics with the advantages of modern technologies and digital solutions. This is a response to the growing challenges related to the dynamic market, changing customer expectations and developing technologies. It refers to the use of both traditional supply chain management methods and modern technologies to create a flexible, effective and integrated logistics system. It creates various distribution channels, including stationary sales, e-commerce, and innovative solutions based on automation and artificial intelligence. Therefore, the following areas of hybrid logistics implementation can be distinguished in the broadly understood sphere concerning the very essence of logistics:

1. *Integrated supply chain*: Hybrid logistics integrates various elements of the supply chain, such as procurement, warehouse management, transportation and delivery, into one integrated system. This enables better understanding and coordination of processes, leading to greater efficiency and flexibility.

2. *Use of digital technologies*: Hybrid logistics uses modern technologies such as the Internet of Things (IoT), big data, artificial intelligence and automation to increase the efficiency and quality of logistics operations. This allows for better monitoring, inventory management, demand forecasting and adaptation to market volatility.

3. *Flexibility and personalization*: Hybrid logistics allows you to adapt to changing market requirements and individual customer needs. Thanks to various distribution channels and advanced technological solutions, enterprises can provide products and services in a more flexible, effective and personalized way.

Regarding the benefits of hybrid logistics, it is important to emphasize:

- Increased efficiency through the integration of various elements of the supply chain and the use of digital technologies allowing for the optimization of logistics activities and minimization of losses.

- Reduction of delivery time thanks to the use of various distribution channels and innovative technological solutions, hybrid logistics enables quick and effective delivery to customers.

- Improving customer service due to personalization of services. Better inventory management and quick response to customer needs contribute to increased customer satisfaction.

- Increasing competitiveness, because hybrid logistics allows enterprises and institutions to adapt to the changing market and compete effectively, offering innovative solutions and flexible services.

Therefore, hybrid logistics is an innovative approach to supply chain management that combines traditional logistics methods with modern technological solutions. Integration of distribution channels, use of digital technologies and flexibility of adaptation allow for greater efficiency, customer satisfaction and market competitiveness. Hybrid logistics also contributes to the perfect organization of logistics operations in the era of dynamic trade and customer expectations. In hybrid logistics, physical elements such as warehouses, transportation, delivery and inventory management still play an important role. However, various technologies and digital solutions are also being implemented here, such as warehouse management systems (WMS), identification and tracking systems (RFID), data analytics, artificial intelligence (AI) and the Internet of Things (IoT). In hybrid logistics, for example, warehouse management systems can monitor inventory levels and predict demand in real time, allowing for optimal warehouse management and avoiding excessive stockpiling. The introduction of digital technologies into logistics can also contribute to the automation of certain processes, such as packaging, sorting, labeling and scanning of goods. This, in turn, can speed up processes, reduce the risk of errors and improve accuracy. One of the main benefits of hybrid logistics is the increased ability to respond to changing market conditions and demand. Thanks to digital technology and real-time connectivity, companies can monitor and analyze data on an ongoing basis, allowing them to quickly respond to changes. Hybrid logistics is also more environmentally sustainable, as digital technologies can help minimize waste and reduce energy consumption.

At the same time, hybrid logistics contributes to sustainable development by reducing losses and energy consumption. By using digital technologies and automation, companies can manage warehouses, transportation, deliveries and inventory more effectively. Real-time data access and analysis enable quick response to changing market conditions and demand. Hybrid logistics is therefore an innovative and effective supply chain management strategy that combines the best features of traditional logistics with digital technology and automation.

However, in its essence, the hybridization of humanitarian logistics involves the precise definition of tasks occurring over time, full information for the involved entities about the status of the aid being implemented and the management of this information in real time, as well as the synchronization of networks, systems and technological tools. This is what largely determines the effectiveness of humanitarian logistics. Difficult to predict events or phenomena resulting from crisis situations with the classic approach to forecasting are the proverbial "divination by tea leaves". In a classic, business-like, stable approach, effective inventory management in production and distribution allows you to reduce costs and increase profits. Each of the existing methods in this area has advantages and disadvantages. They are the basis for creating hybrid models [50]. Previous solutions were based on historical data patterns and omitted information obtained in real time. However, hybrid procedures in humanitarian logistics are particularly effective in conditions of war crisis, observed in real time. This is not about "reinventing the wheel", but only about changing thinking and proper implementation of available tools.

In the hybrid approach to humanitarian logistics, the most important thing is the so-called feeling the current demand, especially on the part of the population in need of help. It manifests itself primarily in: planning aid deliveries and possible immediate evacuation of the population based on constantly incoming data, computerization and a significant acceleration of the process of submitting or withdrawing orders for aid materials, constant balancing and adjustment of the necessary

[50] Jurczak, M. *Prognozowanie hybrydowe, czyli metoda na trudne czasy*, 2020, https://trans.info/es/prognozowanie-hybrydowe-czyli-metoda-na-trudny-czas-176069

reserves resulting from humanitarian aid divided into specific locations in excess-shortage system. The list of benefits of hybrid demand identification results mainly from the way of transmitting basic information, analyzing it faster and immediately taking appropriate feedback. In traditional systems, the forecast most often covers a horizon of several months. In the system of hybridization of humanitarian logistics, forecasts of the demand for aid support are adjusted practically on an ongoing basis. The advantage of "demand sensing" is therefore that short-term trends that may result from unexpected, previously impossible to predict crisis events are immediately taken into account in the forecast. Therefore, "we will have to radically change our views on the design and operation of supply chains if we are to break away from the habits of traditional thinking and move to a higher operational level in the future", and "we must stop lying to ourselves and finally accept that the people (and their behavior) are the driving force of supply chains"[51].

So thinking about how to design and work with hybrid supply chains for life is a must. Sometimes the best proposals are combinations of mixed, hybrid supply chains. These chains are the best solutions in cases of humanitarian aid, but they must be used carefully. Such supply chains reflect the future organization of aid actors[52]. Humanitarian logistics plays a key role in delivering aid to people in need during humanitarian crises. However, traditional approaches to humanitarian logistics may not always be effective in a rapidly changing world. In response to these challenges, the hybridization of humanitarian logistics is a concept that aims to increase the effectiveness of humanitarian operations.

Hybridization of humanitarian logistics involves combining traditional logistics approaches with modern tools and technology. To better understand this concept, it is worth reviewing three main aspects of the hybridization of humanitarian logistics. The first aspect is the use of information and communication technologies (ICT). Today, people around the world have access to smartphones, tablets and computers, creating new

[51] Gattorna, J. *Era dynamicznych łańcuchów dostaw*, 2013, https://log24.pl/news/era-dynamicznych-lancuchow-dostaw

[52] Pokusa, T. *Logistyka humanitarna jako społeczne wyzwanie współczesnych czasów.* Gospodarka Materiałowa i Logistyka, 2022, (5), 14–23. https://doi.org/10.33226/1231-2037.2022.5.2

opportunities in the field of humanitarian logistics. The hybridization of humanitarian logistics uses these tools to collect, analyze and share information on humanitarian needs. This allows humanitarian organizations to more precisely assess the situation and adapt their logistical activities, leading to more effective and efficient operations. The second aspect of the hybridization of humanitarian logistics is integration with the private sector. Traditionally, the private sector has been viewed more as a financial aid than as a needed partner in the area of humanitarian logistics. However, more and more companies pay attention to social issues and social responsibility. Hybridizing humanitarian logistics involves creating partnerships between humanitarian organizations and private companies to better use resources such as car fleets, warehouses and IT systems. Thanks to this, humanitarian organizations can use the existing resource base and infrastructure, which leads to more effective logistics activities. The third aspect of the hybridization of humanitarian logistics is the development of innovative solutions. Thanks to technological progress, new solutions are emerging to help deliver humanitarian aid quickly and effectively. An example is the use of drones to deliver medicines or food to inaccessible areas. Hybridizing humanitarian logistics involves identifying and implementing such innovations in real-world operations, which increases the efficiency and speed of aid delivery.

The hybridization of humanitarian logistics brings many benefits. First, by using information technology, humanitarian organizations can more quickly and accurately identify areas where assistance is needed. Secondly, through integration with the private sector, resources and infrastructure are better used, leading to greater efficiency of logistics operations. Thirdly, the development of innovative solutions contributes to faster and more precise delivery of aid. As a result, the hybridization of humanitarian logistics leads to more effective and efficient delivery of humanitarian aid in times of disasters and conflicts. Hybridization of humanitarian logistics is the process of combining traditional methods with modern technologies and tools such as artificial intelligence, data analysis, Internet of Things and process automation. Thanks to hybridization, humanitarian organizations can quickly respond to sudden crises such as natural disasters, wars or mass migrations. Combined with

advanced planning, monitoring and data management, hybrid humanitarian logistics allows for a better understanding of the needs of crisis victims and better adaptation of aid delivery processes.

Hybridizing humanitarian logistics also minimizes costs and reduces the risk of errors, thereby improving the effectiveness and efficiency of humanitarian operations. Thanks to automation and the use of artificial intelligence for data analysis, it is possible to quickly predict and respond to the changing conditions and needs of crisis victims. Moreover, the hybridization of humanitarian logistics enables better coordination of activities between various humanitarian organizations, government, non-governmental organizations and local communities. As a result, the delivery of humanitarian aid becomes more integrated and effective, resulting in faster and more comprehensive assistance to those in need. It is also worth noting that the hybridization of humanitarian logistics increases the scalability of operations, which means that humanitarian organizations can respond more effectively to growing humanitarian needs on a global scale. This is important as the number and complexity of humanitarian crises around the world continue to grow. As a result, the hybridization of humanitarian logistics contributes to improving the effectiveness, efficiency and reach of humanitarian operations, which allows for better protection and support for millions of people affected by crises around the world.

## 1.6. Conditions for the effectiveness of humanitarian logistics and its comparison with the business approach

One of the main tasks of humanitarian logistics is primarily to analyze the purpose and strategy of aid-giving activities. The most common events that may trigger a crisis are natural disasters, technical failures, riots and terrorist attacks.

Threats, the scale of which depends on the intensity and duration of the above-mentioned events, dictate the direction of actions taken. On the one hand, the aim of logistic activities is to provide injured people with survival conditions (including, if necessary, the necessary medical assistance). Therefore, we are dealing with the organization of the supply

of products and services according to minimum standards of receivables. However, on the other hand, a large and sometimes very large number of injured people and extreme conditions in which logistic (and medical) assistance is provided to them, make it necessary to use the logistic potential (forces and means) on a massive scale. Humanitarian logistics should therefore focus on rational, efficient, effective and reliable management of available resources: technical, technological, information, financial, personnel, etc., in order to counteract threats as well as eliminate their effects. This is related to meeting certain conditions. Taking L. Gustavsson's article as a basis [53] we can list several most important factors that must be met for the humanitarian action to help the victims in need to be effective. The first is rational reconstruction, selection of challenges that await those carrying out the aid operation. These people must know exactly what area the humanitarian operation is to take place in, what the condition of the roads is, whether they are passable for vehicles transporting products for victims, and whether there is access to fuel. The crew participating in the rescue should be thoroughly trained to be able to cope in all conditions. The second, equally important factor is the speed of delivery. This involves communication between logistics units in other countries that order the transport of the most important products to natural disaster areas (these are: food, water containers, cleaning products, blankets, waterproof covers), and the speed of loading the products into the means of transport (usually plane), reaching the country after the disaster, unloading the goods and directly distributing these products to points where there are victims in need of support. The third factor is the evacuation of people from the conflict zone. This is an extremely difficult task and should normally be handled by organizations such as the UN, but this is not always possible. To fulfill this task, means of transport and access to fuel are needed, which is not always possible in disaster or war zones. Moreover, these vehicles should be adequately supplied with food, water,

[53] L. Gustavsson, *Humanitarian logistics: context and challenges*, Forced Migration Review, 2003, Vol. 18.

and sanitary facilities, and should provide a temporary shelter for victims. The aim of this task is to transport disaster victims to a safe zone (transition camps, refugee camps). Another factor is the systematic arrival of rescue teams with humanitarian aid; it is important to also provide these teams with shelter, access to basic goods, and the ability to move. The author of the article also considers the knowledge of people providing aid and investments in new technologies and communication channels to be equally important factors in humanitarian logistics. Therefore, he recommends constantly improving knowledge and skills in the field of humanitarian aid and expanding the scope of investments. L. Wassenhove believes that five key elements should be combined to develop *preparedness* to respond during a crisis [54]. He includes human resources, by which he means the selection, recruitment and training of professional staff. Another element is knowledge management, i.e. experience gained during previous crises and logistic operations, and transferring this experience to others. Logistics infrastructure; it is equally important to identify suppliers, storage locations and appropriate means of transport, thanks to which the aid will be delivered as quickly as possible. Another important element is collecting financial resources that will ensure that the supply chain operates efficiently. Many humanitarian organizations are struggling with a lack of financial resources for training and procedures needed to be better prepared for action.

Finally, cooperation with the local community, the army, the government and various humanitarian organizations is also an important element. Only the combination of these elements can enable the supply chain to operate efficiently in a crisis situation. However, in order to maintain a high level of readiness to provide humanitarian aid, we need, above all, educated people at national, European and international levels. The best way to meet such requirements would be to create an organized network of training and studies based on the experience of Member States and the scientific knowledge acquired at national and European levels in

[54] L.N. van Wassenhove, *Humanitarian aid Logistics: supply chain management in high gear*. Journal of the Operational Research Society. Vol 57, No 5, 2006.

scientific projects under the Natural Disasters and Wildlife Hazards Program.[55] In the context of the presented conditions, it can be stated that the fundamental activities in the supply chain are called "3B" from the first letters of the words: *boxes*, i.e. raw material, physical product delivered to the customer, as well as recycling, product return, services; *bytes*, i.e. information related to the order and its physical flow; *bucks* - financial resources, credit terms, repayment schedule, preparation of batches of goods for shipment. In relation to the humanitarian supply chain, two more elements are added, which together form the "5 B": *bodies* - human resources participating in the supply chain; *brains*, i.e. knowledge and skills. All of the above components are important from the point of view of risk management, and disruptions in one of them directly affect the others. It is very important and crucial to connect all five elements of the chain in such a way that it operates without disruptions and, as a result, effectively meets the real needs of people in areas affected by disasters or other extreme phenomena. Therefore, "5B" freedom and synergy requires three basic pillars supporting the humanitarian supply chain. Firstly, the processes and structure of products are important; modularity of products allows products to be tailored to the specific needs of the environment and gives the supply chain flexibility without the need to introduce specialized production of separate products. Modularity can also add value to logistics processes and products. Secondly, organizational structures which allows to determine who receives information, who makes decisions and how human capital is evaluated and rewarded. Finally, technologies: this mainly concerns information and communication technologies that efficiently adapt to dynamic changes and the extent of damage caused by, for example, natural disasters. The humanitarian supply chain must adapt to the environment in which it operates, and the flow of reliable information enables its efficient operation. Moreover, staff turnover and lack of qualified personnel adversely affect the activity of this chain.

[55]T. Pokusa, *Logistyka humanitarna. Nowa "twarz" logistyki w sytuacjach kryzysowych*, w: T. Pokusa, M. Duczmal (red.) Logistyka humanitarna i zarządzanie kryzysowe. Wybrane problemy, PAN O/Katowice, Opole, 2009.

Dynamic changes in supply and demand are also related to the functioning of activities in the disaster area. All the more so because humanitarian activities are closely related to emergency situations and unfortunately often depend on political connections, ranging from donations to distribution. Sometimes it happens that the total time from order to delivery is longer due to delays at the customs inspection point or in the warehouses where the shipment is held. Excessive controls and bureaucracy slow down procedures, which means delays in delivering goods to affected areas. When it comes to financial resources, it often happens that they are not available on time, which is a serious problem. Infrastructure that suffered during the disaster or simply ceased to exist also interferes with the proper functioning of the supply chain, which undoubtedly affects the quality of humanitarian aid. In this aspect, we talk about the Triple-A Supply Chain,[56] which, due to its properties, is extremely competitive. The first condition that contributes to the competitiveness of this supply chain is *agility*, i.e. quick response to changes in demand and supply occurring in the chain and, consequently, informing chain partners about them in order to trigger their response as quickly as possible to the needs of the injured people. It is also important to work with suppliers and customers to redefine business processes, components and products. Another condition is adaptability, which allows you to adjust the supply chain according to market changes and modify strategies, products and technologies. The third condition is the cooperation of all parties in the chain (alignment) and the definition of incentives motivating the partners of this chain to improve the functioning of each of its stages. This is about providing or enabling access to current data, forecasts and plans, as well as determining the scope of competences of chain partners in order to avoid conflict situations.

The above characterization of humanitarian logistics in the aspect of the specificity of the "supply chain for life" in which it operates allows for a

[56] H.W. Lee, *Triple-A Supply Chain,* Harvard Business Review, October 2004.

comparison between the classic (business) and the humanitarian chain,[57] called „supply chain for life"( Table 1) through the prism of the key criteria for assessing both of these chains.

Table 1

**Business and humanitarian supply chain**

| Criteria | Classic supply chain | Supply chain for life |
|---|---|---|
| **Strategic goal** | High quality customer service with appropriate use of resources, maximizing profits and minimizing costs. | Minimizing the number of victims and reducing suffering for those affected, social gain, response to humanitarian needs |
| **Basic features** | Usually, stability and regularity in shaping supplies, regular demand and freedom of action | Variability in supply and suppliers, usually on a large scale, irregular demand, and the need to act in critical situations |
| **Chain philosophy** | Supplies are "pulled" by buyers, motivating and influencing individual links in the supply chain | Supplies are "pushed" to the disaster site in direct response to demand |
| **Basic principle** | Economy | Effectiveness |

[57] The humanitarian supply chain is understood as a chain shaped and implemented during humanitarian projects where humanitarian logistics constitutes the essence of the chain management process; check. an. 25.

| **The nature of the demand** | Commercial | Non-commercial |
|---|---|---|
| **Structure/Infrastructure** | Wide selection from well-known suppliers/Stable infrastructure | Limited choice, sometimes even unknown suppliers / Unstable infrastructure |
| **Demand** | Predictable and usually stable. It occurs in fixed places and in fixed quantities | It is assessed by analyzing the characteristics of the disaster, its type, size, location and time. |
| **Fundamental actions** | 3B | 5B |
| **Action phases** | Planning, organizing, implementing and coordinating, controlling in terms of flow efficiency | Preparation, direct reaction, restructuring in terms of effectiveness |
| **Product range** | Differential | Homogeneous |
| **Product value** | It's increasing | Doesn't change |
| **Lead time** | It depends on the speed of material and information flow according to the scheme: Supplier – manufacturer – distribution center – wholesaler – retail – customer | The time between demands is zero. Demand response must occur immediately after a disaster. The supply chain must be a direct response and start developing immediately even without comprehensive |

| | | |
|---|---|---|
| | | knowledge of the situation on the ground |
| **Entity structure** | Partnership, coordination, integration of chain link activities, domination of market entities | Stakeholders do not show any clear connections between themselves, governmental and non-governmental actors dominate |
| **Source of funds** | Customers/Consumers | Donors |
| **Distribution network** | The location and number of distribution centers are strictly defined | Distribution significantly difficult due to the often unknown location of distribution centers, the undetermined size of the disaster or the political system and culture of a given country. |
| **Supplies management** | Based on shaped demand | Difficult to determine; experiences and probability |
| **Reverse logistics** | Considerable | Low |
| **Information system** | Very well developed using the latest technologies. | Information often imprecise and incomplete, communication process difficult. |

| | | |
|---|---|---|
| **Operations/Transactions caused by** | Mainly due to the price | Mainly due to humanitarian needs and social and moral obligations |
| **Type of demand** | Product | Aid resources and people saving lives |
| **Control** | Control recognized as a classic management function | No clear control over operations due to emergency situation |
| **Expected results** | Financial: shareholder value (dividends) through customer satisfaction | Fulfillment of the terms of social contracts, compliance with the expectations of the environment |

Source: Own study based on for example G. Kovács, K. M. Spens, *Humanitarian logistics in disaster relief operations,* International Journal of Physical Distribution & Logistics Management, Vol.37, No.2, 2007, s.99-114, A
Thomas, L.R. Kopczak, *From logistics to supply chain management: The path forward in the humanitarian sector*. Fritz Institute, 2005. [http://www.fritzinstitute. org/PDFs/WhitePaper/From Logisticsto.pdf] Coyne, J. *Humanitarian Logistics: Musing Aloud*, Monday Developments, Vol.24, No.20,2006, s. 12-13, M. Howden, *How Humanitarian Logistics Information Systems Can Improve Humanitarian Supply Chains: A View from the Field,* International ISCRAM Conference – Gothenburg, May 2009, s. 1- 10, W. Hyde, *Applied Humanitarian Logistics,* Humanitarian Logistics Conference,Georgia Institute of Technology, February 19, 2009, s.1-8, E. L. Maspero, H.W. Ittmann, *The Rise of Humanitarian Logistics,* Conference Logistics & Quantitative Methods ,7-11 Jully 2008, Pretoria, s.175-184, . J. Szołtysek, S. Twaróg, *Gospodarowanie zasobami krwi jako nowy obszar stosowania logistyki,* Gospodarka Materiałowa i Logistyka, 7/2009 s.12-17 J. Szołtysek, *Logistyka akcji humanitarnych*, Gospodarka Materiałowa i Logistyka 3/2009, s.2-8, , T. Pokusa, *Logistyka humanitarna – podstawy teoretyczne i wstępna ocena implementacji,* w: T. Pokusa, W. Potwora, J. Kaczmarek, (red.) Nauka w służbie wartości, WSZiA, Opole 2009, s.324-341.

In the classic chain approach, the strategic goal is high quality customer service with appropriate use of resources and maximization of profits, where operating in conditions of uncertainty and surprise is a sporadic situation. They are also characterized by economy, stability and regularity in supply, regular demand and a diversified product range. The implementation time depends on the speed of material and information flow. Supplies are "pulled" by buyers, motivating and influencing individual links in the supply chain. The location and number of distribution centers in this case are strictly defined and the expected financial results concern shareholder value and customer satisfaction.

However, from a humanitarian perspective, the strategic goal of the chain is to minimize the number of victims and reduce the suffering of those affected. The basic characteristics are efficiency, variability in suppliers, usually on a large scale, irregular homogeneous demand and the compulsion to act in critical situations. Demand response must occur here immediately after a disaster. The supply chain must also be a direct response and start developing immediately. Supplies are pushed through unstable infrastructure to the disaster site in direct response to demand. Distribution in this case is much more difficult due to the often unknown location of distribution centers or the unspecified size of the disaster, and the results are related to the expectations of the environment.

## 1.7. Humanitarian logistics and global processes

In this part of the work, due to the fact that it is based on the materials of the European Parliament Committee, characterized by a specific, official language, the conscious writing style will also take on a slightly different form[58].

According to global statistics, the frequency of natural disasters related to climate change is increasing. It seems that this phenomenon will increasingly affect the countries neighboring the EU, but also the EU countries. Unfortunately, wars do not bypass the world (e.g. Gaza Strip, Syria), including European countries (conflict in the Balkans or the current war in Ukraine). Moreover, today's disasters are often cross-border in nature and require coordinated and multilateral action. At the same time, the boundaries between internal and external disasters are becoming increasingly blurred. The tsunami in the Indian Ocean and the attacks in Mumbai and Bali affected European tourists as well as local people, floods and fires affected both Member States and neighboring countries, and epidemics may spread between continents, European citizens must be evacuated from the danger area, etc. Often the same instruments - in particular civil protection assets - are used by the Community and Member States to meet the same needs within the EU and beyond, both as a contribution to autonomous disaster response actions and as a complement to humanitarian aid. Any response by the European Union and the United Nations or UNICEF (a humanitarian organization working for children) in the event of a disaster should use the most appropriate elements available in relation to the needs. Additionally, aspects such as the speed and effectiveness of humanitarian logistics operations should be taken into account. (photo 3).

[58] Based on the Communication from the Commission of the European Communities of 13.6. 2007, Brussels 2007, p.1-16


**Photo 3. UNICEF unloads water and food supplies at the airport in Haiti's capital, Port-au-Prince.**

Source: http://www.unicef.pl/projekty/akcje/archiwum-akcji/apelujemy-o-pomoc-dla-dzieci-na-haiti (access 03.01.2024)..

The complexity and scope of these multidimensional challenges require a broad-based EU and UN approach to the entire set of issues related to disaster risk assessment, forecasts, prevention, preparedness and mitigation (pre- and post-disaster), coordination of the various policy areas, instruments and services available for the Community and the Member States working together. This will help balance national responsibility and European solidarity. Existing links between civil protection and environmental policy should be strengthened in order to make full use of preventive measures provided for in environmental legislation and to ensure an integrated EU-UN approach to disaster prevention and mitigation. Furthermore, cost-effectiveness issues and limited resources highlight the need for targeted, coordinated and integrated action. EU action to help people affected by disasters outside the

EU should be an integral part of international action, mainly those of the United Nations.

Humanitarian aid is a moral obligation and the most important expression of solidarity between world citizens and those affected. In a world where natural disasters are becoming more frequent and more severe, and armed conflicts continue to cause suffering for many people, particularly affecting the poorest, all global actors must work together to effectively provide assistance to victims of humanitarian crises and to reduce vulnerability to threats in the future. This assistance largely contributes to the protection and independence of disaster victims, in accordance with the basic humanitarian principles, i.e. humanitarianism, neutrality, impartiality and independence. This approach is essential for the UN and EU to validate and provide assistance to victims of crises, often in highly complex political and security contexts.

Behind the humanitarian actions is a centuries-old tradition of interpersonal solidarity to help victims of crises. Their goal is to save lives and provide immediate help to people who find themselves in a crisis situation as a result of the above-mentioned natural disasters, terrorist attacks, armed conflicts or devastating epidemics. Especially recently, more and more attention has been paid to the principles of providing international aid, its quality and professional operation within the framework of the **humanitarian logistics** work described in the previous part. However, these activities today pose many specific problems. Humanitarian crises are becoming more frequent and their consequences are becoming more severe. This is related to climate change, the changing nature of conflict, increasing competition for access to energy and natural resources, extreme poverty, weak governance systems and failing states. The civilian population is particularly affected by this. It is also increasingly common for international humanitarian law to be ignored or openly violated. Violations of the humanitarian space impede access to vulnerable populations and adversely affect the safety of humanitarian workers, while these factors are two essential conditions for conducting humanitarian operations and enable the UN, the EU and their partners to continue to provide assistance to people affected by the crisis.

Humanitarian aid and logistics in crisis are one of the main areas of the European Union's external policy. The EU is, next to the UN, the largest donor of humanitarian aid in the world, and Europeans - including Poles - are quite willing to support humanitarian actions. This gives the Union a special responsibility. It is time to strengthen global humanitarian action, in response to the current situation, by building a clear consensus from the EU and other global structures on the shared values and principles that underpin humanitarian action. It would also be appropriate to consider practical ways of better complementing humanitarian actions, including: Member States and the Community to improve the effectiveness of aid operations and humanitarian logistics. The Global Consensus on Humanitarian Aid should promote a more coherent, consistent and comprehensive approach to humanitarian aid. A clear commitment to use proven solutions in the field of providing aid and defining the roles of all participants in the activities are necessary to maintain the humanitarian space and, consequently, the ability to provide help to people in need. Humanitarian aid must also be implemented in a transparent manner based on actual demand. Currently, there are still no common principles or agreed approach to needs assessment. The European Community uses a specific global needs assessment method linked to its annual programming strategy and carries out an annual assessment of the so-called forgotten crises. The results are made available to all interested parties. Detailed needs assessments are carried out by a network of numerous experts and officials from the Directorate-General for Humanitarian Aid (ECHO) working in the field, in close cooperation with other Commission services and Member States.

A fundamental element of effective aid delivery within **humanitarian logistics** is partnership. European Union donors work through many implementing partners: European and local NGOs, the UN, the Red Cross - all of these actors have important and complementary tasks. Providing humanitarian aid in difficult conditions requires quality, professionalism, experience and cooperation. All donor partners should comply with international aid standards and guidelines, and their activities should be transparent and accountable to both beneficiaries and aid donors. The Union recognizes and fully supports the leading role of the

United Nations, and in particular the Office for the Coordination of Humanitarian Affairs (OCHA), in promoting international logistic responses to humanitarian crises and welcomes the pooling of efforts to reform the aid system in the framework of humanitarian logistics. Important elements of effective humanitarian aid are good cooperation between partners and donors, especially those operating in the field, and the participation of many entities in the so-called "cluster system" and its flexible use.

Both speed and quality are of paramount importance in providing humanitarian aid. As donors, we are responsible for ensuring that the aid provided is the best possible option and meets its objectives. Aid must be appropriately tailored to the specific crisis situation. Quality and performance indicators, cost-effectiveness criteria (e.g. overhead costs in relation to the value of aid delivered to beneficiaries) and partnership with the local community in delivering aid, especially in the case of long-term crises - the UN and the European Union must carefully consider all these elements, so that the humanitarian aid it provides is effective and serves those in need as best as possible. To ensure high quality, reliable implementation partners are essential, selected based on qualifications and monitored for performance. Community experience shows that it's necessary to combine the speed and effectiveness of humanitarian aid with a strict accountability policy through a system of partner accreditation and financial control. This is an integral part of accountability to European citizens and aid beneficiaries.

A review of humanitarian aid conducted in the 2000s identified significant shortcomings in the overall response capacity of aid actors. Some of them are being removed through reform of the humanitarian aid system. The EU must increase its crisis response capacity to help solve the remaining problems. Its mission is to support international activities that involve identifying and resolving global response capacity issues (e.g. logistics and pre-deployment issues) and ensuring access to these capabilities for all partners. This means, among other things, contributing to regional groups and providing additional capacity in the event of major crises, for example in transport or assessment teams. Long-term response capacity-building measures should also be strengthened, including early

warning systems at local, national and regional levels as long as common training and IT systems. Actions to support local capacity building, particularly in areas where crises are long-lasting or recurrent, should focus on quality and sustainability aspects, with the explicit aim of increasing the capacity of local communities to conduct independent humanitarian response.

## 1.8. Organization of logistic tasks for the injured population

The essence of humanitarian logistics, as the author often emphasizes in his work, is not related to maximizing profit and minimizing the costs of running a business, as is assumed in the business understanding of logistics, treated in this case as a tool for shaping processes in a market economy (check table 1). As mentioned before globalization and the market economy cannot develop effectively without the use of moral resources, such as caring for other people, cooperation and helping those in need (perhaps not entirely selflessly). Humanitarian logistics is designed to meet such ideas[59]. It requires constant readiness because a crisis is never expected; disasters usually come unexpectedly, surprising and destroying those who are unprepared. The causes of disasters (and therefore the forms of assistance to those affected) are diverse - they may be both natural disasters as well as unfavorable political and economic conditions.

We must remember: one of the main tasks of humanitarian logistics is primarily to analyze the purpose and strategy of aid-giving activities. No matter how many times a similar project has been implemented, you should never take everything for granted. Regardless of the scale of the project, its type and location, each of them is unique in its own way. Weather conditions, snow density, sea currents or volcanic eruption are just a few factors that are constantly changing, making each expedition, even in the same place and calendar period, unique. The way of organizing the expedition, the personnel, the selection of equipment and the end result

[59] Pokusa T., Grzybowski W., *Logistyka humanitarna – istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno – wojskowej*, Logistyka 2010, nr 2, str. 30

are unique. Among the many goals of expeditionary projects, projects organized as part of crisis management constitute a separate category. The most common events that may trigger a crisis are[60]:

- natural disasters (e.g. earthquake, flood, climatic, sanitary and epidemiological threats)
- technical failures (e.g. of power grids, heating installations, radioactive contamination)
- riots (e.g. politically motivated, racially motivated, strikes)
- terrorist attacks (e.g. conventional, bioterrorism).

A very similar classification is presented in table 2

Table 2

**Classification of disasters**

| | | |
|---|---|---|
| DISASTERS | NATURAL | earthquakes, floods, hurricanes, lightning, droughts, epidemics, avalanches, volcanic eruptions |
| | CIVILIZATIONAL | communication, fires, chemical failures, failures of technical infrastructure equipment, construction |
| | SOCIAL | disruption of public safety and order, e.g. street riots |
| | WARS AND ACTS OF TERROR | armed disasters, terrorism |

Source: Jaroszyński J.W., *Przepływy informacyjno – materiałowe w wirtualnych łańcuchach pomocy humanitarnej*, Logistyka 2010, nr 6, str.24

[60] Pokusa T., Grzybowski W., *Logistyka humanitarna – istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno – wojskowej*, Logistyka 2010, nr 2, str. 32

The organization and preparation of a logistics project involves initiating a humanitarian aid operation by the general organizer, (Fig. 2) developing an organizational and financial-material concept, developing a program to finance material, transport and logistic tasks, and collecting financial and material resources.

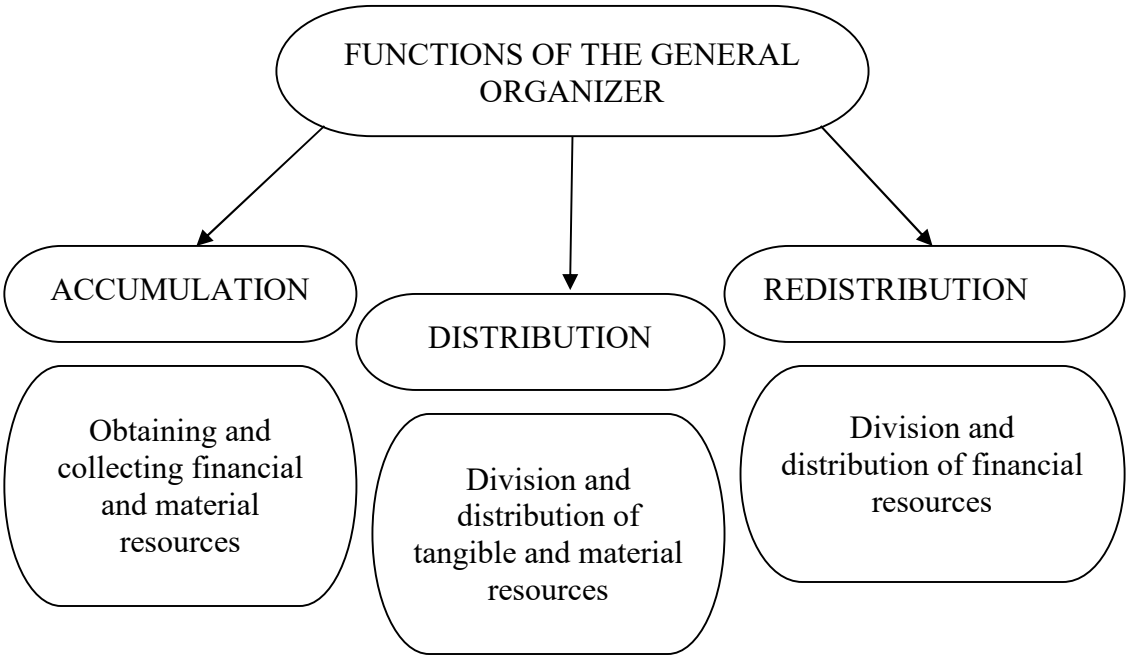



**Fig.2 Fuctions of the general organizer**

Source: Own study based on: Malarski S., Zadania podmiotów-uczestników przedsięwzięć logistycznych [w] *Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy,* red. T. Pokusa, M. Duczmal, Instytut Śląski, Opole 2009 str. 27

These funds come from:

• own funds of associations, foundations or charitable organizations;

• grants and subsidies from government funds (reserves of the Chancellery of the President of the Republic of Poland, the Chancellery of the Prime Minister and ministries);

• obtaining funds from the European Union and international organizations;
• obtaining financial and material resources from individual sponsors (consortiums, banks, large corporations, enterprises);
• obtaining funds and contributions from individual sponsors - private persons.

The implementation of specific financial and material tasks of the general organizer's organizational and coordination activities includes preparing detailed specifications of the necessary material and financial resources, organizing tenders for the purchase of material resources (including tents, containers, blankets, food, medicines and sanitary materials, cleaning products, clothing , equipping schools and kindergartens, organizing field hospitals, kitchens, preparing and serving meals, accommodation of medical staff, organizing brigades for demolition and searching the rubble of destroyed buildings, assistance in the renovation and reconstruction of residential, social and school rooms). The implementation of financial and material tasks includes the organization of logistic and transport services for the prepared humanitarian aid, i.e.

• agreeing orders with contractors for specific logistics tasks,
• concluding cooperation agreements and specific contracts,
• joining multilateral agreements with other partners participating in humanitarian action, i.e. state authorities, the army, international organizations,
• establishing cooperation with state and local authorities and humanitarian organizations of the regions affected by the disaster,
• appointing representatives to cooperate and coordinate the assistance provided with international, national and local organizations.

The implementation of humanitarian material and financial assistance involves appointing and delegating representatives to receive and control supplies arriving in disaster-affected areas, organizing a system for storing, distributing and transporting material resources and protecting them against looting. It also involves organizing the transfer and distribution of incoming supplies to institutions and organizations in accordance with arrangements with state and local authorities of countries and localities affected by the disaster.

The tasks related to the implementation of humanitarian aid also include preparing detailed warehouse and financial documentation of the incoming and distributed aid and obtaining confirmation of the issuance and receipt of the transferred material and financial resources. It is also important to prepare reports on the implementation of material and financial tasks by a representative - a resident of the organization participating in the humanitarian action. The Management Board - bodies of the organization participating in the action, is obliged to prepare a full report on the organization, course and implementation of material and financial tasks of a specific humanitarian action. Then, the financial statements are verified by independent auditors who issue opinions on their correctness and reliability. What remains is to prepare a final, full report by the authorities - bodies of the organization participating in the humanitarian action - on the implementation of the project and its material and financial results. The prepared report is submitted to the competent authorities and bodies, as well as to the headquarters of Polish humanitarian organizations, as well as to the media[61].

The stages of organizing the aid campaign are presented in Figure 3, along with a description of the assigned activities that characterize each of them. A chronological avalanche of events is shown, from the moment the humanitarian disaster occurred until emergency aid was provided to the injured. However, further stages are not included, such as returns of unused aid resources or actions aimed at reconstruction and prevention of a similar disaster in the future[62].

[61] Malarski S., Zadania podmiotów-uczestników przedsięwzięć logistycznych [w]*Logistyka humanitarna i zarządzanie kryzysowe – wybrane problemy,* red. T. Pokusa, M. Duczmal, Instytut Śląski, Opole 2009 str. 26

[62] Jaroszyński J.W., *Przepływy informacyjno – materiałowe w wirtualnych łańcuchach pomocy humanitarnej*, Logistyka 2010, nr 6, str. 26

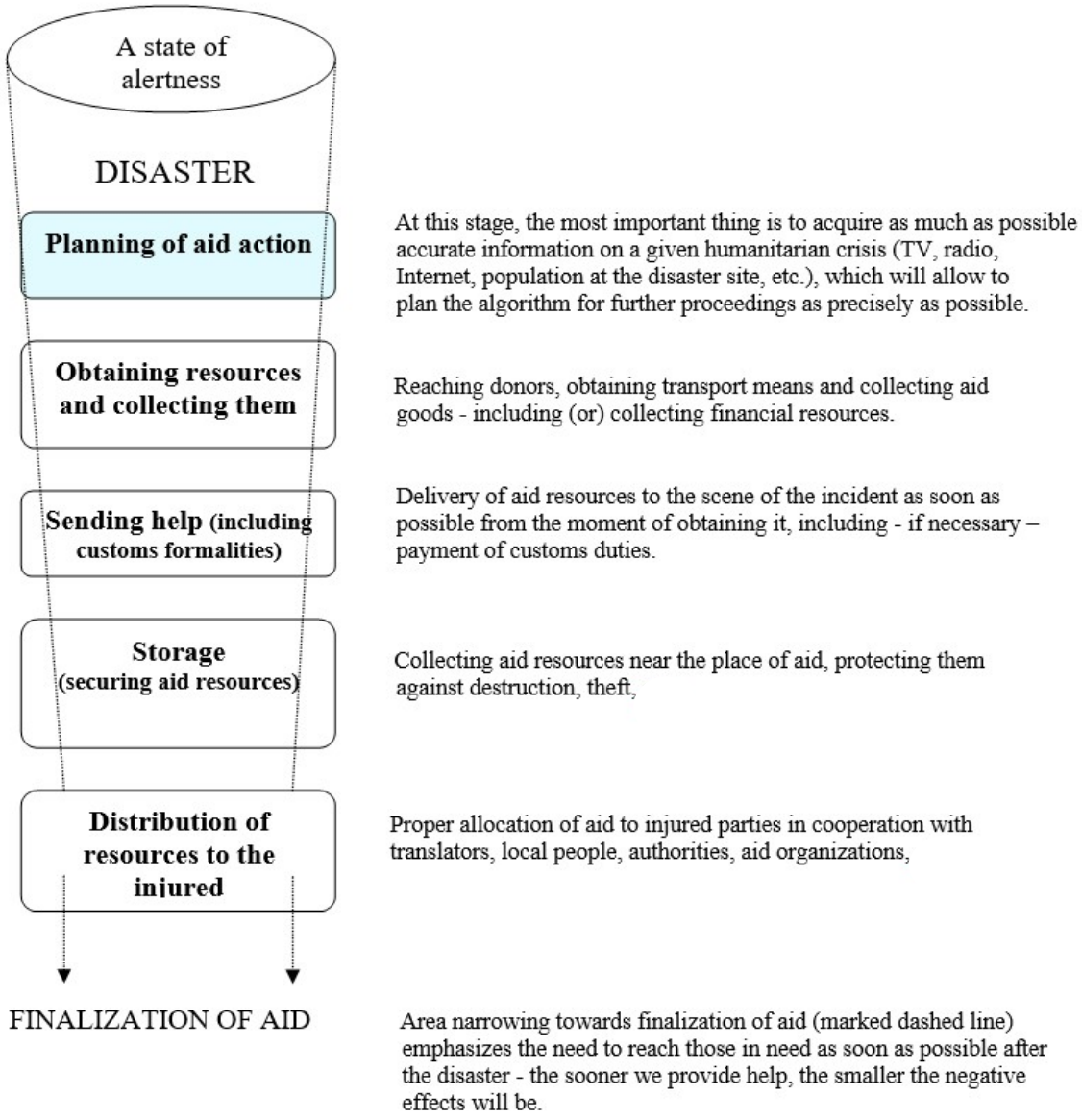



**Fig. 3 Stages of organizing aid action**

Source: Jaroszyński J.W., *Przepływy informacyjno – materiałowe w wirtualnych łańcuchach pomocy humanitarnej*, Logistyka 2010, nr 6, str. 14

Among the formal and uniformed services and the very large number of non-governmental organizations registered and operating in Poland and the human resources associated with them (Fig. 4), the associations that care for public safety (e.g. the Polish Scouting Association) have the greatest predisposition to carry out many logistical tasks for the benefit of the population affected in crisis situations. Tasks such as rescue, protection of people, goods and the environment (e.g. Volunteer Water Emergency Service, Mountain Volunteer Emergency Service, etc.).

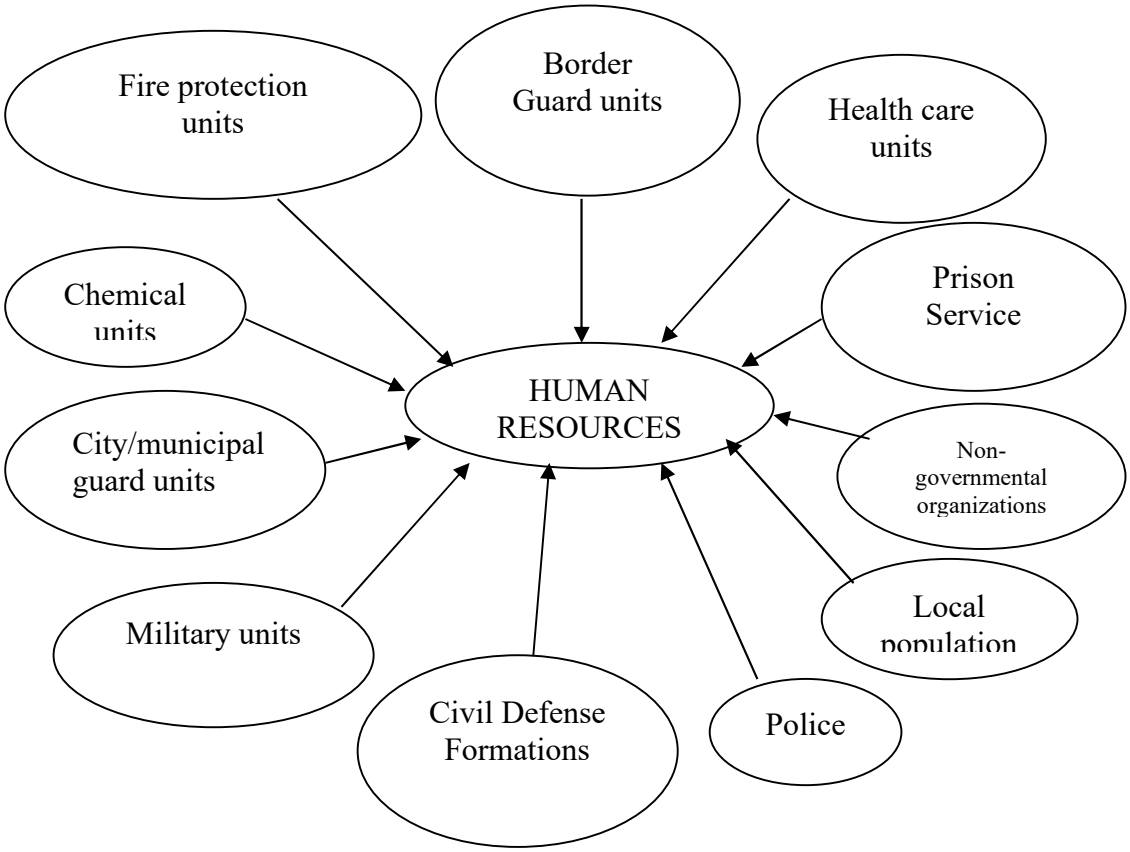



**Fig. 4 Examples of human resources used to organize and implement logistic tasks for the injured population**

Source: Own study based on Jaroszyński J.W., *Przepływy informacyjno – materiałowe w wirtualnych łańcuchach pomocy humanitarnej*, Logistyka 2010, nr 6, str. 24

The next steps are to ensure public safety and order. We are talking about teams carrying out tasks such as a safe home (safe housing estate, parking lot, school, etc.). Social security is ensured by associations, social movements, organizations of churches and religious associations that directly meet specific social needs, e.g. Caritas, the Brother Albert Aid Society, the Polish Red Cross, the Polish Humanitarian Action, the Polish Committee for Social Welfare.[63]

The local population can carry out logistical tasks for people affected in crisis situations on a volunteer basis or as part of personal and material benefits. These tasks usually involve: providing first aid to people who have suffered accidents, performing specific work while providing logistic and medical services, providing rooms to evacuees, taking safekeeping and guarding the property of injured or evacuated people, securing endangered animals, and in particular providing feed and shelter, securing endangered plants or seeds, providing own sources of drinking water to evacuees or injured people, etc.

As a model, H. W. Lee and M. Zbinden distinguish three phases of operations related to the organization and implementation of humanitarian logistics in aid activities, i.e. the phase of preparation, immediate response and reconstruction (Fig. 5), referring to activities before, during and after the occurrence of a disaster[64]. The first phase can also be called preventive, its entire essence is to promote preventive measures, education, and exercises. Their purpose is to avoid a disaster or reduce its negative effects. An important element is promoting the principles of first aid and teaching its basic principles.[65] You should also observe all possible threats that exist in the area. Of course, as far as possible, because there are situations that cannot be predicted. The aim of such a procedure is to prevent a situation of surprise as a result of a phenomenon that was predictable and we could have reacted earlier, but

[63] Nowak E., *Logistyka w sytuacjach kryzysowych*, Wydawnictwo Akademii Obrony Narodowej, Warszawa 2009, str. 82

[64] H.W. Lee, M. Zbinden, *Marrying logistics and technology for effective relief,* Forced Migration Review, Vol. 18, 2003, s..34-35

[65] T. Pokusa, M. Duczmal, *Logistyka humanitarna i zarządzanie kryzysowe-wybrane problemy*, Opole 2009, str.172

we found ourselves in a state of total unpreparedness. To illustrate such behavior, I will use the phenomenon of flooding. By hearing weather forecasts, you can prepare for this disaster, for example by strengthening flood embankments and saving at least some of your property. An important element in the preparation phase is planning rescue operations. In the event of a crisis, we have a ready action plan, which makes the action much more efficient.

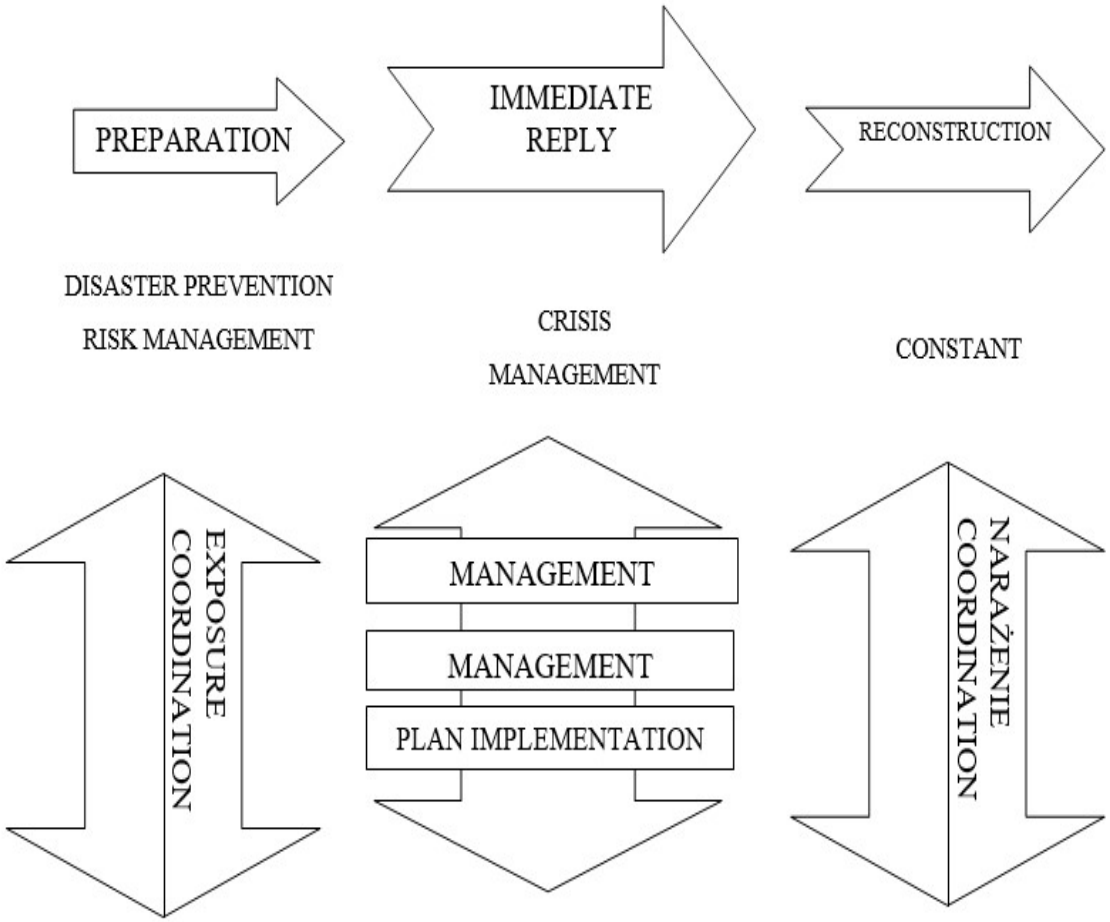



**Fig. 5 Phases of humanitarian logistics**

Source: own study based on Online at : http://www hanken.fi/humloginstitute (dostęp 12 listopad 2023 ), H.W. Lee, M. Zbinden, *Marrying logistics and technology for effective relief,* Forced Migration Review, Vol. 18, 2003, s..34-35

The second phase covers all activities that should be undertaken immediately after a crisis situation occurs. An important step is to recognize and define the area affected by the disaster. Thanks to this, we know where and what steps to take, and what specialized services and equipment to send. The most important thing in a crisis situation is to save human lives. Medical assistance should then be efficiently organized and medical triage should be performed. This activity involves determining the group of the most injured people who need immediate help. It is performed by the doctor of the first ambulance arriving at the scene of the incident or the coordinator of medical rescue operations. This is not an easy task, because many people are injured in disasters, and it is important to be able to recognize the severity of injuries and determine the victims' chances of survival. Victims should be divided into four groups, coded according to the degree of threat to life or injury.

The following codes are distinguished:

- red - a life-threatening condition, immediate medical assistance is required,
- yellow – victims with serious injuries requiring hospitalization,
- green –minor injuries, help may be provided later,
- black – victims who died during a disaster or received aid.

Safety zones should be distinguished. You need to designate a safe place that is not in the danger area where you can start providing first aid. A very important element is the organization of places in nearby hospitals and the transport of injured people to them. This cannot happen chaotically, because in such situations time plays a very important role. It is important to inform hospitals about the number of injured people who will be delivered and the types of injuries. Injured persons should be provided with cards specifying the injury code, description, information on medical assistance provided so far and basic personal data.[66]

After the rescue operation, there comes a time when it is necessary to remove the damage caused by the disaster, rebuild and return to

[66]T. Pokusa, M. Duczmal, *Logistyka humanitarna i zarządzanie kryzysowe-wybrane problemy*, Opole 2009, s. 176 - 177

normality. Reconstruction is a series of projects aimed at restoring a place affected by a crisis to its former state. These activities consist of a whole series of tasks. In the reconstruction phase, further assistance to the victims is necessary, in the form of treatment, rehabilitation, psychological assistance, and compensation payments. Damage to infrastructure and property of the injured is estimated. If rescue services units are damaged as a result of a disaster, they are restored to a condition in which they can continue to respond and provide assistance. Reconstruction of all destroyed transport, energy and telecommunications infrastructure. Restoration of ecological security, if required. Assessing the rescue operation, quick response to the crisis, and the scope of assistance provided. Developing new, improved, more efficient action plans. Counting losses and damage caused by a disaster. All activities described above should exist as one coherent process.[67]

## 1.9. Manifestations of aid activities in the aspect of humanitarian logistics

*Civil-military cooperation in humanitarian logistics*

Civil-military cooperation is not a new phenomenon within NATO. Traditionally, it is perceived as an area not much bigger than a logistical challenge. NATO operations conducted outside its own borders, in areas lacking fully functioning institutions and effective infrastructure, pose different and more complex logistical challenges. These challenges have further highlighted the need to coordinate actions with governments and local authorities, as well as international and non-governmental organizations. Cooperation between NATO forces and the civilian environment, both governmental and non-governmental, in which these forces operate is the basis for the success of these operations.

Civil-Military Cooperation (CIMIC), is defined as "[…] *coordination and cooperation, in support of missions, between the NATO Commander and*

[67] W. Lidwa, W. Krzeszowski, W. Więcek, *Zarządzanie w sytuacjach kryzysowych*, AON, Warszawa 2010 s.122

*civilian actors, including the population, local authorities and international, national and non-governmental organizations and agencies*." [68] When planning and conducting military operations, commanders increasingly have to take into account social, political, cultural, religious, economic, environmental and humanitarian factors. In addition, they must take into account the presence of a large number of international and non-governmental organizations with their own goals, methods and points of view, which must be reconciled with the corresponding goals, methods and points of assessment of NATO.

**Photo 4. CIMIC activities in Iraq**

Source: Colonel Wojciech Grzybowski's own collection

[68] T. Pokusa, Grzybowski W. *Logistyka humanitarna. Istota, warunki skuteczności i zastosowanie w sferze współpracy cywilno-wojskowej*. Cz. 1. Logistyka, (2), 29–31.2010

The challenge will become greater due to the presence of mass media and the existence of expectations from the international community and local communities. Therefore, effective contacts with a large number of civilian organizations, local communities, governments and armed forces will be important in resolving future conflicts. These contacts may include linked planning mechanisms at a strategic level. Civil-military relations in this area include many types of interrelated activities, the main of which are:

a. Military assistance in humanitarian logistics (photo 4). CIMIC in the most general sense is related to cooperation rather than support or assistance to civil authorities, although in practice such support will take place. For example, Military Assistance in Humanitarian Affairs in a disaster situation may take place on a national or international scale. In both cases, national or international forces are called upon to perform specific tasks within a specific time frame under the direct auspices of the civilian authority. The nature of this authority may be national or international. While in both cases CIMIC staff may perform liaison work, neither constitutes a direct action of CIMIC.
b. Civil Emergency Planning (CEP) (photo 5) mainly involves protecting and supporting local people in the event of a natural disaster or war. In the current security environment, the primary function of the CEP is to respond to civil support planning needs through strategic logistics and communications.

Civilian organizations conduct many activities related to humanitarian logistics, human rights, protection of minorities, refugees and displaced persons, legal assistance, medical care, reconstruction from destruction, activities related to the sphere of education, art and science, and general project financing. A full understanding of the mandate of these organizations, their role, structure and principles, is essential for CIMIC staff to establish effective relationships with them.

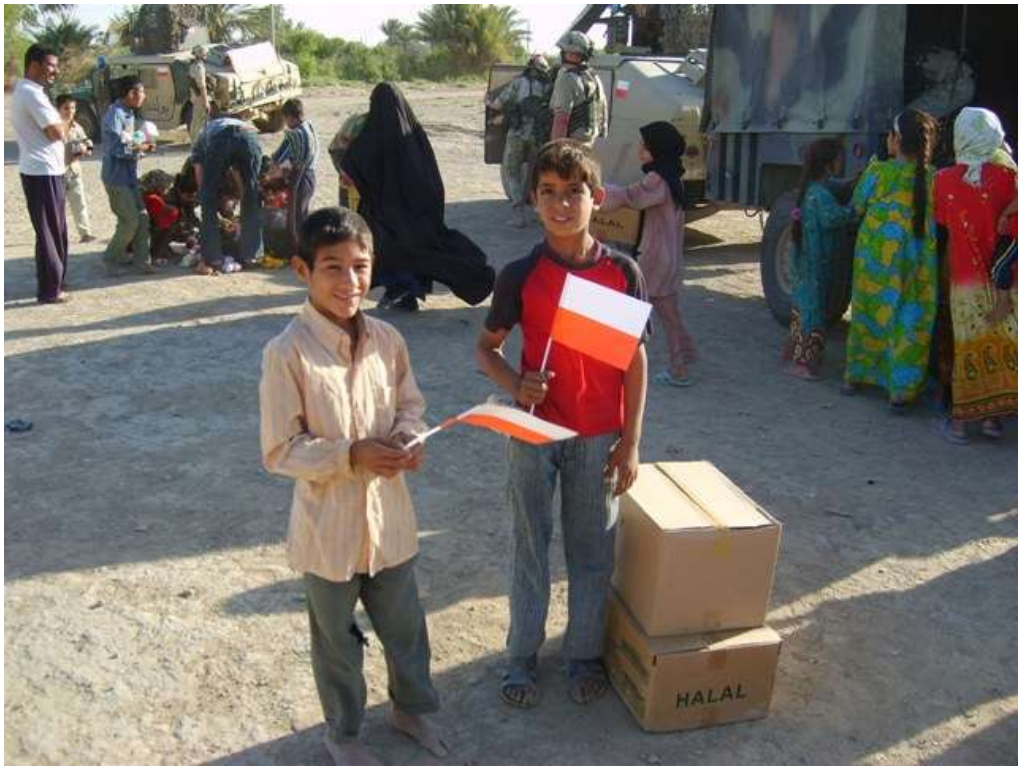



**Photo. 5. Distribution of gifts to the people of Afghanistan**

Source : www.do.wp.mil (access 18.02.2024).

*The Polish Military Contingent (PMC) in Chad and humanitarian logistics*

Moving on to identifying further manifestations of aid activities in the aspect of humanitarian logistics and presenting the principles and tasks of the functioning of a complex system of support and assistance for societies affected by wars or natural disasters, or assistance for people incapacitated in their existence due to the actions of the authorities (local and higher) of a given area for where ensuring conditions for a decent life of residents is a secondary and tertiary problem, this issue will be presented based on an operation carried out in the Democratic Republic of Chad, in which one of the author's collaborators of this work directly participated. Hence, the photographs presented here are mostly from Colonel Wojciech Grzybowski's own collection.

The participation of the Polish Military Contingent in the operation in Chad was primarily a challenge and a test for logistics, consisting in creating appropriate living and functioning conditions for the troops - including activities related to humanitarian logistics - in the complete lack of local infrastructure. The bases intended for troop deployment had no infrastructure apart from runways. Under joint financing, the European Union Operations Command only commissioned civilian contractors to dig wells for each base. The remaining work was a national responsibility. Distances were a significant problem affecting the preparation and course of the operation. For example, traveling 600-700 km (in the absence of railway lines and appropriate roads) took 2 to 3 days in the dry season, and 2-3 times longer in the rainy season. These factors were taken into account in the process of planning the transfer of Polish troops and implementing mandated tasks in the mission area. First of all, the Engineering Preparatory Group (EPG) was moved to the mission area in order to start building the base and create conditions for receiving the main forces.

**Photo 6. A well built for the civilian population**

Source: www.do.mil.pl (access 18.02.2024).

During the described mission, Polish soldiers carried out projects as part of humanitarian logistics, which are presented in selected photographs. The implementation of these projects contributed significantly to meeting the humanitarian needs of the civilian population.

**Photo 7. New benches and a playground for children**

**Photo 8. Humanitarian activities at a Chadian school during Children's Day**

Source: Colonel Wojciech Grzybowski's own collection

*Aid for Haiti and Pakistan*

After the earthquake that occurred on January 12, 2010 in Haiti, immediate action was taken to save lives and provide humanitarian aid. Just a few hours after the disaster, the first teams coordinating humanitarian logistics activities were sent to this country, including Poland. Immediately after the quake, ten million US dollars from the UN-managed *Central Emergency Response Fund* were allocated to support victims of the tragedy.[69] Children's centers were a project of the Polish Humanitarian Action in Haiti implemented in partnership with the People In Need organization, the essence of which was to help those who were orphaned or left homeless as a result of the disaster (so-called Child Friendly Spaces). The project was implemented in the city of Petit Goave. The aim of the project was to provide psychological support to the youngest victims of the disaster, protect their rights and create a substitute for education and a normal childhood. Children stayed in facilities built by PAH during the day, taking part in artistic activities, games and fun. The centers also conducted lessons to promote hygiene and health education. The classes were animated by local employees who gain invaluable skills in working with children. Nearly 600 children were provided with care, education and therapy in two centers.

**Photo 9. Humanitarian aid after the earthquake in Haiti**

Source: http:// //www.unic.un.org.pl/haiti/dzialania.php , (access 06.02.2024).

[69] http://www.unic.un.org.pl/haiti/dzialania.php , (access 07.02.2024)..

In the summer of 2010, Pakistan was hit by the worst flood in 80 years, affecting over 20 million people. From the first days of the flood, UNICEF carried out an extensive logistical humanitarian aid operation on site.

Help was provided from the first days of the disaster. Drinking water was provided to 4.5 million people. Medicines and nutritional supplements to malnourished children were distributed. Psychological help was also provided[70].

**Photo 10. A camp for refugees from flooded areas in Pakistan**
Source: http://www.unicef.pl/images/stories/gallery/40/photos/423.jpg (access 20.11.2023).

[70] Flood in Pakistan, http://www.unicef.pl/projekty/akcje/archiwum-akcji/powodz-w-pakistanie, dostęp 20.11.2023 r.

*Humanitarian aid for Ukraine*

The armed conflict in eastern Ukraine has been going on since 2014 and in the entire country since 2022. Residents are forced to leave their destroyed homes in search of safe shelter in other parts of the country and abroad - including, of course, Poland. Help is needed not only for those who escaped, but also for those who welcomed those escaping in their homes. People fleeing the war lack the most basic products (food, drink, warm clothes, medicines). One of the most sensitive groups are children, for whom war is a huge trauma. They need psychological support, as well as opportunities to learn and develop. Older people are also in a difficult situation, as they find it difficult to take care of themselves and their needs in such dramatic conditions.

**Photo 11. Refugees from Ukraine cross the Polish-Ukrainian border in Medyka**

Source: Darek Delmanowicz, https://polskieredio24.pl (access 18.02.2024).

Poles became involved in helping refugees from Ukraine from the very beginning of the war. The scale of this involvement and its material value is difficult to estimate due to its dispersed and mostly unregistered

nature. Nevertheless, the reaction of Poles' hearts is truly significant. According to research by the Polish Economic Institute, nearly 80 percent of the population was involved in various forms of support for our eastern neighbors, from financial and in-kind transfers, volunteer activities, to making their own houses and apartments available to people.[71] At the beginning of the war, it was 70 percent of adult Poles, and about 50 percent showed consistency in providing help in the following weeks. When it comes to the total value of this help, it is also even 2-3 times higher than the expenditure on charity in the entire 2021. PIE estimates that its most probable actual value is between PLN 9 billion and PLN 10 billion.

This estimate takes into account the value of funds transferred to refugees in the form of direct transfers or participation in public collections. And also the value of things and articles purchased for refugees, the value of accommodation and food offered to them and the value of other forms of support.[72] In Ukraine, for example, through activities related to humanitarian logistics, including the Polish Humanitarian Action, assistance in meeting the most basic needs has been provided since 2014. Its first actions were an immediate response to the crisis: they helped provide medical care, delivered food and hygiene parcels, blankets, sleeping bags and other products necessary for survival. The most important thing is support for the most vulnerable groups (including psychological support): the elderly, women and children, especially now in the conditions of war throughout Ukraine.[73] According to the Border Guard, from the beginning of the war until February 6, 2024, over 18.8 million people from Ukraine crossed the border with Poland (photo 11). Over 1.5 million war refugees remain in our country. These are mainly women, children and the elderly. Their homes were destroyed, their cities were ruined, and many of them lost loved ones in the war. Mothers want to protect their children at all costs, so they leave everything behind and cross the border. For example, on February 5, 2024, at border crossings from Ukraine to Poland, border officers checked 16.4 thousand people into our

[71] https://pie.net.pl, dostęp 27.12. 2023

[72] https://www.rp.pl, dostęp 28.12.2023

[73] https://www.pah.org.pl.Ukraina, dostęp 12.01. 2024

country. people and 17.6 thousand people returning to their country. Considering the challenges related to humanitarian aid and reconstruction in Ukraine - the scale and costs - the actions of individual countries and international organizations simply must be coordinated. When talking about this gigantic undertaking, reference is made to the reconstruction of Europe after World War II. Last year, the Ukrainian authorities, together with the European Investment Bank, estimated the related expenses at "well" over a trillion dollars. One thing is certain: the process of rebuilding the country after the end of hostilities will take a very long time and requires joint, large-scale actions of the international community.

It is argued in the opinions of Polish and international bodies that help from Poland and the world (especially the United States, Great Britain and the European Union) allows Ukraine to function in war conditions. It is indicated that support for humanitarian aid includes, among others: sending gifts, food, medicines and various equipment that allows Ukraine to maintain itself as a state operating in war conditions, i.e. with huge shortages in the supply of products and interruptions in the supply of basic services. It is added that aid also comes from international organizations and EU institutions.

Being aware of the noticeable Polish humanitarian aid for Ukraine, both from the state, non-governmental organizations and private individuals, and the need to include it in the logistic procedures presented in the theoretical part of the work, selected examples of these aid activities will be indicated here. For example, Prison Service officers across the country joined in humanitarian aid to Ukrainians fleeing the war. They organized collections in goods and money, donated blood, and also offered transport and shelter.


**Photo 12. Support for Ukraine from the Prison Service**

Source: https://sw.gov.pl aktualności, (access 10.02.2024).

With each passing moment, there are still many ideas and people joining in various forms of helping Ukraine. Prison Service officers also cooperate with voivodeship offices and local aid centers. They continue to collect and donate long-term food, including: canned food, oil, sugar, flour, groats, rice. As well as cosmetics, personal hygiene products, household chemicals, cups, plates, disposable cutlery, blankets, sleeping bags, pillows, batteries and phone chargers[74].

[74] https://sw.gov.pl aktualności, dostęp 10.02.2024


**Photo 13. Humanitarian aid for Ukraine from one of Mazovia's schools**

Source: https://zsp.wegrów.pl, (access 09.02.2024).

The student government of one of the schools in Mazovia joined the campaign to collect humanitarian aid for Ukraine. Thanks to the involvement of students and their parents, as well as educators, teachers and school employees, they managed to prepare over 30 packages for families in need, including: food, cleaning and personal hygiene products, dressing materials and other necessary items. Moreover, gifts from other schools and institutions were stored in the school premises. Then, students of uniformed classes and technical schools, under the supervision of the school principal, helped pack and load the collected goods. The transport of gifts prepared in this way was sent to aid organizations such as: the Polish Cultural Society of the Lviv Land, the Branch in Zhovkva, the Dominican Sisters and the Parish of St. Wawrzyniec in Żółkiew and the Mayor of Żółkiew. Where they were then distributed among the residents in need and refugees from eastern Ukraine staying in Zhovkva and Rawa Ruska.[75]

[75] https://zsp.wegrów.pl, dostęp 9.02.2024

Providing humanitarian aid is a moral obligation and the most important expression of solidarity between world citizens and those affected by disasters. In a world where natural disasters are becoming more frequent and more severe, and armed conflicts are causing suffering for thousands of people, particularly affecting the poorest, all global actors must act together to effectively provide assistance to victims of war and humanitarian crises, as well as to reduce vulnerability to threats in the future. This assistance, through the social dimension of humanitarian logistics, largely contributes to the protection and independence of victims of disasters in accordance with the basic humanitarian principles already mentioned in the article, i.e. humanitarianism, neutrality, impartiality and independence. This approach is essential for the United Nations and the European Union to provide effective assistance to victims of wars and crises, often in highly complex political and security contexts. The article characterizes the determinants of effective aid, emphasizing in particular the importance of hybridization of humanitarian logistics.

The current situation in Poland and in the world, caused by Russia's aggression against Ukraine, still requires in-depth knowledge of the issues of humanitarian logistics and, consequently, various tools effective in analyzing and solving problems in this area. Humanitarian logistics is undoubtedly a field that deserves a lot of attention, both from the scientific community in order to describe it comprehensively, and from national and international organizations and associations in order to implement its assumptions in a competent and efficient manner. Interest in this topic and investments in new technologies to improve humanitarian operations will certainly contribute to saving thousands of victims of wars and disasters.

High requirements in terms of maintaining readiness, independence and interoperability, and above all, response and actions, require more training, studies and educated staff at the national, European and global level. The best way to meet this requirement would be to create an organized network of training and studies based on the experience of Member States, scientific knowledge acquired at national and European level in research projects under the Framework Program on natural disasters and nature-based threats. The disaster response training and

study network would link existing centers of excellence in Member States and propose a wide range of activities, including training, conferences, exercises, student and expert exchanges. As part of the training and study network, programs for these activities would be developed and integrated quality standards in this area would be established. Taking into account the complementarity between the areas of civil protection and humanitarian aid, the network of training and studies should develop specialist knowledge in areas such as: humanitarian logistics, crisis management, communication in crisis situations, water and food, health care and public health, forecasts weather and environmental protection, volunteering, etc. using, among others, academic programs in the field of crisis management and humanitarian aid in Member States and the experience of other training networks such as the European Group on Training (EGT).

Preparing the appropriate staff, mentioned above, is also related to other important tasks for the effectiveness of crisis management and humanitarian logistics activities. An analysis of the current situation of logistical resources is also required, including the procurement of humanitarian aid items, their storage and transport to the point of use, as well as an analysis of global logistical capabilities in the event of a disaster response, which will be closely related to the relevant work in the field of international humanitarian aid.

# Part II

## SCIENTIFIC AND PRACTICAL SMART FUNCTIONAL OF CLUSTER-FORMERS MILITARY LOGISTICS IN RESOLVING THE ISSUE OF TRANSPORT SYSTEMS` SECURITY

## 2.1. FUNCTIONALITY OF MILITARY LOGISTICS COMPONENTS AND CHARACTERISTICS OF SMART SOLUTIONS IN SAFETY MANAGEMENT PROCESSES OF TRANSPORT SYSTEM COMPONENTS

Military logistics is the science of the army structure, supply and norms of movement duration and rest of troops. It was very widely used in the conduct of various military companies, and many military commanders then already understood that victory is possible only if the army is provided with quality, its combat readiness depends on this. During the Second World War, logistics received enormous development[76].

In the modern world, the American army dominates in this direction. The clearly calculated and reduced work of military-industrial complex, transport and supply warehouses made it possible to fully provide the American troops with everything they needed. It was in these troops that package and container deliveries were used for the first time. A modern example of implementation of comprehensive smart tool of military logistics functionality is the disarmament of Iraq by American troops back in 2003. The implementation of this smart functionality made it possible to ensure implementation of the ratio in structural scheme of modern army, namely, there are 3-4 logistics specialists for almost every serviceman. In Ukraine, this smart functionality is performed by volunteer movement. Which is a vivid example of transition period from old security schemes to innovative ones.

In modern interpretation, military logistics is understood as a clear, seamless system of providing the active army with ammunition, military equipment, food products, medicines, fuel and lubricants and managing

[76] Ступницький О. І. Формування логістики кризових ситуацій у контексті військового конфлікту Росія – Україна // Актуальні проблеми міжнародних відносин: Збірник наукових праць. Випуск 121 (частина І). – К. : Нац. ун-т імені Тараса Шевченка. Інститут міжнародних відносин, 2014. – С.233.

their movement in order to achieve success in military company. Military logistics supply systems are among the largest and have all typical problems: hierarchy, territorial expansion, large number of nomenclature items (over 600 000 units), high cost of spare parts, etc. Taking into account modern requirements for military logistic support systems, we will consider one of the key elements of military logistics concept – the principles of troop support.

To create more objective picture, we will describe not only the main (timeliness, completeness, reliability), but also an additional group of SMART functional components of military logistics in the modern world (sustainability, information security, economy, integrity, hierarchy, system approach, universality)[77,78,79]

*Timeliness functionality*, completeness and reliability provides for the provision of troops in accordance with their real needs in established time space by using guaranteed operational mechanisms. Application of these principles is a necessary (and in some cases mandatory) condition for the effective performance by troops of tasks assigned to them.

*Stability functionality*. Military logistics systems must be built in such a way that during the period of high risks (the period of time that usually characterizes the beginning of war) and in wartime, the armed forces are provided with all the necessary resources with minimal losses, which are necessary to reduce losses as a result of enemy strike.

*Information security functionality* provides for possibility of resisting unauthorized access to information resources of the Armed Forces of Ukraine. The application of this principle will ensure protection of

[77] Лямзін А.О., Разумова К.М., Клименко В.В. Smart функціонал складових військової логістики в сучасному світі // Глобалізація наукового і освітнього простору. Інновації транспорту. Проблеми, досвід, перспективи: XV міжн. наук.-практ. конф., 20 червня 2023. – Київ, 2023. С. 104-106.

[78] Лямзін А.О., Український Є.О., Ніколаєнко І.В. Характеристика особливостей функціоналу безпілотного рухомого складу у розрізі військової логістики // Глобалізація наукового і освітнього простору. Інновації транспорту. Проблеми, досвід, перспективи: XV міжн. наук.-практ. конф., 20 червня 2023. – Київ, 2023. С. 106-108.

[79] Burdiak O. M. Smart logistics in the military service: an overview of the world's military vehicles. Logistics: problems and solutions, № 4(77): 2018, P. 24-35.

information that characterizes the state of Armed Forces of Ukraine and has limited degree of dissemination.

*Principle of economy* in modern realities is characterized by the possible search for less expensive ways of solving logistical tasks. Cost reduction is usually achieved through the use of practical experience of commercial organizations in the field of formation and implementation of logistics services in conditions of low certainty of risks, which collectively form nature of military crisis.

*Integrity functionality* provides for the sub-process connection of elements of the material and technical support system of troops when the mandatory condition of internal structural independence is met. Application of this principle will allow optimization of interconnected resources of system of material and technical support of the Armed Forces of Ukraine and adaptation of its individual elements without violating architectural features of system structure as a whole.

*Hierarchy functionality* assumes that all major issues related to logistical support of troops must be resolved by organizing effective interaction of military administration bodies at all levels (center, military district, military unit).

*Functionality of the system approach* involves consideration of issues of providing troops as a component of economic system of Ukraine. Application of this principle will allow to objectively determine the scope and effectiveness of measures taken.

*Functionality of universality* involves the development and use of unified approaches to organization of material and technical support of troops. Application of this principle allows to ensure unity during activities to provide military consumers with products, works (services) as departmental divisions and organizations of unified economic complex of Ukraine.

The main problems in military logistics arise when combat operations are conducted, especially large-scale ones. Roads and communication routes between populated areas in the territory, where it is

necessary to deliver weapons, uniforms, provisions, are under fire from the opposing sides.

Thus, military logistics in terms of safe operation of transport systems should be distinguished by the greatest flexibility and multivariate SMART solutions that are being formed.

### 2.1.1. Formalization of SMART solutions implementation in safety management of transport system components in wartime conditions

To formalize the process of managing components safety of transport system in wartime conditions, we will describe it as function $Y = f(x)$ in the range $X_n - X_к$ (initial and critical state), nature of which depends on topology of military operations environment (MOE). *Y* is the output signal (axon) of safety assessment of transport system component (for example, traffic flow) in the studied MOE, $X_1$ ... $X_n$ is an input signal (synapse) / linguistic variable that enters the component of this system (for example, potential of architecture of transport routes in the conditions of military operations), reaction of which is evaluated by indicators of functionality of neurons in synapse.

In view of the presence of neuro-bionic features in transport system, it is advisable to display its safety model with two-layer perceptron (fig. 2.1)[80].

The first layer (som) of the model includes many linguistic assessments that determine components functionality of the transport system in the conditions of military operations. Its second layer (som) describes a set of linguistic assessments that determine transport system functionality when interacting with architectural component of transport routes in the conditions of military operations. The model takes into account

[80] Sumets A. M. Smart products for logistics. Logistics: problems and solutions, №3(76), P. 42-51.

importance of influencing factors (W) on the functionality of layer element in the perceptron.

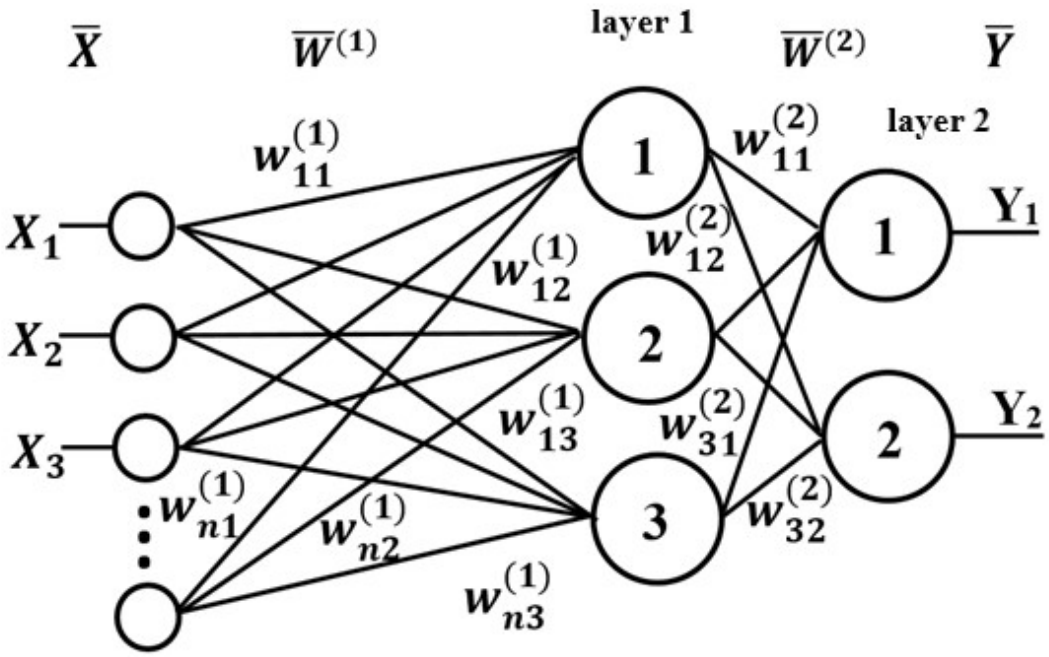



**Fig. 2.1. Graphical model of transport system safety in the form of two-layer perceptron**

All parts of transport and logistics chain in the conditions of military operations are provided with only local feedback, which causes their low "controllability" and "certainty" according to input criteria. The main feedback of the initial parameters is implemented only in rare cases, which generally does not ensure conditions of invariance of transport systems to control influences and to changes in the parameters of control objects.

The presented graphic model of transport systems safety in the form of two-layer perceptron can be used to describe dynamics of macrologistic processes that ensure the vital activity of this system.

The variables of this system are[81]:

$x$ – volumes of cargo and passenger transportation in the conditions of transport systems of military operations environment (TSMOE);

$y$ – total loss of time to ensure the implementation of life cycles of TSMOE components;

$z$ – so-called "safe" investments aimed at maintaining TSMOE safety.

To identify relationships between variables, consider the reasons that cause their changes.

The change in processes in TSMOE life cycles is due to the high dynamics of transportation volume and their reversal. We will consider this factor to be proportional to the value of $z$, which directly takes into account the throughput of linear elements that form the architecture of transport routes in conditions of military operations, taking into account the low stability of economic processes.

Another reason for fluctuation of variable $x$ is the reduction of traffic flows due to the desire of carriers to optimize them. Let us assume that this factor is taken into account by constant indicator $k_3$. Then the equation for $x$ will have the form:

$$\frac{dx}{dt} = \tilde{k}_1 z - \tilde{k}_2 y - \tilde{k}_3, \tag{2.1}$$

The change in time delays occurs due to increase in transport activity (turnover) and as a result of high dynamics of investment volumes, which are aimed at ensuring components safety of TSMOE. The corresponding evolutionary equation has the form:

$$\frac{dy}{dt} = k_4 x - k_5 z, \tag{2.2}$$

[81] *Лямзін А.О.* Науково-методологічні основи управління екологічною безпекою транспортних потоків у середовищі вулично-дорожньої мережі промислових зон.: дис. … докт. техн. наук: 05.22.01: захищена 21.04.21: затв. 29.06.21. – К., 2021. – 372 с.

The most complex expression has an equation for the investments amount, which are aimed at ensuring TSMOE safety in the studied environment.

In this case, investments are divided into:

– permanent, aimed at maintaining the current state of "safety balance";

– planned, aimed at "improving the security balance";

- emergencies aimed at eliminating crisis situations while ensuring " safety balance".

Let's enter limit values for variable *y*:

– lack of $Y_1$ balance, while $y > Y_1$ means the onset of crisis situation;

– corresponding balance of $Y_2$, $y > Y_2$ means the need for planning measures aimed at "improvement". At the same time, we will assume that $Y_1 > Y_2$.

Current investments to support the necessary level of TSMOE "safety balance" are most often proportional to the costs of ensuring the efficiency of transport systems components, which depend on *z*, then we have:

$$\frac{dz}{dt} = \tilde{k}_6(z - \tilde{k}_7 x)z + \tilde{k}_8 y(y - Y_1) + \tilde{k}_9 x(y - Y_2) \qquad (2.3)$$

Thus, the system of equations (1÷3) can be written in the form [5]:

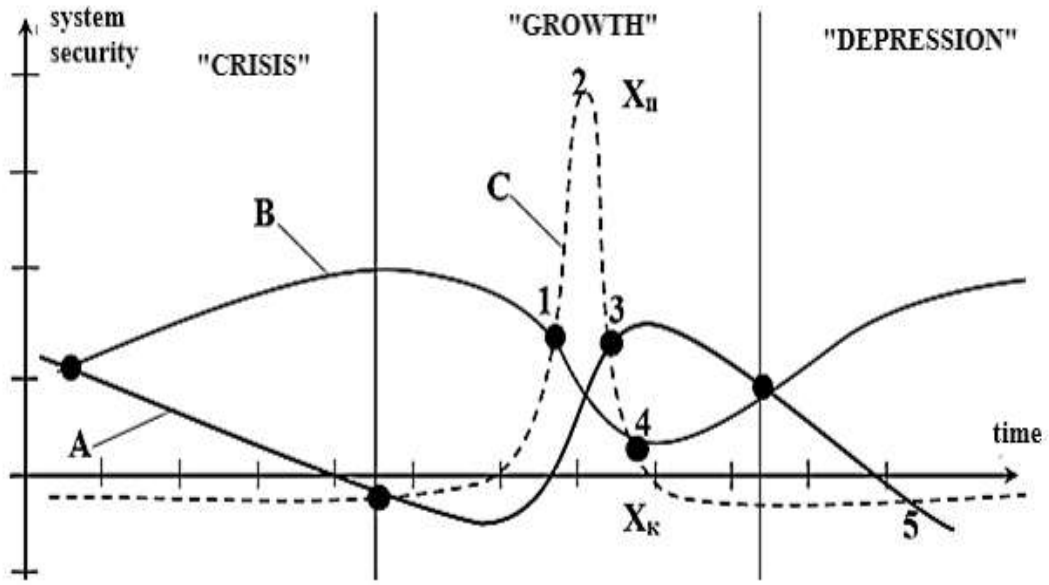
$$\begin{cases} \dot{x} = k_1 z - k_2 y - k_3, \\ \dot{y} = k_4 x - k_5 z, \\ \dot{z} = k_6 x - k_7 y + k_8 y^2 + k_9 xy + k_{10} z^2 - k_{11} xz \end{cases}, \qquad (2.4)$$

which is dissipative under the condition:

$$z < \frac{k_{11}}{2k_{10}} x \quad , \qquad (2.5)$$

Functions (4÷5) are characteristic of TSMOE natural development processes. The decrease in environmental safety of system components occurs as a result of increase in the density of traffic flows and their high daily and seasonal dynamics within the limits of "resources formed in environment of military operations", which is well described by logistic curve $Y=1/\left(a+bc^{t}\right)$.

The developed model allows to qualitatively describe TSMOE safety. We will conduct a study of model variables dependence in the time space associated with economic state of environment under investigation. On the graph (fig. 2.2), three economic phases can be distinguished – "crisis", "growth", "depression" [6].




● bifurcation points

**Fig. 2.2.. Behavioral characteristics of variables of equation system (4) in time space**

In each sphere, there are curves of indicator processes: A – dynamics of transport processes in the conditions of military operations; B – total loss of time in transportation processes in the conditions of military operations; C – investments to ensure the security of the system under investigation.

The bifurcation points of the phase transition in economic cycles determine the limits of TSMOE adaptation processes, as the only limitation due to physical and temporal dimensions of society living space in the conditions of military operations, and the peculiarities of transport flows structure and their dynamics in the conditions of military operations.

The economic phase of "growth" is the most interesting for research. In it, we highlight the stages of system development: "1-2" – security; "2-3" – development of collapse; "3-4" stage of stagnation; "4-5" is the stage of harmonization. Consider the segment (see fig. 2.3), on which it is possible to perform an analysis of their mutual influence on the interval $X_n$ – the initial state; $X_к$ is the point of collapse.

The impact of "crisis" factor on TSMOE safety is characterized by value of assimilation coefficient $Ф_n$, which is of a "soft" nature and denotes the costs incurred to support resources that ensure necessary level of transport route architecture functioning in the conditions of military operations. The coefficient increases in "steps", but has individual amplitude, direction of which depends on economic stability of TSMOE.

The image of influence degree of $Ф_n$ coefficient on the value of its residual resource $T(t)$ can be presented in theoretical graphs form of dependence of degree of economic cycles influence on MOE safety stability in the conditions of the "operational funnel" (fig. 2.3) and in conditions of "loss of control crisis" (fig. 2.4), which are described by the law of normal distribution. The first variant of attractor (fig. 2.3) reflects the development of events in conditions when controlled and controlling systems do not carry out activities aimed at overcoming external influences that make goal set before the system regarding its restoration unattainable – the "operational funnel".

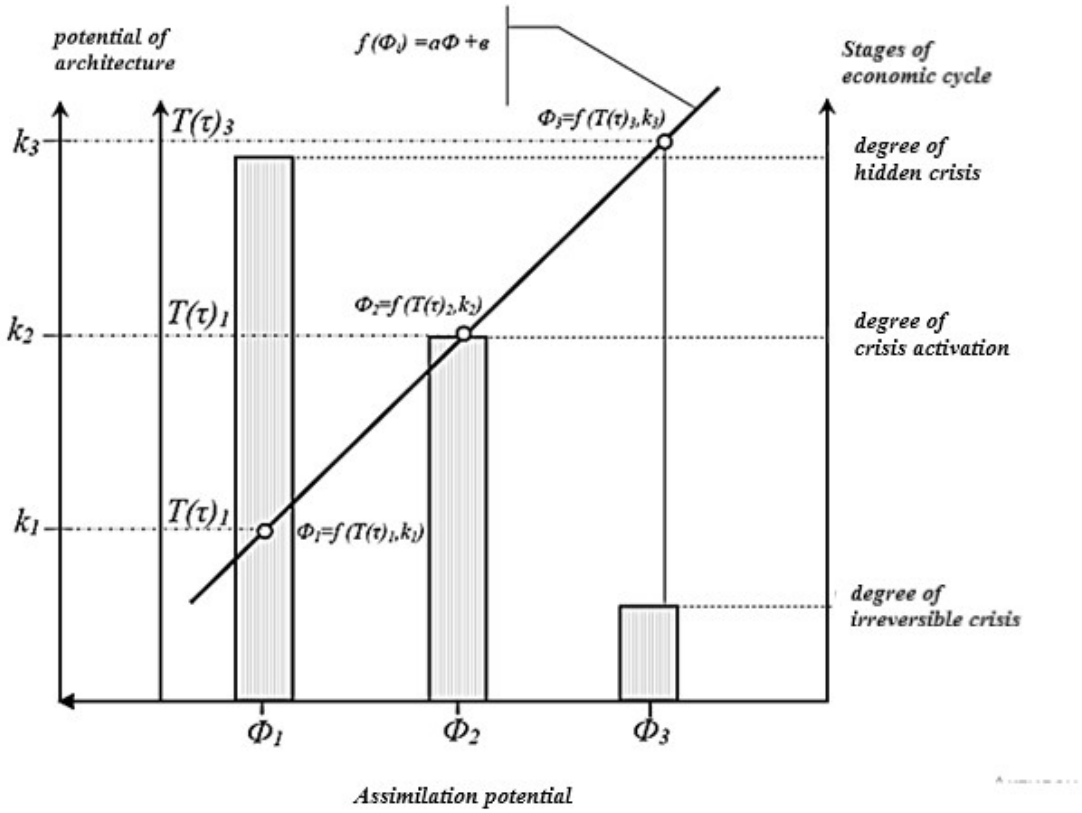



**Fig. 2.3. Theoretical graphs of degree of economic cycles influence on TSMOE environmental safety in the conditions of "operational funnel"**

In this case, change in indicators characterizing environmental safety can be described by linear law of distribution.

The second variant of attractor (see fig. 2.4) represents development of events in conditions when control system is in a state of maximum load, and controlled system does not perform its work – "crisis of management loss".

The process of ensuring safety is limited by critical parameters of economic conditions that correspond to the state of bifurcation and uncertainty of further development process, unpredictability of environment and its transport flows.

Thus, TSMOE safety model is formed in the form of two-layer perceptron. The first layer (som) of model includes many linguistic assessments that determine safety of transport flow components. Its second layer (som) describes a set of linguistic assessments that determine functionality and potential of transport routes architecture in the conditions of military operations.

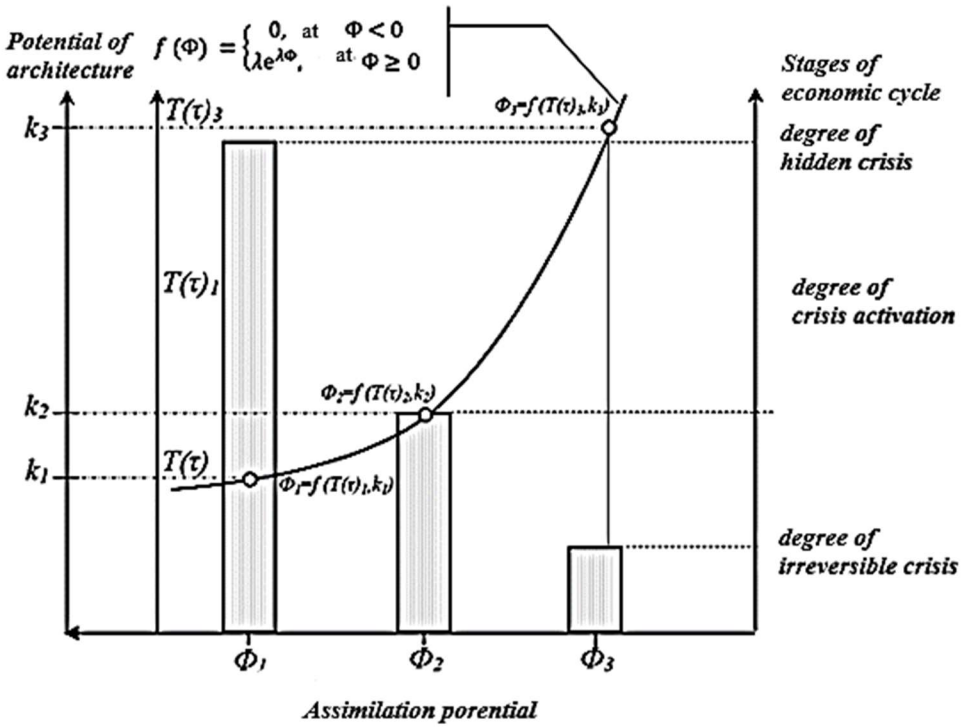



**Fig. 2.4. Theoretical graphs of degree of economic cycles influence on TSMOE safety in conditions of "crisis of management loss"**

The developed model of macrologistic processes dynamics allows to qualitatively describe dependence of total time spent on ensuring safety of system on cargo and passenger transportation volume, taking into account investments aimed at ensuring the TSMOE components safety.

The analysis of model variables in the time space, which is related to economic cycles of TSMOE development, determined the degree of economic cycles influence on its sustainability in conditions of both "operational funnel" and "crisis of management loss".

### 2.1.2. Use of "SMART LOCUS CONTROL" mechanism in managing the processes of transport systems safety ensuring in the military operations environment

Method has been developed to manage the processes of ensuring TSMOE safety.

The method of monitoring TSMOE modules safety is based on the principles proposed by Matis Wackernagel, who defines: "the safety load (ecological footprint) is the area of territories that affects the level of providing a person with everything necessary for his modern lifestyle in the studied space"[82].

We recommend the SMART LOCUS CONTROL (SLC) method to control the point of transition of safety load beyond the regeneration capabilities. Its basic component is the effective technology of setting and formulating SMART goals. The concept of Locus Control in its modern sense was introduced by American psychologist Julian Rotter in the 60s of the last century. This mechanism is based on the possibility of existence: "a continuum in which the extreme points are individuals with pronounced external or internal attribution strategies. The rest of people occupy intermediate positions between these extremes". The authors defined that: "Locus-control (Lat. Locus – place, location and Fr. Controle – check) means a quality that characterizes person's tendency to believe that responsibility for results of his activity is borne by external forces (externality, external locus control), or one's own abilities and efforts (internality, internal locus of control). In relation to groups of people, these qualities can give certain characteristic of the entire nation, individual properties of behavioral assessment of entire nations, and integral and external type of behavior can also be determined"[83].

[82] Клименко В.В., Лозова Г.М. Ефективність діяльності підприємств на ринку логістичних послуг в Україні // Актуальні проблеми розвитку економіки регіону. Вип 17. Т.2, 2021 р., С. 94-108.

[83] Lyamzin A., Khara M., Marintseva K. Synergetic character of architectural elements of transportation networks of industrial areas // Proceedings of the National Aviation University = Вісник Нац. Авіаційного Ун-ту. – 2016. – Vol. 68, N 3. – P. 80-88.

In our opinion, described features of SLC method will allow it to be organically applied in the system of providing and TSMOE modules safety. The method makes it possible to ensure system safety management. To solve the problem, so-called "TSMOE" target function is proposed and its limitations are indicated[84]:

$$F\,(G/R) = \alpha_U \Sigma^{l}_{j=1}\, x_j\, \lambda\{Z^{v}_{j}\} + \\ + \alpha_C\, \Sigma^{K}_{j=1}\, y_j\, \lambda \,/\, \Sigma^{M}_{j=1}\, \lambda\{L_i \in T_j\}\, \Sigma^{n}_{i=1}\, d^{\,j}_{il} \cdot \lambda\{Z^{T}_{il}\} \rightarrow max \qquad (2.6)$$
$$\text{at}$$
$$G/R\ \Omega\ (P, S, L, A)$$

where:

$G/R$ – level of environmental safety of TSMOE modules system;

$\alpha_U$, $\alpha_C$ – weight coefficients of goals priority of a certain modules block in TSMOE;

$x_j$, $y_j$ – priority of requirements (restrictions) put forward by TSMOE modules to achieve the set goals;

$Z^{v}_{j}$ – requirements for studied module;

$\lambda$ – potential of studied module;

$L_i$ – module functionality;

$T_j$ – module group functionality;

$Z^{T}_{il}$ – module activity group sector;

$^{j}_{il}$ – factor that determines module potential;

$l$ – number of conditions, the fulfillment of which ensures modules group potential;

---

[84] Лямзін А. О. Використання технологій «smart-planning» в умовах агресивного транспортного середовища промислових зон // *Университетская наука - 2018 : тез. докл. Междунар. научно-техн. конф.* (Мариуполь, 23–24 мая 2018 г.) : в 3 т. / ГВУЗ «ПГТУ». – Мариуполь, 2018. – Т. 2. – С. 319-320.

$K$ – number of modules in group, which is determined by their combined potential and direction of action;
$M$ – number of modules groups;
$n_i$ – limitations on number of modules in logistics chain;
$\Omega$ – area of limitations;
*P, S, L, A* – the potential of modules, their level of safety and potential of linear and nodal elements as components of "TSMOE".

The implementation of *SLC* method is based on solution of tasks set before each system module individually or as a whole. To determine adequacy of particular solution, it is necessary to check limitations of presented objective function. To optimize computational process using *SLC* method, we recommend using matrix-evolutionary approach. The method can be implemented using electronic table with fields (fig. 2.5).

$$S_E = <Season, Day, CPJ, Cluster\ Type, Conditional\ routing\ number>, \quad (2.7)$$

where:
*Season* – season;
*Day* – day;
*Cassessment of the potential of the journey* (*CPJ*) – assessment of TSMOE potential;
*Cluster Type* – block type of grouped modules in TSMOE;
*Conditional routing number* – conditional number of TSMOE element.

Such structure makes it difficult to check adequacy of decision. Let's simplify it and visualize it with some three-dimensional matrix (tabular structure). Such structure will have the form of parallelepiped, edges of which lie on the coordinate axes $X_1, X_2, X_3$.

$$X_1 = <Season\ /\ Day>, \quad (2.8)$$

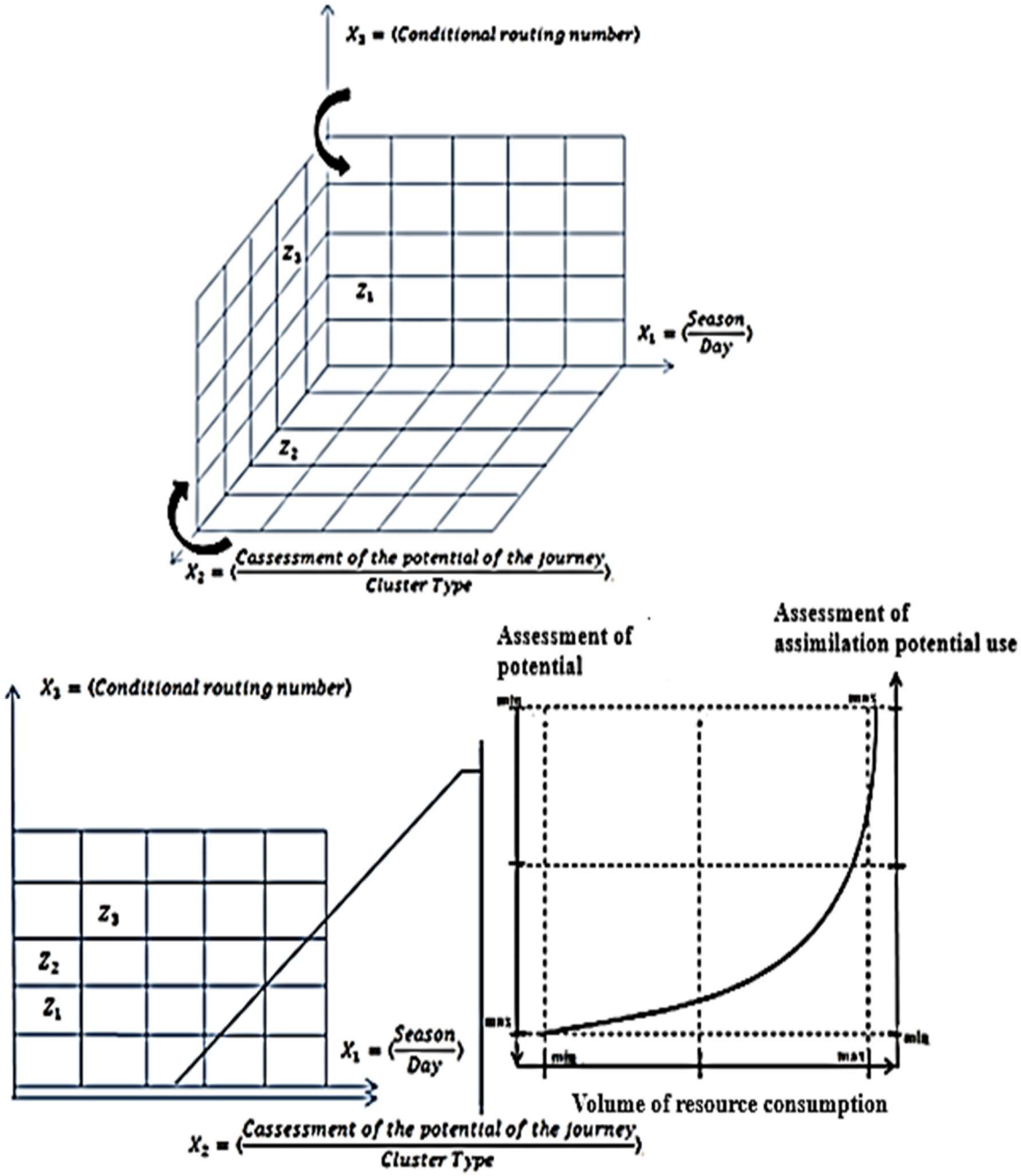



**Fig. 2.5. Graphic representation of the basic principles of "SMART LOCUS CONTROL" method**

$$X_2 = <CPJ\ /\ Cluster\ Type>, \quad (2.9)$$

$$X_3 = <\ Conditional\ routing\ number>, \quad (2.10)$$

$$S_E = <X_1, X_2, X_3> \quad (2.11)$$

where:
$X_1$ – point that determines option of solving task in time space;
$X_2$ – assessment of TSMOE potential in a given time coordinate for a specific block of modules;
$X_3$ – conditional number of TSMOE element.

In the grid nodes of spatial model, there will be *Z* values, which form indicators that characterize transport flow and type of "logistic solution" in conditions of military operations.

Thus, *SLC* method in determining and managing TSMOE components safety allows to control point of transition of system's safety load beyond the system's regeneration capabilities. The implementation of *SLC* method is based on solving the problems set for each module separately or for the entire set of modules in the system. To determine adequacy of particular solution, we check constraints for objective function. To optimize computational process using *SLC* method, we use matrix-evolutionary approach. Graphic representation of *SLC* method is parallelepiped, the edges of which lie on coordinate axes $X_1, X_2, X_3$.

### 2.1.3. Peculiarities of transport processes cycles, their economic evaluation and influence on transport systems condition in the military operations environment

In order to increase the functionality of military logistics components in solving the issue of transport systems safety, analysis of characteristics of transport processes cycles and their impact on transport systems state was carried out. TSMOE safety management is decision-making process

regarding the effectiveness of SMART approach, that is, finding "smart" system safety during interaction of MOE with TS, at each stage of its life cycle. The existence of specific material flow in the TSMOE is influenced by many factors that shape the life cycles or activity phases of all TSMOE subjects.

In general, the task of reducing the external load on TS condition in the MOE conditions from transport activity is connected with transition to the already known principle of its cyclicality, according to which the technological processes cycle is carried out with the help of so-called reduction, including recycling capabilities of the processes.

Examples of SMART solutions according to *G – C – B – I* scheme and the required level of TSMOE safety evaluation from their implementation are given in the table 2.2[85].

Table 2.2.

**– *G – C – B – I* scheme**

| Kind of concept | The desired effect |
|---|---|
| Increased life cycle (G) | Life extension (B) |
| Increase in exploitation term (C) | Extending the exploitation term |
| Increasing the exploitation intensity (I) | Increasing the intensity of exploitation $\rho$ within the interval $t_n$ |

where:

G – TSMOE recycling using SMART technologies;

C – ensuring the control effectiveness over the safety condition of TSMOE components;

B – joint use of TSMOE facilities;

I – application of SMART technologies and modern technical units with the possibility of their multi-purpose use.

[85] Лямзин А. А., Хара М. В. Системный реинжиринг транспортных процессов в транзитной среде промышленного района // *Научные труды SWorld.* – 2015. – Вып. 4 (41), т. 1 : Транспорт. – С. 8-16.

The impact on safety of TSMOE objects cyclical activity (fig. 2.6) is represented by five main cycles.

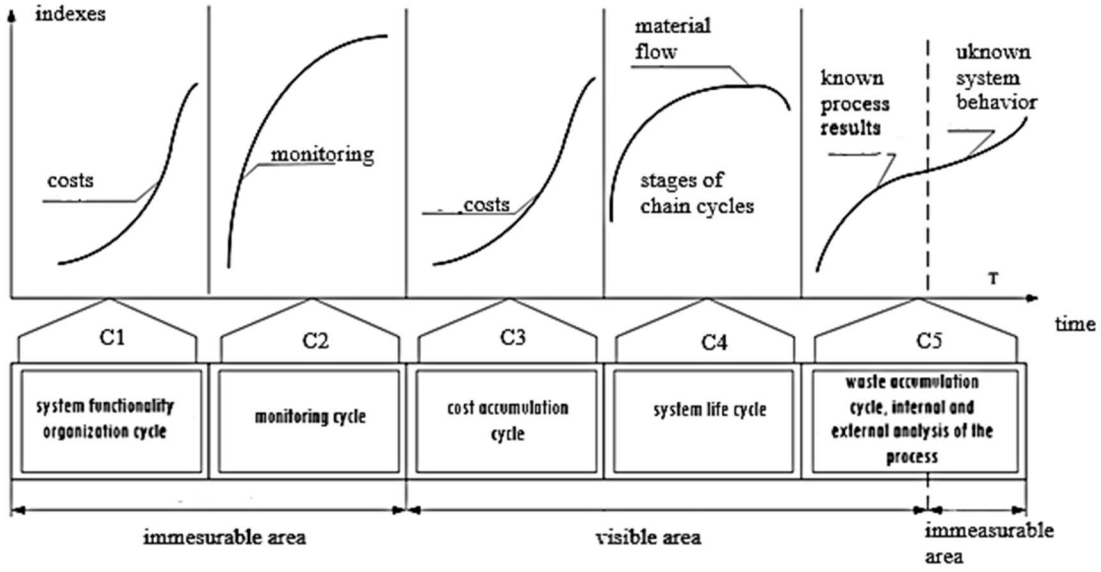



**Fig. 2.6. The nature of cyclical activity impact of TSMOE system objects on their safety**

The C1 cycle forms the TSMOE organization and its structure, which ensures security.

In cycle C2 (monitoring cycle) all network structures are distributed according to their functional characteristics. The cycle provides monitoring of changes in TSMOE state during the implementation of traffic flow functionality and TSMOE links work (transportation, loading and unloading facilities, transport communications, infrastructure objects)[86].

At the same time, there is uncertainty about the response of environment network to the traffic flows influence. In the practice of TSMOE operation, cycles C1 and C2 from the point of view of safety, as a rule, are processes that are not controlled to a sufficient extent.

[86] Чорнописька Н. В., Брень О. В., Данильців О. І. Зародження військової логістики в Україні. URL: http://ena.lp.edu.ua:8080 (17.10.2022)

Cycle C3 involves the accumulation of costs. During TSMOE operation [12], in the C3 cycle, funds are accumulated from the system activity, its network, which are peculiar only to it.

Experience shows that in cycles C1, C2 and C3, safety issues are often neglected.

Cycle C4 (life cycle of TSMOE system) involves providing transport services or selling products and making a profit.

Cycle C5 of transport flow and TSMOE is a cycle associated with the end of operations, with accumulation of material and energy waste and their recycling.

The final stage of life cycle is recycling – it is closely related to the life cycle of transport flow, cargo-handling, storage and management complexes of TSMOE. This is the most important component of life cycle completion in relation to the impact on TSMOE safety state.

Thus, we suggest using the *6S* method (Structure, System, Strategy, Style, Staff, Skill) for further analysis of TSMOE safety level. *6S* is, respectively, Structure, System, Strategy, Style, Staff, Skill shared by participants in the transport process.

The method makes it possible to form a kind of internal "safety frame" for evaluating the most important components of studied structure potential from the point of view of safety and ethical principles developed and adopted by the organizers of military logistics in TSMOE.

Thus, the impact on TSMOE safety state changes in five transport cycles –cycle of organization, cycle of monitoring, cycle of accumulation of costs, which are related to the impact of transport activity on safety, life cycle and cycle of accumulation of safety resources.

Each of the above cycles has its own recovery resource or assimilation potential. The next step in SMART functionality formation of military logistics components in solving the issue of transport systems safety is mechanism development for assessing the assimilation TSMOE safety potential. The impact of TSMOE components activities on its safety as a whole depends on involved land volume, energy and other types of resources and TSMOE ability to restore its technological characteristics. As

long as this ability is preserved, additional costs for restoring parameters that determine TSMOE safety are not required[87, 88].

Therefore, the ability to restore TSMOE safety state is called the assimilation potential (AP) of its resources, which include geographical areas that are natural resource and are extracted in the process of providing transport services either free of charge or for appropriate fee, which depends on damage amount.

The assimilation potential is understood as quantitative assessment of MOE ability to independently reduce impacts from the processes, to the level at which these impacts do not have harmful effect on standard of subjects living in MOE. In this case, we believe that assimilation property of environment has a complex technogenic nature.

It is proposed to define economic component of TSMOE safety assimilation potential as the infinite ability of MOE to respond to various influences of transport processes without changing its quality parameters. This makes it possible to consider TSMOE safety as non-traditional resource that is involved in transport systems operation to preserve their efficiency by using its potential for self-defense. The lack of methods of quantitative determination of assimilation potential prevents it from being considered as an object of ownership in the field of system activity.

Currently, so-called "free access" method is used to determine the assimilation potential. For example, statistical method of successive approximation can be used to estimate TSMOE assimilation potential. In the first approximation, initial assimilation potential is taken to be the minimum total loss of system's resource during the implementation of minimizing mechanism the transport impact in the military operations conditions.

The assimilation potential of system is determined for a specific territory or environment area. For AP use in regulating the technogenic

[87] Альбощий О. В. Дослідження ризиків в системі логістичного забезпечення. Науко-во-практична конференція Національної академії Національної гвардії України 14 березня 2019 р., м. Харків С. 5–6.

[88] Сапіга Р. І. Військова логістика у забезпе-ченні воєнно-економічної безпеки країни: автореф. дис. ... канд. екон. наук: 21.04.01. К., 2013. 22 с

impact of transport processes on system safety, it is necessary to take into account the following conditions of its application [89]:

– AP value to ensure TSMOE territory safety (for example, transport area) is determined taking into account all diversity of factors that reflect peculiarities of territory and extraterritorial influence of traffic flows;

– nature and magnitude of AP changes over time, i.e. in dynamics;

– determined partial value of AP can be used to ensure the efficiency of transport flows without the threat of qualitative changes in TSMOE safety condition, which are incompatible with human habitation in the given territory;

– minimum AP value for MOE is determined, at which further technogenic load will not be allowed.

Therefore, assimilation potential can be defined as a free resource of transport area in the military operations conditions, in the presence of which there are no qualitative changes in MOE. In this case, additional compensatory measures to restore the studied environment from the influence of traffic flows and bring it to a state that contributes to safe and healthy standard norms of living are not required.

Thus, the amount of AP can be interpreted as a free resource that allows you to receive income without additional costs, that is, rent-type income. Based on the fact that any resource is object of ownership and can be in commodity circulation, and therefore have a value estimate, assimilative potential can also be estimated by the total amount of costs to support MOE assimilative potential ($P_{AP}$). AP becomes an ordinary commodity that participates in activity and is subject to market laws of supply and demand. The mechanism of using assimilation potential to ensure TSMOE safety is presented in the form of dependence of costs for maintaining assimilation environment potential on the volume of transport

[89] Білоус М. В., Рижов О. А., Шматенко О. П., Дроздов Д. В. Особливості реалізації логістичної під-тримки збройних сил в історичному аспекті прове-дення військових операцій. Зб. наук. праць НМАПО.2018. No 32. С. 54–69.

services (works) that were performed in the military operations conditions (*W*) (fig. 2.7)[90].

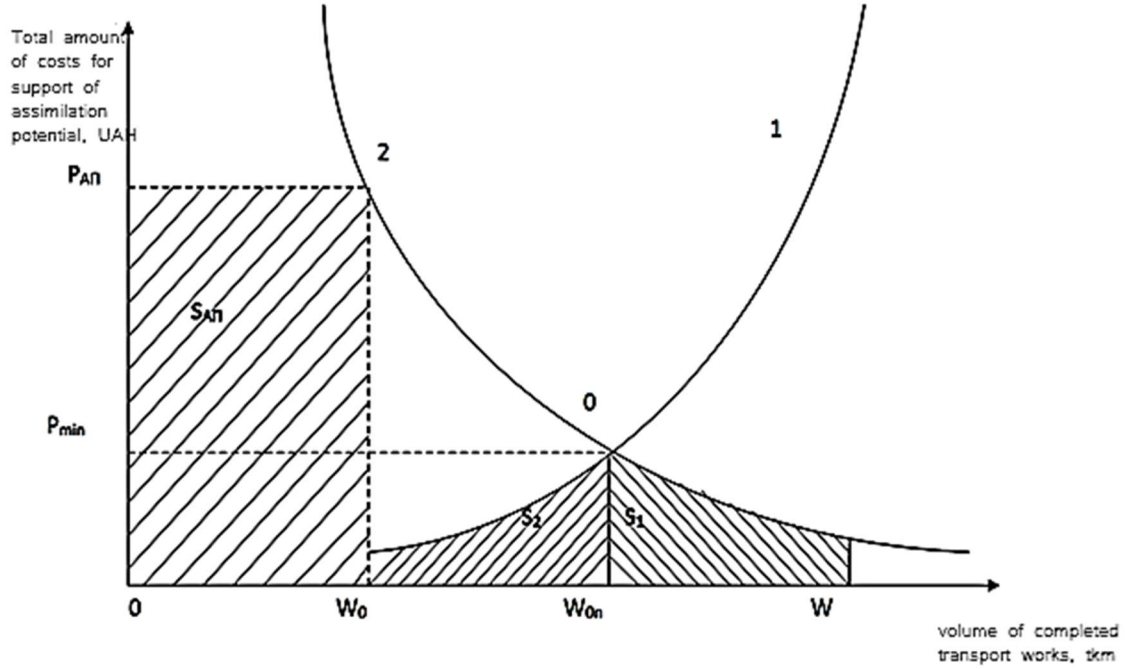



**Fig. 2.7. Dependence of costs for maintaining assimilation TSMOE potential ( $P_{AP}$ ) on the amount of pollutants emissions (*W*)**

where:

$S_{AP}$ – the value of MOE assimilation potential;

$S_1$ – expenses for reducing technogenic impact of transport activities in the military operations conditions;

$S_2$ – costs associated with deterioration of MOE state;

$W_{on}$ – economically optimal level of technogenic influence of transport activity in the military operations conditions;

$P_{AП}$ –total amount of costs for maintaining MOE assimilation potential;

$P_{\min}$ –minimum amount of costs for maintaining potential to maintain the possible limit of its use without MOE harming.

[90] Остащенко Т. М., Шматенко О. П., Білоус М. В., Галан О. В., Дроздов Д. В. Концепція військової логістики: від зародження до сучасного тракту-вання в Збройних Силах України. Український жур-нал військової медицини. No 3. 2021. Т. 2. С. 84–92

As the utilization of resources by transport systems (curve 2) increases, AP decreases, and the loss in MOE (curve 1), on the contrary, increases.

The intersection of curves 1 and 2 gives the point *O*, coordinate of which on the ordinate axis means MOE assimilation potential value for the minimum amount of consumed resources as a result of transport processes, and on the abscissa axis – the point of economic optimum of pollution of studied TSMOE.

At the point, equilibrium is established between the marginal costs and the marginal loss from resource consumption process. The area of manifestation of assimilation properties, which can be freely involved in circulation from transport flows development ($S_{AII}$), is clearly distinguished.

If curve 2 is presented as demand curve for consumed resource, and the loss (curve 1) as supply curve, then optimal amount of completed transport work ($W_{0n}$) will determine the point of so-called economic optimum, which is often mistaken for minimum value of TSMOE assimilation potential. Assimilation potential is determined by point $W_0$ and this value determines the capabilities of system.

The economic assessment of AP is carried out based on the need for rational use of this resource. The value of AP is determined by the role it plays in the process of forming costs and results of production activities in the military operations conditions.

According to Homo economikus strategy, overcoming negative consequences of transport processes influence on MOE requires transport companies and owners of vehicles to solve economic problems, in connection with the needs of society living in MOE.

Damage from transport systems in environmental conditions is monetary assessment of negative changes in the main properties of environment under transport processes influence, from deterioration of human health, from decrease in systems efficiency that serve the vital activities of enterprises in the studied environment.

Theoretical dependence of the amount of costs for material flow movement in TS in MOE conditions and the costs that must be foreseen for safety measures implementation in the studied environment are shown in figure 2.8.

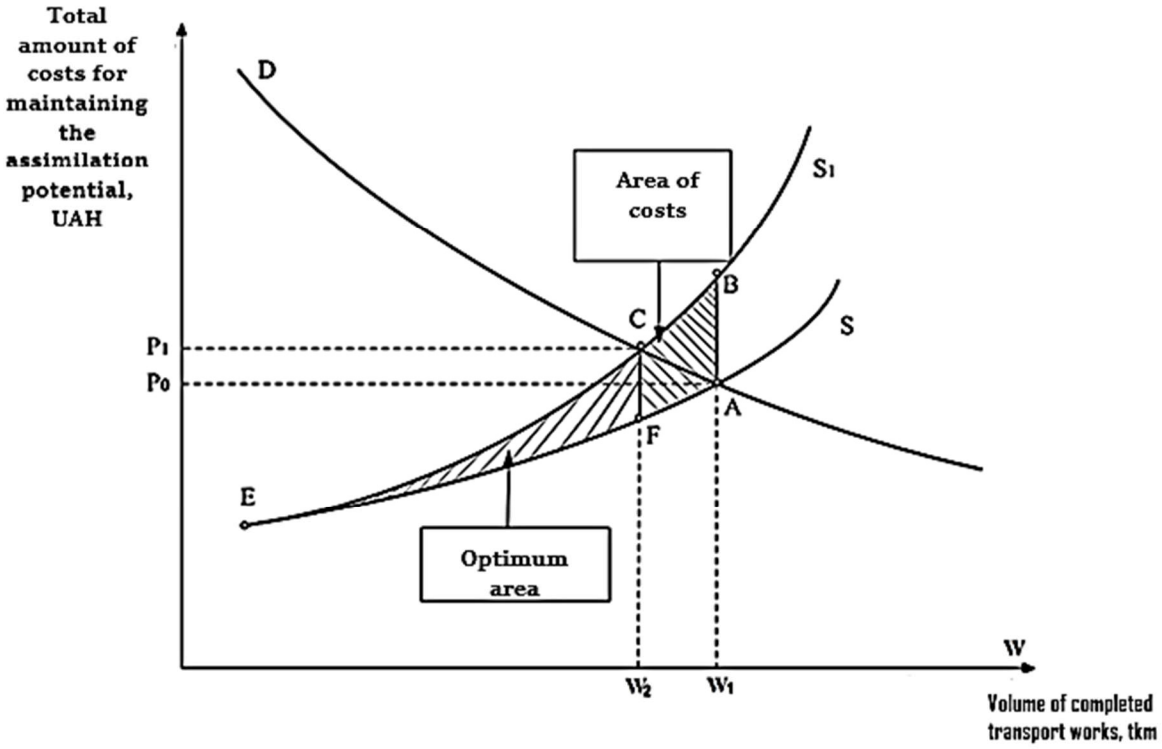



**Fig. 2.8. Economic optimum of TS safety efficiency, taking into account costs of MOE restoring resources**

Introduction of dependence $S_1$ (marginal economic costs) of relationship between *D* (demand) and *S* (supply) from the sphere of optimal solution is shifted in the direction of decreasing traffic flow. The area of *ABCF* characterizes the loss of efficiency, and the area of *CFE* is economic optimum of traffic flow, taking into account the costs for MOE safety.

If we depict economic mechanism of damage determination for natural TS objects in the form of "supply-demand" model, then points of curves intersection will determine economically optimal volume of consumed resources and their minimum, that is, assimilation potential.

### 2.1.4. Practical assessment of SMART solutions effectiveness and implementation of logistical concept of ensuring the transport systems components safety in the military operations environment

To evaluate the effectiveness of logistical concept of ensuring TSMOE components safety, a set of indicators is needed that determine the level of its safety (fig. 2.9) and determine the development of their ranking (data are shown in table 2.3).

The basic stage of working with experts, who determine logistical concept effectiveness of ensuring TSMOE components safety, is to characterize the consistency of their assessments.

This consistency is determined using Kendall's concordance coefficient ($W$)[91]:

$$W = S / (1/12\ n^2 (m^3-m) - n\Sigma T)), \quad (2.12)$$

,

$$S = \sum_{g=1}^{m} \left( \sum_{i=1}^{n} C_{gj} - \frac{\sum_{g=1}^{m}\sum_{i=1}^{n} C_{gj}}{m} \right)^2 \quad (2.13)$$

[91] Oliveira A. Managing Supply Chain Networks / A. Oliveira, A. Gimeno // Building Competitive Advantage in Fluid and Complex Environments. – New York – Pearson, 2014.

Table 2.3

**Factors that determine the degree of TSMOE safety**

| Names of distribution groups of system components | Conventional indicator | Indicator name | Rank of indicator |
|---|---|---|---|
| **1** | **2** | **3** | **4** |
| Economic group | $r_1$ | Volume of products produced by enterprises in conditions of military operations environment | 3 |
| | $r_2$ | Assimilative potential of system components in military operations environment | 16 |
| | $r_3$ | Length of transport routes in conditions of military operations environment | 4 |
| | $r_4$ | Specific weight of municipal transport | 5 |
| | $r_5$ | Specific weight of industrial transport | 17 |
| | $r_6$ | Specific weight of private transport | 6 |
| | $r_7$ | Specific weight of specialized transport | 15 |
| | $r_8$ | Volume of investments in the fixed capital of municipal transport enterprises | 1 |
| | $r_9$ | Volume of investments in the fixed capital of industrial transport enterprises | 11 |
| | $r_{10}$ | Turnover (revenue) of commercial enterprises from implementation of transport (works and services) | 12 |
| | $r_{11}$ | Turnover (revenue) of municipal enterprises from implementation of transport (works and services) | 2 |
| | $r_{12}$ | Volume of loans granted to municipal enterprises, organizations in the conditions of military operations environment | 13 |

**Continuation of table 2.3**

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | $r_{13}$ | Volume of loans granted to industrial enterprises, organizations in the conditions of military operations environment | 14 |
| | $r_{14}$ | Specific weight of profitable organizations that ensure vital activity of society in the conditions of military operations environment | 22 |
| | $r_{15}$ | Sum of concluded leasing contracts for transport enterprises | 9 |
| | $r_{16}$ | Amount of environmental fines from the activities of industrial enterprises in the conditions of military operations environment | 7 |
| | $r_{17}$ | Amount of environmental fines from the activities of municipal enterprises in the conditions of military operations environment | 8 |
| Social group | $r_{18}$ | Wages of employees of municipal transport enterprises | 25 |
| | $r_{19}$ | Wages of employees of industrial transport enterprises | 23 |
| | $r_{20}$ | Percentage of road accidents of industrial transport from the total volume of road accidents in the conditions of military operations environment | 24 |
| | $r_{21}$ | Amount of financial costs to eliminate the results of road accidents in the conditions of military operations environment | 21 |
| Resource group | $r_{22}$ | Percentage of areas occupied by recreational areas from the total area of the state in the conditions of military operations environment | 18 |

**Continuation of table 2.3**

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | $r_{23}$ | Percentage of areas occupied by transport territories from the total area of the state in the conditions of military operations environment | 19 |
| | $r_{24}$ | Percentage of areas occupied by industrial enterprises from the total area of the state in the conditions of military operations environment | 20 |
| | $r_{25}$ | The percentage of transport, the service life of which is higher than passport, established standards in the conditions of military operations environment | 10 |
| | $r_{26}$ | Expenditures for measures aimed at ensuring safety in the conditions of military operations environment | 26 |

$$T = \frac{1}{12}\sum_{d=1}^{D}\left(R_d^3 - R_d\right) \quad , \qquad (2.14)$$

where:

$n$ – number of factors;

$m$ – number of experts;

$C_{gj}$ – assessment of importance of the $j$-th factor given by the $g$-th expert (in ranks);

$T$ – indicator of related ranks;

$D$ – number of groups of related ranks;

$R_d$ – number of equal ranks in the $d$-th group.

To assess the statistical significance of concordance coefficients, the $\chi^2$ Pearson test is used, which is subject to the $\chi^2$ distribution with the number of freedom degrees ($m$-1). It is calculated according to the formula:

$$\chi^2 = W\, n(m\text{-}1), \qquad (2.15)$$

To achieve adequacy of concordance coefficient $W$, it is necessary and sufficient that calculated value of $\chi^2$ is greater than tabular value determined by number of freedom degrees ($m$-1) and level of confidence probability $\rho$.

Calculation of concordance coefficient and verification of its significance gave the following results:

$$W = 0{,}53; \quad \chi^{2calc} = 198{,}7;$$
$$\chi^{2calc} = 198{,}7 > \chi^{2table} = 37{,}7.$$

Therefore, assumption that there is consistency of expert testimony, which is calculated using Kendall concordance coefficient, is confirmed. There is consistency among experts about the weighting assessment of factors.

Proposed scientific concept of ensuring TSMOE components safety is based on the need to define and identify basic factors on which its effectiveness and safety depend.

The main method of forming this scientific concept is statistical modeling based on correlation-regression analysis.

To conduct a study of concept adequacy, correlation matrix was built to determine the degree of dependence between performance indicator and variables – regression dependences (table 2.3 and fig. 2.9).

Correlation matrix of indicators reflects direct close relationship (correlation coefficient above 0.7) between the volume of transport works ($r_1$) and indicators: amount of environmental fines from the activities of municipal and industrial transport ($r_{16}$ and $r_{17}$) in the conditions of military operations environment.

The highest correlation coefficient (0.97) characterizes relationship between revenue of municipal enterprises from implementation of transport works and services ($r_{11}$) with loans for municipal transport enterprises ($r_{12}$) in the conditions of military operations environment.

At the same time, relationship between percentage of industrial transport accidents from the total volume of road accidents and the amount of financial costs to eliminate results of road accidents in the conditions of military operations environment (-0.74) emphasizes the level of economic crisis of studied system.

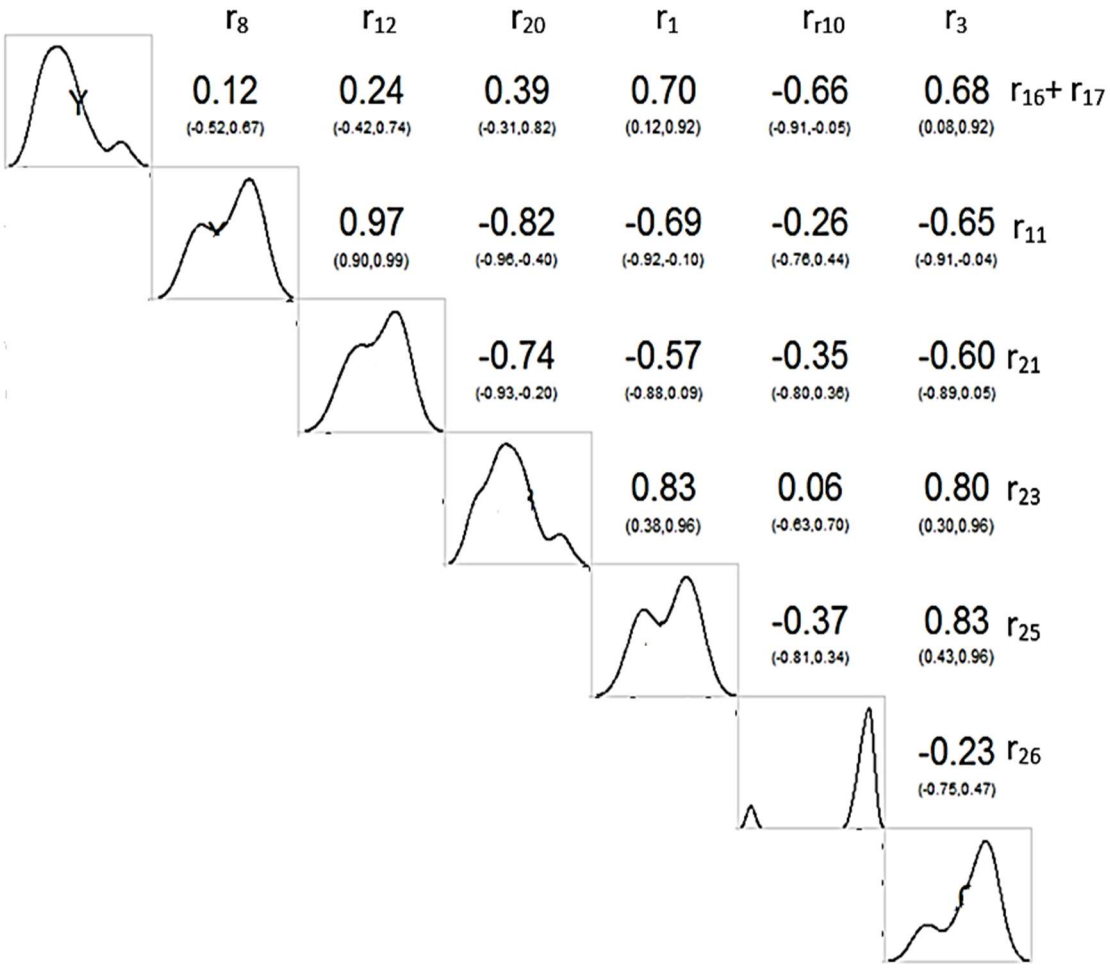



**Fig. 2.9. Matrix-evolutionary approach to determining indicators, which characterizes TSMOE state within framework of concept**

This situation characterizes the dependence of transport services volume on the process of adaptation of studied environment in the conditions of wartime. Regression dependencies, which reveal connection between the transport work volume and development level, which introduces economic mechanisms in the conditions of TSMOE, have the form:

$$Y = -199{,}74+0{,}381r_8+0{,}12\ r_9+0{,}597r_{10}+0{,}801r_{11}+0{,}712\ r_{12}-0{,}567\ r_{13}-0{,}356\ r_{14}$$
$$(R^2 = 0.97)$$

Negative nature of completed works volume is revealed by such factors as investments, which testify to low trust in TSMOE.

$$Y = 318.82 - 0{,}52\ r_{26}$$
$$(R^2 = -\ 0.23)$$

In this way, developed *SLC* method (SMART LOCUS CONTROL – safety control) of TSMOE allows you to control the point of transition of safety load beyond regeneration capabilities of environment under study. The method makes it possible to ensure safety management of transport systems in military conditions. The implementation of *SLC* method is based on solving the problems of ensuring effectiveness of TSMOE components separately or as a whole together. To determine adequacy of particular solution, constraints for the objective function are checked. To optimize computing process using *SLC* method, we use correlation matrix based on principles of *7S* method (Structure, System, Strategy, Style, Staff, Skill + Shared values/green ethics). To ensure safety of transport system logistics cycles, "value chain" is applied, according to which strategic tasks are formed for value chain of all activities types, including infrastructure support, human resources management, and development of transport technologies in the context of military operations.

### 2.1.5 Forecasting SMART solutions assessment in the safety management processes of transport system components

The process of forecasting TSMOE safety level is quite difficult to analyze using generally accepted quantitative methods. The use of neural networks theory, namely its architectural element of *fuzzu*-structure (fuzzy neural network (*HCF*)) opens up great opportunities for obtaining qualitative information. In turn, synthesis of fuzzy sets with neural networks into *fuzzu*-structure makes it possible to ensure accuracy of forecast and eliminate subjectivity in formulation of forecasting rules . Positive effect obtained as a result of such synthesis of *fuzzu*-structure is the ability to "learn", that is, to independently adjust predicted results based on statistical materials fig. 1.10)[92] [93].

Model for forecasting TSMOE safety level was built on the work of two *HCF* that form traffic flow in MOE conditions and the level of its resource or assimilation potential. Let's consider the sequence of its functioning.

On the first layer ($L_1$), user enters data characterizing the level of initial *PEC*, the impact of traffic flows in MOE and its potential:

$$y_i = x_i, \tag{2.16}$$

where

$y_i$ – neurons of the first layer, values of which are assigned the value of input variable;

$x_i$ – input variables whose values are specified by user;

$i$ – number of input variables ($i$ =1...3).

[92] Індекс ефективності логістики [Електронний ресурс]. – Режим доступу : http://lpi.worldbank.org.

[93] Trends and Strategies in Logistics and Supply Chain Management / [R. Handfield, A. Wieland, F. Straube, H.-Chr. Pfohl] // Embracing Global Logistics Complexity to Drive Market Advantage, Bremen, 2015.

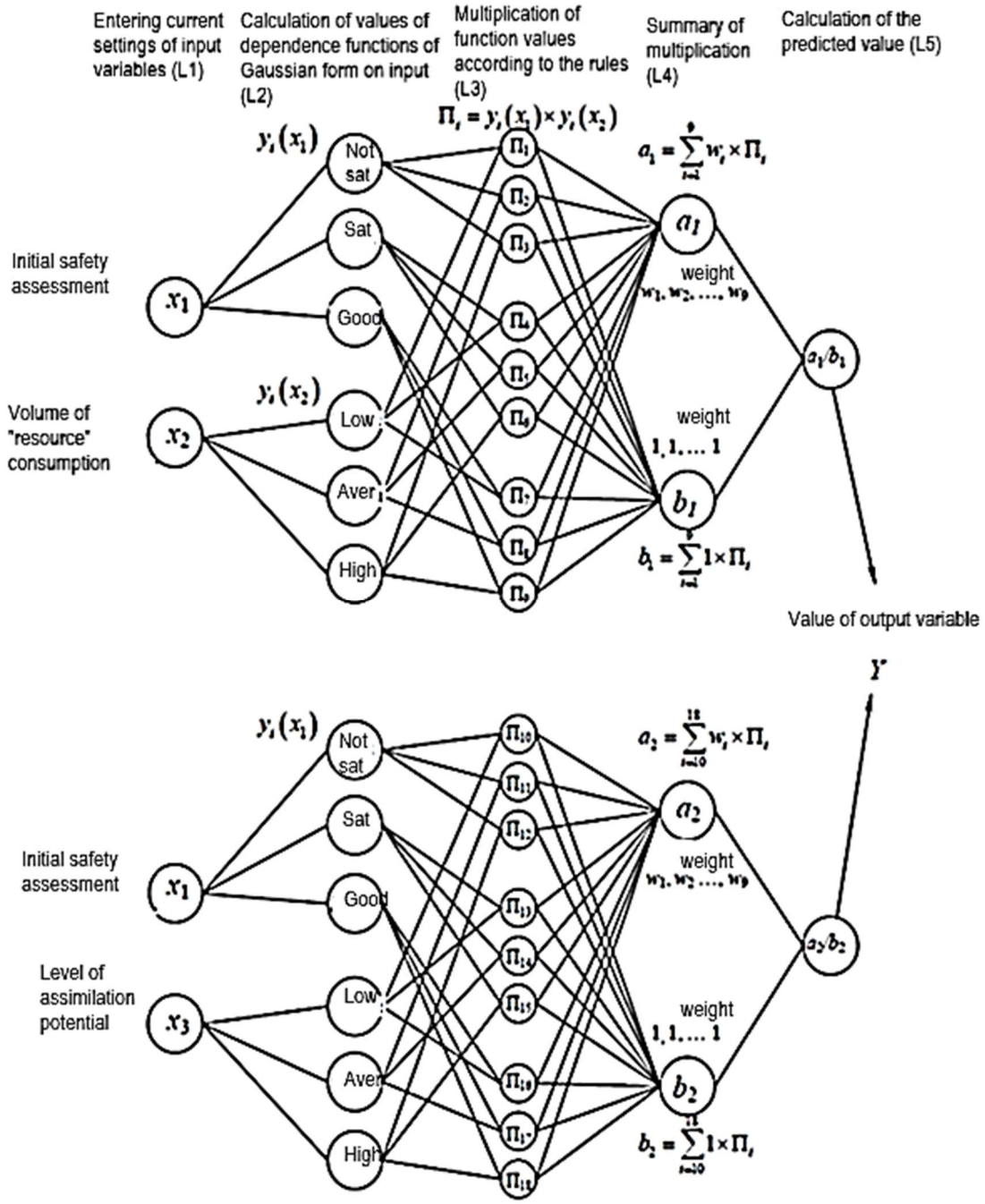



**Fig. 2.10. Graphic diagram of *PEC* model, based on two *HCF* with two parallel outputs**

On the second layer ($L_2$), each variable of the first layer is represented by three membership functions of Gaussian type[94]:

$$y_{i,r} = \mu_r (x_i) , \tag{2.17}$$

where
$\mu_r (x_i)$ – membership functions of fuzzy sets of input variables (table 2.4):
$r$ – number of fuzzy sets ($i$ =1...3).

On the third layer ($L_3$), values of neurons of the second layer are created, which is selection of options for possible combinations:

$$y_j = \prod_{\substack{i=1\dots3 \\ r=1\dots3}} \mu_r (x_i), \tag{2.18}$$

where
$j$ – number of multiplications: neurons of the third layer (in each of the two grids $j$ =1...9).

On the fourth layer ($L_4$), multiplication results of the third layer, multiplied by connections weights, are summed up. As a result, there are only two neurons in this layer:

$$y_a = \sum_{j=1}^{9} \omega_j \prod_{\substack{i=1\dots3 \\ r=1\dots3}} \mu_r (x_i) \quad \text{and} \quad y_b = \sum_{j=1}^{9} \prod_{\substack{i=1\dots3 \\ r=1\dots3}} \mu_r (x_i). \tag{2.19}$$

where
$\omega_j$ –initial weight of connection.

[94] Gong Z., Yang X., Wang S., and Zhang Y. (2013) Model Building of Integrated Military Logistics Supply Chain. ICTE 2013: pp. 371-378.

Table 2.4

**Type of membership functions (neurons of the second layer)**

| Initial level of safety (*PEC*) | | Influence of level of MOE potential | | Influence of volume of TS "resource" consumption | |
|---|---|---|---|---|---|
| Name of set | Membership function | Name of set | Membership function | Name of set | Membership function |
| Unsatis factory | $y(x) = exp\left[-(\frac{x-0}{0.2})^2\right]$ | Low | $y(x) = exp\left[-(\frac{x-0}{0.2})^2\right]$ | Low | $y(x) = exp\left[-(\frac{x-0}{0.2})^2\right]$ |
| Satis factory | $y(x) = exp\left[-(\frac{x-0.6}{0.15})^2\right]$ | Average | $y(x) = exp\left[-(\frac{x-0.4}{0.15})^2\right]$ | Avera ge | $y(x) = exp\left[-(\frac{x-0.3}{0.15})^2\right]$ |
| Good | $y(x) = exp\left[-(\frac{x-1}{0.2})^2\right]$ | High (destructi ve) | $y(x) = exp\left[-(\frac{x-1}{0.2})^2\right]$ | High (inten se) | $y(x) = exp\left[-(\frac{x-1}{0.2})^2\right]$ |

At the fifth layer ($L_5$), initial value of *PEC* predicted is obtained by dividing value of neuron *a* by value of neuron *b*:

$$Y = \frac{y_a}{y_b}. \tag{2.20}$$

Adjusting the weighting coefficients eliminates subjectivity in formulating a set of fuzzy rules. *HCF* learning algorithm is as follows:

1. Based on materials of actual roads inspection for the past years, training sample is determined. It is statistical set of actual values of input variables and corresponding values of output variables –predicted *PEC* (table 2.5).

Table 2.5

**Training sample for *PEC* with two axons**

| Sample number $m$ | Actual value of first variable axon $x_1^m$ | Actual value of second variable axon $x_2^m$ | Actual value of output variable synapse $Y_{act}^m$ | Estimated value of output variable synapse $Y_{est}^m$ | Actual value of prediction error $\varepsilon_{act}^m = Y_{act} - Y_{est}$ |
|---|---|---|---|---|---|
| 1 | $x_1^1$ | $x_2^1$ | $Y_{act}^1$ | $Y_{est}^1$ | $\varepsilon_{act}^1$ |
| 2 | $x_1^2$ | $x_2^2$ | $Y_{act}^2$ | $Y_{est}^2$ | $\varepsilon_{act}^2$ |
| … | … | … | … | … | … |
| $M$ | $x_1^{\mathrm{M}}$ | $x_2^{\mathrm{M}}$ | $Y_{act}^{\mathrm{M}}$ | $Y_{est}^{\mathrm{M}}$ | $\varepsilon_{act}^{\mathrm{M}}$ |

2. Determine estimated value of output variable $Y_{est}^{m}$ for each of $m$-examples of training sample, which are also listed in array next to actual data.
3. Set the value of average permissible error for training cycle ($\varepsilon_{per}$), as well as value of learning speed ($\eta$).
4. Calculate new values of connections weights between the third and fourth layers according to following formulas:

$$\omega_j^m(t+1) = \omega_j^m(t) + \Delta\omega_j^m, \tag{2.21}$$

$$\Delta\omega_j^m = -\eta \times y_j \times \varepsilon_{act}^m, \tag{2.22}$$

where
$t$ – training cycle number.

One training cycle includes iterating over all examples from training sample.

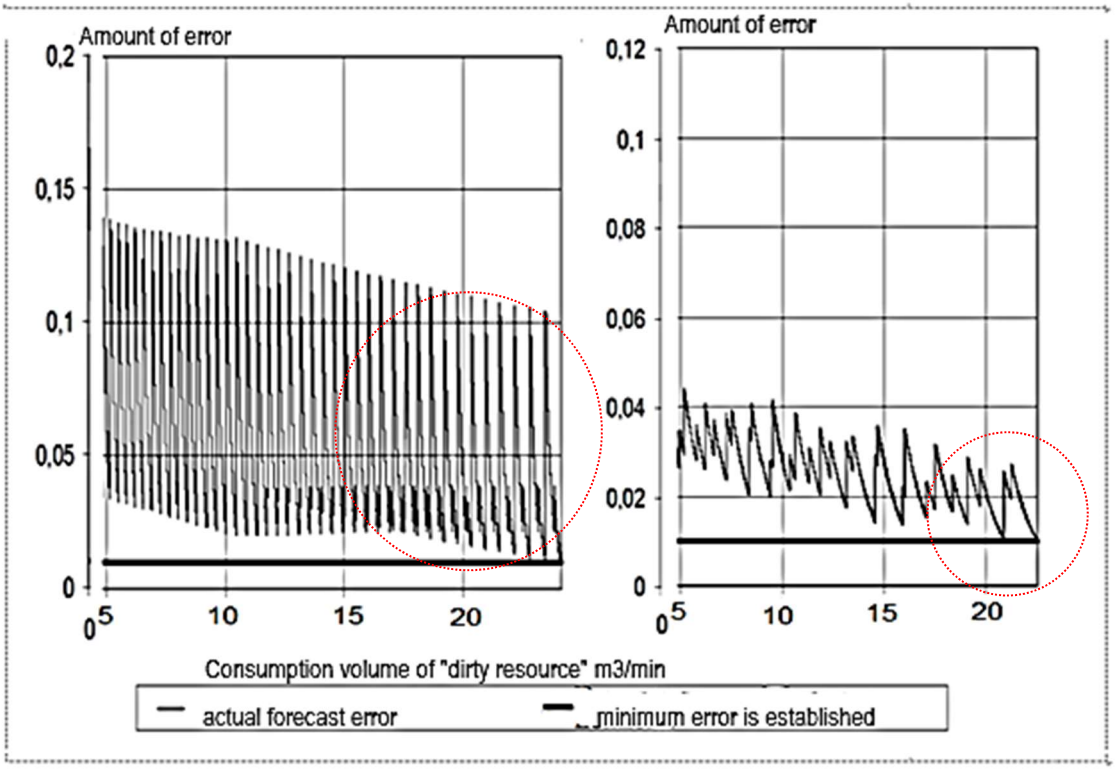
5. Determine average actual error for training cycle:

$$\varepsilon_{act} = \frac{\sum_{m=1}^{M} \varepsilon_{act}^m}{M}. \tag{2.23}$$

If the value of average actual error for training cycle exceeds value of average allowable error, then there is return to step 4.

6. Otherwise, learning process is stopped, and network is considered to have learned.

Practical calculations based on model using parallel *HCF* work showed jump-like reduction in error caused by independent work of two *HCF* even at low learning rates and high dynamics of changes in statistical data in TSMOE conditions (fig. 2.11), where: $a$ – prediction of *PEC* error diagram before using *fuzzu*-structure; $b$ – prediction of *PEC* error diagram after using *fuzzu*-structure.




– "area" of research on safety level, where there is a high probability of stopping occurrence in transport systems crisis in military operations conditions

**Fig. 2.11. Graphs of *PEC* forecasting error when applying model based on two parallel *HCF***

Analysis of obtained results, i.e. reduction of prediction error of EC safety assessment on average from 10% to 2%, allows you to confirm the effectiveness of using *fuzzu*-structure and ensure possibility of redistributing traffic flows in the temporal and geographical space of industrial zones, taking into account existing "picture" of ecological component.

## 2.2. CONVERGENCE AS MECHANISM FOR SMART SOLUTIONS FORMATION IN SAFETY MANAGEMENT PROCESSES OF TRANSPORT SYSTEM COMPONENTS IN THE MILITARY ACTIONS CONDITIONS

### 2.2.1 Disclosure of convergence characteristics in various aspects of SMART solutions formation for transport systems in the military operations conditions

To reveal the basic characteristics of convergence in various aspects of transport logistics services provision, it is necessary to emphasize the fact that logistics approach has become recognized by majority of users of these services, especially in the military operations conditions, as very important. Military logistics continues to remain heterogeneous both in the scientific aspect and in the theoretical plane of its application.

Research results of based on results of 2017 made it possible to determine the quality of logistics infrastructure in Ukraine (on five-point scale) and rate it at 2.74 points[95, 96]:

– adaptability of organization of international goods supplies – 2.59;

– quality of logistics services – 2.55;

–ability to track cargo – 2.96;

– timeliness of delivery – 3.51.

Compared to 2014, as the time point that determined the beginning of military conflict, according to indicators set, Ukraine received the following results: it took 80th place in rating and had score of 2.74 points, which is 79 positions lower than the leader and 47 positions lower than in Poland. In the assessment, Ukraine is inferior to Germany by 1.49 points, and it is inferior to Poland by 0.69 points. In the categories, Ukraine held different positions: the best logistics of the country was evaluated from the point of

[95] Siva Kumar; Aaron Chia Commercial logistics vs. military logistics : a conceptual analysis/ Cases on supply chain and distribution management : issues and principles. – Hershey, Pa. : Business Science Reference, ISBN 978-1-4666-0065-2. – 2012. – P. 290–329.

[96] Сапіга Р. І. Військова логістика у забезпеченні воєнно-економічної безпеки країни: автореф. дис. … канд. екон. наук: 21.04.01 / Р. І. Сапіга. – К., 2013. – 22 с.

view of "Timeliness", where it took 54th position. "Tracking and control" category was rated a little worse, in which Ukraine took 61st place. Country received a lower overall score for "Infrastructure" (84th place), "International transportation" and "Quality of logistics services" (95th place). Below, Ukraine was evaluated according to the "Customs" criterion, where it took 116th place [97, 98].

Presented results of quantitative assessment of the provided transport services quality from standpoint of logistics principles implementation during the period of military conflict in the period from 2014 to 2024 allow us to draw conclusion: representatives of scientific community and business in crisis conditions use many (sometimes incompatible with each other) different of logistics technologies, develop and implement "unique" models, methods, mechanisms and algorithms designed for logistics of material and technical processes support for consumers of transport services. At the same time, role of the state, which needs to accelerate adaptation of regulatory framework necessary for modern logistics technologies introduction, remains insignificant.

It should be noted that in modern conditions existing crises, including military crisis, encourage transport systems development, which changes approaches to building supply chain, which are becoming more and more integrated and flexible from the point of view of all participants in logistics relations. Sustainable development of the field of transport logistics in the military operations conditions is provided by Internet technologies. Commercial and state enterprises that seek to use Internet technologies in their activities in the context of military operations should be guided by fact that it is necessary not only to consider the issue of single precedent introduction within the scope of warehouse work, provision of transport services or their documentation, but also to ensure quality and safety of these processes.

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[97] Global Firepower Military Ranks 2015 [Електронний ресурс]. – Режим доступу: http://www.globalfirepower.com/ countries-listing.asp/

[98] ENISA programming document 2019-2021 // - Strategic plan 2020-2024 – Informatics - European Commission (europa.eu) // https://commission.europa.eu/publications/strategic-plan-2020-2024-informatics_en.

From the point of view of transport logistics theory in the military operations conditions, Internet technologies can combine various assets from supply chain, and then analyze data obtained from these connections to generate SMART solutions in the processes of managing safety of transport system components.

Thanks to this, Internet technologies allow transport and logistics services to achieve higher levels of operational and safety efficiency, creating individual, dynamic and automated services for their customers in the military operations conditions.

Let's consider peculiarities of transport and logistics systems functioning using example of material and technical support systems (MTS) of military organization of the state (Armed Forces of Ukraine (AFU)), which functions for benefit of providing military consumers with products, works and services. It is possible to qualify MTS AFU system as complex and accumulating in itself all problems characteristic of transport and logistics systems: hierarchy, geographic branching in terms of its components location, large number of nomenclature items, high cost of spare parts, etc.

Interaction of elements of MTS AFU system is a complex set of information processes that include customer, consumers, suppliers, relevant departments and services, warehouses, arsenals, etc.[99].

Information processes that flow in the system involve collection, processing, storage and formation of new aggregated information about the system state. On the basis of information received and accumulated in this way, SMART decisions are generated and appropriate actions are taken. Therefore, effectiveness and safety of information processes largely determines effectiveness of functioning in the transport and logistics systems of MTS AFU.

In this regard, implementation of SMART solutions in the military sphere can be focused, first of all, on increasing efficiency of information processes (here direct connection with commercial logistics systems can be seen). The main innovations in this field, according to military experts,

[99] Tsvetkov V. Ya. Information interaction // European researcher. Series A.– 2013, № 11- 1 (62). – C. 2573-2577.

should include creation of automated systems for managing transport and logistics processes in AFU, introduction of automatic identification means of military products, development of cataloging system of supply items to AFU, etc.

Implementation of automated systems will allow to ensure effective solution of the main tasks:

– accounting for condition and movement of entire spectrum of material resources (items of supply, fuel and lubricants, consumables, military-technical property, etc.);

– collection and assessment of needs of military formations in material resources, works and services;

– assessment of purchased resources volumes; planning of execution of works and resources supply;

– rational spending of material resources;

– estimation of costs for MTS of military consumers.

In our opinion, promising direction for management of logistics processes development in AFU is the use of "updated" control tools and related software and technical complexes designed for collection, storage and processing of data on availability, need, accounting for movement and consumption of material resources.

This technology allows to register and transmit to military administration data on: technical condition; movement of military equipment; fuel and lubricants consumption, which ensures high reliability and relevance of information necessary for decision-making on MTS management.

If we talk about possibilities of convergence of commercial and departmental logistics, then it is necessary to proceed from the fact that by convergence we understand the process of convergence and search for compromises between two logistic approaches that have both the same and specific characteristics. Commercial logistics systems are more open and, as a rule, ready for rapid changes, introduction of new managerial and technical innovations. Departmental logistics systems, on the contrary, are conservative.

Information on providing military consumers with products (items and volume of material resources to be supplied or placed at storage facilities), as a rule, has access restrictions.

Nevertheless, modern realities are such that convergent approach to optimizing supply chains in departmental logistics systems involves the possible convergence of various methods of optimizing supply chains used by commercial companies, one way or another embedded in supply system of military products.

In order to form common understanding of convergence directions in supply chains optimization in departmental logistics systems, we will consider the main levels at which it is possible to use new technologies and approaches that are not traditional for the MTS AFU system.

In total, three levels can be distinguished:

1) strategic level, at which tasks that arise before military logistics systems are solved (development, administration of logistics system, performance of basic management functions in order to achieve its main goals);

2) operational level (management of material and technical resources movement necessary for military organization functioning), the main task of which is to ensure constant control over progress of production orders execution and provide necessary influence on logistics system in order to keep its parameters within specified limits for goals achievement set for organization. At this level, it is possible to distinguish its main functions of flow management, such as demand forecasting, supply planning, coordination of actions, supply control and performance analysis;

3) tactical level: obtaining material resources, transportation of material resources, their cargo processing, storage and distribution.

Presented levels of logistics system were compared with possible directions of commercial and departmental logistics convergence. As a result, matrix of application of promising logistics technologies at specific level was obtained, which shows compliance with principle of "task-tool-SMART solution" (table 2.6).

Table 2.6

**Evaluation matrix of SMART solutions application within framework of commercial and departmental logistics convergence of transport systems in the military operations conditions**

| Level of transport and logistics systems | Solutions used in transport systems in the military operations conditions (existing and SMART) | |
|---|---|---|
| | Departmental transport systems | Commercial transport systems |
| 1 | 2 | 3 |
| Strategic (development planning, logistics system administration, performance of basic management functions) | Administration of logistics system is carried out centrally, all decisions are made after approval at all management levels. Planning measures, as a rule, are short- and medium-term in nature | It is used as centralized and decentralized approach. In transport systems, due to the high degree of IT implementation, some management decisions can be made without human participation. There is possibility of long-term planning in the transport systems development |
| | It is allowed to expand degree of MTS processes automation of military consumers, development and implementation of algorithms and programs, purpose of which is to increase autonomy degree in the performance of some administrative tasks within the framework of transport planning | |

**Continuation of table 2.6**

<table>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr><td rowspan="2">Operational (forecasting the need for material resources, supply planning, coordination, control and analysis of the effectiveness of logistics processes)</td><td>Tasks are performed, as a rule, using classic technologies. The use of IT is limited and fragmented, which significantly reduces efficiency of their use, document circulation is carried out on paper media. Measures of control and analysis of logistics processes require direct human participation</td><td>IT technologies are widely used. The use of modern SMART concepts makes it possible to automatically replenish stocks, redistribute them between warehouses, taking into account the need. The process of monitoring and analyzing efficiency of transport systems allows to assess effectiveness of technological operations in real time</td></tr>
<tr><td colspan="2">In the process of convergence, it is possible to adapt commercial channel distribution technologies to support military consumers. Forecasting and planning can be carried out by connecting all consumers to a single network, as result of which degree of reliability of the material and technical means need will increase. At the same time, departure from centralized model of provision is possible. This will reduce number of elements in supply chain and reduce amount of inventory held in warehouses. Control, analysis and evaluation of departmental logistics systems efficiency will be carried out fully automatically.</td></tr>
</table>

**Continuation of table 2.6**

| 1 | 2 | 3 |
|---|---|---|
| Tactical (receiving materials, their transportation, processing, storage and delivery) | Existing scheme of supplies of material funds has practically not undergone transformation since the middle of 20th century. Transport, warehouse, end consumer are connected by operations of loading/unloading, receiving/issuing in certain (set) terms (periods). In real time, information about availability and quantity of materials stored in warehouse is usually unavailable to the end user. Tracking their movement, with some exceptions, is also impossible in logistics system | Logistics operations carried out on the "last mile of delivery" are not considered in isolation. Everything, starting from product characteristics and its packaging and ending with feedback of the final consumer, is a single system synchronized in time and space. It is possible to track order movement according to logistics system, both at the control points of its passage and in real time. Depending on activity effectiveness, the system is constantly adapted to customers requirements |
| | Tactical level of logistics system has significant prospects for temporary logistics technologies implementation, since, unlike strategic and operational, it is directly related to end consumers. Not only technical innovations that allow monitoring and control of material resources movement (storage) on real-time scale may be in demand. | |

As part of commercial and departmental logistics convergence, one should not forget that this process has some peculiarities, first of all, they will be associated with the need for significant investments in logistics systems development, finding common properties and verifying principles of joint work. The second feature is the need to preserve and protect

information on real amounts of material resources produced and supplied for benefit of the state military organization and to prevent collection, analysis and use of relevant information for benefit of foreign countries intelligence services. Thus, summarizing, it can be concluded that in order to achieve the goals of implementing convergent approach in optimization of supply chains in commercial and departmental logistics systems, it is necessary to solve a complex of interdependent tasks [24÷29]:

– to ensure flexible approach to existing technologies use for various types of logistics systems;

– to combine elements of administration for information exchange between all participants of logistics processes;

– to form confidential data processing system of closed nature (encryption, information protection, etc.);

– focus on the implementation and use of Internet by creating a whole network of smart assets interconnected throughout the supply chain.

### 2.2.2 Information safety assessment mechanism of SMART solutions components for transport systems in the military operations conditions (for example an airline)

With the transition of air transport companies' operation from their "regular" activities to work in the conditions of military conflicts, changes have occurred in the field of providing transport services, which have contributed to a fundamental reformatting of the market for their consumption. Such changes have necessitated the development and implementation of organizational-management SMART decisions in the work of air transport companies, capable of flexibly responding to conditions characterized by low certainty and insufficient security stability.

Ensuring the necessary level of organizational-management SMART decisions' efficiency is achieved using an innovative mechanism for assessing the level of information security of air transport companies in rapidly changing conditions inherent in military conflicts.

The practical implementation of organizational-management SMART decisions will ensure the necessary level of competitiveness of air transport organization systems, the activities of which are aimed at satisfying the demand for transport services, formed especially during periods of "peak" loads on the activities of air transport companies caused by military conflicts. The specificity of "peak" loads during military conflicts is characterized by the need to organize the operation of air transport in such a way as to maximize amount of transportation across various geographical directions within a limited time interval. This task can be effectively solved using the basic principles of military logistics.

***The research hypothesis*** assumes that the process of forming effective organizational-management SMART decisions is complex, aimed at ensuring the information security of systems providing transportation services. The level of complexity of the process depends not only on the qualitative and quantitative characteristics of its subprocess components, which, in turn, are affected by various factors, including seasonality, temporal and geographical scope of the research, but also on the rapidly changing conditions inherent in military conflicts.

To formalize the task of ensuring effective management of information security levels, the results of research characterized by the destructive impact of various "nature" inherent in rapidly changing conditions of military conflicts have been used.

Decomposing the process of managing the level of information security in the operations of air transport companies in conditions of military conflicts has allowed identifying the main elements of the task:

– ***the object of destructive changes*** – types of cyber threats and mechanisms of counteraction in the sphere of activities of air transport companies, represented in the form of an Ishikawa diagram (Fig. 2.12) based on the performance indicators of the European Union Agency for Network and Information Security (ENISA) [100, 101].

[100] The Internet of Things [Электронный ресурс] Режим доступа: https://www.cisco.com/web/offer/emear/38586/images/Presentations/P11.pdf.
[101] Tsvetkov V. Ya. Information Units as the Elements of Complex Models // Nanotechnology Research and Practice. – 2014, Vol. (1), № 1. – P. 57–64.

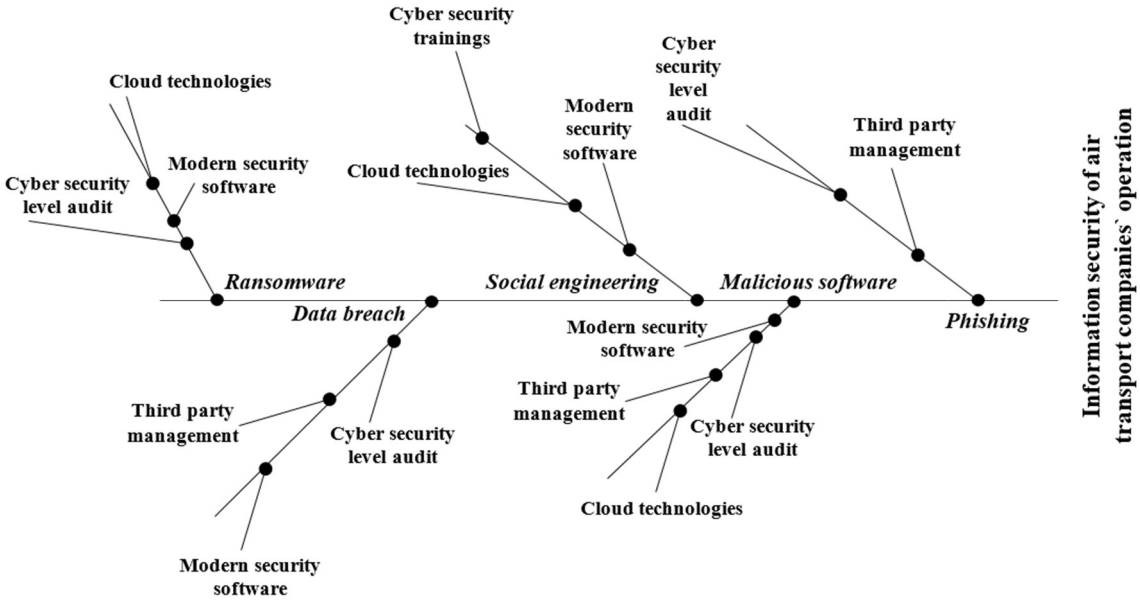



**Fig. 2.12. Ishikawa Diagram: Types of Cyber Threats and Common Countermeasures in of Air Transport Companies**

The disruption of the functionality of the transportation service provision system, which is attributed to the constant conflict of goals among its subprocess components, insufficient level of security stability in the activities of air transport companies, and the rapidly changing conditions inherent in military conflicts:

– ***managerial influence*** – influence aimed at determining the weight characteristics of destructive changes from cyber threats and mitigating their consequences in the activities of air transport companies in conditions inherent to military conflicts;

– ***external regulation*** – influence of external forces regarding the systems of organizing transportation by air, which determines the possibilities of management (legislative, economic, organizational, and other constraints).

As part of the object of destructive changes, subprocess elements can be distinguished, which directly implement its basic functions, as well as those elements formed to protect against adverse effects of the external environment in conditions inherent to military conflicts.

***Mechanisms supporting the information security of air transport companies*** are divided into two groups:

(1) pre-formed and operate on a permanent basis;

(2) implemented in conditions inherent to military conflicts without significant adjustments and to counteract destructive influences.

***Recovery mechanisms for the information security of air transport companies*** are absent during the "normal" functioning of the system but are created in case of a destructive process.

Let's provide conditional symbols for further ***formalization of the task***:

*D(t)* – state of the system where the actual maximum security (the "peak/emergency" operation mode of the airline) corresponds to its maximum planned information security (the "normal" operation mode of the airline);

*I(t)* – indicators characterizing the state of the components of the transportation service provision system and requiring protection from the existing spectrum of cyber threats in conditions of military conflicts;

*u(t)* – indicators characterizing the state of the components of the transportation service provision system and aimed at preventing disruptive changes;

*a(t)* – indicators characterizing the state of the components of the system aimed at eliminating the consequences of disruptive changes;

*e(t)* – "security" effect from organizational-management influence;

*EN(t)* – indicators characterizing external regulation in conditions inherent to military conflicts;

*W(t)* – intensity of disruptive influences;

*z(t)* – managerial influence (developed complex of organizational-management SMART decisions in the work of air transport companies in conditions of military conflicts) and existing standards;

*Θ, Ω, Ξ, Ψ* – functions defining the change in the state of the controlled and controlling components of the systems, as well as the efficiency of organizational-management SMART decisions in the work of air transport companies in conditions of military conflicts;

*t* – time space;

$n$ – the number of observation operations in the research procedure.

$$D(t_i) = \Theta(I(t_i); u(t_i); a(t_i); EN(t_i)), i = 1...n, \quad (2.24)$$

$$I(t_i) = \Omega(I(t_{i-1}); e(t_{i-1}); W(t_{i-1})), i = 2...n, \quad (2.25)$$

$$u(t_i) = \Psi(u(t_{i-1}); e(t_{i-1}); W(t_{i-1})), i = 2...n, \quad (2.26)$$

$$a(t_i) = \Psi(a(t_{i-1}); e(t_{i-1}); W(t_{i-1})), i = 2...n, \quad (2.27)$$

$$e(t_i) = \Xi(z(t_{i-1}); D(t_{i-1})), i = 1...n, \quad (2.28)$$

The procedure for restoring the level of information security of the components of the system, which operate at a specific j-th level of the system, also includes mechanisms that affect the entire controlled subsystem. Therefore, the number of elements in this set is one more than the number of hierarchical levels of the transportation service provision system.

The security level of the transportation service provision system can be determined as:

$$\varphi(t, D(t)) = \int_0^t D(\xi)d\xi, \quad (2.29)$$

Thus, the initial task of forming effective organizational-management SMART decisions in the work of air transport companies in conditions of military conflicts boils down to finding, for a given time period, numerous managerial influences z(t) such that:

$$\forall t: \varphi(t, D(t)) \xrightarrow[Z(t)]{} max. \quad (2.30)$$

The relationship between equations (2.24) ÷ (2.27) is a formalized expression of a mathematical model, which serves as the basis for developing mechanisms to support the adoption of SMART decisions aimed

at ensuring security for the components of the system against destructive influences of the external environment in conditions of military conflicts.

***The developed theoretical basis*** involves managing the assessment of the level of interaction of several constraints defining the level of information security of the transportation service provision system in conditions of military conflicts. This enables the achievement and enhancement of the goal from attempts of scattered influence on all or numerous of these same constraints in the work of air transport companies in conditions of military conflicts.

The level of information security of the transportation service provision system in conditions of military conflicts is proposed to be determined by the following SMART indicators, distributed according to factors formed into cluster groups:

*1. Factor of trust level in the digitization process:*

- attitude towards the digitization processes of the information space by transportation service consumers ($I_1$);
- trust in digitization technologies ($I_2$).

*2. Factor of digitization space interactivity:*

- demand for digitization process ($I_3$);
- clarity of digitization processes ($I_4$).

*3. Factor of "adaptiveness" level of digitization space:*

- complexity of digitization processes ($I_5$);
- intensity of digitization process ($I_6$);
- intensity of digitization platform usage ($I_7$);
- intensity of usage of information space digitization technologies ($I_8$);
- level of confidentiality of digitization platforms ($I_9$);
- level of security of digitization platforms ($I_{10}$);
- "transparency" level of digitization platform operators ($I_{11}$);

*4. Factor of users' "development" level for using digitization platforms:*

- assessment of access level to digitization platforms ($I_{12}$);
- assessment of infrastructure development level of digitization platforms ($I_{13}$);
- assessment of interaction level of digitization platforms ($I_{14}$).

The applied implementation regarding the formed indicator pairs of correlations[102] was carried out using the software package Statgraphics 19. The verification of the "weight" of the correlation relationship was performed using the standard statistical criterion α (P-Value - the assessment of the "weight" should not exceed 5%), Samuel S. Wilks' statistic (determines the degree of discriminant analysis quality of the homogeneity assessment of groups, the closer to zero the indicator is, the better the distribution is obtained), and the Chi-square test. The conducted analysis allowed for the well-founded identification of 5 pairs of correlation dependencies between:

- "digitization space" and the degree of trust in the digitization process (Table 2.7);
- "digitization space" and the interactivity of the digitization space (Table 2.8);
- "digitization space" and the degree of "adaptiveness" of the digitization space (Table 2.9);
- "digitization space" and the level of "development" of users for using digitization platforms (Table 2.10).

Table 2.7

**Statistical characteristics of correlations between the "digitization space" and the level of trust in the digitization process**

| No | Characteristic numbers | Correlation coefficient | Lambda Wilks statistic | Chi-square statistic | Number of degrees of freedom | Level of significance |
|---|---|---|---|---|---|---|
| 1 | 0.370650 | 0.6088772 | 0.61509 | 18.4019 | 5 | 0.0051 |
| 2 | 0.021063 | 0.145171 | 0.97893 | 0.80936 | 3 | 0.6669 |

[102] Tsvetkov V. Ya. Information Relations // Modeling of Artificial Intelligence, 2015, Vol. (8), Is. 4. – P. 252–260. DOI: 10.13187/mai.2015.8.252 www.ejournal11.com.

The results of calculating the characteristics of correlations between the "digitization space" and the level of trust in the digitization process, as shown in the table, indicate the presence of a statistically significant relationship of the first pair with a P-Value ≤ 5%. The correlation model between the components of the pair is represented as follows:

$$\begin{cases} U_1 = -0{,}892K_9 + 0{,}345K_{10} + 0{,}183K_{11}, \\ V_1 = 0{,}008K_1 + 0{,}999K_2. \end{cases} \quad (2.31)$$

The weight of each indicator is determined by the coefficient value: the higher it is, the more significant and contributory it is.

Table 2.8

**Statistical characteristics of correlations between the "digitization space" and the interactivity of the digitization space**

| No | Characteristic numbers | Correlation coefficient | Lambda Wilks statistic | Chi-square statistic | Number of degrees of freedom | Level of significance |
|---|---|---|---|---|---|---|
| 1 | 0.573598 | 0.757291 | 0.27049 | 47.049 | 18 | 0.0003 |
| 2 | 0.265989 | 0.516399 | 0.63459 | 16.3675 | 10 | 0.0886 |
| 3 | 0.134399 | 0.366969 | 0.86554 | 5.18791 | 4 | 0.2598 |

The results of calculating the characteristics of correlations between the "digitization space" and the interactivity of the digitization space presented in the table allowed for providing the mathematical expression of the model:

$$\begin{cases} U_1 = -0{,}166K_3 - 0{,}487K_4 + 0{,}073K_5 + 0{,}348K_5 - 0{,}603K_7 - 0{,}337K_8, \\ V_1 = 0{,}148K_9 + 0{,}546K_{10} + 0{,}435K_{11}. \end{cases}$$

Table 2.9

**Statistical characteristics of correlations between the "digitization space" and the degree of "adaptiveness" of the digitization space**

| No | Characteristic numbers | Correlation coefficient | Lambda Wilks statistic | Chi-square statistic | Number of degrees of freedom | Level of significance |
|---|---|---|---|---|---|---|
| 1 | 0.519098 | 0.720498 | 0.21879 | 45.4998 | 18 | 0.0003 |
| 2 | 0.40498 | 0.636957 | 0.58591 | 19.2197 | 10 | 0.0369 |
| 3 | 0.01349876 | 0.115897 | 0.97896 | 0.49197 | 4 | 0.8975 |

The existing correlation dependency, which determines adaptive behavior in the digitization space, is statistically significant for the investigated pair and is described by the model:

$$\begin{cases} U_1 = -0{,}107K_3 + 0{,}231K_4 + 0{,}838K_5 + 0{,}210K_5 - 0{,}179K_7 + 0{,}169K_8, \\ V_1 = -0{,}243K_{12} - 0{,}070K_{13} + 1{,}212K_{14}. \end{cases} \quad (2.32)$$

Table 2.10

**Statistical characteristics of correlations between the "digitization space" and the level of "development" of users for using digitization platforms**

| No | Characteristic numbers | Correlation coefficient | Lambda Wilks statistic | Chi-square statistic | Number of degrees of freedom | Level of significance |
|---|---|---|---|---|---|---|
| 1 | 0.669580 | 0.819398 | 0.27938 | 46.8169 | 9 | 0.0001 |
| 2 | 0.1489596 | 0.89089 | 0.84987 | 6.05199 | 4 | 0.1899 |
| 3 | 0.0001998 | 0.0159687 | 0.99986 | 0.010150 | 1 | 0.9399 |

The existing correlation dependency, which determines the level of connection between the digitization space and the level of "development" of users for using digitization platforms, is described by the model:

$$\begin{cases} U_1 = 0{,}202K_9 + 0{,}348K_{10} + 0{,}580K_{11}, \\ V_1 = 1{,}060K_{12} + 0{,}683K_{13} - 0{,}757K_{14}. \end{cases} \quad (2.33)$$

Creating a digitization space raises an important question of its preservation and security, which is highly relevant for air transport enterprises, especially in the context of military actions. Therefore, let's consider the process of developing a concept for long-term and secure storage of information by air transport as a component of ensuring the efficiency of organizational-managerial SMART decisions in the operation of air transport companies in conditions of military conflicts.

The technological component of the concept of long-term storage and protection of information consists of data backup operations. Modern hardware and software solutions allow implementing the backup process quite flexibly and easily.

Let's highlight the most functional backup mechanisms: full backup; differential backup; incremental backup; image backup; continuous data protection (CDP).

Among the listed mechanisms, directly under the IT systems of transportation logistics, IT "hybrids" can be formed. One such IT "hybrid" is structural backup. This mechanism, during its development, is not subject to automation and is created by programmers. Its distinguishing characteristic is its classification as a structural software system (program engine).

The main goal of creating and implementing these systems is to enable the full restoration of the information complex's operation in conditions of a "deep" crisis, when the downtime of the IT complex ($T_{emergency(IT)}$) tends to zero:

$$T_{emergency(IT)} \to 0 \quad (2.34)$$

The duration of creating comprehensive backup copies and their deployment ($T_{backup}$) can be influenced by endogenous and exogenous factors. Endogenous factors ($T_{en}$) include the loyalty and competence of the air transport company's employees, while exogenous factors ($T_{ex}$) include infrastructure damage due to military actions or natural disasters.

Thus, the time for comprehensive recovery of the IT system ($T_{recovery}$) of the air transport company will be:

$$T_{recovery} = T_{en} + T_{ex} + T_{backup} \quad (2.35)$$

The concept of data backup (DPC) cannot be universal, and there can be no "simple solutions for complex problems" in it. It needs to be developed for each transportation project. In general, it can be represented by a technological scheme (Fig. 2.13).

The secure stability of the IT system (Q) can be represented by the mathematical expression[103]:

$$Q = T_{recovery} / T_{emergency(IT)}, \quad (2.36)$$

Where

$T_{emergency(IT)}$ – an indicator directly dependent on the number of software failures associated with the integrity violation of binary data.

To protect against such threats, it is necessary to implement a document and software certification service. This service is a standard element for modern server operating systems.

[103] Tsvetkov V. Ya. Information Constructions // European Journal of Technology and Design. – 2014, Vol. (5), № 3. – P. 147–152.

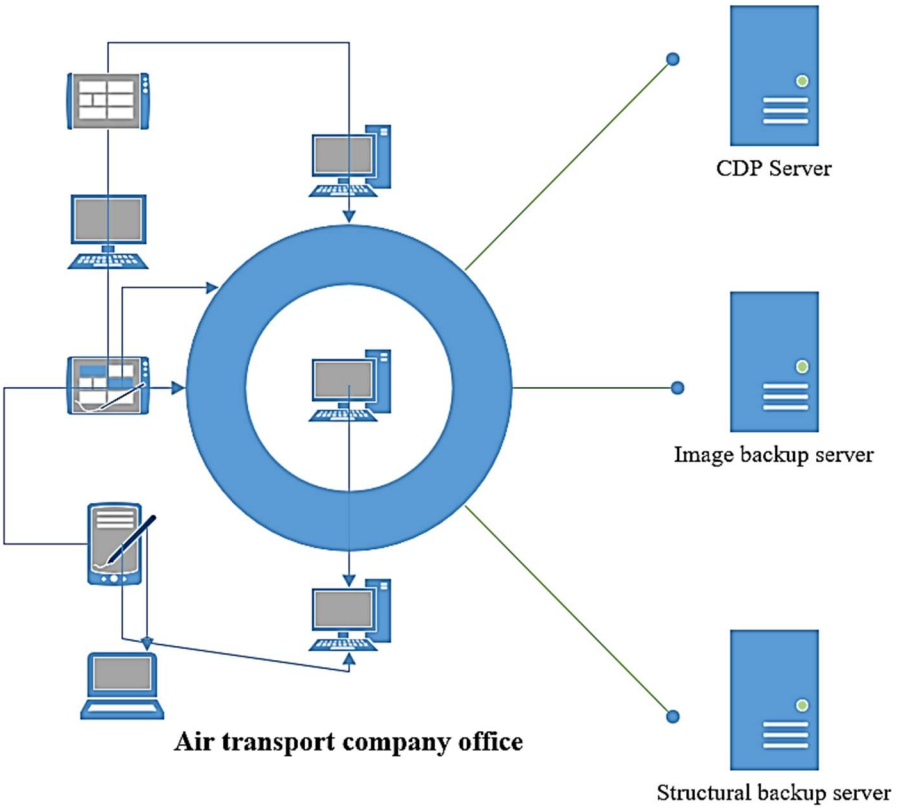



**Fig. 2.13. Technological diagram of the transport company IT system**

Deploying the Public Key Infrastructure (PKI) service activates security technology based on the X.509 standard [104]. This technology utilizes two cryptographic mechanisms: encryption and digital signature. Encryption protects data from unauthorized access by encrypting data with cryptographic keys. Only users with the necessary keys can access the data. Encryption ensures data confidentiality but does not protect against data tampering. Digital signature protects data from unauthorized modification or forgery by applying special algorithms to the data, forming a digital signature. Any manipulations to change the data will be immediately detected during digital signature verification. Digital signature ensures data integrity rather than confidentiality. By combining encryption and digital signature, it is possible to provide data confidentiality and protection

[104] Chen K., Miles I. C. ITS Handbook 2000: Recommendations from the World Road Association (PIARC). – Boston; London: Artech House, 1999. – 434 p.

against unauthorized modifications. The operation scheme of the PKI service is shown in Fig. 2.14.

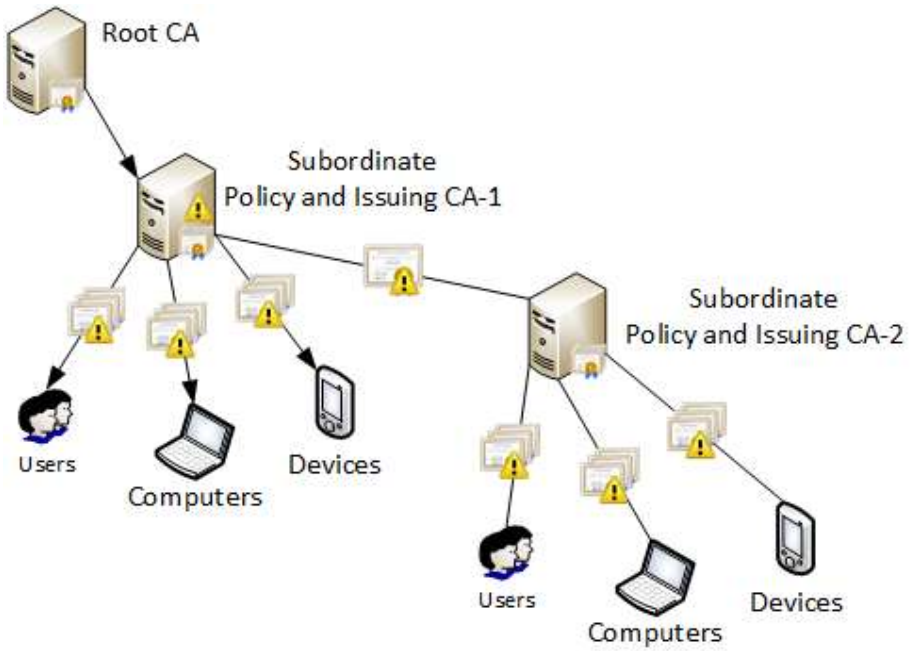



**Fig.** 2.**14**. **Operation scheme of the Public Key Infrastructure service**

Thus, the PKI service is a reliable software component responsible for confirming the identity of employees, as well as confirming the authenticity of computers within the company.

## 2.3. FEATURES OF IMPLEMENTATION OF "HAZARD ANALYSIS AND CRITICAL CONTROL POINTS" SMART SOLUTIONS IN TRANSPORT SYSTEMS IN THE MILITARY ACTIONS CONDITIONS

### 2.3.1 Features of mechanism for analyzing transport system activity quality in the military operations conditions and critical control points (HACCP)

Analysis of hazards and critical control points (HACCP) (fig.2.15) is structured method of identifying hazards and establishing management measures on all analyzed parts of the process to prevent hazards and maintain stability of product quality and safety, but not through inspections of final products.

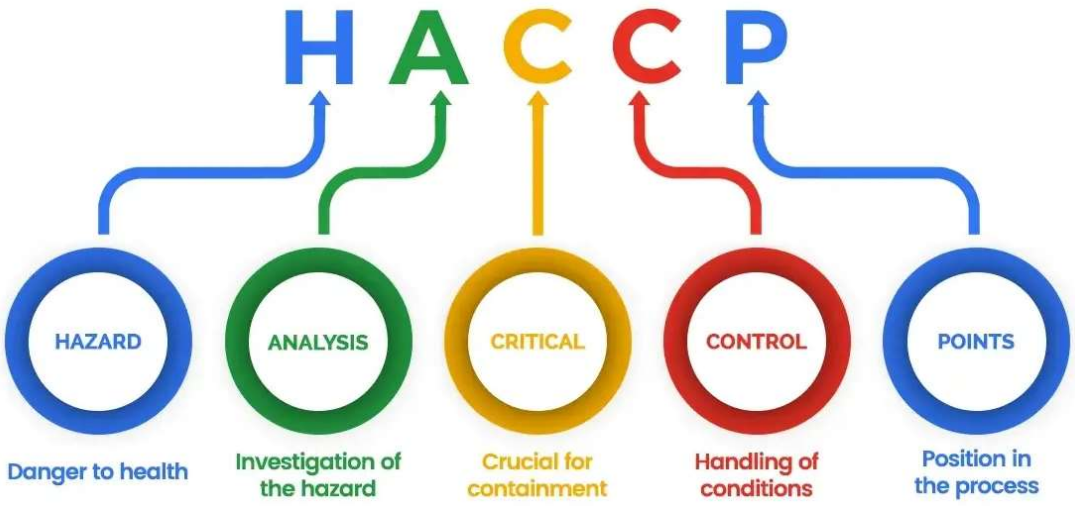



**Fig. 2.15. Seven basic principles of HACCP**

In the military operations conditions, most transport companies develop and implement quality management system (hereinafter referred to as QMS) focused on requirements of international standard ISO 9001. Main idea of QMS is to increase competitiveness, investment attractiveness, simplified crediting, confirmation of customer orientation, etc.

ISO 9001-2009 "Quality management systems. Requirements" (hereinafter – QMS) provides for the use of process approach in the development, effectiveness implementation and improvement of quality management system, essence of which is application of "Plan – Do – Check – Act" (PDCA) cycle to all processes, which is described as follows[105] :

– plan – establish goals and processes necessary to achieve results in accordance with consumer requirements and organization policy;

– do – implement processes;

– check – monitor and measure processes and products in relation to policies, goals and requirements for products and report the results;

– act – to take actions for continuous improvement of processes functioning.

Application of process approach in the context of military operations requires manufacturer of transport services to:

– understanding and fulfilling requirements of service consumer in order to increase satisfaction;

– consideration of processes from the point of view of added value;

– obtaining results of processes and their effectiveness execution;

– constant improvement of processes, based on objective monitoring of service consumer satisfaction and analysis of results.

Model embedded in QMS shows that consumers play significant role in determining service requirements. A key part of QMS is the need to monitor consumer satisfaction (AFU), essence of which is to assess information about consumer's perception of quality of fulfilling his requirements.

Monitoring is based on the study of data from consumers about quality of delivered products or services, analysis of lost opportunities, positive feedback, claims for warranty obligations and dealer reports.

[105] Ambrosino G. Introduction / G. Ambrosino, M. Boero, J. D. Nelson, M. Romanazzo // Infomobility Systems and sustainable transport services / G. Ambrosino, M. Boero, J. D. Nelson, M. Romanazzo. – ENEA, 2010. – Chapter 1. – 340 p

### 2.3.2. Methods of assessing sustainable quality of transport sy.tems functioning using the basic principles of military logistics

Considering transport system from the point of view of military logistics approach, it was found that transport systems must have ability to maintain stable mode of operation under influence of external factors. To assess the level of quality stability of transport systems functioning and degree of adaptation to external conditions, it is necessary to develop appropriate criteria and methods for evaluating effectiveness of their functioning.

Criteria characterizing quality of functioning and degree of transport systems adaptation to rapidly changing external military conditions are currently not fully considered, and as result, there are no systems for analyzing these properties.

This led to the fact that transport systems management in military conditions in order to ensure quality of their functioning and adaptability is at an intuitive level. Thus, development of methodology for assessing quality of transport systems functioning based on analysis of stability and the degree of adaptation to external conditions is relevant and will allow to ensure adoption of adequate and timely management decisions in their work and will meet the norms of ISO 9001-2009.

In the course of research, it was found that for rational application of military logistics principles in service flows management, it is necessary to develop single concept of service quality assessment, based on criteria used by buyer when choosing service provider, to adjust management system in the direction of minimizing discrepancy between expected and actual quality levels.

We consider transport system as micrologistic system, understanding logistic system as an adaptive system with feedback, consisting of several subsystems and having developed connections with external environment. Transport system becomes micro-logistic if it is able to satisfy such criteria as providing each consumer of transport services with transportation at

time convenient for him from the point of departure to destination with minimal costs, in required quantity.

As a result of analysis of various literary sources, it was found that any system is characterized by: circulation of material, financial, and information flows in it, which acquire such relationship, forming final result of its activity, that it becomes not only possible, but also necessary to use logistics, its methods that implement principles of compatibility, actualization, concentration, and stability when solving relevant tasks.

It is necessary to pay attention to the fact that transport systems in military conditions operate in pronounced uncertainty conditions, and its level is constantly changing and depends on factors that determine operation of transport and on complexity of connections between them.

Analysis of transport system functioning in military conditions as logistics system allows us to consider it as a system in which individual needs of consumers of transport services and economic needs of carriers are equally combined.

The purpose of transport company functioning in military conditions as a micro-logistic system is to provide adequate, efficient, convenient and affordable transport service that meets requirements of safety and environment.

It was revealed that the less correspondence between quality level of intrasystem connections of transport systems and characteristics of military environment affecting its functioning, the less it will be adapted to rapidly changing conditions, function less stably, and, therefore, be less sustainable.

Accordingly, degree of adaptation determines the level of transport system adaptability to unforeseen changes in properties of managed object, management objectives or military environment by choosing optimal algorithm of operation, which allows providing high-quality transport service at the right time, in the right place and of high quality.

The smaller the change in military environment leads to reaction of transport system, the higher the level of adaptation, and therefore the quality of transport systems functioning.

Thanks to adaptation, constant optimal level of internal processes of system is maintained, which ensures its quality and survival in this environment.

Therefore, it is suggested that quality of transport systems functioning should be understood as their ability in military operations conditions, as dynamic micrologistic system, to resist influence of external forces that seek to remove it from the "corridor" of effective work within a certain period of time and to maintain values of main functioning parameters within the given limits.

As a criterion for assessing quality of transport systems functioning in military conditions, it is proposed to use the level of system organization as a micrologistic system.

Organization is evaluated taking into account impact of information on the level of uncertainty in system. Degree of organization $R$ determines degree of system deviation from the maximally disordered state and can be determined by formula:

$$R = 1 - (H_t/H_{max}) = H_E/H_{max}, \quad (2.37)$$

where

$H_t$ – target entropy or current value of entropy (uncertainty) of the system;

$H_E$ – negentropy of the system (value inverse of entropy);

$H_{max}$ – maximum possible entropy or uncertainty in the structure and function of system.

If the system is fully deterministic and organized, then $R = 1$ and $H = 0$, and probability of achieving the set goal = 1. If the system is disorganized, then $R = 0$ and $H = H_{max}$ and probability of achieving the set goal = 0. For logistics systems of relative disorganization lies in the range $0 < R < 1$.

It follows from equality (38) that transition to higher degree of system organization reduces its current uncertainty (entropy) due to accumulation of information (increase in negentropy). This means that in order to increase the level of system organization, influx of information and energy is needed both from within system and from the outside.

The degree of system organization increases only with purposeful interaction of system elements. Thus, organization of system is dynamic state of system that allows it to achieve or achieve a set goal.

Solution to the task of quality evaluating the functioning of transport systems in military operations conditions as micrologistic systems consists, first of all, in selection of evaluation criterion.

Entropy, which means organization, fully satisfies universality requirements of reflection of analyzed problem specifics, consistency with previous theories, and dynamism.

### 2.3.3. Method of predictive quality assessment of transport system functioning and its process components based on the risk matrix of military operations

Quality evaluation of transport systems functioning based on the cost of life cycle has drawback, which is that the losses from random events in military operations conditions are calculated according to some probable scenario, parameters of which are determined by an expert. At the same time, in the case of incorrect assumption about possible parameters of risk factors, as well as in the case of their sudden change, which is not foreseen priori, result of the preliminary assessment of economic risk may differ significantly from the actual values and lead to some (sometimes significant) decrease in economic indicators of the project. In this, it is appropriate to evaluate project both according to its various scenarios, and also through parameter that would determine the ability of project to achieve stated goals under the conditions of resource limitations and regardless of development of external and internal factors. In scientific works, such criterion is usually called "stability".

To assess quality, we introduce coefficients of transport system vulnerability and its functional components to risks ($k_y$) and volatility ($k_в$) [106]:

[106] Cruz I. Efficient Selection of Mappings and Automatic Quality-driven Combination of Matching Methods / I. Cruz, F. Antonelli, C. Stroe // The Fourth International Workshop on Ontology

$$k_y = R / LCC \quad (2.38)$$

where:

$k_y$ – coefficient of system vulnerability to risks;

$k_y = 0 \div 1{,}0$;

$R$ – losses from accidental events in the most likely scenario;

LCC – cost of system life cycle, taking into account losses from random events in the most likely scenario.

By analogy with the work[107], we will distinguish levels characterizing level of system vulnerability to risks in military operations conditions (table 2.11):

Table 2.11.

**Levels of transport system vulnerability and its process components in military operations conditions**

| Value $k_y$ | System vulnerability level |
|---|---|
| < 0.15 | Inconsequential |
| 0.15–0.3 | Small |
| 0.3–0.45 | Mild |
| 0.45–0.6 | Average |
| 0.6–0.75 | High |
| 0.75–0.9 | Very high |
| > 0.9 | Critical |

Volatility is a parameter that characterizes frequency of indicators over a period of hour. Initially, this term has been stagnated only in vocabulary of finance to indicate volatility of financial instruments rates, but it will also be stagnated in the lexicon of transport systems, where it means instability, etc. There is stable functionality of any parameter of device.

Matching, Washington DC. – 2009. Pp. 1-12.

[107] Dewan K.K. Carpooling: A Step To Reduce Congestion (A Case Study of Delhi) / K. K.Dewan, I. Ahmad // International MultiConference of Engineers & Computer Scientists. – Newswood Limited, 2006. – Pp. 408-413.

$$k_v = \frac{R_{pes} - R_{opt}}{R_{pes}} \quad (2.39)$$

where:

$k_v$ – volatility coefficient, $k_v$ = 0 ÷ 1.0;

$R_{opt}$ – losses from random events under optimistic scenario;

$R_{pes}$ – losses from random events under pessimistic scenario.

Let's highlight levels that characterize volatility of indicators that determine level of sustainable quality of transport system functioning (table 2.12):

Table 2.12

**Volatility levels of system and its process components in military operations conditions**

| **Value $v$** | **Volatility level** |
|---|---|
| < 0.2 | Stable |
| 0.2–0.4 | Moderately stable |
| 0.4–0.6 | Average |
| 0.6–0.8 | Changeable |
| > 0.8 | Very changeable |

For integral influence assessment of the above-mentioned factors, we will introduce concept of functioning quality stability to risks, which is evaluated using stability coefficient:

$$Ky = (1 - k_v)(1 - k_y) \quad (2.40)$$

Depending on obtained values, seven levels of risk can be distinguished in transport system during implementation of technical rearmament in transport processes (table 2.13).

Table 2.13

**Levels of vulnerability of transport system and its process components in military operations conditions**

| **Value $y_r$** | **Risk level** |
|---|---|
| > 0.9 | Inconsequential |
| 0.75–0.9 | Small |
| 0.6–0.75 | Mild |
| 0.45–0.6 | Average |
| 0.3–0.45 | High |
| 0.15–0.3 | Very high |
| < 0.15 | Critical |

Thus, using obtained values of coefficients, we will build matrix of risk levels, which is the basis for making management decision regarding system (see fig. 2.17).

If *Ky* > 0.75, system can be recognized as not vulnerable and recommended for implementation. When *Ky* < 0.3, system is obviously vulnerable. The most difficult from the point of view of decision-making is so-called "transitional" zone (fig. 2,16), in which there is no unambiguous solution according to "vulnerability" criterion. At the same time, when comparing analog systems with close levels of vulnerability, those that are less volatile are better. Due to the fact that, having more reliable forecast of losses from random events, it is possible to build better risk management system.

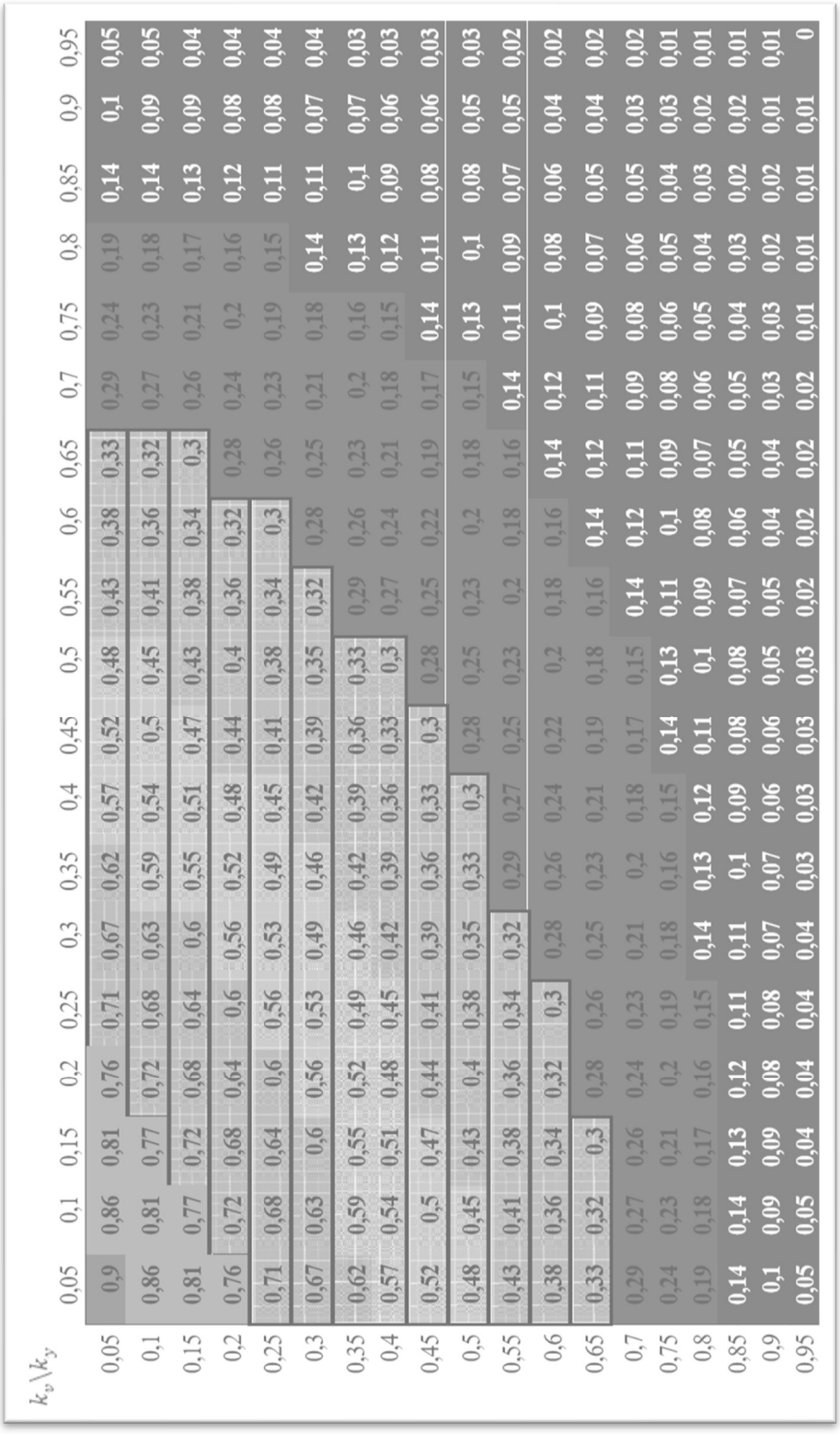
### 2.3.4. Algorithm for making management decision regarding transport systems in military operations conditions using method of cognitive maps

One of the tasks of risk analysis and management is to identify relationships between risk factors and risks. The most difficult from the point of view of decision-making is highlighted in fig. 2.16 range of values. To make decision on such projects, it is necessary to analyze risk factors of second level in detail. We use method of "cognitive cards" for analysis.

Cognitive maps were first proposed by R.M. Axelrod as a tool for modeling political decisions, and then extended by B. Kosko by introducing fuzzy values. Also, fuzzy cognitive maps are used in risk assessment, for example, in risk modeling, crisis management and decision-making, analysis of economic systems development and introduction of new technologies, system analysis. An overview of fuzzy cognitive maps and their applications can be found in works[108].

Cognitive maps are directed graphs whose vertices are concepts, while edges are used to express causal relationships between them. The set of concepts C = {c1 … c*n*} appearing in model includes events, conditions of their occurrence or other relevant factors. Classical state is *n*-dimensional vector of levels of concepts influence on each other (n = |C|), which can represent values belonging to ranges [0; 1] or [-1; 1]. Causal relationships between concepts are represented in FCM by edges and assigned weights. Positive weight of edge connecting two concepts $c_i$ and $c_j$ simulates situation where increase in level of $c_i$ leads to increase in $c_j$. Negative weight is used to describe opposite relationship. In the simplest form of cognitive map, values from the set {–1, 0, 1} are used as weights. They are graphically represented as minus sign (-) attached to edge, absence of edge (no connection), or a plus (+).

[108] Yanton-Drozdovska E. International competitiveness of the enterprise // Actual problems of economic development of the region. -2020. -Issue 16. - Vol. 2. -P. 10-17.



| $k_v \backslash k_y$ | 0,05 | 0,1 | 0,15 | 0,2 | 0,25 | 0,3 | 0,35 | 0,4 | 0,45 | 0,5 | 0,55 | 0,6 | 0,65 | 0,7 | 0,75 | 0,8 | 0,85 | 0,9 | 0,95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0,05 | 0,9 | 0,86 | 0,81 | 0,76 | 0,71 | 0,67 | 0,62 | 0,57 | 0,52 | 0,48 | 0,43 | 0,38 | 0,33 | 0,29 | 0,24 | 0,19 | 0,14 | 0,1 | 0,05 |
| 0,1 | 0,86 | 0,81 | 0,77 | 0,72 | 0,68 | 0,63 | 0,59 | 0,54 | 0,5 | 0,45 | 0,41 | 0,36 | 0,32 | 0,27 | 0,23 | 0,18 | 0,14 | 0,09 | 0,05 |
| 0,15 | 0,81 | 0,77 | 0,72 | 0,68 | 0,64 | 0,6 | 0,55 | 0,51 | 0,47 | 0,43 | 0,38 | 0,34 | 0,3 | 0,26 | 0,21 | 0,17 | 0,13 | 0,09 | 0,04 |
| 0,2 | 0,76 | 0,72 | 0,68 | 0,64 | 0,6 | 0,56 | 0,52 | 0,48 | 0,44 | 0,4 | 0,36 | 0,32 | 0,28 | 0,24 | 0,2 | 0,16 | 0,12 | 0,08 | 0,04 |
| 0,25 | 0,71 | 0,68 | 0,64 | 0,6 | 0,56 | 0,53 | 0,49 | 0,45 | 0,41 | 0,38 | 0,34 | 0,3 | 0,26 | 0,23 | 0,19 | 0,15 | 0,11 | 0,08 | 0,04 |
| 0,3 | 0,67 | 0,63 | 0,6 | 0,56 | 0,53 | 0,49 | 0,46 | 0,42 | 0,39 | 0,35 | 0,32 | 0,28 | 0,25 | 0,21 | 0,18 | 0,14 | 0,11 | 0,07 | 0,04 |
| 0,35 | 0,62 | 0,59 | 0,55 | 0,52 | 0,49 | 0,46 | 0,42 | 0,39 | 0,36 | 0,33 | 0,29 | 0,26 | 0,23 | 0,2 | 0,16 | 0,13 | 0,1 | 0,07 | 0,03 |
| 0,4 | 0,57 | 0,54 | 0,51 | 0,48 | 0,45 | 0,42 | 0,39 | 0,36 | 0,33 | 0,3 | 0,27 | 0,24 | 0,21 | 0,18 | 0,15 | 0,12 | 0,09 | 0,06 | 0,03 |
| 0,45 | 0,52 | 0,5 | 0,47 | 0,44 | 0,41 | 0,39 | 0,36 | 0,33 | 0,3 | 0,28 | 0,25 | 0,22 | 0,19 | 0,17 | 0,14 | 0,11 | 0,08 | 0,06 | 0,03 |
| 0,5 | 0,48 | 0,45 | 0,43 | 0,4 | 0,38 | 0,35 | 0,33 | 0,3 | 0,28 | 0,25 | 0,23 | 0,2 | 0,18 | 0,15 | 0,13 | 0,1 | 0,08 | 0,05 | 0,03 |
| 0,55 | 0,43 | 0,41 | 0,38 | 0,36 | 0,34 | 0,32 | 0,29 | 0,27 | 0,25 | 0,23 | 0,2 | 0,18 | 0,16 | 0,14 | 0,11 | 0,09 | 0,07 | 0,05 | 0,02 |
| 0,6 | 0,38 | 0,36 | 0,34 | 0,32 | 0,3 | 0,28 | 0,26 | 0,24 | 0,22 | 0,2 | 0,18 | 0,16 | 0,14 | 0,12 | 0,1 | 0,08 | 0,06 | 0,04 | 0,02 |
| 0,65 | 0,33 | 0,32 | 0,3 | 0,28 | 0,26 | 0,25 | 0,23 | 0,21 | 0,19 | 0,18 | 0,16 | 0,14 | 0,12 | 0,11 | 0,09 | 0,07 | 0,05 | 0,04 | 0,02 |
| 0,7 | 0,29 | 0,27 | 0,26 | 0,24 | 0,23 | 0,21 | 0,2 | 0,18 | 0,17 | 0,15 | 0,14 | 0,12 | 0,11 | 0,09 | 0,08 | 0,06 | 0,05 | 0,03 | 0,02 |
| 0,75 | 0,24 | 0,23 | 0,21 | 0,2 | 0,19 | 0,18 | 0,16 | 0,15 | 0,14 | 0,13 | 0,11 | 0,1 | 0,09 | 0,08 | 0,06 | 0,05 | 0,04 | 0,03 | 0,01 |
| 0,8 | 0,19 | 0,18 | 0,17 | 0,16 | 0,15 | 0,14 | 0,13 | 0,12 | 0,11 | 0,1 | 0,09 | 0,08 | 0,07 | 0,06 | 0,05 | 0,04 | 0,03 | 0,02 | 0,01 |
| 0,85 | 0,14 | 0,14 | 0,13 | 0,12 | 0,11 | 0,11 | 0,1 | 0,09 | 0,08 | 0,08 | 0,07 | 0,06 | 0,05 | 0,05 | 0,04 | 0,03 | 0,02 | 0,02 | 0,01 |
| 0,9 | 0,1 | 0,09 | 0,09 | 0,08 | 0,08 | 0,07 | 0,07 | 0,06 | 0,06 | 0,05 | 0,05 | 0,04 | 0,04 | 0,03 | 0,03 | 0,02 | 0,02 | 0,01 | 0,01 |
| 0,95 | 0,05 | 0,05 | 0,04 | 0,04 | 0,04 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,02 | 0,02 | 0,02 | 0,02 | 0,01 | 0,01 | 0,01 | 0,01 | 0 |

**Fig. 2.16. Matrix of risk levels**

Figure 2.17. shows example of cognitive map, vertices of which are assigned concepts $c_1$, $c_2$, $c_3$ and $c_4$, and edges are assigned linguistic weights that determine mutual influence. Corresponding $E$-matrix is determined by formula:

$$E = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & -0.33 \\ 0.66 & 0.33 & 0 & 0 \\ 0 & 0.66 & -1 & 0 \end{bmatrix} \quad (2.41)$$

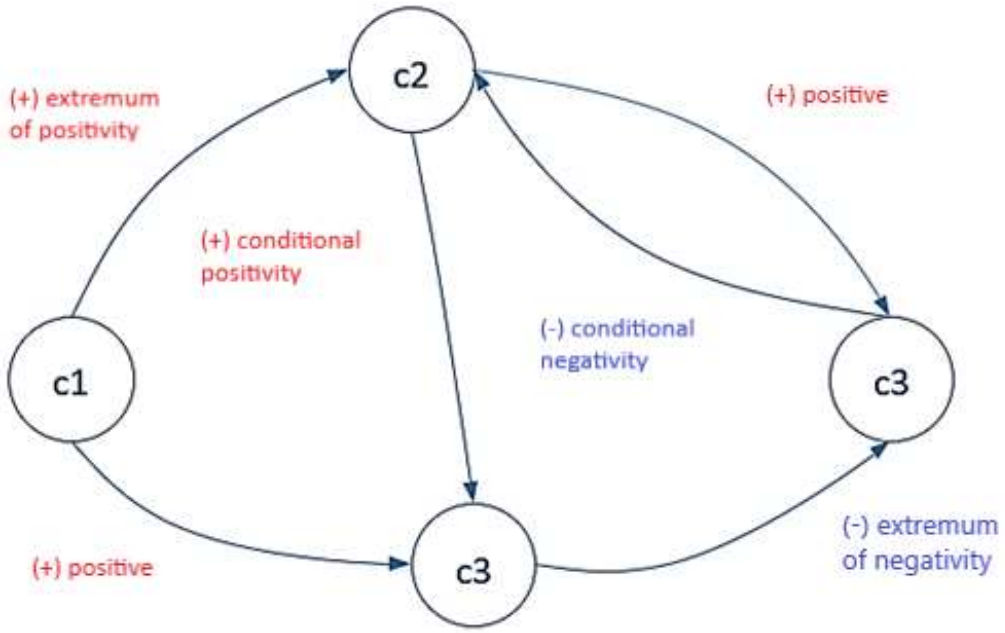



**Fig 2.17. Example of cognitive map**

Risk assessment methodology consists of basic steps common to various standards and manuals. Significant difference of cognitive maps method is analysis of risk factors influence on each other and tracking of their dependencies during risk assessment.

Proposed cognitive map (figure 2.18) has three hierarchical levels:

1. Higher level – "Damage from accidental events".
2. Middle level – "Factors of the 1st level".

3. Basic level – "Factors of the 2nd level".

Negative impact of threat on damage can be offset by appropriate countermeasure. Countermeasures are determined in accordance with the requirements for object's operation reliability. Usually countermeasures on their own do not qualitatively improve resulting parameters of project, they only reduce the risk.

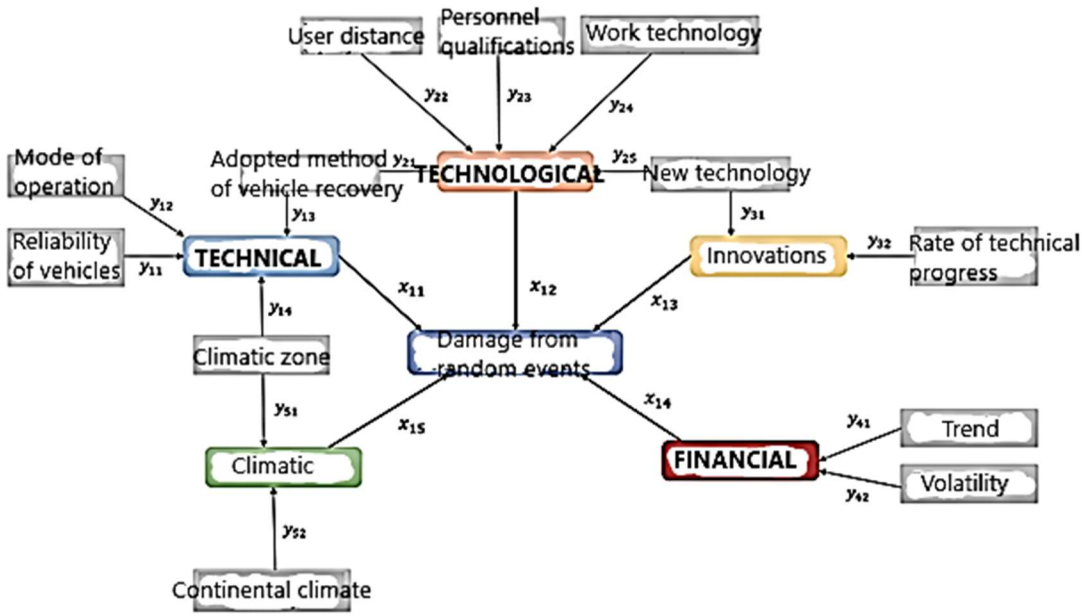



**Fig. 2.18. Conceptual model of cognitive card for assessing losses from accidental events in military operations conditions**

Parameters $x_{11}...x_{15}$ are calculated as share of losses from random factors in the total amount of losses from random events according to formula:

$$x_{1i} = R_i / R \qquad (2.42)$$

where:

$x_{1i}$ –influence of $i$-th factor;

$R_i$ – damage from random events by $i$-th factor;

$R$ – general damages from random events.

Evaluation of parameters $y_{11} - y_{52}$, which reflect influence of the 2nd level factors on the 1st level factors, can be carried out both completely by expert methods and on the basis of factor weights and their deviations from optimal values. Such assessment is carried out in following sequence:

1) Determine weight of each factor of 2nd level [0; 1]. At the same time, equality must be fulfilled:

$$\sum_{j=1}^{n} w_j = 1 \tag{2.43}$$

where

$w_j$ –weight of the *j*-th factor;

n – number of influencing factors.

2) Determine optimal value of parameters of factors $Z_{j\,\text{opt}}$.

3) Calculate influence of each factor according to formula:

$$y_{ij} = \frac{|Z_{j\,\text{опт}} - Z_j| * w_j}{\sum_{j=1}^{n} |Z_j - Z_{j\,\text{опт}}| * w_j} \tag{2.44}$$

where

$Z_j$ – is current value of 2nd level factor;

$Z_{j\text{opt}}$ –optimal value of 2nd level factor.

1. Determination of significant factors. Input for this step is existing project documentation defining its concept and structure, as well as statistical data on projects of this type. Result is considered to be a set of factors, impact of which is significant for system.

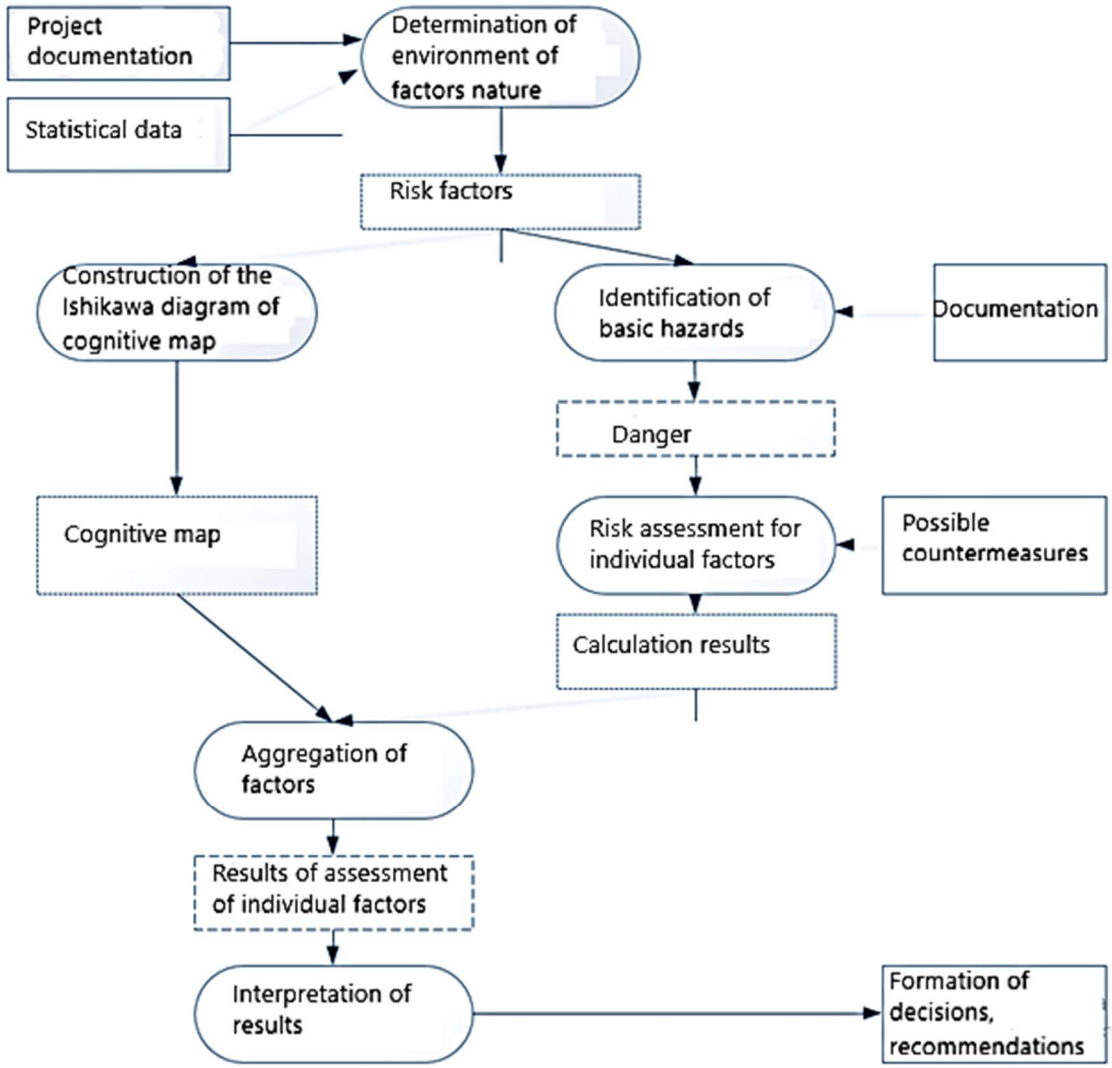



**Fig. 2.19. Risk assessment process**

2. Construction of cognitive maps. At this stage, influence of low-level factors on higher-level factors is determined.

## 2.4. SMART SOLUTIONS IMPLEMENTATION IN INNOVATIVE COMPONENTS OF AVIATION TRANSPORT SYSTEM UNDER MILITARY CONDITIONS

### 2.4.1. Problems of patrolling large areas

Patrol tasks take place in real time, so response time to alarming events must be minimized. Alarming event in this context means unauthorized intrusion into protected perimeter. Usually, it is not by chance that outsiders enter guarded object, they understand that perimeter is fenced, or there are signs on it prohibiting passage. In other words, we are dealing with group of people who have certain intention, which implies actions with the aim of penetrating protected object.

Therefore, uniform of offenders will have elements of camouflage in environment and nature of their movement will be thought out. Of course, it cannot be ruled out that people who accidentally got lost can enter protected area. But unlike intruders, strays will signal their presence in protected area to get help as soon as possible. Therefore, the main purpose of air patrol will be to detect groups of violators of guarded perimeter. Main advantage of using aviation in patrolling is speed of detecting alarming event. Psychological factor cannot be overlooked, if violators know and visually detect air patrol of the territory, they will be traumatized to commit crime. Whereas ground patrols give violators big head start in time. Of course, it should be taken into account that road patrolling affects roads and area adjacent to them. This gives violators considerable advantage, they can, taking advantage of time interval for passage of patrol cars, go to protected territory, while avoiding passage of cars.

### 2.4.2. Problems of patrolling large geographical area and features of using UAV for patrolling

With the advent of UAV era, many tasks from transport sector have passed to robotic "hands" of drones. It is indisputable fact that there are many closed and protected areas in cities and beyond. And indeed, we see work of patrol drones there. But as practice shows, use of UAV is effective in small areas and perimeters. In most cases, helicopter-type UAVs are used for patrolling. This is due to their high maneuverability. But this also results in disadvantages – such UAVs cannot use lifting force of wing, so they require a lot of energy to power engines. By equipping UAV with high-contrast camera, night vision camera, and infrared scanner, you can fully monitor small perimeter and objects located on it.

Today, electronics have made great strides and what we see now was only seen in sci-fi movies until recently. However, UAVs still have very weak point, and that is the power source. With all modern developments, industry cannot provide batteries that ensure ultra-long operation of UAV electric motors. In small and large cities, this problem is solved by installing many charging stations. In addition, UAVs are charged automatically. Approaching such station, drone (helicopter type) carefully lands on specially equipped landing pad. After landing, UAV transmits authentication data, and voltage is applied to electrodes, which ensures rapid recharging of batteries. Such stations are installed in large numbers in Seoul, Tokyo and other cities.

Situation is completely different in sparsely populated area, which can be forests, sea bays in mountainous landscape, wide riverbeds and reservoirs, and steppe landscape. At the moment, it is difficult and economically impractical to install charging stations in such area, so it is not worth counting on patrolling large and remote perimeter only with drones. To solve the problem of patrolling hard-to-reach large perimeters, it is necessary to use manned aviation.

Thanks to the use of navigation fields of GPS satellites, or Galileo, it is possible to track location of UAVs in almost real time. Also, thanks to the Starlink system, it is possible to receive data stream and control the drone.

However, relying on single external system is not right solution. Any, even the most reliable system should be duplicated. History already knows cases of failures in the Starlink system, which could theoretically lead to the loss of control and the loss of UAV.

We offer to create auxiliary navigation fields and data flow transmission channels for remote control of UAVs based on radio relay communication. Radio relay communication towers are closed hardware and software navigation system on certain perimeter. This will allow, in absence of GPS or Starlink signal, to control, receive telemetry and receive data stream from drone. Scheme of application of such UAV communication complex is shown in figure 2.20.

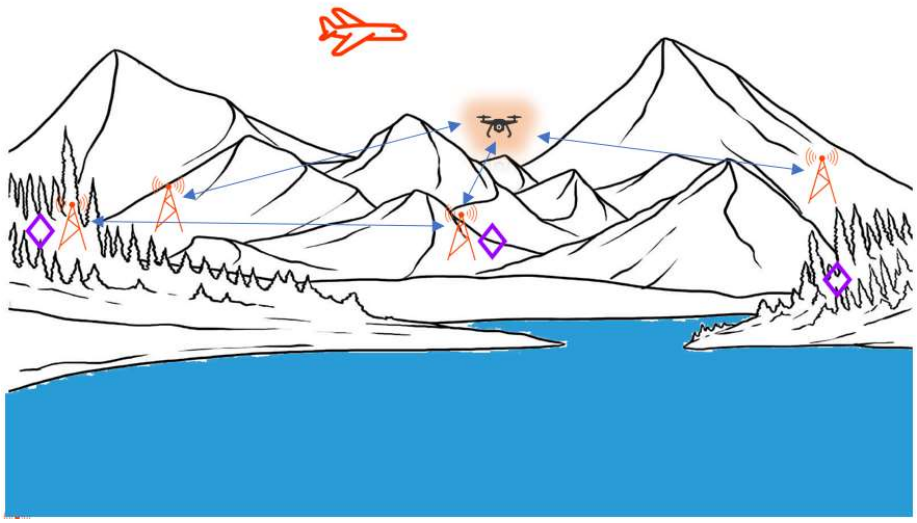



**Fig. 2.20. Scheme of UAV activity in difficult conditions of geographical plane**

Radio relay communication towers are communication system that provides high-speed data exchange with drone and operator. Their task is also formation of narrowly directed stabilizing signal, which allows you to

keep UAV in a given contour. Thus, radio relay towers must be in line of sight of each other.

Communication equipment on communication towers is powered by solar batteries and battery stations. This is quite enough, since UAV tracking process will not be constant, it will be carried out only at the time of patrolling. Modern radio relay systems consume little electricity, and distance between towers can be up to 40 km.

### 2.4.3. Technical and economic characteristics of air patrol complex

To patrol large areas, it is necessary to use helicopter-type UAV. The DJI Mavic pro 3 UAV is quite suitable for this task. This model can be in flight with load of about 40 minutes, but if weather conditions deteriorate, flight time will be 30 minutes. As workload, high-contrast camera and infrared camera are installed on UAV. When battery life reaches the end, UAVs proceed to landing sites shown in figure 2.21. All UAV landing sites are equipped with vehicle access roads.

**Fig. 2.21. Light aircraft AHRLAC manufactured in South Africa**

Light manned aircraft is used to deliver UAVs to given area of perimeter. Two hanging containers containing UAVs are installed on aircraft wings. Note that UAVs must be equipped with flight stabilization system after separation from container.

As patrol aircraft, it is better to use light AHRLAC aircraft manufactured in South Africa. Namely, civilian version of AHRLAC[109].

Technical and flight characteristics of AHRLAC

Crew: 2 (pilot, copilot/observer)

Length: 10.5 m

Wingspan: 12.0 m

Height: 4.0 m

Maximum take-off weight: 3,800 kg

Mass of fuel in internal tanks:

Powerplant: 1 × Pratt & Whitney Canada PT6A-66 turboprop

Engine power: 1 × 950

Maximum speed: 500 km/h

Operational range: 2,100 km

Service ceiling: 9,500 m

Airport: 550 m

Carrying capacity: 800 kg

This aircraft is operated by one pilot, the second seat is reserved for operator. Judging by technical characteristics, AHRLAC can patrol fairly large perimeter.

Cost of such an aircraft is $10 million, but it is military version. If we talk about civilian version of aircraft, AHRLAC may be smaller. Quest Kodiak 100 aircraft could be considered, it would cost about $4 million, but it would need to be equipped with visual, infrared and radio surveillance equipment, UAV tracking equipment and manned drone drop containers.

### 2.4.4. Preparatory work on organizing patrols and solving problem of patrolling large areas

For operation of this integrated system, it is necessary to organize operation of airfield, ensure refueling of aircraft with aviation kerosene and

[109] Occupying aircraft can no longer fly in European airspace. - URL: https://mtu.gov.ua/news/33492.html

charging of UAVs with electricity. AHRLAC aircraft is not demanding on high quality of runway, and its length must be at least 600 meters. UAV drop containers are designed to tell drones to accelerate away from aircraft and down. This is necessary to avoid damage to UAV by thruster of aircraft.

This task can be performed in three modes:

Patrolling with the help of aircraft;

Patrolling by aircraft and UAVs at the same time;

Aircraft delivers UAV at the specified coordinates and moves further along the route.

Modes 2 and 3 will be called hybrid type of patrol, in which aircraft and UAV are involved. In mode 2, aircraft and UAV work together, and data stream is transmitted directly to aircraft operator. In mode 3, aircraft delivers UAV to patrol area and leaves for further tasks, while UAV patrols given perimeter. Data flow is transmitted through radio relay towers.

UAVs used for hybrid patrolling (aircraft is used as carrier) must be equipped with dynamic horizontal stabilization system. This system establishes communication between gyroscope, altimeter, wind flow sensor and drone engines. After aircraft arrives at required point, container is opened, and UAVs are separated from it, which after stabilization begin their independent flight. When battery of UAV drops to value set by software, drones stop patrolling and head to their landing sites. Landing sites are located in such way that, being camouflaged as much as possible, they are close to approach roads and are easily accessible.

Patrolling large perimeters is a complex task, and to solve it, it is necessary to use engineering and innovative solutions in complex. Patrolling large area can also be patrolling state border. There are many factors to consider when dealing with such problem. AHRLAC aircraft is not demanding on quality of runway and can take off from normal highways. Length of take-off and run of AHRLAC is about 600 meters. Thanks to use of this aircraft together with helicopter-type drones, it is possible to successfully solve problem of patrolling large perimeters in hard-to-reach areas.

## 2.5. ENSURING THE COMPETITIVENESS AND FINANCIAL STABILITY OF TRANSPORT AND LOGISTICS COMPANIES IN CONDITIONS OF RUSSIAN-UKRAINIAN WAR

The Russian-Ukrainian war of 2022 caused heavy losses for Ukraine, primarily human casualties and mass killings of civilians. Military action and rocket fire have led to a humanitarian catastrophe in the country and are daily destroying the Ukrainian economy, destroying business and infrastructure. As of April 11, 2022, the losses of the Ukrainian economy since the beginning of the war amounted to $ 600 billion. According to experts, Ukraine has already lost 30-50% of production capacity located in the east of the country. Only 1% of Ukrainian companies have not yet suffered losses due to hostilities [110]. The Russian-Ukrainian war has a painful effect on the entire world economy every day. It poses new difficult challenges for global markets, including the market of transport and logistics services. Due to the introduction of sanctions against Russia by many countries, including the EU, USA, Great Britain, Canada, Norway, and Japan, international logistics has undergone significant changes, and export-import relations and cargo flows to and from Russia have been suspended. Due to the closure of their airspace for Russia, other countries of the world had to build new logistics routes, which significantly increased the time of transportation and their cost.

With the deteriorating economic situation in all countries of the world as a result of the Russian-Ukrainian war, the question of the survival of transport and logistics companies, ensuring their competitiveness and stability in the modern world is acute. Ukrainian transport and logistics companies face special challenges, as they must provide reliable and secure logistics for the delivery of weapons and equipment for the Armed Forces of Ukraine, humanitarian aid and medicines to Ukraine in the context of

**110** Valerii Osetskyi, Viktoriia Klymenko, Ganna Lozova, Yurii Umantsiv Ensuring the competitiveness and financial stability of transport and logistics companies in the conditions of russian-ukrainian war July 2023 Academic Review 2(59):25-47

significant destruction of transport infrastructure (airports, seaport blockade, roads and bridges destruction, Russia's bombing of railways). The issue of providing transport companies with fuel and lubricants is acute. Significant part of Ukrainian transport runs on oil, and Russia and Belarus have completely cut off supplies. In addition, Russia is methodically destroying Ukrainian oil depots, where fuel reserves are stored, by launching missile strikes. The outlined range of problems requires from transport and logistics companies new approaches to doing business, reviewing the formation of their strategic competitiveness in both short and long term to maintain market position

The aim of this article is to analyze the formation of the competitiveness of enterprises in the transport and logistics industry in the Russian-Ukrainian war in terms of the results of optimizing its activities and ensuring stability in military conditions

Studies of various aspects of enterprise competitiveness are presented in the publications of both domestic and foreign scholars. In particular, the works of Oliynyk N. and Buryk Y. are devoted to the systematization of approaches to determining the essence of the category "competitiveness", to determine the factors ensuring the competitive advantage of the enterprise in the market. Yanton-Drozdovska E. studied the impact of globalization on the international competitiveness of enterprises. In the work of Khrapkina V.V. the periods of formation and development of the competitiveness management system are determined and the modern views on the competitiveness management of enterprises in the conditions of unstable market environment are generalized. Logistics management has been seen as a major element in the customer service process in the papers of Persson Goran. Analysis of the system of methods for assessing the competitiveness of the enterprise is presented in the work of Bogatskaya N.M.. The analysis of the the variability of the financial results of sector-varied enterprises is presented in the work of Edyta Mioduchowska - Jaroszewicz.

In the conditions of the Russian-Ukrainian war there are tectonic shifts in the transport market and logistics services, which encourage companies to seek new business models, strategies that would create a competitive

advantage of a fundamentally ne level. While the analysis of the formation of the competitiveness of the enterprise in peacetime is devoted to many scientific papers and publications, the research on the problems of ensuring the competitiveness of enterprises in the transport and logistics industry in wartime is virtually absent. In our opinion, the analysis of trends and changes since the beginning of the Russian-Ukrainian war in the global market of transport and logistics services in general, and the transport and logistics market of Ukraine in particular, in order to determine the competitiveness of transport and logistics an important scientific and applied task, which is currently not given attention,unstudiability of the problem and asymmetry of information.

The methodological basis of the study is dialectical and abstract-logical methods, which identified the main factors and trends in the international market of transport and logistics services in the Russian-Ukrainian war, revealed their relationship and interdependence. The use of structural analysis allowed to establish the contribution of different modes of transport in the volume of transportation and cargo turnover in Ukraine in the prewar period. On the basis of systemic and synergetic approaches, the challenges in wartime for the activities of transport and logistics companies in close connection with ensuring their competitiveness were studied. Methods of analysis and synthesis were also used to study the stages of formation of strategic competitiveness of the transport and logistics company and to identify promising areas for strengthening competitive advantages in wartime.

The market of transport and logistics services is a system of organizational and economic, commercial and legal, financial and information relations between all its participants on the full range of operations with material flows (loading and unloading, storage, packaging, assembly, packaging, warehousing), insurance, customs clearance, settlement operations, information and documentation) for the transportation of goods and passengers to meet the needs of the economy at the local and regional, as well as national and international levels.

Russia's invasion of Ukraine has dramatically changed trends in the international market for transport and logistics services. If before February 24, 2022 the main factors influencing the market were: development of transport infrastructure, optimization of supply chains, expanding the range of goods and geography of transportation under the influence of globalization, global pandemic COVID -19 (Fig. 2.22).

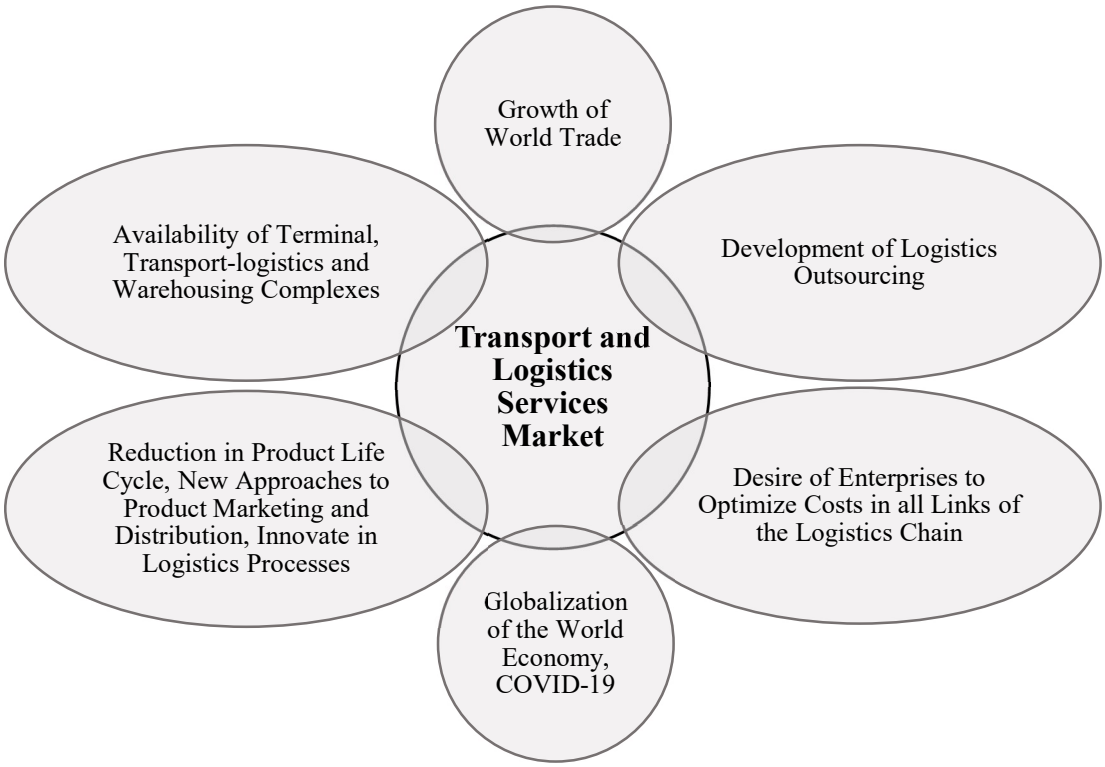



**Fig. 2.22. Factors Influencing the Market of Transport and Logistics Services Before the Russian-Ukrainian War**

Increased competition in all modes of inland transport, especially in the COVID-19 pandemic, increasing the potential for interchangeability of different modes of transport have formed new requirements for the quality of transport services, identified the need to adapt the transport system to new environmental and safety norms and standards. The definition and formation of the institutional framework for the development of the transport and logistics industry in the world market are engaged in

international and regional organizations, whose role has grown significantly in the last decade for the development of the transport industry. A diagram in fig. 2.23 presents the main international actors in the market of transport and logistics services.

The Russian-Ukrainian war has updated new trends and tendencies for the international transport and logistics market. Due to the fighting, there is a daily destruction of Ukraine's transport infrastructure as a transit state. 94 ships of Ukraine with export products are blocked by Russia in the Black Sea. Ignoring the law of the sea, the Russian military captures and takes hostage members of the crew of merchant ships. In particular, in the territory of the Mariupol sea trade port, the military of the Russian Federation took hostage members of the crew of the dry cargo ship " Blue Star-1" under the flag of Liberia.

Due to the introduction of international sanctions against Russia and Belarus, there have been significant changes in the market of air, sea, road and rail transport , including container transportation. The structure and geography of cargo flows have changed, as well as the composition of the main market players. The problem of restructuring regional and international governmental organizations regulating the market of transport and logistics services has arisen due to violations of international norms and rules. First and foremost, Russia is excluded from the International Maritime Organization, the International Civil Aviation Organization, the Railway Cooperation Organization and the Danube Commission, as Russia neglects transport safety issues, destroying transport infrastructure and shelling rolling stock, bypassing the Black Sea and river basins, captured the crews of merchant ships, deciding not to return the leased aircrafts and not being able to service them due to lack of spare parts and equipment. For example, in April 2022, the issue of meeting of governing bodies is raised in Railway cooperation organizations to discuss the termination of traffic with Russia and the exclusion of its representatives from participation in international organizations, and deprivation of the right to make any decisions.


**Fig. 2.23. International Participants in Transport and Logistics Services Market**

Let's analyze the main changes that have taken place in various segments of the international transport and logistics market due to the large-scale Russian invasion of Ukraine. In particular, in the field of *air*

*transport*, the following changes can be identified. 32 countries, including the United Kingdom, Poland, Bulgaria, the Czech Republic, Lithuania, Latvia, Estonia, Romania, Slovenia, Germany and Finland, have closed their airspace to aircrafts from Russia. Currently, air delivery from Europe is possible through Serbia, Turkey, Qatar and the UAE.

Due to the ban on the supply of aircraft and spare parts to them, equipment for airlines, it is impossible to operate the civil aviation fleet, including Airbus-322, which provided 40% of passenger traffic in Russia [50]. As a result, in early April 2022, the EU Flight Safety Committee blacklisted 21 Russian-certified airlines, including the national carrier Aeroflot, due to serious security concerns. EU and the UK have introduced bans on the purchase of leased aircraft, existing agreements will be terminated, which means the loss of 50% of the civilian fleet. In response, Russia has decided not to return the leased aircrafts, which will further cause lawsuits and worsen the investment climate in Russia.

The consequence of such actions was a decrease in the cargo turnover of Russian airlines in February 2022 by 1.4% (from 601.4 million t-km to 593.1 million t-km), and the volume of cargo transported by air – by 6.3%. The turnover of Russia's largest cargo carrier AirBridge Cargo decreased by 5.9% in February, the volume of cargo and mail - by 6.7%. “Aeroflot” also has negative dynamics of cargo turnover decreased by 13.8%, volume of transported cargo and mail decreased by 12.3%.

Mass bankruptcies of Russian airports begin. In particular, on March 18, 2022, it became known that the payment of interest on loans at the Russian airport "Zhukovsky" was suspended due to the disappearance of international flights, and thus lack of income and financial problems for the carrier. Restrictions also apply to *road transport.* In particular, the European Union has banned trucks from Russia and Belarus from entering the EU and has ordered Russian and Belarusian hauliers to leave the EU by April 16, 2022.

More and more EU countries are weakening the work and rest regime of drivers transporting humanitarian goods to Ukraine. This is a deviation from the provisions of the EU Regulation 561/2006 on working hours and

rest of truck drivers. The first countries to introduce easing were Poland, Belgium and Germany [53]. 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. Denmark extended the working day from 9 to 11 hours. In addition, France, Poland, the Czech Republic and Germany have exempted hauliers from tolls for the transportation of humanitarian aid to Ukraine. Hungary has also exempted trucks weighing more than 3.5 tonnes from tolls. The sanctions also apply to *sea transport***.** The largest sea carriers refused to work with Russia. Global maritime logistics operators MSC and Maersk are canceling maritime cargo voyage. The United Kingdom, the United States, and Canada closed their ports to Russian and related ships at the beginning of the war, and were joined by EU countries in April 2022.

Deep changes are observed in the market of *rail transportation.* Lithuanian Railways has suspended the lease of platform cars to Russian and Belarusian customers, including platform cars that cannot be transported to Russia or Belarus, and transit to other eastern countries except Latvia and Estonia. In response, Russia is blocking the departure of freight wagons from "unfriendly" countries that are imposing sanctions on it. As a result of the war in Ukraine, the structure of the leading players in the *container transportation* market is also changing . Thus, due to EU and US sanctions in response to the Russian invasion, the French logistics group Gefco, a controlling stake (75%) owned by Russian Railways and 25% by the Italian-French-American carmaker Stellantis, will be absorbed by French container operator CMA CGM.

March 23, 2022 Danish maritime container carrier Moller-Maersk, whose market share in Russian container traffic is about 30%, sells all its assets in Russia, stops buying Russian oil for ships and accepting new bookings at all its services - sea, transcontinental rail and aviation, to and from Russia. Sanctions against Russia also apply to Russian transport and logistics companies. On the other hand, more and more large foreign logistics operators are terminating their cooperation with Russia, such as Maersk, DSV and DB Schenker.

The United States has imposed sanctions on Gazprom, RusHydro and Transneft. At the same time, the issue of the EU's abandonment of Russian energy (gas, oil and coal) and the search for other sources of supply of these resources (in particular, the United States, Australia) is being addressed. Italy has signed an agreement on gas supplies from Algeria to reduce its dependence on Russian imports. All this together leads to a change in *the geography of cargo flows*, especially oil and gas.

The war in Ukraine, new sanctions and the related closure of airspace have led to increased transit times and an overall reduction in air traffic capacity. The world's leading transport and logistics companies are developing new additional routes connecting Europe and Asia. In particular, Dachser Air&Sea Logistics is launching an additional weekly charter flight from Frankfurt to Shanghai. The aircraft can carry 100 tons of cargo.

Changes in logistics routes are also due to disruptions in the supply of certain goods from Russia. For example, India has decided to increase fertilizer imports from Canada and Israel to provide stocks for the agricultural sector, which accounts for 15% of the economy and 60% of the country's employed population [56]. There is also a need to build new logistics routes for transporting goods from Ukraine to Europe by road and rail due to Russia's blockade of Ukrainian seaports and the destruction of airports. Cargo flows were redirected through Ukraine's international railway crossings to the Republic of Poland, the Slovak Republic, Romania, Hungary and further to Western Europe.

The war in Ukraine has also caused a crisis in *global supply chains*. We are talking primarily about the automotive industry, as sanctions and blocked trade routes hinder the supply of cars and spare parts to and from Russia. Prior to the Russian aggression in February 2022, Ukraine had significant potential in the field of transport and logistics services, primarily due to the favorable geographical location of the country, the availability of transport and logistics infrastructure, state programs to support transport development, Ukraine-EU Association Action Plan. In particular, table 2.13 and table 2.14 represent represents the structure of the transport and

logistics services market in Ukraine in terms of cargo transportation, cargo turnover and their distribution by individual modes of transport in 2020.

Table 2.13.

**Modes of Transport in Ukraine, 2020**

| Mode of Transport | Volume of Transportation | | Cargo Turnover | |
|---|---|---|---|---|
| | thousand tons | % | billion tkm | % |
| Rail | 305480 | 18.62 | 175.6 | 56.1 |
| Sea | 1812.2 | 0.11 | 1.5 | 0.5 |
| River | 3788.4 | 0.23 | 1.4 | 0.4 |
| Road | 1232392 | 75.10 | 65.1 | 20.8 |
| Air | 88.3 | 0.01 | 0.3 | 0.1 |
| Pipeline | 97464.7 | 5.94 | 69.3 | 22.1 |
| Total | 1641026 | 100 | 313.2 | 100.0 |

Table 2.14

**Dynamics of the Volume of Transportation by Certain Modes of Transport in Ukraine, 2018-2020**

| Mode of Transport | 2018 | | 2019 | | 2020 | |
|---|---|---|---|---|---|---|
| | thousand tons | % | thousand tons | % | thousand tons | % |
| Rail | 322342.1 | 19.62 | 312939 | 19.82 | 305480 | 18.62 |
| Sea | 1892 | 0.12 | 2120.3 | 0.13 | 1812.2 | 0.11 |
| River | 3698 | 0.23 | 3990.2 | 0.25 | 3788.4 | 0.23 |
| Road | 1205531 | 73.37 | 1147050 | 72.65 | 1232392 | 75.10 |
| Air | 99.1 | 0.01 | 92.6 | 0.01 | 88.3 | 0.01 |
| Pipeline | 109418.2 | 6.66 | 112656 | 7.14 | 97464.7 | 5.94 |
| Total | 1642980 | 100.00 | 1578848 | 100 | 1641026 | 100 |

As can be seen from tables 1, 2 the largest share of cargo (75%) was transported by road transport. The geography of road transportation is represented in Fig. 2.24.

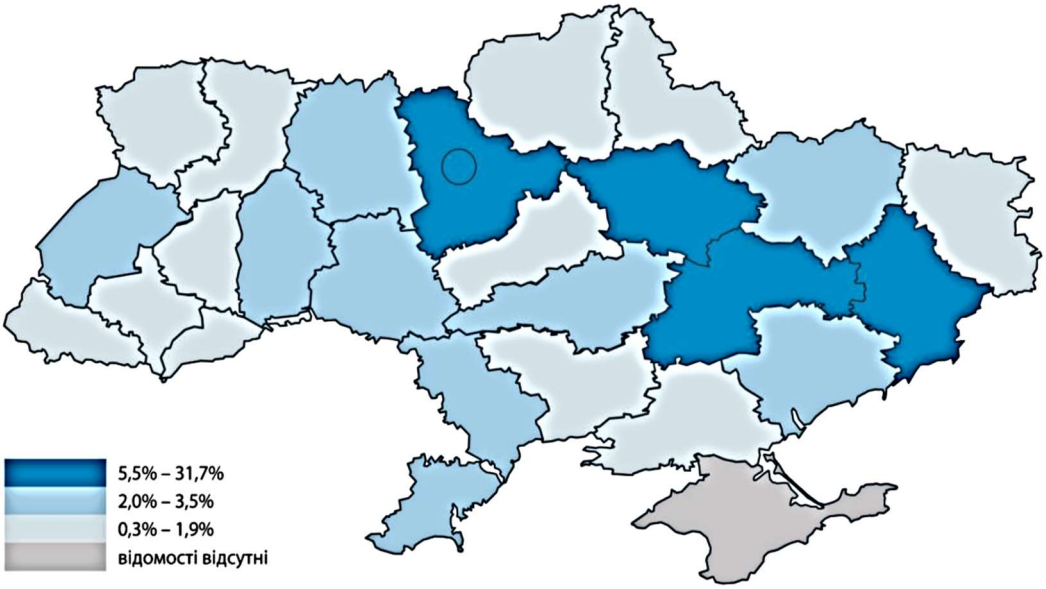



**Fig. 2.24. Distribution of Cargo Transportation by Road by Regions of Ukraine, 2020**

As can be seen from Fig. 2.24, the largest share of cargo transportation was performed in Dnipro, Poltava, Donetsk, Kyiv regions and the city of Kyiv. As a result of hostilities, the road transport infrastructure in Donetsk and Kyiv regions was virtually destroyed.

The analysis of export-import of transport services is presented in table 2.15.

Table 2.15

**– Exports and Imports of Transport and Logistics Services, 2020**

| Transport and Logistics Services | Exports | | Imports | |
|---|---|---|---|---|
| | thousand $ | % | thousand $ | % |
| 1 | 2 | 3 | 4 | 5 |
| Maritime Transport Services | 605952.9 | 13.11 | 309925.4 | 30.88 |
| River Transport Services | 25759.1 | 0.56 | - | - |
| Air Transport Services | 802191.7 | 17.36 | 319904.2 | 31.87 |

**Continuation of table 2.15**

| | | | | |
|---|---|---|---|---|
| Rail Transport Services | 405158.3 | 8.77 | 197393.3 | 19.67 |
| Road Transport Services | 339839.3 | 7.35 | 176500.4 | 17.58 |
| Pipeline Transport Services | 2443157.2 | 52.86 | - | - |
| Other Ancillary and Additional Transport Services | 320123.2 | 6.93 | 27625.2 | 2.75 |
| TOTAL | 4622058.50 | 100.00 | 1003723.30 | 100.00 |

According to the data in table 2.14, international services were dominated by pipeline, sea, air and rail services. Fig. 2.25 shows the average distance of transportation of one ton of cargo by certain modes of transport in 2020, including international traffic.

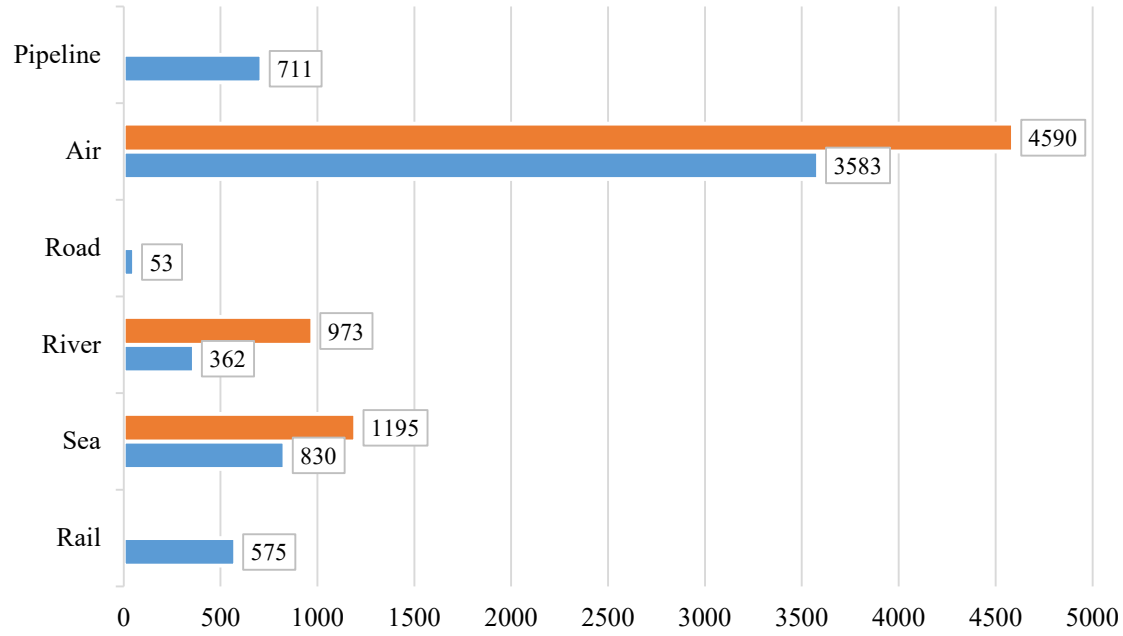



**Fig. 2.25. Average Distance of Transportation of One Ton of Cargo by Certain Modes of Transport In 2020, km (Blue Area - for Domestic Transportation, Orange Area - for International Transportation)**

Table 2.16 represents the results of financial activity in transport system of Ukraine in 2018-2022.

Table 2.16

**Financial Indicators of Transport and Logistics Companies in Ukraine, 2018-2020**

| № | Financial indicators | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| *1.* | *Financial Results before Taxation of Enterprises by Type of Economic Activity, mln. UAH* | | | |
| | Transport and Storage, Postal and Ccourier Activities | -22661.6 | 14414.8 | 17013.3 |
| | including land and pipeline transport | -34503.7 | -12585.3 | 24676.1 |
| | including water transport | 73.2 | 255.5 | 152.3 |
| | including air transport | -1421.4 | – | – |
| *2.* | *Profitable Enterprises, % to the Total Number of Enterprises* | | | |
| | Transport and storage, postal and courier activities | 74.1 | 73.8 | 71.7 |
| | including land and pipeline transport | 77.5 | 77.7 | 75.3 |
| | including water transport | 53.6 | 66.7 | 56.5 |
| | including air transport | 68.5 | – | – |
| *3.* | *Net Profit (loss) of Enterprises by Certain Types of Economic Activity, mln. UAH* | | | |
| | Transport and Storage, Postal and Courier Activities | -24265.4 | 8421.8 | 9054.8 |
| | including land and pipeline transport | -32504.2 | -14659.8 | 19373.6 |
| | including water transport | 54.3 | 213.4 | 125.4 |
| | including air transport | -1722.8 | – | – |
| *4.* | *The Level of Profitability (loss) of Operating Activities of Enterprises,%* | | | |
| | Transport and Storage, Postal and Courier Activities | -1.6 | 4.1 | 4.4 |

| | | | | |
|---|---|---|---|---|
| | including land and pipeline transport | -9.7 | -2.3 | 5.1 |
| | including water transport | 1.7 | 6.9 | 12.3 |
| | including air transport | -2.6 | – | – |
| 5. | *The Level of Profitability (loss) of All Activities of Enterprises,%* | | | |
| | Transport and Storage, Postal and Courier Activities | -4.3 | 1.4 | 1.6 |
| | including land and pipeline transport | -11.5 | -5.0 | 7.1 |
| | including water transport | 1.6 | 5.6 | 3.0 |
| | including air transport | -3.1 | – | – |

During the war in Ukraine, the situation on the market of transport and logistics services has changed dramatically. From the very beginning of the war, the Russian occupiers aimed to destroy *the transport infrastructure*. Ukrainian airports became the first targets of the lesions for the Russian aggressors. 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 has reached $ 80.4 billion, according to the Russia Will Pay project. In particular, almost 8,000 km of roads, dozens of railway stations, airports were destroyed and damaged, ports were blocked, and failures in supply chains. *The air transportation market* has suffered significant losses. First, there are no flights by air, the world's largest transport aircraft of Ukrainian production AN-225 "Mriya" was destroyed.

As for *the road transport market,* its volumes prevail. Road transport is involved in the transportation of weapons and equipment for the Armed Forces of Ukraine, humanitarian goods and medicines for the population. In view of this, a number of countries, including Hungary, Austria, Italy, Lithuania, Latvia, Estonia, Bulgaria, Slovakia, Germany, Poland, Turkey, Moldova and Georgia, have relaxed rules for Ukrainian carriers on transit and all bilateral transport without transport permits. will operate for the period of martial law. However, in order to cross the territory of Hungary and be exempted from paying tolls while transporting humanitarian aid, the

haulier must submit an application (Toll exemption request, in English or Hungarian) to the Office of the Deputy State Secretariat of the Ministry of the Interior of Hungary for Transport Registration.

On the other hand, the closure of transit through the territory of Belarus and Russia, as well as due to the increase in the volume of cargo transportation by road, the Ministry of Infrastructure has simplified the rules for issuing permits for international cargo transportation. Restrictions on the crossing of the border for male drivers have also been lifted to ensure the transport of critical goods.

The next step of the Ministry of Infrastructure in the road transport market was to simplify the procedure for obtaining a license for:

- domestic transportation of passengers by buses;
- domestic transportation of dangerous goods and hazardous waste by trucks;
- international transportation of passengers by buses;
- international transportation of dangerous goods and hazardous waste by trucks;
- international transportation of goods by trucks (except for transportation of dangerous goods and hazardous waste).

Thus, for all types of licenses the amount of required documents has been halved; the need to confirm three years of work experience was abolished; the submission of documents on the availability of material and technical base and the availability of contracts was canceled. For the period of martial law, the term of consideration of the application for a license under the new procedure was reduced from 10 days to 1-3 days. Ukraine's *rail transport* also plays a key role in passenger and cargo transportation. OJSC Ukrainian Railways (Ukrzaliznytsia) has taken on a key role in evacuating the population from the war zone and Russian-occupied settlements. As of April 9, 2022, Ukrzaliznytsia has evacuated 3.5 million people since the start of the full-scale Russian invasion. At the same time, more than 470 thousand will be transported by train abroad.

At the same time, the management of Ukrzaliznytsia decided to confiscate 15,000 freight wagons belonging to Russian companies

(including VEB-Leasing, VTB Leasing, Gazpromtrans, SberbankLeasing) and standing on the tracks of Ukraine. Ukraine also confiscated Belarusian freight wagons that transported export goods in transit to Ukrainian ports. This will partially replenish the wagon park of domestic rail transport, which has also suffered significant losses due to shelling and bombing.

The Government of Ukraine is promptly implementing measures to ensure "Wartime Logistics", which provides for the stable operation of new logistics routes. In particular, in order to ensure the possibility of further entry of ships in conditions of military aggression in the ports of Ukraine in the Danube region and to stabilize the situation by rail, provide guarantees for shipowners, railway carriers and insurance companies (March 30, 2022 'Some issues of ensuring the safety of navigation in the waters of Ukrainian ports in the Danube region and rail transport'. The order provides for the allocation of funds from the reserve fund of the state budget to compensate for damage caused by the armed aggression of the Russian Federation against Ukraine and hostilities in Ukraine, and in case of refusal of insurers to provide insurance coverage.

Reimbursement is provided for charterers, operators and/or owners of seagoing and inland waterway vessels flying under the flag of Ukraine and under the flags of foreign countries - in the case of such vessels in the waters of Ukrainian ports in the Danube region, as well as for owners and/or operators of the warehouse admitted to circulation by railways of the European standard - in case of stay of such rolling stock in the territory of Ukraine. A number of international companies provide assistance to Ukraine, including large *logistics operators*. In particular, in March 2022, the Kuehne+Nagel Group decided to provide immediate assistance to Ukraine in the amount of 10 million Swiss francs (9.8 million euros) in the form of free logistics services for organizations involved in providing assistance to Ukraine. By the summer of 2022, the group will provide transportation and temporary storage of resources in Ukraine, Poland, Slovakia, Hungary and Romania.

It should be noted that the Russian-Ukrainian war raised the issue of ensuring the competitiveness of enterprises. Competitiveness is a complex, systematic characteristic of the enterprise. In our opinion, the main factors

of competitiveness of the transport and logistics enterprise in the conditions of war are: 1) safety and reliability of transportation; 2) staffing and provision; 3) effective and flexible management in the new environment; 4) the amount of costs for transport services; 5) quality and quantity of offered transportations / related services; 6) system of tariffs for transportation; 7) ensuring the continuity of export supplies; 8) availability of reserves to cover risks.

Additional factors that affect the competitiveness of transport and logistics companies are: regular availability, cost-effectiveness, availability of operational information, speed of response to consumer requests, innovation. Fig. 2.26 represents the process of forming the strategic competitiveness of the transport and logistics company in peacetime, aimed at expanding the market position of the company in a competitive market, efficient use of its resources and obtaining moderate risk of profit in the amount not less than the industry. In the fourth paradigm of competitiveness, the main criterion for success for the company in peacetime was the ability to find the shortest way to solve the problem to meet consumer needs.

In the conditions of military actions the formation of stability of the enterprise acquires key value first of all. Therefore, the formation of the strategic competitiveness of the transport and logistics company should begin with goal setting (defining the mission, vision and main purpose of the company in the market of transport and logistics services); development of a general plan taking into account risks and threats in wartime; preparation of the enterprise for activity in the conditions of war and systematic application of measures for anticipation and reduction of negative influences and consequences on the enterprise. Fig.2.27 represents formation of a strategy for the competitiveness of the transport and logistics company in wartime.

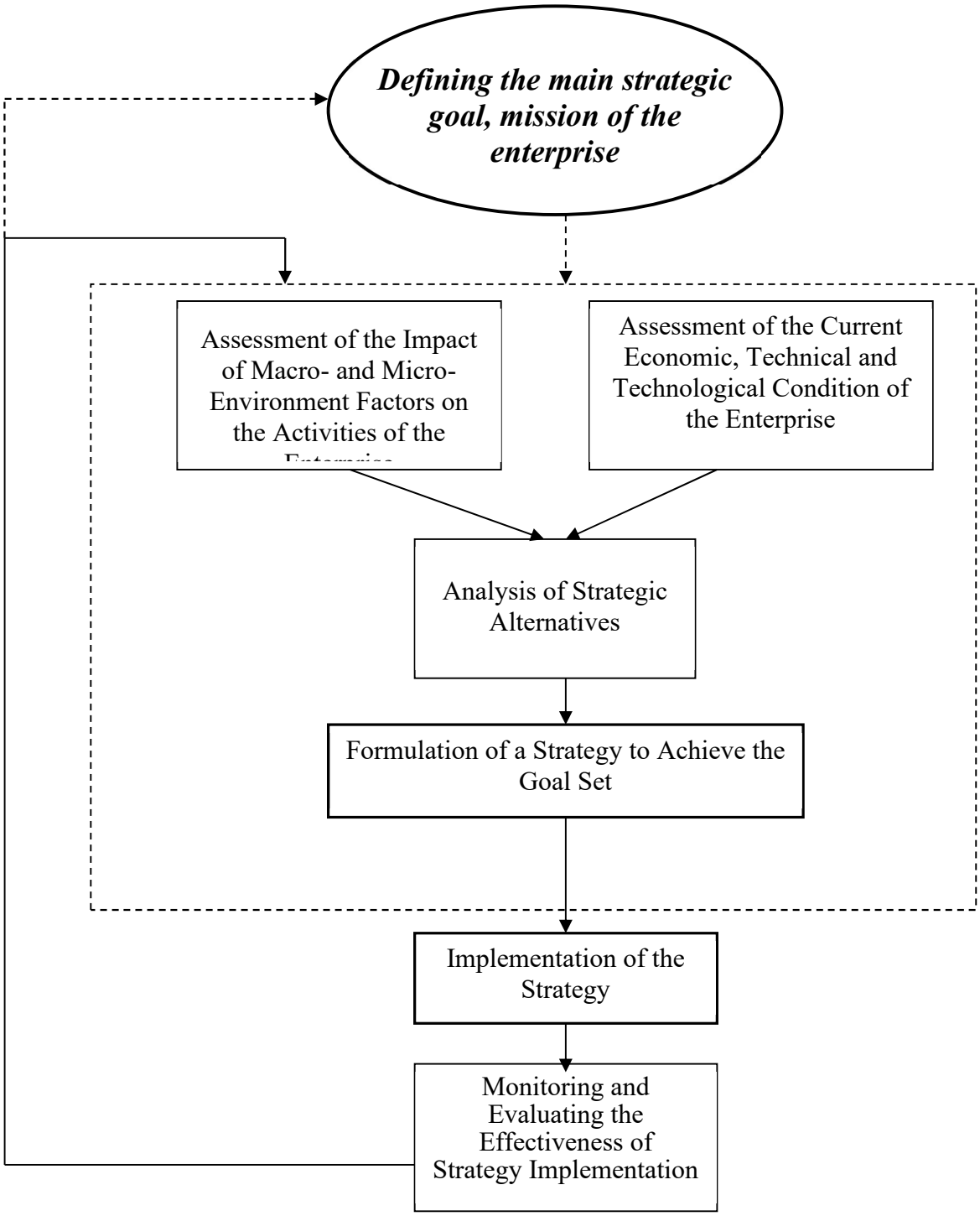



**Fig. 2.26. The Process of Forming Strategic Competitiveness in the Transport and Logistics Company**

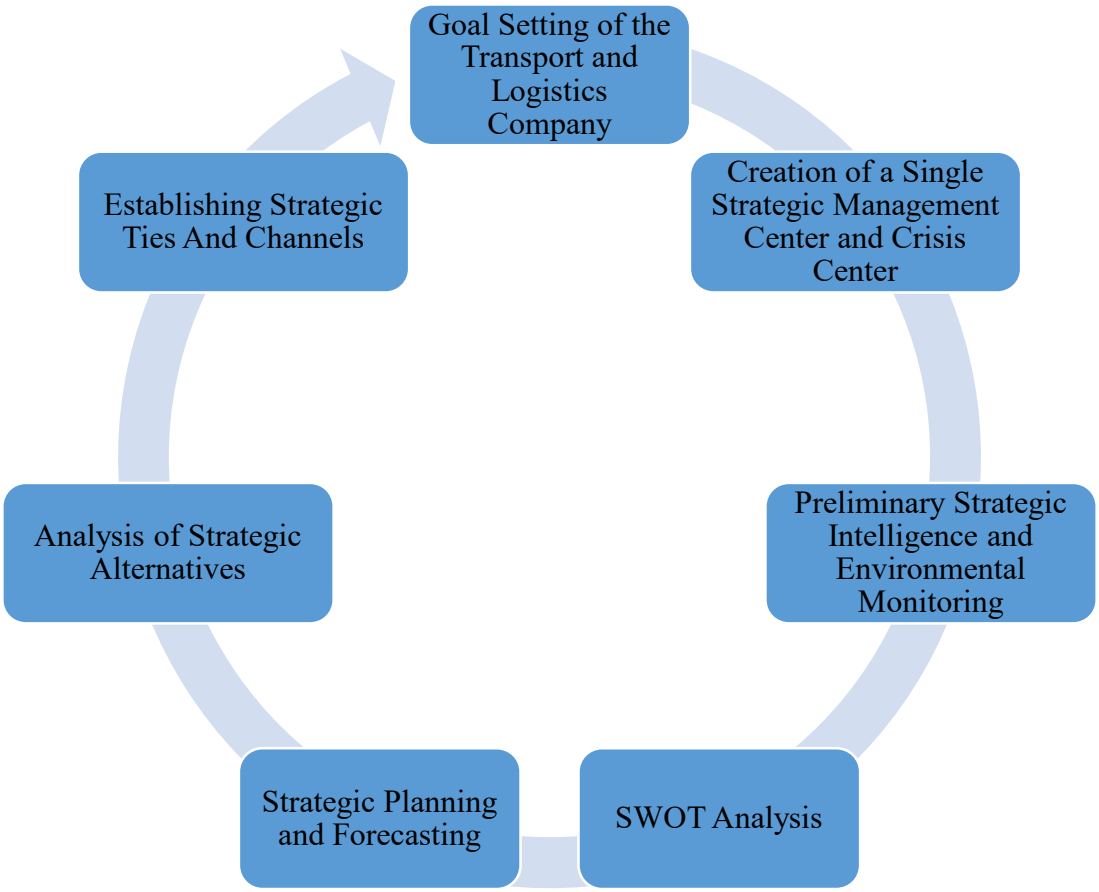



**Fig. 2.27. Formation of a Strategy for the Competitiveness of the Transport and Logistics Company in Wartime**

If in peacetime the formation of the competitiveness strategy of the transport and logistics company covers three main stages: SWOT analysis and assessment of the impact of macro - and micro-environmental factors on the activities of the transport and logistics company; analysis of strategic alternatives; in wartime conditions, the formation of competitiveness should be complemented by the stage of preliminary strategic intelligence and monitoring, as well as strategic planning and forecasting; establishing strategic ties and channels both

within the structural units of the enterprise and external strategic ties and channels.

In the context of hostilities, it is important to create a single strategic management center (SCM) of the enterprise and a crisis center, which would quickly make decisions and provide a rapid and effective response to threats to the enterprise.

At the first stage, goal-setting is carried out for the transport and logistics company, adjusting its mission and purpose in war. The second stage creates a single strategic center of enterprise management and crisis center for end-to-end and continuous monitoring of the situation in the industry, in the market of transport and logistics services, and to track changes occurring nationally and globally through hostilities. To ensure a single strategic center for the management of reliable and operational data, it is necessary to conduct preliminary strategic intelligence and market monitoring, which can be performed by the security service of the enterprise. This stage also includes an assessment of the impact of macro factors- and microenvironment for the activities of the transport and logistics company, in particular: political and legal factors, military, economic, natural, scientific and technical factors. In the context of digitalization of the economy it is important to protect the enterprise from cyber-attacks.

The next step is SWOT analysis of strengths and weaknesses of the enterprise; the type of market and the nature of competitive relations inherent in the market are determined. At this stage, the motivation of customers, the peculiarities of their economic decisions, etc. are studied. Then strategic planning and forecasting is carried out; analysis of strategic alternatives, the choice of market strategy and competitive strategy of the transport company, taking into account plans and forecasts of events for a particular transport and logistics company, and the market and the economy as a whole. An important component of the formation of the competitiveness strategy of the transport and logistics company is the establishment of effective strategic ties and channels both within the structural units of the company and the formation of external strategic ties and channels. At the final stage, based on the analysis of the information

collected in the previous stages, the strategy of achieving the goal of the transport company is determined. The management process involves the implementation of the strategy of competitiveness of the transport and logistics company, includes processes: planning, creation of appropriate organizational structures for the management of the PSC of the transport company, control and evaluation of the effectiveness of the strategy. The foundation for the formation of strategic competitiveness of the enterprise is to ensure the competitiveness of the service provided by this enterprise.

In conditions of intensifying competition, the formation of competitive advantages and ensuring the competitiveness of transport and logistics services are priorities for the transport and logistics company. Under the competitiveness of transport and logistics services, we understand its property, which is manifested in the ability to be sold in a certain market at a certain price at a certain time. The main parameters that determine the competitiveness of transport and logistics services are the complex parameters of quality, price and compliance of the product with certain standards.

Qualitative parameters of transport and logistics services include a set of their properties and characteristics that allow to meet the needs of consumers in the process of offering and consuming these services. The key indicators of the quality of transport and logistics services to consumer enterprises include:

- Time from receipt of the application for transportation to delivery;
- Reliability and possibility of delivery on demand;
- Availability of stocks, stability of supply;
- Safety of goods during transportation and loading and unloading operations;
- Timeliness of supply of rolling stock for cargo operations;
- Completeness and degree of availability of the order;
- Convenience of placement and order confirmation;
- Objectivity of tariffs and regularity of information on maintenance costs;

- The possibility of providing loans;
- Efficiency of cargo handling in warehouses;
- Quality of packing, and also possibility of package and container transportations.

An influential factor in the competitiveness of transport and logistics services is also a fairly low price, i.e. the size of the tariff for transportation. The price parameter can be estimated using the following indicators:

- The ratio of the level of the offered price and the reference service;
- Cost of additional services;
- Attractiveness of the price discount system for the consumer;
- Terms of payment.

The structure of the assessment of the level of competitiveness of the transport and logistics company can be represented in the form of a diagram (Fig. 2.28).

In wartime, the company should focus not so much on increasing and increasing market share, but on maintaining its position. In this aspect, the end-to-end monitoring of the financial performance of the transport and logistics company plays an important role.

Assessment of the level of the financial component of the logistics company is based on the analysis of the balance sheet and cash flow of the enterprise. These are the following coefficients:

(a) Coefficient of Financial Autonomy $= \frac{\text{Equity}}{\text{Company Ass}}$;

(b) Coefficient of Financial Dependence $= \frac{\text{Company Assets}}{\text{Equity}}$;

(c) Financial Risk Ratio $= \frac{\text{Borrowed Cap}}{\text{Equity}}$;

(d) Financial Stability Ratio $= \frac{\text{Equity + Long–term Liabilities}}{\text{Liabilities of the Company}}$;

(e) Liquidity Solvency Ratio $= \frac{\text{Current Assets + Deferred Expenses}}{\text{Long–term and Current Liabilities + Deferred Income}}$.

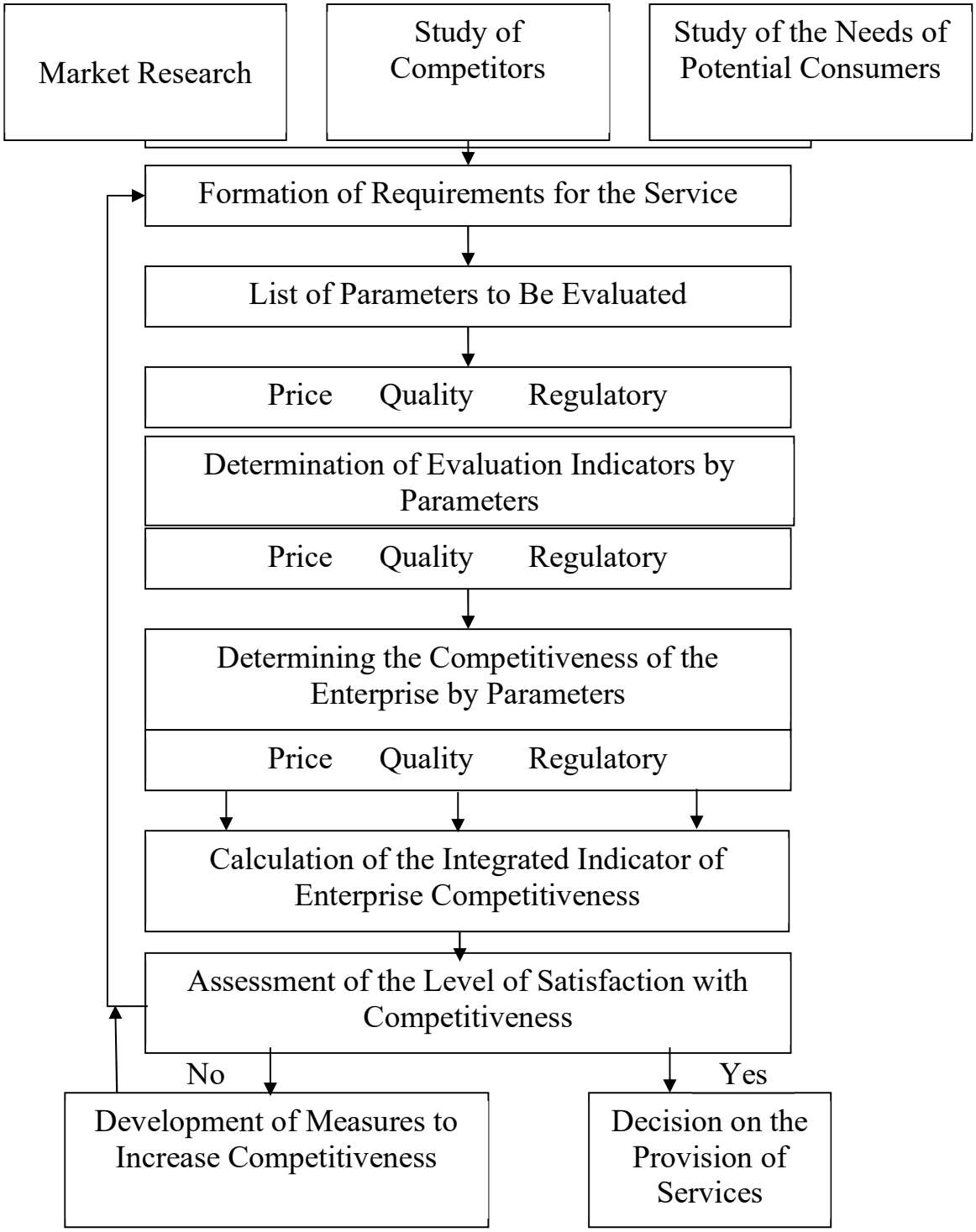



**Fig. 2.28. Assesment of the Level of Competitiveness of the Transport and Logistics Company**

They show the ability of companies to cover their liabilities at their own expense. In particular, the decrease in the coefficient of financial autonomy indicates an increased risk of financial difficulties for the company in the future, is a negative signal to creditors. The coefficient of financial dependence actually complements the previous figure. The normal limit of this indicator is considered to be within one.

The long-term financial independence ratio is calculated as the ratio of equity and debt to the total balance sheet currency. A condition is considered normal when this coefficient is greater than one. The liquidity solvency ratio is defined as the ratio of total current assets to total financial and current liabilities, its regulatory value is 1. Stable financial condition is characterized by no defaults, normal profitable work, no significant violations of internal and external financial discipline for several years, has a positive effect on the efficiency of the logistics company. Conversely, the presence of violations of financial discipline, problems in the receipt of funds on the current account due to inefficient management of receivables, non-fulfillment of the financial plan leads to a decrease in the efficiency of these enterprises in the market.

Let's calculate such indicators for Ukrainian transport and logistics company "TRANS LOGISTICS" (2008), which provides domestic and international cargo transportation by road (table 2.17).

As we can see, the company has some problems with the financial stability. All calculated coefficients do not meet normative values. The Russian-Ukrainian war has led to the crisis of non-payment due to inflation, depreciation of national currency, breaks in economic links, destroyed road infrastructure. Unfortunately, the impact of the war on the company's financial condition cannot be assessed, as at the beginning of the war the Ukrainian government abolished the mandatory requirement for companies to report.

Table 2.17

**Financial Indicators of "TRANS LOGISTICS", 2018-2020**

| № | Financial indicators | Normative Value | 2018 | 2019 | 2020 | I quarter 2021 |
|---|---|---|---|---|---|---|
| 1 | Coefficient of Financial Autonomy | > 0.5 | 0.44454 | 0.40702 | 0.4347 | 0.4350 |
| 2 | Coefficient of Financial Dependence | ≤ 0.5 | 2.24947 | 2.45686 | 2.2999 | 2.2986 |
| 3 | Financial Risk Ratio | < 0.25 | 1.24947 | 1.45686 | 1.2999 | 1.2986 |
| 4 | Financial Stability Ratio | > 1 | 0.90163 | 0.87045 | 0.8530 | 0.8258 |
| 5 | Liquidity Solvency Ratio | 1 | 0.43858 | 0.40670 | 0.4501 | 0.2034 |

Since the level of competitiveness of the enterprise (CE) can be determined by comparing the services provided by it with analogues of competitors, as well as by determining differences in the degree of its compliance with social needs, the process of forming CE should begin with analysis of transport and logistics services, where the implementation of the service is planned in the future. The next step is to study the real and potential demand, determine the main characteristics and requirements for transport and logistics services offered by a particular transport and logistics company, and analyze the supply of competitors of the company. This is quite a time consuming and tight process. To save time and resources, one can use the method of rapid analysis to identify promising transport and logistics services among the alternatives.

Since the CE of the transport and logistics company is an integrated indicator, the total useful effect of the company is calculated, the total costs are determined at the appropriate stages of the life cycle of the company, including costs to eliminate negative consequences of negative effects and risks that may arise during operation. The Russian-Ukrainian war radically changed both the international market of transport and logistics services and the national market of Ukraine. The paper thoroughly analyzes the main

factors that affected the market before February 24, 2022 and after that date. In particular, among the main factors determining the market situation until February 24, 2022 are the following: development of transport infrastructure, optimization of supply chains, expanding the range of goods and geography of transportation under the influence of globalization, global pandemic COVID-19 in 2020-2021. After February 24, the main factors influencing the functioning of the international market of transport and logistics services include: the impact of international sanctions, which not only changed the structure and geography of cargo flows, but also affected changes in the composition of major market players; destruction of Ukraine's transport infrastructure as a transit state, Russia's blockade of Ukrainian seaports and destruction of airports; simultaneous growth of the flow of humanitarian goods to Ukraine; weakening in the EU countries the regime of work and rest of drivers transporting humanitarian goods to Ukraine; increasing the burden on market players due to the closure of airspace for Russia. Insolvency of regional and international organizations to respond to the global challenges of wartime indicates the urgent need to reorganize them, which is also emphasized in the work.

The authors conducted a study of the impact of the Russian-Ukrainian war on national market of transport and logistics services in Ukraine. It is determined that before the Russian aggression in February 2022 Ukraine had significant potential in the field of transport and logistics services, due primarily to the favorable geographical location of the country, the availability of transport and logistics infrastructure, state programs to support the development of the transport complex, EU-Ukraine Association Action Plan. According to the statistical data presented in the work, in the domestic market the largest share of goods in Ukraine was transported by road. International services were dominated by pipeline, sea, air and rail services. Due to the war in Ukraine, the situation on the market of transport and logistics services has changed dramatically. Since the invasion, the actions of the Russian invaders have been aimed at destroying Ukraine's transport infrastructure. Due to hostilities and missile strikes, almost thousands of kilometers of highways, dozens of bridges, railway stations, airports were destroyed and damaged, and Ukrainian ports were blocked.

With the increase in the flow of weapons, military and humanitarian goods, problems with the supply of fuel and lubricants due to the destruction of oil depots and warehouses, began failures in supply chains. The air transport market has suffered the most, due to the threat of missile strikes, the destruction of airports and aircraft, in fact, no flights are operated by air. Maritime transport is also virtually inoperable due to the Russian blockade of Ukrainian ports. All loads fall on road and rail transport, which play a key role in ensuring passenger and cargo transportation. The Government of Ukraine is promptly implementing measures within the framework of the Wartime Logistics Program, which it envisages ensuring stable operation of the transport system and opening new logistics routes. In order to stabilize the situation with transportation and to provide guarantees for transport owners, the government provides funds from the reserve of the state budget to compensate for damage caused by the armed aggression of the Russian Federation against Ukraine and hostilities in Ukraine, and in case of refusal to provide insurance coverage. As practice shows, international governments and companies, including large logistics operators, provide significant support and assistance to Ukraine.

The Russian-Ukrainian war raised the issue of ensuring the competitiveness of transport and logistics companies, as their effective activities largely depend on the economic and military security of the country. To confirm the scientific hypothesis, the paper analyzed in detail the changes that have occurred at both micro and macro levels in the field of transport and logistics services.

In our opinion, the main factors of competitiveness of the transport and logistics enterprise in the conditions of war are: safety and reliability of transportations; staffing and provision; effective and flexible management in new conditions; the amount of costs for transport services; quality and quantity of offered transportations/related services; system of tariffs for transportation; ensuring the continuity of export supplies; availability of reserves to cover risks.

# Part 3

## AGRI-FOOD SYSTEMS LOGISTICS

## 3.1. Theoretical and methodological approaches to the organization and current trends in the development of logistic support for agricultural production

The agricultural sector is one of the important spheres of material production, which has a number of specific features inherent only in this industry, namely:

1. The land is the main means of production and the element of productive forces. The peculiarity of the agricultural sector is that land is an object of labor and at the same time a means of labor. Therefore, the land used in agricultural production needs to be constantly reproduced to maintain its productivity, quality, and value. This necessitates its rational use (compliance with the rules of growing crops, biologically and economically justified crop rotations, etc.), preservation and maintenance of soil fertility;
2. In agriculture, both groups of objective laws – natural-biological and socio-economic – interact. The action of natural and biological laws turns out to be spontaneous and unpredictable;
3. The activities of agricultural enterprises are related to the production of basic, necessary, and safe products that should be available to all social strata of the population;
4. Labor productivity depends not only on the level of innovation of the equipment and technologies used but mainly on natural processes, weather conditions, several biological factors, etc. This causes riskiness, instability of the functioning and development of the agricultural sector;
5. The same amount of financial investment and the same quantity and quality of labor expended can give significantly different results;
6. The production of agricultural products is seasonal, and the rhythm of production depends on natural climatic and weather conditions. This generates fluctuations in the use of capital resources (in particular, equipment), human resources, and, accordingly, the supply of products on the market;
7. Final amount of income is formed only after the sale of products;

8. The level of concentration of production is largely determined by the available size of land, the intensity of its use, as well as the quality and productivity[111].

The presence of the above features distinguishes agriculture from other sectors of the economy; That is why it is important to take them into account when organizing logistics systems in this industry. High efficiency of the country's agro-industrial complex and its accelerated development should be ensured by a progressive system of building production processes, consisting of three interrelated parameters: equipment, technology, and organization.

Agricultural production is dispersed over vast areas and requires the movement of significant volumes of intermediate and final products, and operational and auxiliary materials to ensure the continuity of the technological chain. Moreover, the vast majority of products produced by agricultural enterprises are subject to processing before being sent to the consumer. The function of processing, and, consequently, production in the agro-industrial complex is performed by enterprises of the food and processing industries. For their normal functioning, a production infrastructure is needed, which ensures the performance of the production functions of enterprises: energy, water supply, logistics, road communications, information networks, trade, etc.

Because of this, the agrarian sector of the economy is characterized by a certain autonomy and a pronounced seasonality of production, as well as a strong dependence on natural, climatic, and soil-biological conditions. It is closely intertwined with social, economic, and natural processes of reproduction, and the result is the sum of the efforts of man and nature.

Agricultural production is biological in nature, so biological organisms, land, and other natural resources are used as means of

[111] Economic Theory : Political Economy : textbook / ed. V.D.Bazilevich; Kiev. National. University of them. 9th ed., supplement. Kyiv: Znannia, 2014. 710.

production, therefore material flows in the logistics of agri-food products have some specifics[112]:

– diversification – the ability to generate 2 or more streams that differ significantly from each other in their properties, promotion paths, and end users;

– seasonality – the need to store products due to seasonality;

– dualism – the ability of the material flow at any stage to act as both a raw material for the next stage and a final product;

– transformation is a significant change in the material flow on the way to the end consumer, which in turn requires appropriate changes in the mode of storage and transportation;

– assortment – expansion of the assortment of material flow as it moves through the supply chain, which in turn requires increased efforts to maintain it.

Agricultural production is characterized by the lack of territorial localization of production processes. In addition, enterprises of the processing industry that use the products of agricultural enterprises, as a rule, are territorially distant from the sources of raw materials, which necessitates the physical movement of material flows, both in time and in space. Even the shortest agri-food supply chains range from 30 to 100 km in Europe[113], and in the United States, they can reach more than 600 km,[114] which in turn leads to losses. The main losses in the agro-industrial complex are caused by:

– disconnection of production processes by areas of activity;

– uncoordinated activities of commercial services (sales, contracts, marketing), technical services and suppliers;

[112] Zagurskyi O., Pokusa T., Zagurska S., Ohiienko M., Titova L., Rogovskii I. Ohiienko A., Razumova K., Berezova L. Current trends in development of transport and logistics systems of delivery of fast perishable foodstuffs. Monograph. Opole: The Academy of Management and Administration in Opole, 2021, 238, 84.

[113] Pretty J.N., Ball A.S., Lang T.,. Morison J.I.L, Farm costs and food miles: An assessment of the full cost of the UK weekly food basket, Food Policy, Volume 30, Issue 1, 2005, Pages 1-19.;

[114] Engelseth, P. "Developing Exchange in Short Local Foods Supply Chains," International Journal on Food System Dynamics, International Center for Management, Communication, and Research, 2016.vol. 7(3), pages 1-14, June.

– lack of basic calculations of safety stock, storage cost, optimal order size,

– the flow of information about them.

The costs of this inconsistency are quite significant: in the final cost of the goods, they approach 70%.[115]

Agrarian management is characterized by conservatism and inelasticity, which make it impossible to adequately respond to market changes. Thus, with the growing demand for agricultural products, the agricultural sector, due to its peculiarities associated with the long terms of its production, cannot increase production in a short time. A significant accumulation of certain types of food can lead to the fact that it will be impossible to sell it even at low prices, because according to physiological properties, a person is not able to eat more than he needs, and the shelf life of food products is limited.

The distribution system of agri-food products itself differs from the distribution of other products, because moving along the supply chain to the end consumer, agricultural products undergo continuous changes. Given this, much more attention is paid to the distribution, quality, usefulness, and safety of agricultural products than to other goods. With a high level of competition between participants in the agri-food market, the effective organization of logistical support for agricultural businesses is extremely relevant. Without the rational organization of supply chains of goods, no enterprise in the agricultural sector will be able to maintain the achieved positions in the competition for a long time, and even more so to achieve leadership in the country and the world.

Agri-food supply chains refer to a system that encompasses all activities, organizations, actors, technologies, information, resources, and services related to the production of food for consumer markets. They cover the agricultural sectors of primary processing and manufacture of products,

[115] Alexander P., Brown C., Arneth A, Finnigan J., Moran D., Rounsevell M., Losses, inefficiencies and waste in the global food system, Agricultural Systems, Volume 153, 2017, 190-200.; Hoehn D., Vázquez-Rowe I., Kahhat R., Margallo M., Laso J, Fernández-Ríos A.,Ruiz-Salmón I., Aldaco R A critical review on food loss and waste quantification approaches: Is there a need to develop alternatives beyond the currently widespread pathways?, Resources, Conservation and Recycling, Volume 188, 2023, 106671.

from the supply of agricultural inputs (e.g. seeds, mineral fertilizers, feed, medicines, or equipment) to production, post-harvest processing, processing, transportation, marketing, distribution, and retail. They also include support services such as knowledge extension services, research and development, and market information. As such, they are made up of a wide range of businesses, ranging from small farms, farm organizations, cooperatives, and start-up companies to multinational companies through parent companies or their local affiliates, public enterprises and foundations, private financial entities, and private institutions.

Businesses are interconnected by relationships and arrangements. Primary processing enterprises can be involved in various types of relationships with farm enterprises to ensure access to agricultural products. They can apply standards and specifications to manufacturers with little involvement outside of the purchase contract. But they can also be involved more actively, in particular through contract agriculture, to coordinate production and ensure quality and safety. In practice, these categories are often difficult to delineate. For example, cooperatives often own or operate agricultural machinery as well as primary processing assets (e.g., a sugar factory) and can therefore be considered not only farm enterprises but also primary processing enterprises.

Logistics in agricultural supply chains plays a critical role in producing and supplying agricultural products. It covers a bunch of key aspects:

1. Input Material Flows: Includes all inputs for agricultural production, such as utility, fertilizers, and fuels. Optimal management of these resources ensures continuity of production.

2. Production and Processing Process: Logistics is ready to optimize work processes, ensuring that agricultural products are processed and produced with maximum efficiency and minimum costs.

3. Storage and distribution: covers all aspects of storage and transportation of agricultural products to end consumers or markets. This stage requires precision and speed to maintain product quality.

4. Information and financial flows: Logistics also includes the management of information on prices, transportation capabilities, and

financial aspects of agricultural operations. This is important for decision-making and planning.

Logistical efficiency can affect the reliability, timing, and quality of agricultural products. Proper management of these aspects can not only avoid problems such as supply interruptions or reduced quality but also create a competitive advantage by optimizing costs and improving the quality of customer service. The complexity and heterogeneity of logistics services for the movement of agricultural products lead to the strengthening of cooperation between all participants in supply chains, the creation of integrated associations with their participation together with agricultural enterprises, and the functioning of specialized agro-logistics providers. It is obvious that ensuring a high level of competitiveness of agricultural products through the effective organization and management of its logistics supply chains is an extremely difficult task, and its successful implementation, according to World Bank experts, depends on three main components: infrastructure (especially roads and railways, for example, between major economic centers and ports); the market of logistics services; Procedural and Regulatory Environment of the Agro-Industrial Complex

Therefore, today, to achieve a competitive advantage, a different approach to agri-food supply chain management is needed, which ensures the maximum value of the goods promoted through them. According to it, suppliers and consumers of agri-food products are considered primarily as partners. Suppliers contribute to engineering and the development of ideas for the regular provision of agricultural production with high-quality raw materials, inventory management, etc. Performing different roles, but collaborating, They establish a transparent and trusting environment through the information organization of the basic principles of this cooperation. And consumers, by increasing the level of their loyalty and trust in products, will contribute to an increase in income. It should be noted that investing in customer loyalty is one of the most profitable environments for business development. Some researchers believe that increasing customer loyalty is more important than reducing transaction costs. A 2%

increase in customer loyalty affects profitability in the same way as a 10% decrease in operating costs[116].

According to P. Bartlett, D. Julien, and T. Baines[117], increased transparency leads to greater productivity, because participants can better plan their actions throughout the supply chain through increased up-to-date information. For this type of joint activity to be successful, production planning and delivery schedules must be closely coordinated, intermediate products must be integrated quickly, and logistics partners make deliveries using tracking and visibility functions and Information and Communication Technologies[118].

For this purpose, in the field of agricultural business management, the scope of application of logistic methods and models is being expanded. Theoretical, methodological, and applied developments of logistics management are actively implemented in the operational and strategic activities of many agricultural enterprises. In the practical activities of entrepreneurial organizations, the reverse return is manifested in a specific economic effect from reducing costs and time for the transformation of resources in logistics systems.

Accordingly, the logistics system of distribution of agri-food products is the main subject of discussion both in society and in the scientific literature, and food security is considered in close relationship with the concept of sustainable development of the country's economy. Logistics, as a science and practice of managing material and related flows of financial resources and information, is becoming more and more in demand in the agro-industrial complex. The need to use tools is especially relevant to logistics in the process of material and technical support of agricultural production and sales of products and the creation of a new direction in logistics - agri-food logistics. After all, the organization of resource provision

[116]Ozuysal C. Customer Loyalty: The Key to Business Growth. 2021. Retrieved from https://userguiding.com/blog/customer-loyalty/ (accessed 13 March 2022)

[117] Bartlett P.A., Julien D.M., Baines T.S. Improving supply chain performance through improved visibility. Int. J. Logist. Manag. 2007, 18, 294-313.

[118] Kupriyanovsky V. P., Sinyagov S. A., Klimov A. A., Petrov A. V., Namiot D. E. Digital Supply Chains and Blockchain-Based Technologies in the Joint Economy. International Journal of Open Information Technologies. 2017. №8. URL: https://cyberleninka.ru/article/n/tsifrovye-tsepi-postavok-i-tehnologii-na-baze-blokcheyn-v-sovmestnoy-ekonomike

by agricultural producers and the promotion of their products to the market on the principles of logistics has significant economic, social, and environmental effects.

Agri-food logistics is a type of entrepreneurial logistics according to industry differentiation or a type of economic activity of enterprises. Of course, it, like all other types of business logistics, can have rationalistic and supporting types or their integrated manifestation. Accordingly, in the system of agrarian management, logistics acts both as an approach to enterprise management and as an object of management. Rationalistic agrologistics elaborates scientific principles, formal models, and methods of substantiation of decisions and rational organization of economic activity in the agrarian sphere of the economy.

It should be noted that in the scientific circles of Ukraine, the terms "agrarian logistics" or "agrologistics" are more widely used, which are understood as a logistical function to ensure the processes of production, storage, and movement of agricultural products.

Thus, T.V. Bozhydarnik and N.V. Bozhydarnik determine that "Agrarian logistics as a science develops scientific principles, methods, mathematical models that make it possible to plan, control and manage transportation, warehousing, and other tangible and intangible operations that arise in the process of bringing raw materials and materials to an agricultural enterprise, organizing the production process, bringing agricultural products to the consumer following his requirements".[119]

A.V. Petryk believes that in contrast to an industrial enterprise, where the main two aspects of logistics activities are distinguished. The first concerns the problems of operation of warehouses and vehicles, the selection and use of loading and unloading equipment, packaging methods, and the functioning of information and control systems, and the second covers the organization of management of material, information, and financial flows. Agrarian logistics involves the aspect of introducing rational forms of material support of agricultural enterprises, production, and

[119] Bozhydarnik, T. V., and Bozhydarnik, N. V. "Osnovni shliakh pryvlennia logytsii v agropromyslovom kompleks Ukrainy" [Main ways of applying logistics in the agro-industrial complex of Ukraine]. URL: http://www.nbuv.gov.ua/Portal/soc_gum/ekfor/2011_1/5.pdf

bringing of agricultural products to sales markets while ensuring optimization of logistics costs with the maximum beneficial effect of agricultural activity, resource conservation, and environmental safety in flow processes[120].

O.M. Sumets defines "agro-logistics" as a scientific and practical direction in the management system of economic entities of the agricultural market, which makes it possible to increase the economic efficiency of their activities by reducing intra-company costs associated with the implementation of logistics operations and processes in the production, storage, and movement of agricultural products and information about them at a certain logistics site within the established time limits, and ensuring timely and high-quality customer service[121].

I.G. Smirnov and T.V. Kosareva "Agrologistics is a new applied direction of logistics related to the application of its provisions and methods in the field of agricultural production.[122], N.A. Potapova "Agrologistics in agricultural markets is identified with the optimal management of the proportions of economic and technological characteristics in certain parts of the supply chain, covering micro-, meso- and macroeconomic levels"[123]. Instead, in foreign scientific literature, the concepts of "food logistics" or "food[124] logistics" are used[125], which to a greater extent cover the provision of the

[120] Petryk A.V. Peculiarities of the formation of transport systems in agro-industrial production. Service market

Integrated Transport Systems and Applied Systems of Logistics Problems. Kyiv, 2004. 17-18.

[121] Sumets, O. M. Logistic activity of enterprises of the oil and fat industry and evaluation of its efficiency. Dis. ... Dr. Econ. Sciences: 08.00.04; NUFT. Kyiv, 2016. 43.

[122] Smirnov I.G., Kosareva T.V. Logistics infrastructure of the agro-industrial complex: theory and practice /Agroincom. 2003.№ 5–6. 24–27.

[123] Potapova N. A. Prospects for the development of agrologistics in the markets of agricultural crops. Economy. Finance. Management: topical issues of science and practice. 2017. № 1. 28-36.

[124] Bayir, B.; Charles, A.; Sekhari, A.; Ouzrout, Y. Issues and Challenges in Short Food Supply Chains: A Systematic Literature Review. Sustainability 2022, 14, 3029. https://doi.org/10.3390/su14053029.; Luo J, Leng S, Bai Y. Food Supply Chain Safety Research Trends From 1997 to 2020: A Bibliometric Analysis. Front Public Health. 2022 Feb 3;9:742980. doi: 10.3389/fpubh.2021.742980. PMID: 35186862; PMCID: PMC8850300. ; Paciarotti C., Torregiani F. The logistics of the short food supply chain: A literature review, Sustainable Production and Consumption, Volume 26, 2021, 428-442.

[125] Palazzo, M. and Vollero, A., "A systematic literature review of food sustainable supply chain management (FSSCM): building blocks and research trends", *The TQM Journal*, 2022. Vol. 34 No. 7, pp. 54-72. https://doi.org/10.1108/TQM-10-2021-0300.; Kafi, A., Zainuddin, N., Saifudin, A. *et*

final link in the supply chain – the production of the finished product and the sphere of distribution and consumption of food products. Thus, according to P. Becker and co-authors[126], logistics Food supply connects different sectors of the economy (agriculture, food processing, and distribution sector) in a market dominated by changing customer preferences. It is extremely complex due to the high level of unpredictability in terms of demand and cost, the fragile nature of food, and increased consumer awareness of risks and safety issues[127].

The broadest concept of logistic support of the agricultural sector is reflected in the work of O. Kvilinsky and co-authors, where the logistics activities of agricultural enterprises are proposed to be considered comprehensively as a system, which includes:

– the continuous integrated process of performance of management functions (forecast, planning, organization, accounting, control, analysis, and regulation);

– an integrated approach to logistics processes (supply and purchase of material resources, contractual work with suppliers, production of agricultural products, their storage in logistics centers, waste processing using the tools of the circular economy and reverse logistics, logistics services for customers, transportation and sale of agricultural products);

– the process of applying digital technologies and information systems[128].

A comparative analysis of the definitions of Ukrainian and foreign authors regarding the definition of logistics for the provision of agricultural

*al.* Meta-analysis of food supply chain: pre, during and post COVID-19 pandemic. *Agric & Food Secur* 12, 27 (2023). https://doi.org/10.1186/s40066-023-00425-5

[126] Beske P., Land A., Seuring S. Sustainable supply chain management practices and dynamic capabilities in the food industry: a critical analysis of the literature, International Journal of Production Economics, 2014, Vol. 152, 131-143.

[127] Sharma V.K., Chandna P., Bhardwaj A. Green supply chain management related performance indicators in agro industry: a review Journal of Cleaner Production, 2017, Vol. 141, pp. 1194-1208.; Rejeb, A.; Rejeb K., Appolloni A., Iranmanesh M., Treiblmaier H., Jagtap S. Exploring Food Supply Chain Trends in the COVID-19 Era: A Bibliometric Review. Sustainability 2022, 14, 12437. https://doi.org/10.3390/su141912437.

[128] Kwilinski A., Hnatyshyn L., Prokopyshyn O., Trushkina, N.. Managing the Logistic Activities of Agricultural Enterprises under Conditions of Digital Economy. Virtual Economics, 2022, 5(2), 43-70. ttps://doi.org/10.34021/ve.2022.05.02(3).

products shows their similarity in terms of the object of study and approaches to application and some differences in the number of logistics processes that are part of the logistics system of the agricultural sector. In our research, we will combine these approaches and further use the term agri-food logistics, meaning the full cycle of logistical support for the promotion of agricultural products along the supply chain.

Accordingly, the essence of the interpretation of agri-food logistics is to combine scientific and practical management of flow processes in the agrarian economy and, in particular, the management of the movement and storage of raw materials, materials, semi-finished products, and finished products in economic circulation from the primary source of raw materials to the final consumer of food products.

However, if we consider the logistics system of the agro-industrial complex from a functional approach, we can give the following definition: agri-food logistics is the mutual influence of cyclical forecasting and planning of agricultural production, obtaining loans or financial resources, purchasing or preparing for the season of mechanical engineering and equipment, purchasing materials, organizing production, processing raw materials, delivering finished products to consumers, receiving proceeds to the accounts of enterprises. If with the same process, maintenance is a form of optimal organization of flows of material and technical products between suppliers and consumers of these products in a market economy, as well as rational planning, regulation, and management of financial, information, service, and other flows in the agro-industrial complex. Thus, agri-food logistics is directly focused on the study of various logistics formations (objects, organizations, channels, chains, networks, etc.) related to specific logistics operations (processes) that create the necessary conditions for conducting the main activity of the agricultural business (meeting consumer demand through the production of agricultural products). According to O.V. Kornietsky, the features of the mutual influence of logistics and the agro-industrial complex should be considered at the three levels of functioning: at the level of the agro-industrial complex, infrastructure, and flows (Fig. 3.1).

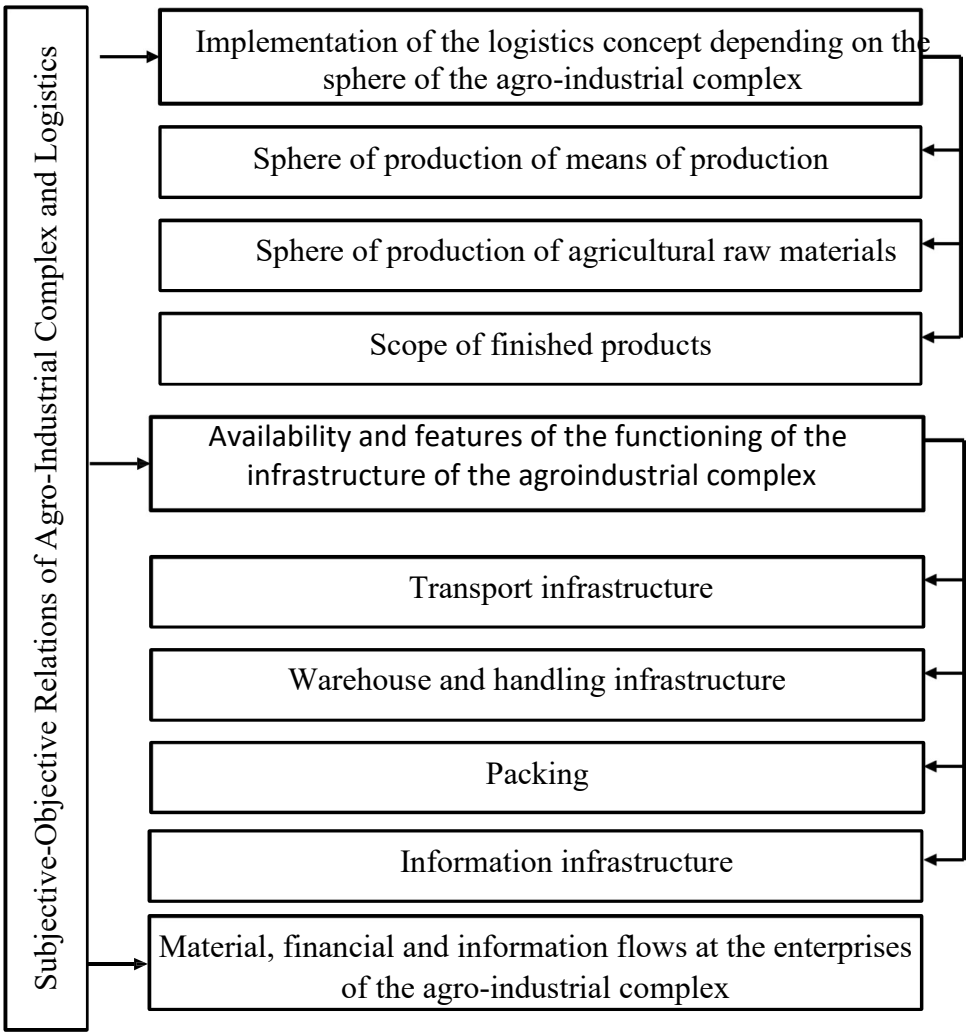



**Fig. 3.1. Levels of manifestation of logistics in the structure of the agro-industrial complex**

*Source:* Problems of Formation of Optimal Regional Logistics Systems of Agricultural Enterprises: http://www.nbuv.gov.ua/portal/soc_gum/knp/177/knp177_1519.pdf

Specialized and integrated logistics of the agrarian sector of the economy, in contrast to the general one, are directly concentrated on parts of the material flow (Table 3.1).

Table 3.1

**Features of certain types of agri-food logistics**

| Criterion for comparison | Agri-food logistics | | |
|---|---|---|---|
| | General | Specialized | Integrated |
| Directions | Certain Phenomena and Flow Processes in the Economy | Separate logistics processes (storage, handling, sorting, transportation, etc.) | A set of logistics processes |
| Relationship with Flows in Agricultural Economics | Manifestation Within and Beyond the Material Flow | Directly related to a part of the material Flow | Directly related to a part of the material Flow |
| Communication with the supply chain | In and out of the logistics system Chain | Link in the logistics chain | Supply chain |

*Source: Developed* by the authors

The peculiarity of the agrarian sector of the economy is the availability of production of both agricultural raw materials (whole milk, grain, etc.) and finished products (fresh vegetables, honey, etc.). Therefore, procurement logistics is clearly expressed and very important in the internal logistics of an agricultural enterprise. In this case, harvesting is carried out from two sources:

– supply of material resources of industrial origin (plant protection products, fuel, mineral fertilizers, etc.);

– revenues from the sphere of own production of resources of agricultural origin (seeds, fodder, manure, etc.).

In many agricultural enterprises, on-farm industrial processing of agricultural raw materials is carried out, which gives grounds to distinguish the logistics of processing. Recycling logistics at such enterprises is less

common, but it also takes place. In agribusiness, a significant place is occupied not only by internal transport but also by warehousing, technical and technological, agrochemical, and other types of logistics support (Fig. 3.2).

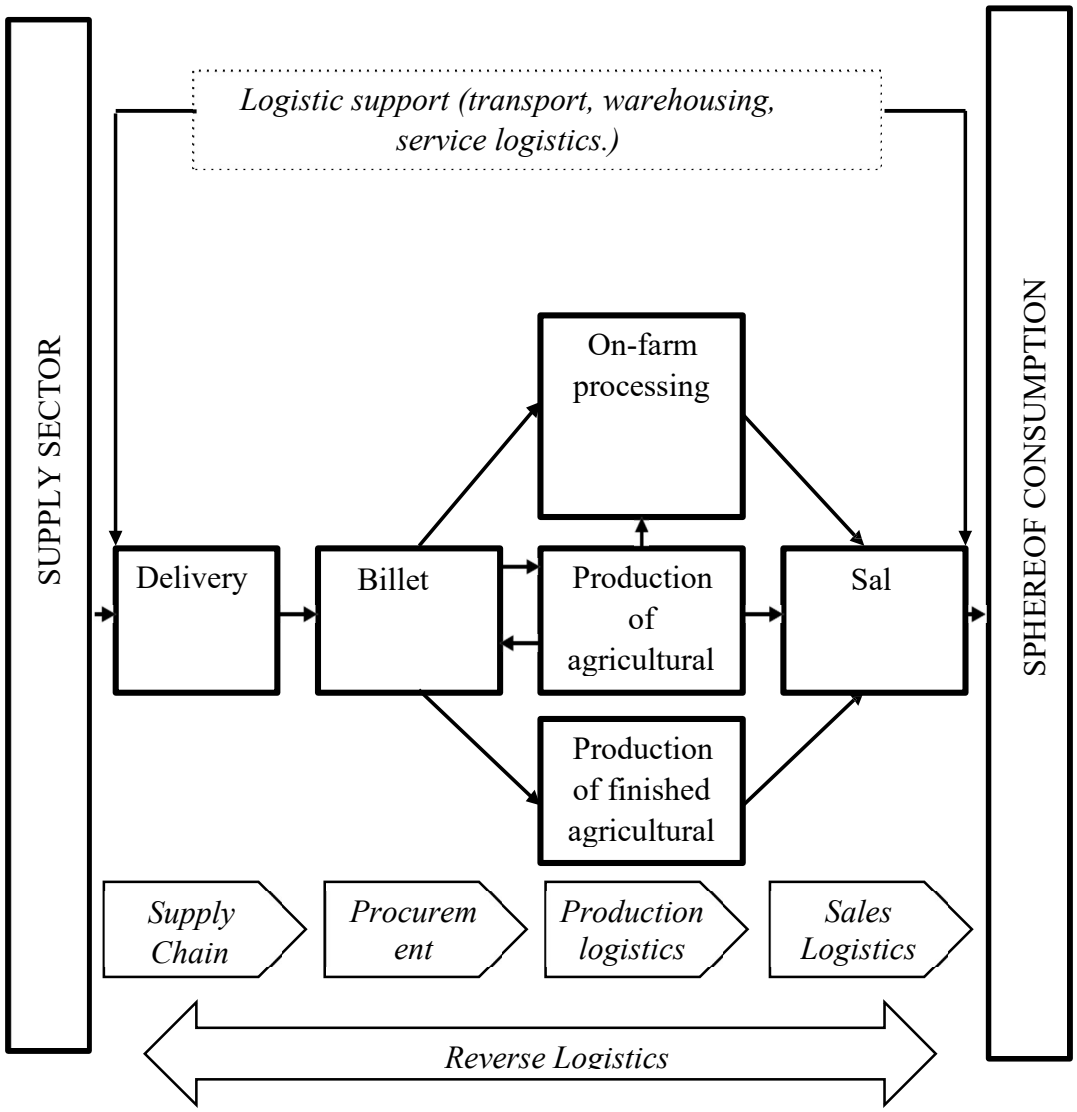



**Fig. 3.2. Functional structure of internal logistics of an agricultural enterprise**

*Source:* compiled based on Velychko O.P. Internal and external logistics and its features in agribusiness Development Economics. 2012. № 1(61). 41-47.

Thus, according to L.V. Frolova[129], one of the main functional areas suitable for the use of logistics tools is the main activity of agricultural enterprises, in respect of which it is possible to apply the tools of production (intra-production) logistics to solve the issues of optimizing the size of agricultural enterprises, determining the need of the enterprise for fixed means of production, organizing their productive use, ensuring technical maintenance and repair of machinery, buildings, equipment, etc.

But such functional areas as supply and distribution in the agricultural business are no less suitable for the application of logistics methods to management in the agricultural business, and in their environment even most of the operations (processes) of logistics support (storage, sorting, packaging, transportation, etc.) are carried out. Accordingly, in the organizational structure of agricultural enterprises, it is mandatory to include in the field of logistics the following important industries, supply, sales, transportation, warehousing, inventory management, production planning, etc. In support of this, O.M. Volnova[130] draws attention to three important features of agricultural logistics, which organically resonate with the features of agricultural production itself.

Firstly, the material flow can be biological in nature and is characterized by a significant consumption of already-produced products within the production cycle. This applies, first of all, to the branches of animal husbandry: cattle breeding, pig breeding, and poultry farming, where animals are transferred from one sex and age group to another.

Secondly, the peculiarity of agricultural production is the use of living organisms, which are included in the fixed assets of an agricultural enterprise and are accounted for in the financial statements. This peculiarly divides the material flow into two or more parts, which differ from each other both in biological characteristics and like the supply to the final consumer, and partially or fully these material flows can be consumed in the production process. That is, there may be a certain expansion in the range of material flow when passing through the logistics chain.

[129] Frolova L.V. Logistic management of the enterprise: theoretical and methodological aspects. Donetsk: DonDUET them. M. Tugan-Baranovsky, 2004. 161.

[130] Volnova O.M. Logistic approach to the formation of agrarian production. Bulletin of Khmelnytskyi National University. 2010. No 2, vol. 1. 161–164.

Thirdly, the seasonality of agricultural production necessitates the creation of additional logistics stocks of raw materials and supplies, as well as finished products. At the same time, crop production is a raw material for the feed industry, which provides animal feed, and animal husbandry is a supplier of organic fertilizers for the crop industry.

O.V. Kornietsky[131] considers the expediency of using logistics, as a science and practice, in the agro-industrial complex and first of all focuses on the need to use logistics tools in the process of material and technical support of agricultural production and sales of products, that is, in the field of agricultural circulation.

N.R. Struk[132] also notes that the logistic approach to solving the issues of procurement logistics in agricultural enterprises involves the widespread use of methods of economic and mathematical modeling of the processes of using the machine and tractor fleet and, accordingly, determining the need for this equipment to purchase it. Logistics in essence are also methods for determining such a need based on the use of calculation and design methods, which are associated with the development of technological maps, schedules for the use of the machine and tractor fleet, as well as procurement procedures for tractors, combines, agricultural machines necessary for the formation of a rational composition of the machine and tractor fleet, and other material resources based on tender bidding.

The tools of procurement logistics in the activities of agricultural enterprises include not only methods for determining the need for machines and materials but also methods for organizing procurement, ways of organizing quality control of purchased products, algorithms for selecting suppliers, etc.

[131] The importance of logistics for the agro-industrial complex. Efficient economy. 2015. №8. URL: http://www.economy.nayka.com.ua/?op=1&z=4240.
[132] Struk N.R. Supply management in logistic systems of agricultural enterprises: practical aspect. Bulletin of Lviv State Agrarian University: Economics of Agro-Industrial Complex. 2006. № 13. 794-801.

Supporting logistics for the sale of agricultural products, first of all, is associated with the operational processes of "storage" and "transportation", as well as the formation of appropriate logistics entities (warehouses, transport units, distribution centers, etc.). It is significantly influenced by the purchasing power of end users[133]. Accordingly, rationalistic agri-food logistics in this area is comprehensively focused on solving the problem of optimizing total sales costs while maintaining the required level of quality of all business processes in the sphere of circulation.

Therefore, we can note that considerable attention of scientists is focused on the study of theoretical and conceptual aspects of the general logistics activities of organizations. At the same time, many theoretical and methodological issues of sectoral logistics remain insufficiently studied, poorly structured, and adapted. To a large extent, this also applies to the logistics management of agribusiness[134].

In particular, here and today the issues of the essence and features of the functioning of such an object of management as the agri-food logistics system remain debatable. Therefore, there is an objective need for further deepening of research in this direction.

Agro-industrial formations are production and logistics systems in which different industries or elements of the technological process of agribusiness are integrated into a single whole. At the same time, the categorical apparatus of logistics management of the agro-industrial complex is based on general logistics categories, but for accuracy and greater objectivity, its content should be filled with industry features.

[133] Bo Yan, Xiaoxu Chen, Congyan Cai, Shiyan Guan, Supply chain coordination of fresh agricultural products based on consumer behavior, Computers & Operations Research, Volume 123, 2020, 105038

[134] Dementyev V.V., Kwilinski, A.. Institutional Component of Production Costs. Journal of Institutional Studies, 2020, 12, 100-116. https://doi.org/10.17835/2076-6297.2020.12.1.100-116.; Dzwigol, H.. Meta-Analysis in Management and Quality Sciences. Marketing and Management of Innovations, 2021, 1, 324-335. http://doi.org/10.21272/mmi.2021.1-25.; Kwilinski A., Litvin V., Kamchatova E., Polusmiak J., & Mironova, D. Information Support of the Entrepreneurship Model Complex with the Application of Cloud Technologies. International Journal of Entrepreneurship, 2021, 25(1), 1–8.

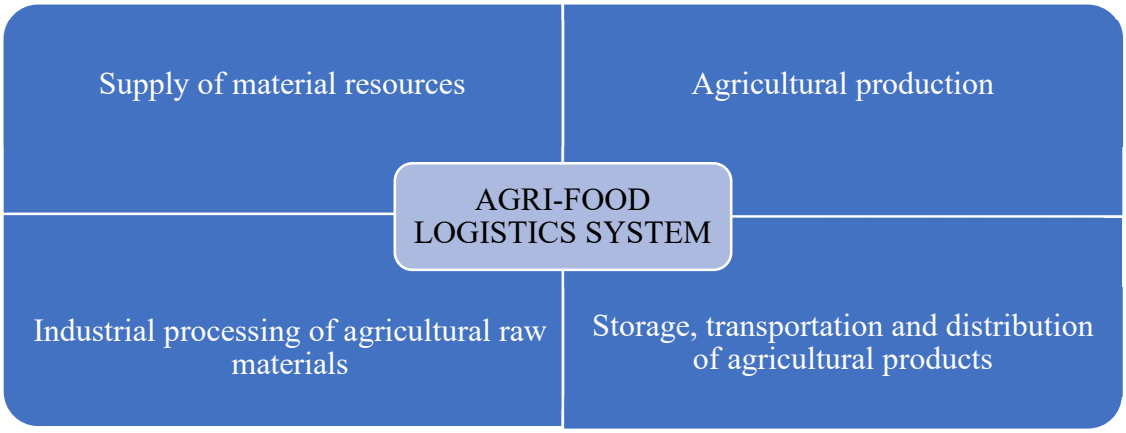



**Fig. 3.3. Matrix of integrated construction of the agri-food logistics system in agribusiness**

*Source:* compiled by the authors

This, in particular, applies to such concepts as "agri-food logistics system", "logistics flows in the agro-industrial complex", "logistics organization of agribusiness" and "formation of goals of the agri-food logistics system".

Depending on the specifics of the activities of the agro-industrial complex, different production and logistics systems are formed (Fig. 3.3).

The agri-food logistics system can also be considered as a separate management object. In modern research on general logistics, there are many definitions of the concept of "logistics system"[135]. One of the most quoted is the explanation of the content of this category by M.A. Oklander, "The logistics system is an organizational and managerial mechanism associated with the achievement of the required level of integration of logistics functions through organizational transformations in the management structure (logistics unit) and the introduction of management procedures

[135] Sumets O. M. "Suchasni pidkhody do interpretuvannia denitsii «Logisticna sistema» [Modern approaches to the interpretation of the definition of "Logistic system"]. Visnyk of the East Ukrainian Nats. Un-tu them. Vladimir Dahl: Science. Journ. 2013. Part 1, No 5 (194). 106–110.; Galkin A., Dolia C., Davidich N., The Role of Consumers in Logistics Systems, Transportation Research Procedia, Volume 27, 2017, 1187-1194.; Sonny Sanjaya, Tomy Perdana, Logistics System Model development on Supply Chain Management of Tomato Commodities for Structured Market, Procedia Manufacturing, Volume 4, 2015, 513-520.

(operating systems), the basis of which is the planning of supply, production support, and physical distribution as a single material flow"[136].

The logistics system is also understood as an ordered set of logistics operations and chains that ensure the optimal organization of interrelated economic flows in the process of achieving system-wide goals. At the same time, the logistics system includes a set of actions of the links in the logistics chain (manufacturing enterprises, transport, trade organizations, and others). Each of these definitions, in turn, reveals the semantic content of the concept of "logistics system".

But, in our opinion, the essence of this category should be considered through the prism of the value chain of products, which, from the point of view of a business organization, "includes a set of productive (valuable) actions carried out by capital and labor resources (or firms and employees) at the entire stage from the "origin" of a product or service to their final consumption and beyond"[137]. After all, if the supply chain describes the flow of resources from the supplier to the consumer, then the value chain is the flow (movement) of value (from the consumer's point of view). And if the consumer doesn't see any value in what the supply chain offers, then there will be no demand. And if the supply chain can't deliver resources that are valuable to the consumer (at a price the consumer is willing to pay), then there will be no movement of these resources.

Accordingly, the goal of the agri-food logistics system as a technical and economic system is to provide maximum profit to each partner participating in the supply chain. This can be achieved by ensuring that the main six resources – space, time, materials, labor, energy, and money – are used to a minimum. Based on the above, we can state that the agri-food logistics system is an economic system that is a set of interrelated main and auxiliary logistics processes and agro-business flows in the value chain of products, work, or services, the purpose of which is to ensure the satisfaction of external needs of consumers and internal needs of

[136] Oklander M.A. Logistic system of the enterprise: monograph. Odesa: Astroprint, 2004. 312.

[137] Zagurskyi O.M. Upravlinnia tsepnom supplyom [Management of the supply chain]. Kyiv: FOP Yamchynskyi O.V., 2023. 333.

agricultural production with the required intensity and optimal logistics costs (Fig. 3.4).

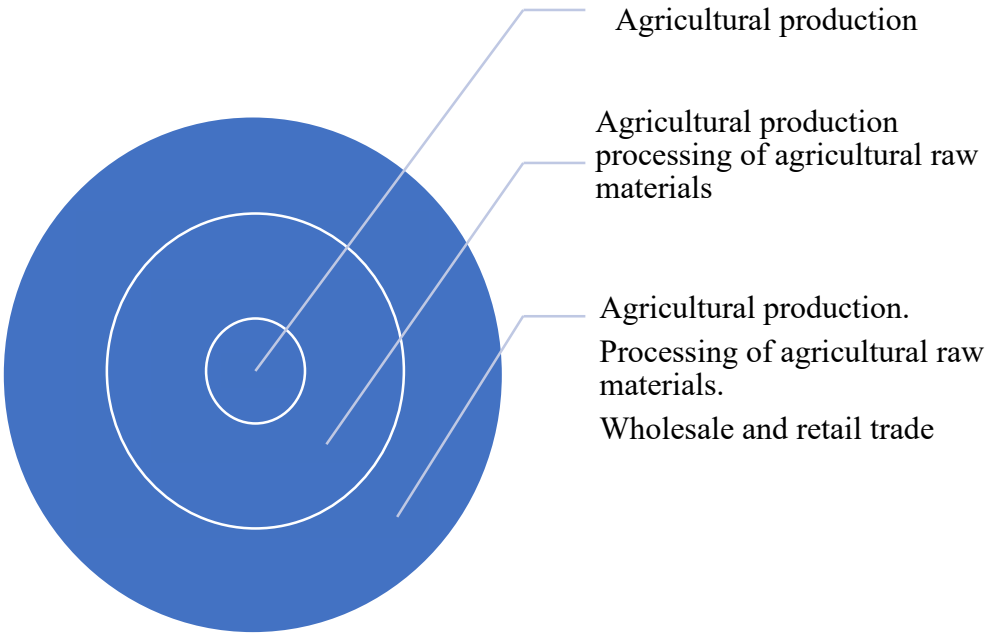



**Fig. 3.4. Development of the agri-food logistics system in the direction of concentration and increasing the length of the agribusiness value chain**

*Source:* compiled by the authors

At the same time, the integration of individual logistics systems takes place in the process of business management. In addition, business entities may seek to combine logistics systems in quite different directions. Thus, agri-food logistics systems are formed as intra-organizational, inter-organizational, and mixed logistics formations, in some cases – as part of organizational logistics formations. Integration in agricultural entrepreneurship is carried out to control logistics chains by creating various systems for this.

Taking into account the given essence of the agri-food logistics system, the logistic organization of the agrarian business is the construction of the main and auxiliary operational processes in the value chain of agricultural products, work, or services using the concept of logistics.

At the same time, the matrix of the main goals of the agro-logistics system should be built based on the logistics mix 8 "R-s": ensuring the supply of the right product of the right quality in the right quantity to the right consumer in the right place at the right time at the required cost of service and the required level of logistics service (Fig. 3.5).

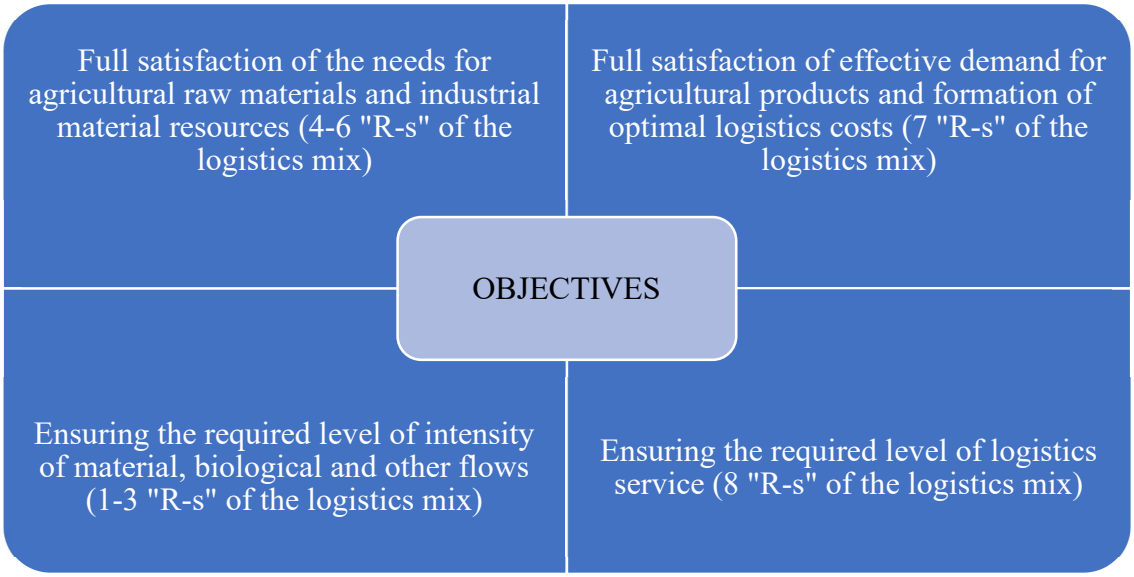



**Fig. 3.5. Matrix of the main objectives of the functioning of the agri-food logistics system**

*Source:* compiled by the authors

As the main goals of the agri-food logistics system, it is expedient to consider ensuring the satisfaction of the external needs of consumers and the internal needs of agricultural production with the necessary intensity and the minimum possible logistics costs.

The required level of intensity of material, financial, informational, and biological flows (the use of appropriate varieties, breeds, biochemical stimulation of growth, etc.) is important, because it directly affects the time of order implementation. Logistics costs are proposed to be separately

allocated in the "matrix" of goals, since this is one of the fundamental factors in the efficiency of logistics management.

Logistics, as a scientific discipline and area of professional activity, is closely related to the processes of planning, regulating, and controlling the flow of materials, finance, and information. Accordingly, the object of the study of logistics as a science and the object of logistics management is the system of flows. (material, financial, informational, etc.).

A flow is a mass of something that is directed in some direction[138]. The main criteria that characterize the flow are it's starting and ending points, speed and time of movement, and intensity. In the agrarian sector of the economy, as well as in other sectors of the economy, the main object of logistics management is the material flow. At the same time, scientists note that in agriculture, many material flows are biological. Therefore, in [139] agricultural logistics, it is worth talking about the existence of two separate types of flows: material and biological.

The main reason for distinguishing the latter in agribusiness is the formation and use of artificial ecological systems (agrobiocenoses) that are created by man (arable land, nurseries, greenhouses, etc.), and individual natural ecosystems (pastures, meadows, lakes, etc.).

Artificial ecosystems have the same set of components as natural ones (producers, consumers, and decomposers), but have significant differences in the redistribution of flows of matter and energy. In particular, man-made ecosystems differ from natural ones by:

– the predominance of organisms of one or more species;

– insignificant stability and strong dependence on energy introduced into the system by humans;

[138] Modern explanatory the dictionary of the Ukrainian language: 65000 words / edited by V.V. Dubichynsky. Kharkiv: Shkola Publishing House, 2006. 1008.

[139] Volnova O.M. Logistic approach to the formation of agrarian production. Bulletin of Khmelnytskyi National University. 2010. No 2, vol. 1. 161–164.; Kosareva T.V. Agrarian logistics: essence and multifaceted content. Economics of the agro-industrial complex. 2008. № 10. 37–43.; Amede T., Konde A.A., Muhinda J.J., Bigirwa G. Sustainable Farming in Practice: Building Resilient and Profitable Smallholder Agricultural Systems in Sub-Saharan Africa. Sustainability 2023, 15, 5731. https://doi.org/10.3390/su15075731; Fernandez-Mena H., Gaudou B. Sylvain Pellerin, Graham K. MacDonald, Thomas Nesme, Flows in Agro-food Networks (FAN): An agent-based model to simulate local agricultural material flows, Agricultural Systems, Volume 180, 2020, 102718.1

– short food chains due to the small number of species;

– open circulation of substances due to withdrawal harvest, etc.

Without the support of energy flows on the part of humans in artificial ecosystems, natural processes are restored at one speed or another, and the natural structure of the components of biocenosis and information-substance-energy flows between them are formed[140].

All these streams are interconnected and often combine (intersect). Therefore, their selection is often conditional and is carried out in bioecological sciences for the convenience and accuracy of the analysis of a very complex object – a functioning ecosystem. In agri-food logistics, taking into account other tasks, information-matter-energy flows should be considered under the general name "biological".

Biological flow is predominantly seen as a sequential, predominantly[141] continuous transformation of biological resources (biomass and standing crops) in a natural process. The main features of the classification of biological flows should be considered as the degree of controllability, variability, and ordering. In this case, the biological flow in agricultural production is a consistent, mostly continuous transformation of biological resources (biomass and standing crops) into artificial ones (increase in live weight, crown formation, etc.), as well as natural ecosystems (formation of meadows and pastures, etc.).

At the same time, in agri-food logistics, it makes sense to consider biological flows together with material flows as the main ones, and financial, informational, and other flows as supporting (auxiliary). Accordingly, the biological flow can also be partially managed as an object of control. At least, such an approach is possible in the system of organic farming, in the use of biological plant protection products, in experimental seed farms, in the

[140] Velychko O. P. Development of logistics in the system of management of enterprises of the agrarian sphere of economy. ... Dr. Econ. Sciences: 08.00.04 / O. P. Velichko. Dnipropetrovsk, 2016. 566.

[141] Stark S., Biber-Freudenberger L., Dietz T., Escobar N., Förster J., Henderson J., Laibach N., Börner J., Sustainability implications of transformation pathways for the bioeconomy, Sustainable Production and Consumption, Volume 29, 2022, 215-227.; Holden N.M., Neill A.M., Stout J.C., O'Brien D., Morris M.A. Biocircularity: a Framework to Define Sustainable, Circular Bioeconomy. Circ Econ Sustain. 2023; 3(1):77-91. doi: 10.1007/s43615-022-00180-y. Epub 2022 Jun 8. PMID: 36970551; PMCID: PMC10033560.

creation of genetically modified organisms, etc. All these processes also include separate logistical support operations.

However, the main function of agri-food logistics is directly related to the distribution of agricultural products, and in a broader sense – to the creation of the most optimal system for the movement of all types of agricultural products through the commodity distribution network with high standards of service for the consumption sector.

Accordingly, the management of logistics systems for the supply of agricultural products should primarily be aimed at transforming the supply chain into a single, effective system of customer service – the population of the country. The analysis of literary sources[142] makes it possible to form the main problematic issues on the way to the formation of an effective logistic system for the distribution of agricultural products and possible options for their solution (Table 3.2)

Despite all the problems and shortcomings of the agro-industrial complex, according to the World Bank, GDP growth, which is due to the growth of agriculture, is at least twice as effective in reducing poverty as GDP growth at the expense of other industries, and it is the innovative development of this industry that provides a large-scale reduction in poverty in villages in recent years in many countries of the world[143].

[142] Abbasi M., Varga L. Steering supply chains from a complex systems perspective, European Journal of Management Studies , 2022, Vol. 27 No. 1, pp. 5-38. https://doi.org/10.1108/EJMS-04-2021-0030 Fonseca J.M.,Vergara N. Logistics Systems Need to Scale Up Reduction of Produce Losses in the Latin America and Caribbean Region.Proc. III rd Int. Conf. on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions. 2014. P. 173-180.; Themen D. Food losses and waste in Ukraine. Regional Office for Europe and Central Asia Food and Agriculture Organization of the UN. 2013. URL: http://www.fao.org/europe/agrarian-structures-initiative/en.; Shekhar S., Singh, Shahbaz Khan R. Barriers to Minimisation of agri-products wastage through Optimizing logistics in India: An ISM modelling approach, Heliyon, Volume 9, Issue 11, 2023, e21551.; Bayir B., Charles A., Sekhari A., Ouzrout Y. Issues and Challenges in Short Food Supply Chains: A Systematic Literature Review. *Sustainability* 2022, *14*, 3029. https://doi.org/10.3390/su14053029.: Mittal A., Krejci C.C., Craven T.J. Logistics Best Practices for Regional Food Systems: A Review. *Sustainability* 2018, *10*, 168. https://doi.org/10.3390/su10010168; Zhao X., Wang P., Pal R., The effects of agro-food supply chain integration on product quality and financial performance: Evidence from Chinese agro-food processing business, International Journal of Production Economics, Volume 231, 2021, 107832.; Astuti R., Hidayati L. How might blockchain technology be used in the food supply chain? A systematic literature review, Cogent Business & Management, 2023, 10:2, DOI: 10.1080/23311975.2023.2246739.;

[143] New Course: Reforms in Ukraine 2010-2015 : National Report / [V. B. Averyanov, B. M. Azhnyuk, B. M. Bogdan, T. P. Borodina et al., ed. by V. M. Heitsa et al.] ; National Academy of Sciences of Ukraine, Section of Susp. and humanitarian. Sciences. Kyiv: NVC VNLU, 2010. P. 135.

Table 3.2

**List of the main problematic issues of creating an effective transport and logistics system for the distribution of agricultural products and ways to solve them**

| Problematic issues | Solutions |
|---|---|
| Infrastructure | Investing in shared logistics centers that will create economies of scale that will lead to improved logistics efficiency by reducing routes, distances and transportation times |
| Information Technology | The implementation of information technologies will help reduce losses and increase competitiveness. |
| Integrated Logistics Systems | Improving the efficiency of agri-food supply chain management is aimed at uniting all participants in the supply chain into a single, efficient system |
| Qualified personnel | Training of specialists in the field of logistics management and employees specializing in the commodity processing of products with a limited shelf life. |
| Specialized Vehicles | The involvement of refrigeration equipment in the supply chain of agricultural products improves its quality and freshness and extends its shelf life. |
| Services of logistics companies | Involvement of operators for the provision of logistics services. |
| Packing | Improvement of packaging technologies that lead to minimization of losses and ensuring appropriate product quality. |
| Monitoring & Traceability | Improving monitoring of product identification and carrying out measures to maintain its proper quality |

*Source: compiled by the authors based on literary sources*

In addition, the calculations of scientists show that one percent of additional products produced in the agricultural sector provides an increase in the production of industrial infrastructure by 2.5%, respectively, processing industries by 1.4%, transport services – by 0.33%, and adequate trade – by 2.7%[144].

Therefore, accelerating the growth rate of agricultural production based on increasing its competitiveness is a priority direction of economic policy[145]. If we add to this a reduction in logistics costs by about 1% equals a 10% increase in sales. Then it becomes clear that a well-built transport and logistics system at an agricultural enterprise can generate more income than a traditional extensive business development scheme.

The modern development of the agro-industrial complex with the use of agri-food logistics will allow:

– reduce stocks along the entire path of the material flow by 30-50%;

– to reduce the time of movement of goods along the logistics chain by 25-45% (according to the scientists of the Institute of Agrarian Economics of the Ukrainian Academy of Agrarian Sciences, the transportation of products by field roads, which are typical for most on-farm transportation at grain producing enterprises, is accompanied by annual losses of 1-2% of the gross grain harvest)[146];

– reduce transportation costs;

– reduce the cost of manual labor.

The foregoing indicates the need to adapt the logistics systems of the agro-industrial complex to the market model of management, to increase the efficiency of management of logistics activities of economic entities of the agro-industrial complex, taking into account the peculiarities of digitalization of business processes. Accordingly, the priority task of

[144] The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London. FAO. 2011. 285.

[145] Ulyanchenko Y. O. Competitiveness of the agrarian sector of the economy: mechanisms of state regulation. Kharkiv: Vyd-vo Asociatsiya doktoriv gauk z gosudarstven. Management, 2013. 368.

[146] Formation and functioning of the market of agro-industrial products: a practical guide / ed. P.T. Sabluka. Kyiv, IAE Publ., 2000. 556.

agricultural enterprises is to create an effective logistics information system that, a flexible response to crisis phenomena in the global world, changes in the institutional environment, unstable economic situations, and fluctuations in the market of agricultural products[147].

Accordingly, the development of logistics in the agro-industrial complex will become more and more in demand shortly. Its enormous efficiency in business development is proved by the results of the application of the logistics approach in the economies of developed countries and large agricultural vertically integrated firms.

If we consider the logistics systems of the agro-industrial complex or agri-food supply chains, it should be noted that these are self-organized systems that depend on the internal and external environment. Over time, some factors determine the evolutionary direction of the development of the entire system. A self-organized system has the initiative to adapt and select parameters, which means that key enterprises can negotiate and actively cooperate, weakening and assimilating negative parameters, and vice versa, increasing and developing positive parameters of activity.

As a result, synergies between key enterprises and synergies between supply chains and the environment can be created, and supply chain efficiency can be improved. Under certain conditions, supply chain subsystems can form self-organizing structures and create new ordered relationships through nonlinear interaction[148].

In the agri-food chain, the decisive factor for creating and maintaining a competitive advantage is access to the best buyer (the one that provides

[147] Kwilinski A., Slatvitskaya I., Dugar T., Khodakivska L., Derevyanko B. Main Effects of Mergers and Acquisitions in International Enterprise Activities. International Journal of Entrepreneurship, 2020, 24, 1-8.; Lyulyov O., Pimonenko T., Kwilinski A., Us Y. The heterogeneous effect of democracy, economic and political globalisation on renewable energy. E3S Web of Conferences, 2021, 250, 03006.; Vaníčková R., Szczepańska-Woszczyna K. Innovation of business and marketing plan of growth strategy and competitive advantage in exhibition industry. Polish Journal of Management Studies, 2020, 21(2), 425-445. https://doi.org/10.17512/pjms.2020.21.2.30..

[148] Dan T. Developing Agricultural Products Logistics in China from the Perspective of Green Supply Cain. International Jornal of Business and Management. 2012. No 7. 106-111.

the highest income) at the right level of quality, with the right shelf life and proper passage through the supply chain[149].

Nevertheless, these requirements need to be expanded when we talk about sustainability issues in strategic decision-making. Since the ultimate goal of a sustainable agri-food chain is to meet the needs of consumers, it is most appropriate to consider the impact of operating activities on the environment and society. In his research, O.P. Velichko and M.P. Butko[150] emphasize that in the context of transformation, the concept of socially responsible business is gradually becoming widespread. In their opinion, socially responsible enterprises receive a positive result from their social activities aimed at both the external and internal environment, which is manifested in an increase in labor productivity, an increase in product quality, a reduction in the duration of the production cycle, as well as in an increase in the reputation of the company, an increase in sales and a positive attitude of the population to the company, which he proposes to perceive as a long-term unique competitive advantage of the company.

At the same time, food products are special and so far irreplaceable goods for daily consumption. Their availability, quality, and accessibility are the main conditions for human life and performance. However, despite the stable demand for food products, the current market conditions are characterized by certain difficulties:

1. Growing customer requirements for the quality of products.
2 The importance of maintaining the sustainability of results.
3 Unpredictable changes in the market.
4 Rising logistics costs[151].

[149] Ahumada O.,Villalobos J. R. Operational model for planning the harvest and distribution of perishable agricultural products. International Journal of Production Economics. 2011. No 133. 677-687.

[150] Velychko O. P., Butko M. P. "Upravlinnia distributsionnoi diiatsii pidpryiemstvo pidpryiemstvo promyslovi" [Management of distribution activities of food industry enterprises]. Modern transformations of the organizational and economic mechanism of management and logistics of business entities in the system of economic security of Ukraine: collective monograph. Ed. Dnipro: Bila K.O. 2017., 125-130.

[151] Carter R.H. Stores Management and Related Operations. Second Ed., Macdonald & Evans. 1985 . xii, 228.

Taking this into account, companies in the food and processing industry, to ensure the competitiveness of their products, it is necessary to maintain a balance in the supply chain by providing optimal solutions that provide value for the company, namely:

– maintaining logistics costs at a reasonable level;

– efficiency of use of production equipment;

– differentiation of markets;

– ensuring the possibility of production growth;

– ensuring the reliability and sustainability of deliveries of its products[152].

Along with the difficulties in managing business processes in food supply chains, there are also several problems in the development of the market for such products as a whole:

1. Constant changes in retail formats – growth in the forms of distribution channels. Retailers strive to reach customers in different geographical locations, they create different store formats, which in turn requires an understanding of the business model for each store format and the orientation of logistics to this format;

2. Expansion and specialization of the assortment. Retailers use customer segmentation to more accurately determine their needs. However, most of them are not able to support the growth of the assortment, which affects the availability of goods on the shelf. Fulfillment of this requirement requires a reduction in consignments of supplies of certain commodity items and a corresponding increase in logistics costs in general;

3. Growing importance of individual products. Trademarks are a source of differentiation for retailers. Providing these items with stocks requires significant demand support, which is difficult to obtain without sales statistics, which leads to both an increase in inventory levels and additional transportation costs. Accordingly, improving the quality of the forecast will increase the quality of forecasting parameters, and this will affect the level of stocks in the supply chain. Reducing stocks in the supply

[152] Gartner Research: Improving On-Shelf Availability for Retail Supply Chains Requires the Balance of Process and Technology. May 2011. URL. https://www.gartner.com/en/documents/1701615/improving-on-shelf-availability-for-retail-supply-chains

chain will reduce the share of urgent deliveries and, as a result, reduce logistics costs.

The presence of internal difficulties in managing the supply of food products and external externalities of this market prompts the analysis of the supply chain and the technologies used in it. If we consider in detail the process structure of the food supply chain, it usually includes all types of activities for the cultivation and preparation of raw materials, the direct production of the final product, and all post-production activities, such as storage, transportation, sale (wholesale and retail trade) of finished products, their export and import.

It should be noted that these activities have several specific characteristics, such as the duration of the production of finished products, seasonality in production, the limited shelf life of products, and the need for conditioning at the stages of transportation and storage of products. In this regard, food supply chains are subject to increased requirements related to their safety. Stringent food safety regulations and ever-increasing consumer awareness of food safety are driving businesses to take steps to improve and modernize agri-food chains and are attracting increasing attention from researchers in food science, engineering, and supply chain management.

To ensure food safety, food quality must be carefully and continuously monitored and controlled at every stage of the supply chain. The International Organization for Standardization (ISO) gives the most popular definition of food quality. "A set of properties and characteristics of products and services related to the ability to meet the established requirements or needs of the consumer"[153]. To preserve the value and quality of food products and meet customer requirements, the freshness and safety of these products must be ensured at every stage of the logistics chain[154].

[153] ISO 90000-1-94

[154] Marucheck A., Greis N., Mena C., Cai L. Product safety and security in the global supply chain: issues, challenges and research opportunities, Journal of Operations Management, Volume 29, Issues 7–8, 2011, 707-720.; Speier C., Whipple J.,. Closs D., Voss M. D. Global supply chain design considerations: mitigating product safety and security risks, Journal of Operations Management, Volume 29, Issues 7-8, 2011, 721-736.; Theeraworawit M., Suriyankietkaew S., Hallinger P. Sustainable Supply Chain Management in a Circular Economy: A Bibliometric Review. Sustainability 2022, 14, 9304. https://doi.org/10.3390/su14159304.;

However, today's global food supply logistics systems face a variety of social challenges that are constantly deepening[155]. Their consequence is that many of them operates in a "below ideal" state, with the result that approximately one-third of the food produced for human consumption is lost. A key factor contributing to such a high amount of waste is the inability to control, and track temperature in global food supply logistics systems[156].

The problem of food losses at all stages of the logistics chain is inherent in most economies of the world and needs to be solved both at the national level to improve the efficiency of the agricultural sector of the economy and the well-being of the country's population, and at the international level to solve complex problems related to global food security and prevent hunger.

In the USA, Canada, Australia and New Zealand (in total) in 2011 (according to the Food and Agriculture Organization of the United Nations – FAO) the following losses were observed:

– cereal products: 38% lost vs. 62% consumed;
– seafood: 50% lost vs. 50% consumed;
– fruits and vegetables: 52% lost vs. 48% consumed;
– meat: 22% lost vs. 78% consumed;
– milk: 20% lost versus 80% consumed[157].

[155] Amir Gharehgozli, Eleftherios Iakovou, Yanling Chang, Ryan Swaney, Trends in global E-food supply chain and implications for transport: literature review and research directions, Research in Transportation Business & anagement,

Volume 25, 2017, 2-14.; Osman S., Xu C., Akuful M., Paul E. Perishable Food Supply Chain Management: Challenges and the Way Forward. Open Journal of Social Sciences, 2023, 11, 349-364.; Bibiana Porto Da Silva, Ricardo Augusto Cassel, Priscila Wachs & Tarcisio Abreu Saurin The influence of sustainability on the complexity of food supply chains, Production & Manufacturing Research, 2023. 11:1

[156] Badia-Melis R., Mc Carthy U., Ruiz-Garcia L., Garcia-Hierro J., Robla Villalba J.I. New trends in cold chain monitoring applications - A review, Food Control, Volume 86, 2018, 170-182.; Jhao-Yi Wu, Hsin-I Hsiao, Food quality and safety risk diagnosis in the food cold chain through failure mode and effect analysis, Food Control, Volume 120, 2021, 107501; Maiyar, L.M.; Ramanathan, R.; Roy, I.; Ramanathan, U. A Decision Support Model for Cost-Effective Choice of Temperature-Controlled Transport of Fresh Food. Sustainability 2023, 15, 6821. https://doi.org/10.3390/su15086821 ; Skawińska E, Zalewski RI. Economic Impact of Temperature Control during Food Transportation-A COVID-19 Perspective. Foods. 2022 Feb 4; 11(3):467. doi: 10.3390/foods11030467. PMID: 35159616; PMCID: PMC8834265.;

[157] Gunders D. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue Paper 2012 Natural Resources Defense Council URL.: https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Moreover, food losses occur along the entire food supply chain. Thus, according to the same FAO, about a third of all food (1.3 billion tons of edible food) for human consumption is lost annually and thrown away throughout the supply chain.[158] Data from FAO's Regional Office for Europe and Central Asia show that the average loss rate of major perishable foods (cereals, potatoes, fruits and vegetables, meat, milk) is almost evenly distributed between operations in the supply chain (Table 3.3).

Table 3.3

**Average level of losses of agricultural products along the supply chain, %.**

| Products | Supply Chain Operations | | | | |
|---|---|---|---|---|---|
| | Production | Storage | Processing & Packaging | Distribution | Consumption |
| Cereal | 10-40 | 5-10 | 5-10 | 4-10 | 5-15 |
| Potato | 10-20 | 10-30 | 2-5 | 2-10 | 2-15 |
| Fruits and vegetables | 2-10 | 10-40 | 2-5 | 5-15 | 5-10 |
| Meat | 5-15 | 5-20 | 5-15 | 5-20 | 2-5 |
| Milk | 10-30 | 2-5 | 10-30 | 10-20 | 10-15 |

*Source:* Themen D. Food losses and waste in Ukraine. Regional Office for Europe and Central Asia Food and Agriculture Organization of the UN. 2013. URL: http://www.fao.org/europe/agrarian-structures-initiative/en

The researchers estimate that, in global mass percentage, the amount of food in food supply chains at the production, post-harvest, and consumption stages is 24 and 35 percent, respectively[159].

Among the main reasons for such losses, scientists determine:

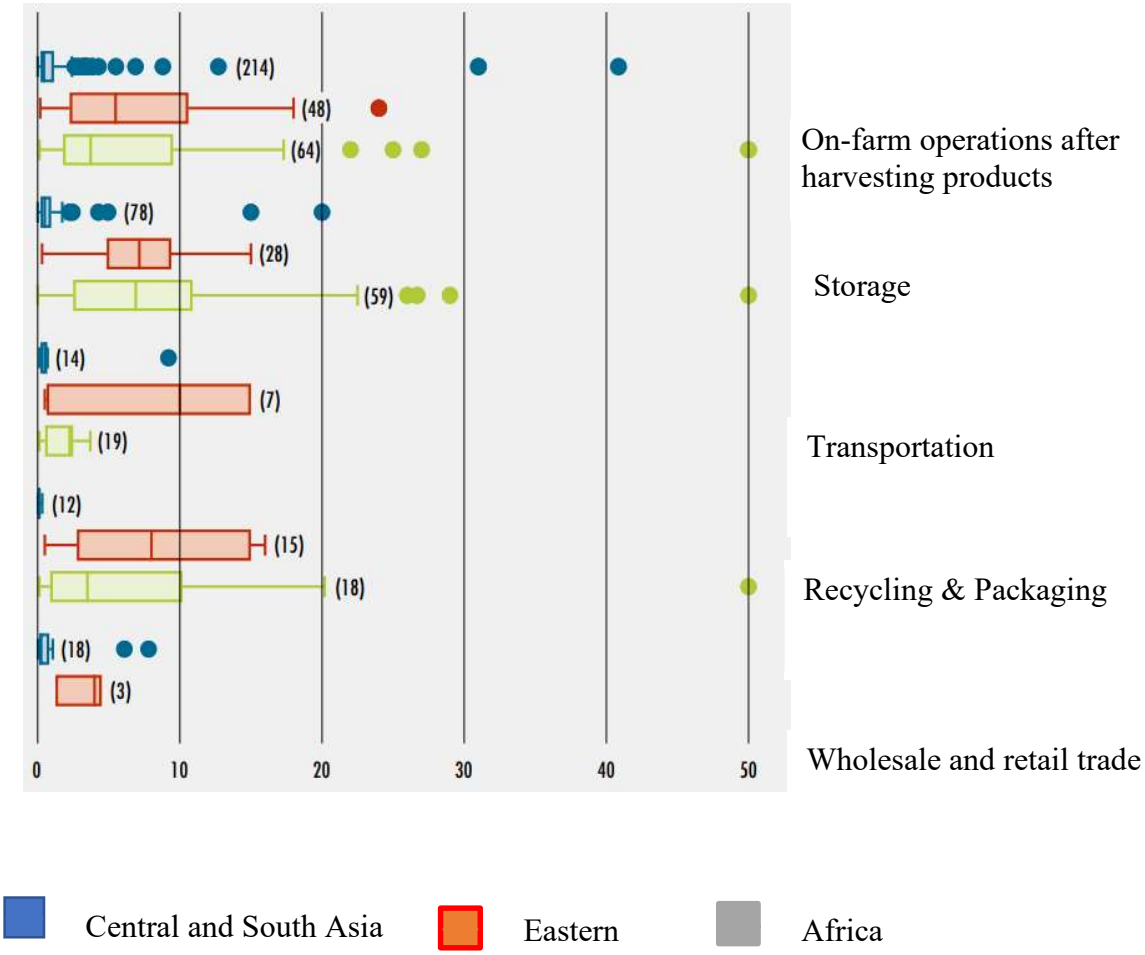
– micro-level reasons (e.g. packaging and transportation);

– meso-level reasons (e.g., supply chain certification infrastructure and practices);

[158] Ishangulyyev R., Kim S., Lee S.H. Understanding Food Loss and Waste–Why Are We Losing and Wasting Food? Foods 2019, *8*, 297. https://doi.org/10.3390/foods8080297

[159] Xue L., Liu G., Parfitt J., Van Herpen X.L.E., Stenmarck A., Clementine O'Connor, Karin Östergren, and Shengkui Cheng Environmental Science & Technology 2017 51 (12), 6618-6633.

– macro-level reasons (e.g., procurement options).[160]




NOTE: The number of observations is in parentheses. Dates (2000-2017) refer to the dates of measurements, but in cases where the dates of the studies were unknown or known inaccurately, the dates of their publication were used.

**Fig. 3.6. Places of loss and spoilage of cereals and leguminous crops in Asia and Africa in 2000-2017 - (%)**

*Source:* FAO research data for 2000-2017

[160] Bahadur K., Haque I., Legwegoh A., Fraser E. Strategies to Reduce Food Loss in the Global South *Sustainability* 2016, 8, no. 7: 595. https://doi.org/10.3390/su8070595 Diaz-Ruiz R., Costa-Font M., López-i-Gelats F., Gil J.M. A Sum of Incidentals or a Structural Problem? The True Nature of Food Waste in the Metropolitan Region of Barcelona. Sustainability 2018, 10, 3730. https://doi.org/10.3390/su10103730.;

If we take a closer look at the places of occurrence and the extent of food loss and spoilage at all stages of the food supply chain, for example, for cereals and leguminous crops (Figure 3.6), then according to FAO studies in 2000-2017 for the countries of Asia and Africa, they were as follows.

Such losses led to the fact that in 2010 the total volume of unsold goods increased by 3-5 billion US dollars compared to 2008[161]. The causes of such deterioration can be divided into three categories.

First, a decrease in consumer tolerance regarding the level of food quality.

Secondly, it is the potential lack or deficiencies in cargo control, which can lead to the supply of goods unsuitable for sale to the market, which, in turn, can pose a threat to the health of consumers. Product spoilage during the distribution process is a serious problem. Approximately one-third of the total food produced worldwide is spoiled or lost – a total loss of $1.3 billion. tons per year[162]. Food losses in the U.S. alone are estimated at about 10% of the country's total food at the retail level[163].

Thirdly, the difficulty is the urgent need to reduce high operating costs in transport and logistics systems and at the same time increase the efficiency of their work.

In Ukraine, agri-food logistics is at the stage of development. At the same time, the developed countries of the world – the USA, Canada, Western Europe, Australia, etc. – have long appreciated the high efficiency of the use of logistics approaches in agribusiness. Today, in many countries of the European Union, government agencies take a proactive role in the implementation of logistics approaches in the activities of agricultural enterprises. At the same time, scientists conclude that, in particular, the

[161] Grunow M., Piramuthu S. RFID in highly perishable food supply chains – remaining shelf life to supplant expiry date? / Martin Grunow, International Journal of Production Economics 2013 Vol. 146 Issue 2, 2013. URL: https://proxy.library.spbu.ru:2069

[162] Zhang Y., Zhao L., Qian C. Modeling of an IoT-enabled supply chain for perishable food with two-echelon supply hubs / Y. Zhang, // Industrial Management & Data Systems, 2017.Vol. 117, Issue 9, 2017. URL. https://proxy.library.spbu.ru:2156

[163] Gunders D. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue Paper. 2012 Natural Resources Defense Council. URL. https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

European experience of agri-food logistics proves the high efficiency, environmental friendliness, and versatility of the use of logistics in the field of agricultural production. In addition, the achieved high level of agribusiness development does not eliminate the governmental, entrepreneurial, and research structures of the countries from the search for new logistical ways to improve the efficiency and environmental friendliness of agricultural production. The importance of agri-food logistics is understood and maintained at the highest level of governance in the country.

### 3.2. Development of export-oriented agri-food logistics in Ukraine during the war

The agricultural sector of Ukraine is one of the largest sectors of the country's economy. In 2021, about 14% of the country's population was employed in agricultural production, accounting for 10.9% of the country's GDP and 41% of exports. Ukraine is one of the world's largest grain exporters, and its share of the world market has been growing steadily over the past decade. As of 2021, Ukraine accounted for more than 40% of[164] global sunflower oil exports, more than 10% of corn and barley, and about 10% of wheat and rapeseed.

Fig. Figure 3.7 shows the volumes of grain exported in the pre-war 2021/2022 marketing year and projected export data in 2022/2023 according to the US Agricultural Service (FAS).

In 2021/2022, Ukraine was the fourth largest grain exporter in the world and one of the world's largest producers, harvesting more than 3.7% of the world's cereal volume[165]. The market share of cereal exports is even larger: 6% of the food calories on the world market come from Ukraine[166]. Exports were

[164] World Data Center. Ukraine: Agricultural Overview.URL.http://wdc.org.ua/en/node/29

[165] Sobolev D. Grain and Feed Update. 2021. URL.https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Grain%20and%20Feed%20Update_Kyiv_Ukraine_10-15-2021.pdf

[166] Weiland P., Zachmann G. The Impact of the War in Ukraine on Food Security. URL https://www.bruegel.org/2022 /03/the-impact-of-the-war-in-ukraine-on-food-security/

dominated by corn, wheat, and barley, Ukraine was the 4th, 5th, and 2nd largest exporter of these cereals in the world[167].

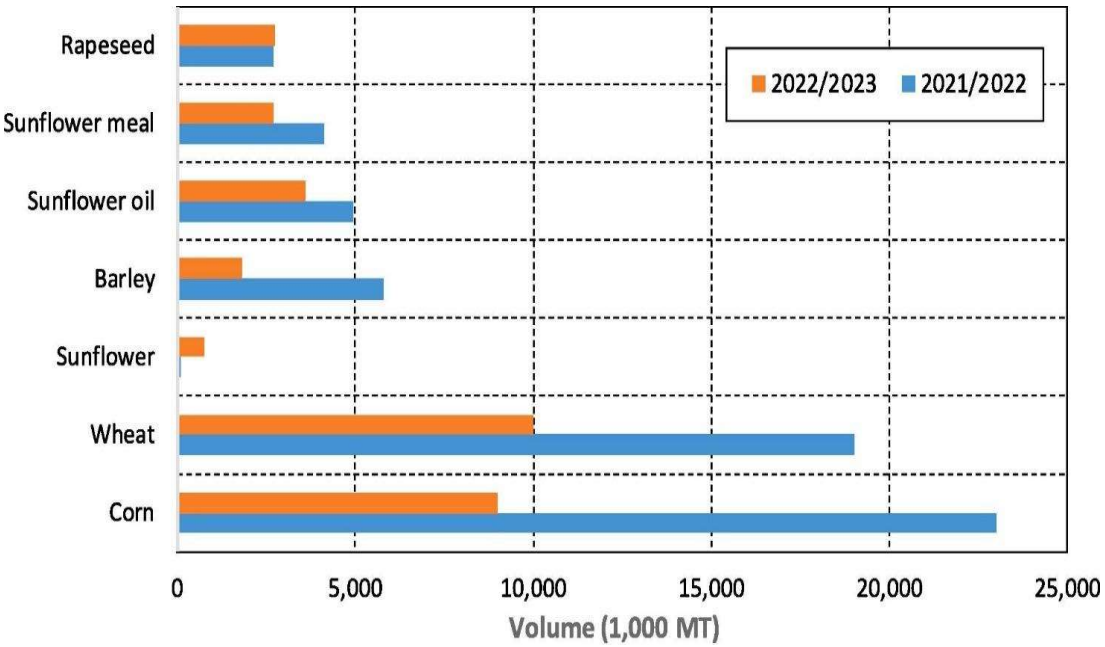



**Fig. 3.7. Export of Ukrainian grain in 2021/2022 and 2022/2023 marketing years.**

*Source*: FAS. Ukraine Agricultural Production and Trade, Foreign Agricultural Service, US. Department of Agriculture, April/July, 2022. Washington DC, USA. URL.https://fas.usda.gov/sites/default/files/2022-04/Ukraine-Factsheet-April2022.pdf

It is clear that to export such an amount of grain, it was necessary to effectively organize the logistics system of agricultural production. The analysis of the system of logistic support of the agricultural market of Ukraine should begin with determining the scale of its sphere of activity, which is dictated primarily by the volume of output, commodity structure, and trade orientation of the domestic agro-industrial complex.

Agricultural supply chains in Ukraine have their unique features, determined primarily by the diversity of their participants. Suppliers also work in this market, such as traders, processing enterprises, and direct

[167] Jagtap S., Trollman H., Trollman F., Garcia-Garcia G., Parra-López C., Duong L., Martindale W., Munekata P.E.S., Lorenzo J.M., Hdaifeh A. et al. The Russia-Ukraine Conflict: Its Implications for the Global Food Supply Chains. oods 2022, 11, 2098. https://doi.org/10.3390/foods11142098

agricultural and farming enterprises. Each of them is characterized by a significant volume of production, planned parameters, various logistics areas, and pricing policy. One of the key features of agri-food supply logistics chains in Ukraine is their considerable length, which often includes cross-border delivery. This requires the involvement of more participants and a higher level of resilience to carry out logistics operations.

The production of various types of grain is dispersed throughout Ukraine but is subject to some regional concentration. Thus, wheat production in Ukraine is mainly carried out in the south, especially in the south-east and south-west (Kharkiv, Dnipro, Zaporizhzhya, and Odesa regions), while corn production is concentrated in the north-central region in Kyiv, Vinnytsia, Poltava, Sumy, and Chernihiv regions. Sunflower is produced mainly in the center (Kirovohrad, Cherkasy, and northern parts of Odesa, Mykolaiv, and Kherson regions). (Figure 3.8).

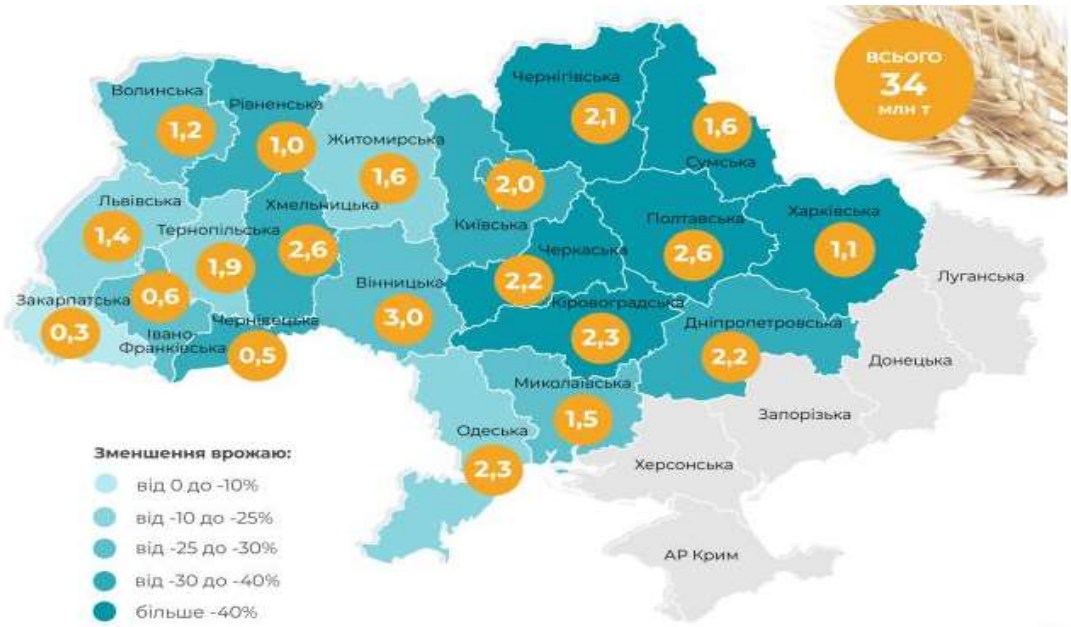



**Fig. 3.8. Indicators of the gross harvest of grain crops by regions of Ukraine in 2022**

*Source:* Consulting agency "AAA" URL.https://agriagency.com.ua/events/14291.html

In recent years, the construction of high-quality warehouses has been actively carried out in Ukraine for grain storage, and projects for the construction of modern warehouses for the storage of agricultural products with the participation of foreign technologies and investors have been

implemented. For example, NAI Pickard, which is part of the NAI group of companies (the sixth largest group of real estate agencies in the world) in 2008 built 260 thousand square meters in Ukraine. m2 of storage space. Kuehne + Nagel has built 35 thous. m2 of warehouses. The British operator Raven & Russia has invested about $600 million in the construction of Ukrainian logistics complexes. Their clients are foreign logistics operators, as well as Ukrainian agricultural companies and supermarkets: "Velyka Kyshenya", "Fursheta", etc.

Among the agricultural companies of grain storage market operators, the leader is the State Food and Grain Corporation of Ukraine. It includes an extensive network of branches: linear and port elevators, mills, feed mills, and cereal plants. The total working capacity of elevator branches, including transshipment capacities in ports, is about 3.5 million tons. The top ten largest Ukrainian agricultural companies in terms of elevator capacity are shown in Table 3.4, and the location of elevator capacities by regions of Ukraine in Fig. 3.9.

Table 3.4.

**10 largest market operators in elevator capacity of grain storage**

| № | Name | Elevator capacity, million tonnes |
|---|---|---|
| 1 | DPGCU | 3,5 |
| 2 | Kernel | 3,0 |
| 3 | UkrLandFarming | 2,66 |
| 4 | NIBULON | 2,03 |
| 5 | Prometheus | 1,69 |
| 6 | Epicenter Agro | 1,57 |
| 7 | MHP | 1,11 |
| 8 | OptimusAgro Trade | 0,84 |
| 9 | TESSLAGROUP | 0,83 |
| 10 | Derzhrezerv | 0,7 |

*Source:* Top-15 companies in terms of elevator capacity 2021. Elevators of Ukraine. URL. https://elevatorist.com/rating/top-15-kompaniy-za-elevatornimi-potujnostyami-u-2021-r


**Fig. 3.9. Map of the location of elevator capacities by regions of Ukraine**

*Source:* Elevators of Ukraine URL. http://www.4sg.com.ua/elevators.php

If we analyze the density of construction and capacity of granaries by regions of Ukraine (Figure 3.9), we can make an important conclusion that the main elevator capacities are concentrated in the central, eastern, and southern regions of the country. Western Ukraine is the most unbalanced in terms of production potential and grain storage potential. Thus, about 15% of the total elevator grain storage potential is concentrated in western Ukraine. At the same time, the production potential is about 36%-38% of the total gross product. That is, even before the war, there was a certain disparity, and with the beginning of the full-scale aggression of the Russian Federation against Ukraine and, accordingly, the direction of logistics routes for the export of grain towards Europe, it is only increasing.

At the same time, it should be noted that the elevator business in Ukraine is built on the export orientation of domestic grain production. Before the start of the full-scale war, the total capacity of certified granaries was 42-45 million tons of simultaneous grain storage, including oilseeds, which have been produced by about 100 million tons in recent years.

Therefore, it can be stated that the vast majority of Ukrainian elevators are not designed for long-term storage of grain, And on the turnover of its volume: "accepted – finalized – shipped". Yes, sometimes grain "lingers" in silos for several months, but before the war, this was due to the marketing policy of its owners, who were waiting for the best purchase price. More common were cases when relatively small elevators with a simultaneous storage capacity of 30-50 thousand tons. During the season, they made three to five or even more revolutions, passing through hundreds of thousands of tons of grain per season. The pricing policy of granaries is also designed for fast turnover. Grain acceptance and shipment services have always been more expensive at Ukrainian elevators than storage because it was the acceptance and shipment that generated the main profit for elevator operators.

Along with storage, transportation is one of the key business processes of supporting entrepreneurial agri-food logistics and an important management object in the logistics management system. This is primarily because one of its tasks is the effective performance of the function of moving products and raw materials of a particular enterprise to ensure production and sale. At the same time, transportation in business is manifested in two aspects:

– internal (associated with short distances of movement, mainly in the system of production logistics);

– external (carried out over long distances between different organizations or remote divisions of the same enterprise, mainly in the supply and distribution logistics system).

Transport support logistics is an important component of the agricultural entrepreneurship system. Moreover, in the context of intensive dynamics of export of agricultural products, for vertically integrated private and corporate agribusiness enterprises, effective provision of external movement of goods and raw materials of agricultural origin is of particular importance.

The export orientation of the agricultural sector of Ukraine provides for the transportation of goods in relatively larger consignments than in domestic traffic, which determines their orientation towards mainline

modes of transport, multimodal transportation, and the use of capacities of large transshipment complexes. In addition, the positive balance in trade in agricultural products for Ukraine means that the responsibility for the functioning of its supply chains lies mainly with domestic market participants.

Transportation in global agribusiness is diversified and is mainly carried out by three modes of transport: road, rail, and water (river and sea). In some cases, pipeline transport is also used (for example, during oil delivery). In the agricultural sector of Ukraine, due to high mobility, motor transport plays a dominant role. This is due to the supply of material and technical resources to agricultural enterprises, the transportation of finished products in the process of primary post-harvest delivery for storage, etc.

In recent years, the main export flow of agricultural products has shifted towards seaports and terminals. Almost 95% of grain and oilseed exports come from Ukrainian ports, which are delivered by three modes of transport: 65% by rail, 25% by road, and 10% by river.

Logistics costs for transportation by rail to seaports are often the most optimal today, so such transportation is dominant in agribusiness. But road and river transport is often recognized as an effective alternative in modern transport agri-product logistics. Thus, road transport is most often used for the transportation of agricultural products over relatively short distances (up to 200 km) or during peak periods of shipment of agricultural raw materials by rail (November, March, etc.). The transport infrastructure of the inland waterways of Ukraine (the Dnieper River, the Southern Bug River, and the Danube River) has been actively reviving in recent years, and river transport is also becoming an important logistical component of ensuring and reducing the cost of grain and oilseeds for export.

At the same time, agricultural companies in the system of road and year transportation use the services of both third parties and their own logistics providers, in contrast to rail transportation, which is in a state monopoly. In addition, today more than 95% of grain cars are state-owned.

And since the grain market in Ukraine is export-oriented, the price of grain depends on the export price – that is, the one that buyers-importers

are willing to pay for it. And because the main volume is sold through ports, this is the FOB price – in Incoterms terminology, this is the price in the port for grain already loaded on board the vessel, it is denominated in US dollars. The price of the CPT port depends on the FOB price – the price of grain with delivery to the port. In other words, the hryvnia price in the port is determined by the export price and does not depend on how much the seller paid for the delivery of grain and even spent on its cultivation. Thus, the more expensive the delivery, and the logistics component, the less the seller receives for the grain itself.

However, it should be noted that only large grain producers sell grain directly on FOB – usually, this is done by traders who can form a large, uniform quality batch of grain and receive an additional premium from the buyer on its sale. Farmers, small and medium-sized farms most often sell grain on EXW – that is, on the terms of its export by the buyer from the place of production or storage (elevator). Traders buy grain on EXW and pay the CPT port price minus the cost of transportation to the port. Again, the higher the cost of delivery to export bases, the less the producer/seller receives for grain on the spot. Given this pricing procedure, buyers have always paid and continue to pay more for grain from the southern port regions, even if they buy it not by traders/exporters, but by local consumers/processors. Conversely, grain from regions far from ports is cheaper due to the longer transport leg and the higher cost of delivery to the main export basis FOB.

Russia's full-scale invasion of Ukraine has caused extensive damage to Ukraine's agricultural sector. The areas directly affected by the hostilities accounted for about 36% of the country's pre-war grain cultivation. About 30% of the territory of Ukraine is mined. In addition, the blockade of the Black Sea and damage to agricultural enterprises have increased the costs and risks for grain production and exports.

The amount of direct damage caused to the agro-industrial complex of Ukraine in the first year of the full-scale war alone amounted to $8.7 billion (see Figure 3.10). According to the experts of the KSE Institute project "Russia Will Pay", the largest share of losses in the agricultural sector is due to the destruction and damage to agricultural machinery, as a result of which the estimated losses of producers amount to more than

$4.65 billion.[168] In total, 109.6 thousand hectares were damaged or destroyed as a result of the war. units of agricultural machinery.

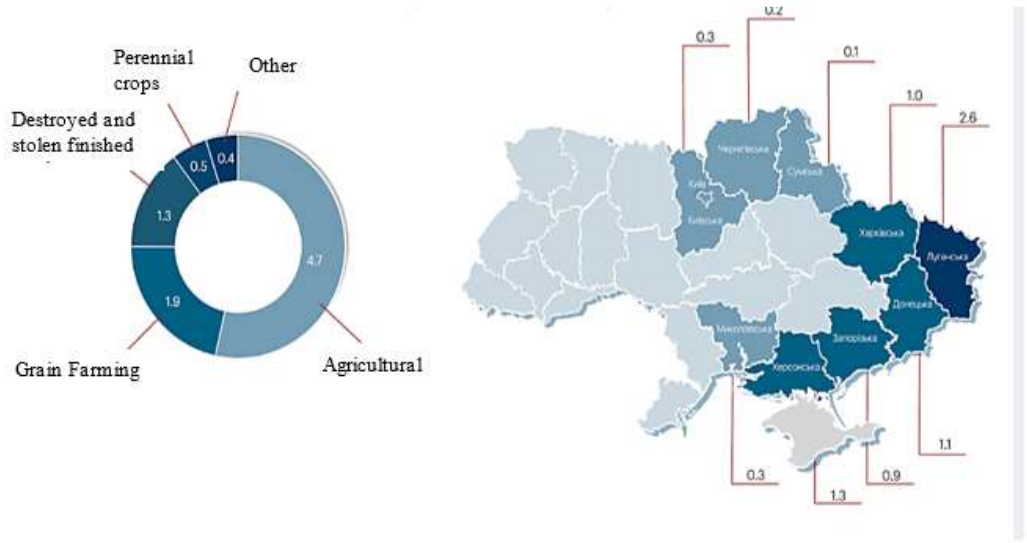



**Fig. 3.10. Direct losses of the agricultural sector of Ukraine by type of property and the most affected regions**

*Source*: Report on direct damage to infrastructure from destruction as a result of russia's military aggression against Ukraine for the year since the start of the full-scale invasion. Kyiv School of Economics. URL. https://kse.ua/wp-content/uploads/2023/03/UKR_Feb23_FINAL_Damages-Report-1.pdf

The second largest category of losses in this area is associated with the destruction and theft of manufactured products. More than 4 million tons of destroyed and stolen finished agricultural products were recorded. The total cost of these losses is estimated at $1.87 billion.

The infrastructure for storing agricultural products also suffered significant losses. The total capacity of the destroyed granaries reaches 8.2 million tons of manufactured products, and the damaged granaries – 3.25 million tons of capacity for simultaneous storage. The cost of restoring the

[168] During the year of the full-scale war, Russia caused almost $144 billion in damage to Ukraine's infrastructure. KSE Institute "Russia Will Pay". URL https://kse.ua/ua/about-the-school/news/za-rik-povnomasshtabnoyi-viyni-rosiya-zavdala-zbitkiv-infrastrukturi-ukrayini-na-mayzhe-144-mlrd/

destroyed facilities is estimated at $1.33 billion.[169] Among the most affected regions are Donetsk, Luhansk, Dnipropetrovsk, Kharkiv, Zaporizhzhia, Kherson, Mykolaiv, and Sumy. It should be noted that some elevators affected by shelling have resumed their work, while others, on the contrary, have lost their capacity. So, according to Elevatorist.com estimates, as of June 2023, about 49.26 million tons are in operation in the country in all regions[170]. (see Figure 3.11)

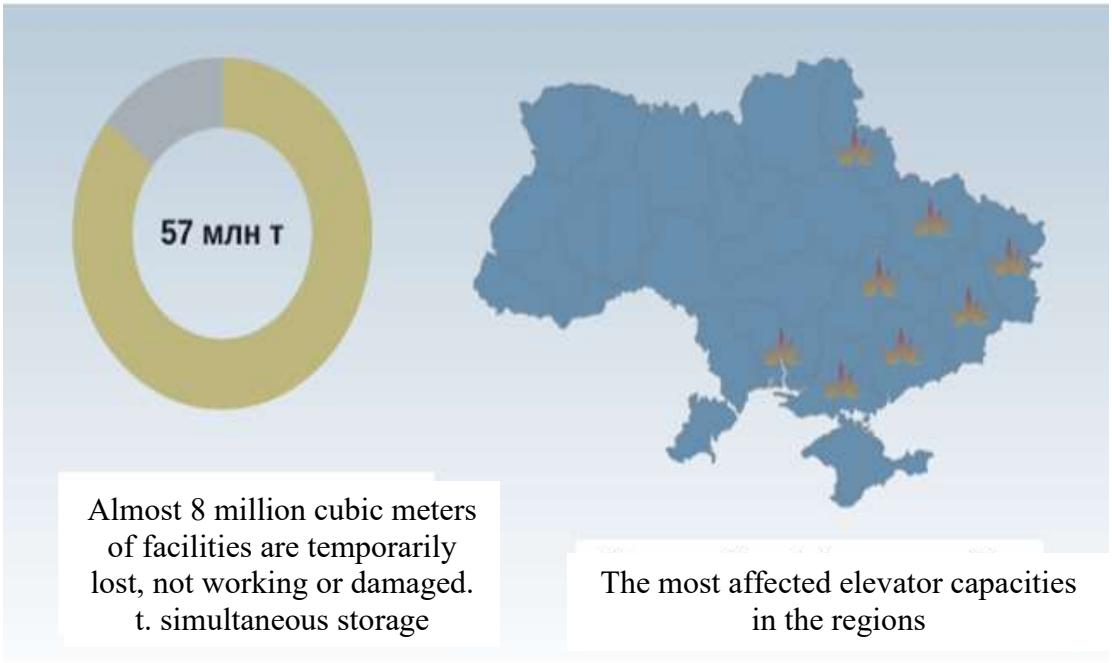



**Fig. 3.11. Statistics of elevator losses from the war in Ukraine**

*Source*: Ukraine's elevator losses due to the war. Elevatorist.com. URL. https://elevatorist.com/blog/read/853-elevatorni-vtrati-cherez-viynu-na-cherven-2023-roku

However, the indirect damage caused by the war to agriculture is much greater. Thus, the lost income of farmers from a reduction in

[169] Losses to the agricultural sector and land resources of Ukraine from the full-scale war amount to $8.7 billion. URL. https://borgexpert.com/news/zbytky-ahrosektoru-ta-zemelnym-resursam-ukrainy-vid-povnomasshtabnoi-vijny-skladaiut-8-7-mlrd

[170] Ukraine's elevator losses due to the war. Elevatorist.com. URL. https://elevatorist.com/blog/read/853-elevatorni-vtrati-cherez-viynu-na-cherven-2023-roku

production and a decrease in domestic prices, as well as additional costs caused by the war, is estimated at $34.25 billion. More than half of this amount, namely $18.5 billion, is estimated losses from disruptions in logistics and lower prices for export-oriented goods, and therefore directly relate to the storage of grain, the vast majority of which Ukraine exported before the war[171].

Given the significant loss of storage capacity during the war in Ukraine, the international community is helping farmers organize additional storage facilities. Thus, in August 2022, the Food and Agriculture Organization of the United Nations (FAO) announced the provision of grain storage capacity to Ukrainian agricultural producers and a solution to the current shortage of storage facilities, which will be supplied free of charge with plastic bags (sleeves) for storing more than 4 million tons of grain, which is 25% of the estimated deficit of granaries. For its part, the government exempted equipment for loading and unloading such hoses from import duties. Farmers in Lviv, Volyn, and Odesa regions have already reported receiving the first batches of aid.

The country's transport infrastructure suffered even greater losses. According to preliminary estimates, the total amount of infrastructure losses in Ukraine amounted to $36.2 billion. As a result of hostilities, 25.1 thousand people were destroyed. km of roads and 344 bridges and bridge crossings of state, local or municipal importance.

The total volume of the damaged railway track is up to 507 km; The number of damaged railway stations and stations is 126. The total direct losses of the railway are estimated at $4.3 billion.[172]

The decrease in freight traffic volumes in the context of individual segments of the relevant market is presented in Fig. 3.12.

[171] Export logistics in wartime. URL. https://agrotimes.ua/article/eksportna-logistyka-u-voyennyj-chas/

[172] The report on direct damage to infrastructure from destruction as a result of russia's military aggression against Ukraine for the year since the beginning of the full-scale invasion. Kyiv School of Economics. URL. https://kse.ua/wp-content/uploads/2023/03/UKR_Feb23_FINAL_Damages-Report-1.pd

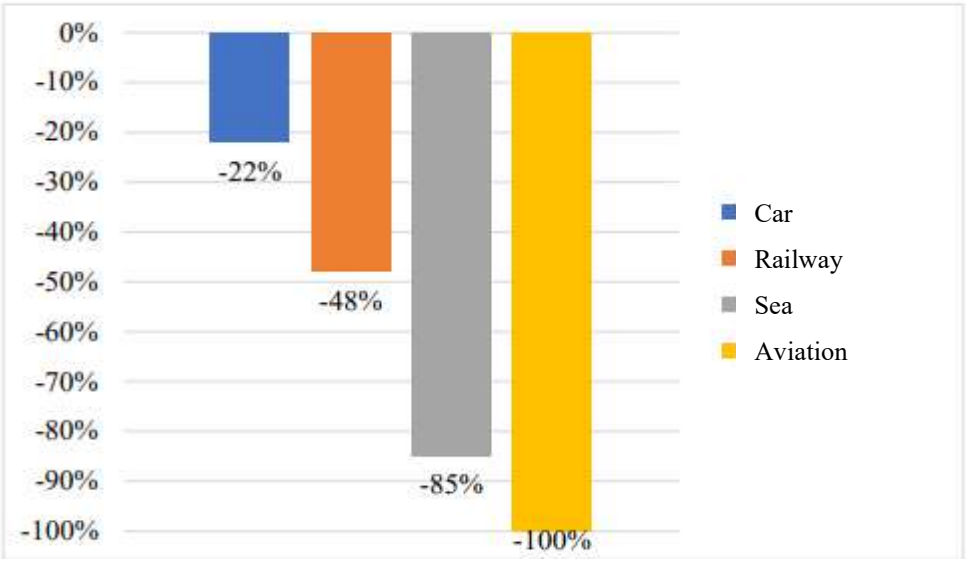



**Fig. 3.12. Decrease in the volume of freight traffic on the territory of Ukraine after the start of the full-scale Russian invasion, %**

*Source: formed* by the authors based on TradeMasterGroup Freight transport market in 2022, URL.https://trademaster.ua/articles/313620

These circumstances have led to a natural decrease in the volume of transportation in the Ukrainian transport and logistics industry. According to analytical data on trends in the development of the freight transportation market in 2022[173], the war led to a decrease in road transportation by 22%, rail transportation by 48%, sea transportation by 85%, and air transportation by 100%.

At the same time, international transportation played an important role in freight transportation, because in the context of restrictions on exports of the main items of the agricultural sector of Ukraine (such as wheat, corn, barley, etc.), there was an urgent need to ensure foreign trade turnover, which is necessary for the inflow of foreign currency to Ukraine and a certain stabilization of the economic situation.

Thanks to the efforts of government agencies and private businesses, the volume of cargo turnover in international traffic in 2022 was maintained

[173] Trade Master Group Freight transport market in 2022, URL.https://trademaster.ua/articles/313620

at the level of 91.2 million tons, among which 59.5% (54.2 million tons) was provided by land transport.[174]

The losses in the water transport infrastructure were even greater. In 2022 alone, direct losses as a result of hostilities to port infrastructure and related enterprises are estimated at $496 million. This assessment includes both the infrastructure of seaports and inland water transport facilities that were destroyed as a result of the war. In total, about a third of the port infrastructure has been destroyed or damaged since the beginning of the war.[175]


**Fig. 3.13. Ports of Ukraine during the war**

*Source*: UA War Infographics. URL. https://www.uawarinfographic.toplead.com.ua

In addition, according to the International Chamber of Shipping (ISS), at the beginning of May 2022, more than 70 vessels remained blocked in Ukrainian ports. The largest number of ships were stuck in the ports of "great Odesa": 23 in Chornomorsk, another 10 were anchored in Odesa and

[174] Bielashov Ye. The role of land transport in the stability of international cargo transportation in the conditions of the war with the Russian Federation", National institute for strategic studies, 2023, URL http://surl.li/hlhrv

[175] Suspilne. URL https://suspilne.media/573803-z-momentu-vihodu-z-zernovoi-ugodi-rosia-zavdala-118-udariv-po-ukrainskih-portah-kubrakov/

6 in Pivdennyi. In addition, 25 were stuck in Mykolaiv, 16 in Kherson, 8 in Berdyansk, 5 in Mariupol, and two more ships in Ochakiv and the specialized port of Nika-Tera[176]. There were 1.2 million cargo already loaded on the blocked ships, of which 2/3 was food. In particular, only in the Odessa region, 480 thousand tons were loaded into the holds of ships. tons of corn, wheat, and oil.

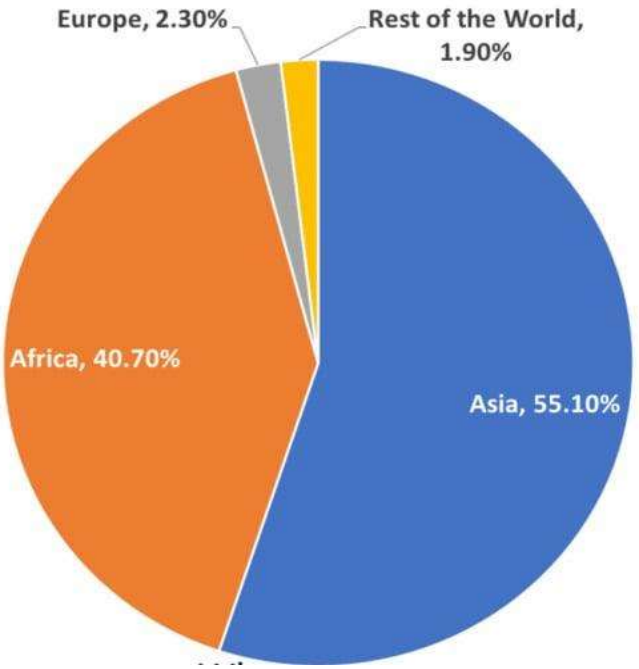



**Fig. 3.14. Export directions of Ukrainian wheat in 2021**

Source: Ebrahim N. Egypt Caps Bread Prices as Shockwaves of Ukraine War Hit the Middle East. CNN Business. 2022. URL. https://edition.cnn.com/2022/03/23/business/mideast-summary-03-23-2022-intl/index.html

As a result, in April 2022, the volume of international freight traffic by sea reached its historical minimum and amounted to 0.9 million tons. t (its value was 15.5 times less than the pre-war level), and until September 2022[177] remained at a level much lower than the values of the corresponding indicator of freight transportation by land, while before the

[176] The Black Sea Institute of Strategic Studies
URL. https://www.blackseanews.net/en/read/209291

[177] Bielashov Ye. The role of land transport in the stability of international cargo transportation in the conditions of the war with the Russian Federation", National institute for strategic studies, 2023, URL. http://surl.li/hlhrv

war sea transport was significantly ahead of land transport in terms of these indicators).

The closure of Ukrainian ports has become a serious problem for both Ukraine and the world as a whole, as many countries, especially in the Middle East and Africa, depend on Ukrainian grain as a source of food for their populations. India, China, and some countries in the Middle East rely on sunflower oil imports, while Egypt and Libya get two-thirds of their wheat supplies[178] from Ukraine. Lebanon gets 80% of its wheat from Ukraine[179,] Ethiopia and Yemen are heavily dependent on wheat imports. [180]Lithuania, China, and India receive more than 80% of their corn imports from Ukraine.[181]

The European Union also has important trade relations with Ukraine, importing wheat, corn, sunflower seeds, and oil, as well as malt, rye, and sorghum[182]. The main destinations of Ukrainian wheat, corn, sunflower seeds, and oil in 2020 in the EU were Bulgaria, Cyprus, Estonia, Greece, Hungary, Italy, Lithuania, the Netherlands, Portugal, and Spain[183].

Given also the importance of these exports for the Ukrainian economy, the war has become a serious problem, as it has caused an almost complete halt in exports. Relatively small volumes of grain are still exported using transport chains passing through the river-sea ports on the Danube (Reni and Izmail), the port of Constanta (Romania). But their share in total exports has always been insignificant and fluctuated between 5-10% of the total transshipment volume. Despite all the efforts made to increase shipments of agricultural products, it was not possible to significantly

[178] Ritchie H. How Could the War in Ukraine Impact Global Food Supplies? Our World in Data. 2022. URL. https://ourworldindata.org/ukraine-russia-food

[179] Bentley A. Broken Bread–Avert Global Wheat Crisis Caused by Invasion of Ukraine. Nature 2022, 603, 551.

[180] Leiva M. Which Countries Are Most Exposed to Interruption in Ukraine Food Exports? Investment Monitor. 2022. URL. https://www.mining-technology.com/special-focus/countries-exposed-ukrainian-food-exports/

[181] Ritchie H. How Could the War in Ukraine Impact Global Food Supplies? Our World in Data. 2022. URL. https://ourworldindata.org/ukraine-russia-food

[182] European Commission. Trade Monitoring through Customs Surveillance Data. URL. https://circabc.europa.eu/sd/

a/8df1b7d8-1098-42b3-b29b-366d9c77192e/OILSEEDS%20TAXUD_Surv.pdf (

[183] FAO. FAOSTAT Statistical Database URL. https://www.fao.org/faostat/en/#data/QC

increase their volume. Due to the limited depths of the water areas and berths of these ports, they can handle only small vessels and barges.

The best option for exporting grain from the Danube region could be its transit to the Romanian Black Sea port of Constanta, followed by transshipment into vessels with a large deadweight, say, of the Panamax class. However, a significant obstacle to the increase in such transit traffic was the low capacity of the Sulina Canal, which connects the Danube with the Black Sea, because on some days from a dozen to a hundred vessels accumulated in it. In addition, the port of Constanta itself turned out to be unable to handle any significant volumes of Ukrainian grain due to the lack of free capacity, especially during the peak months of the grain season, when Romania itself actively ships its grain for export.

Although transshipment through the Danube ports helped to move the seaborne export of Ukrainian grain in the first months of the war, it quickly reached its limit, despite the willingness of traders and stevedores to build new grain terminals, and berths and purchase equipment. Already in April-May 2022, the queue for shipment in these ports reached several months, so it became obvious that it was impossible to export grain from the country without alternative routes.

Due to transport problems, access to domestic consumers and grain processors became more difficult, due to which the price of grain began to fall rapidly, and the cost of transportation, on the contrary, increased. This was a powerful blow to the economy of grain production, from which agricultural producers have not recovered to this day.

However, thanks to the measures taken by the government, the help of foreign partners, and the support of international organizations, the situation with logistics and access to agricultural markets has improved significantly despite the war. An alternative to sea deliveries of agri-food products from Ukraine in the first months of the war was road and rail transportation across land borders with EU countries.

Road and rail transport have become the driving force behind the export of Ukrainian grain, allowing domestic elevators to be gradually unloaded. In particular, the export of grain by road was accelerated by the permission for agricultural producers to export products by their vehicles,

adopted in April 2022, and the simplification by several neighboring countries of the requirements for crossing their borders by Ukrainian trucks – the abolition of special permits and the weakening of requirements for the compliance of machines with strict European environmental requirements. Thus, Hungary, Romania, Slovakia, Bulgaria, Turkey, and Greece canceled permits for the export of Ukrainian products for various periods and lowered the requirements for compliance of vehicles entering Ukraine with the norms of the Euro 3 standard.

On the other hand, an obstacle to road transport was numerous barriers and roadblocks in Ukraine itself, road sections and bridge crossings destroyed as a result of enemy shelling, and an acute shortage of fuel, which was either not available at some gas stations in the first months of the war, or its release for civilian cars was limited.

However, despite all the difficulties, the road transport corridor for the export of grain worked. According to the Internet resource Zernovoz.ua, the radius of grain transportation by road, which before the war was about 400 km, has increased to 1000 km[184]. However, due to difficulties on the road and military risks, the price of delivery has also increased – for short distances within the country it reached 5-6 UAH/t-km, and in peak periods in some places, it even reached 8-10 UAH/t-km, and in long-distance routes it was 1.8-2 UAH/t-km.

The first step to reducing the cost of road transportation was the abolition of excise duty and the reduction of VAT on fuel, which made it more affordable. Thanks to this, farmers were able not only to transport their products cheaply but also to carry out spring sowing. The liberation of territories, demining, and repair of the most destroyed sections of roads, road junctions, and bridge crossings also simplified and somewhat reduced the cost of road transportation, in particular, since the routes became "straighter" and less transport had to go around. Yes Even despite the improvement of domestic conditions and the liberalization of international

[184] Export logistics in wartime. URL. https://agrotimes.ua/article/eksportna-logistyka-u-voyennyj-chas/

transportation, road logistics of grain still make up a significant part of the costs that agricultural producers have to pay. Thus, the delivery of grain to ports by road today costs an average of 1500-2500 UAH/t, which reaches 30-50% of its price[185].

Ukrzaliznytsia also did everything possible to increase the export of agricultural products. Already in the first 20 days of April, Ukrzaliznytsia loaded 801 thousand tons. tons of grain, increasing this volume compared to March by 116 thousand tons. Tons. In addition, railway workers at that time transported 275 thousand tons for export. tons of grain. And in July, the volume of grain loading into wagons amounted to 1206 thousand tons. tons, of which the railway exported 905 thousand tons for export through land crossings and ports. tons of grain, which is per 100 thousand tons. tons more than in June.

The main strategy of Ukrzaliznytsia to increase grain transportation for export was the expansion of border railway crossings. Since the beginning of the war, it has been possible to increase the capacity of existing and open several new crossings on the borders with Poland, Slovakia, Moldova, and Romania. At the end of October 2022, there were already 13 freight border crossings with five neighboring countries. This made it possible to increase the transfer of grain wagons through them from 200 per day in March to 560-580 in July 2022.

Even though Ukrzaliznytsia is a state monopolist and prices for its services are more stable, the cost of rail transportation in 2022 also increased significantly. Although the tariff for rail transportation is fixed, another component of their cost – the use of wagons – is set through auctions on Prozorro. Sales". And as before the full-scale war, the main component of costs was the cost of transportation, due to the rapid increase in bids at the auctions of Prozorro. Sales", was the cost of using grain wagons. After all, thousands of hoppers were stuck abroad, standing in queues at the border, and thousands more were moving slowly around the country, which is why the number of free wagons for loading was limited.

[185] Grain prices in Ukraine: how much wheat costs as of mid-October 2023. URL. https://novyny.live/groshi/tsini-na-zerno-v-ukrayini-skilki-koshtuie-pshenitsia-na-seredinu-zhovtnia-124809.html

In July 2022, Ukrzaliznytsia also increased the tariff for the transportation of all classes of cargo, including grain, by 70%,[186] which was explained by the devaluation, rising production costs, and the need to cover the financial deficit of the state carrier. Still, the wagon component in the cost of rail transportation of grain prevailed and still exceeds the tariff one. In particular, due to the low speed of trains, transportation costs are multiplied for each day of stay wagons on the way. To calculate the cost of using wagons, Ukrzaliznytsia sets a standard speed. Before the start of the full-scale war, it was 320 km/day for export and import block trains and 200 km/day for wagon shipments. Since March, Ukrzaliznytsia has been forced to reduce the standard speed of wagon shipment due to the difficulty of coordinating the processing of wagons at the border. Reduction of the standard speed by more than four times led to a significant increase in both the estimated and actual period of use of grain wagons, and, consequently, to an increase in the cost of rail transportation of grain.

In general, according to experts, after the start of the war and until the end of 2022, the logistics costs for the use and transportation of Ukrzaliznytsia grain carriers increased to $85 per ton (based on the average transportation distance and average standard speed), or 4.5 times more than before the war.[187] And freight forwarding services and other logistics costs in Ukraine accounted for another 10-40% of additional costs.

On the eve of the full-scale war, the price of grain in Ukraine on EXW was UAH 100-400 per ton less than the price of the CPT port – this difference was the cost of logistics from domestic elevators to ports, and at the then exchange rate it was, depending on the current market conditions, about 5-10% of the export price of corn or 2-7% of the export price of food wheat. Since the end of February last year, the logistics share in the export price has

[186] The Ministry of Infrastructure has increased Ukrzaliznytsia's tariffs by 70% for all groups of cargo. Ekonomichna pravda. URL. https://www.epravda.com.ua/news/2022/06/29/688654/

[187] Agroportal. URL. https://agroportal.ua/news/ukraina/logistika-zabiraye-vsi-groshi-agrarijiv

increased significantly, The cost of transporting grain to the port has increased to 10-40% of its price in the port[188].

Given the difficulties faced by Ukraine's transport and logistics sector due to russia's full-scale invasion, in July 2022 the EU included Ukrainian logistics routes in the Trans-European Transport Network. This made it possible to develop multimodal transportation, reduce logistics costs, and also help attract European investments to modernize the logistics sector of the country's economy. For the effective operation of the logistics and transport system of Ukraine, it has become extremely important to develop a system of innovative logistics centers, the projects of which will be presented at the event. In this regard, the country faces a number of urgent tasks in the field of logistics:

– restoration of logistics capacities to meet the needs of trade and production;

– development of logistics hubs near borders and large airports;

– automation in the logistics industry;

– development of overland logistics partnership with EU countries.

It should be noted that the Government of Ukraine and the international community have made and are making great efforts to preserve the logistics routes for grain exports. Thus, in 2022, two extremely important agreements were signed, the impact of which on international freight transportation turned out to be quite significant. One of these agreements is the agreement on the liberalization of freight transport with the EU (the so-called. "transport visa-free regime"), which relieved Ukrainian road carriers of the need to obtain additional permits for bilateral and transit transportation through the EU countries, thus significantly accelerating Ukraine's foreign trade operations. The effectiveness of the transport visa-free regime is confirmed by the increase in the number of border crossings with the EU by trucks, which increased by 43% in 2022 compared to the same period in 2021[189].

[188] Rail.insider URL. https://www.railinsider.com.ua/bilshist-eksportu-agroprodukcziyi-sogodni-zabezpechuye-zaliznychnyj-transport-ministr-apk/

[189] Ukraine and the EU extended. Transport Visa-Free" for a year, European pravda, 2023. URL. http://surl.li/kbaqu

The second of the above-mentioned agreements is the grain agreement, according to which part of the seaports of Ukraine was unblocked for the export of grain and some other agricultural products. As of July 2023, nearly 33 million tonnes of grain and other food products have been exported through the Black Sea Grain Initiative.

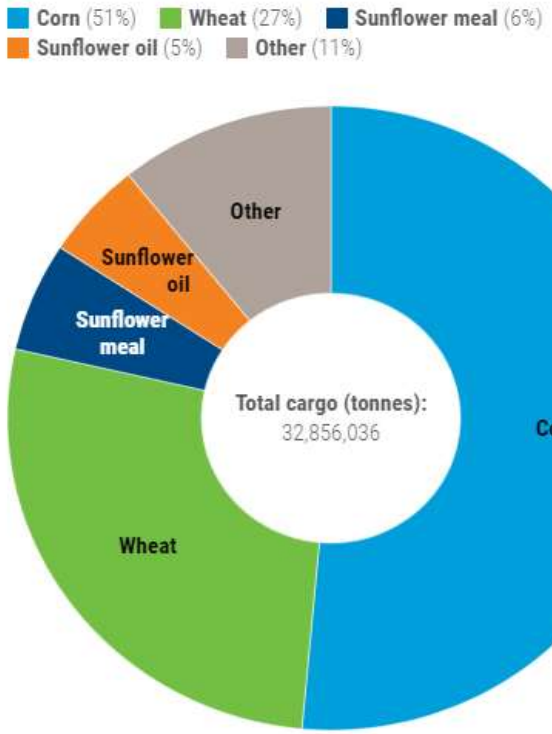



**Fig. 3.15. Share of various cereals in exports through the Black Sea Grain Initiative**

Source: Black Sea Grain Initiative Joint Steering Committee, 18 July 2023. URL. https://www.consilium.europa.eu/en/infographics/ukrainian-grain-exports-explained/

The Black Sea Grain Initiative eased logistical constraints on transportation through the Black Sea, which contributed to the partial resumption of grain exports. More than 50% of the cargo was corn, the grain most affected by the littering of Ukrainian granaries at the beginning of the war. It had to be moved quickly to make room for summer harvest wheat.

The share of wheat, sunflower seeds, and other cereals was 27%, 11%, and 10%, respectively[190].

The dynamics of international cargo traffic through seaports after the signing of the grain agreement (in particular, the growth of the corresponding indicator from July to September 2022 by more than 3 times) confirms the effectiveness of the signed agreement. Despite all the difficulties, Ukraine in 2023 increased exports of goods compared to 2022 by 112 thousand tons to 99.8 million tons. This was achieved due to an increase in deliveries by sea in December compared to November 2022 by 30.7% to 7.34 million tons. However, even despite the enormous efforts, according to the Ministry of Agrarian Policy and Food, as of April 2023, grain exports decreased by about 13% compared to the previous marketing year.[191] However, in July 2023, the grain deal was suspended, as the Russian Federation announced its withdrawal from this initiative[192].

At the same time, it should be noted that the Government of Ukraine, together with logistics operators, has constantly searched for other alternatives to the transportation of Ukrainian agricultural products by sea. Thus, in December 2023, the Ukrainian ports of "Greater Odesa" exported more agricultural products than at any time since the Russian invasion. In 2023 515 vessels used the Black Sea humanitarian corridor. They delivered 16.5 million tons of grain and other food cargo [193], which was also reflected in the financial performance of logistics operations.

Thus, freight rates for the transportation of corn by "Panamax" from the ports of Odesa, Pivdennyi, and Chornomorsk in the direction of China decreased by $3/t to $72/t[194]. Such indicators became possible due to the resumption of the work of the main Black Sea ports of Ukraine and the

[190] Corn became Ukraine's main export position in 2023. URL. https://agrarii-razom.com.ua/news-agro/kukurudza-stala-osnovnoyu-eksportnoyu-pozicieyu-ukraini-u-2023-r

[191] The M. Analytical. Rhinock earth. URL. https://voxukraine.org/silske-gospodarstvo-ta-rynok-silskogospodarskyh-zemel-ukrayiny-vplyv-vijny

[192] Russia withdrew from the "grain agreement". What does this mean for Ukraine and the world? BBC News Ukraine. URL. https://www.bbc.com/ukrainian/articles/ c72ve44j72qo

[193] Agroportal . URL. https://agroportal.ua/news/ukraina/ukrajina-vidpravila-morskim-koridorom-15-mln-t-produkciji

[194] Agroportal. URL. https://agroportal.ua/news/ukraina/perevezennya-zerna-panamaksami-do-kitayu-podeshevshalo

creation of a one-way maritime export channel, which was officially presented by Ukraine in mid-July 2023 in London, at the headquarters of the International Maritime Organization (IMO). The peculiarity of this route is its proximity to the coast of Ukraine from Odesa to Snake Island. It passes at a distance of 15-40 km from the coast, That is, within the Ukrainian Shipping Protection Zone. According to Ukrainian high-ranking officials: "The average monthly volume of supplies of goods through the new sea corridor will be about 7 million tons. The throughput will be enough not only for the export of harvests in 2023-2024"[195].


**Fig. 3.16. Route of the one-way maritime export corridor**

Source: The Black Sea Institute of Strategic Studies URL. https://www.blackseanews.net/en/read/209291

[195] Ukraine compensated for the loss of the "grain corridor" and increased exports through the Black Sea. URL. https://www.rbc.ua/rus/news/ukrayina-kompensuvala-vtratu-zernovogo-koridoru-1706876692.html

Ukraine has achieved this by largely preventing the Russian Black Sea Fleet from operating in the western part of the Black Sea, where it is threatened by Ukrainian missiles and surface drones. This allowed Ukrzaliznytsia to increase the average speed of transportation of its wagons in export traffic through seaports (for wagon/container shipment up to 134 km/day, and as part of a block or container train – up to 206 km/day). Previously, the corresponding figures were 124 km/day. Such an increase in the speed of grain carriers in the direction of ports allows to reduce the cost of grain logistics by another 7-9%[196].

In 2024, Ukraine plans to restore export volumes to the level of 2021, cover export logistics with air defense systems, and open alternative export routes to avoid complications in the transportation of agri-food products. According to the forecasts of the Ministry of Economy, exports of goods and services in 2024 should grow by 9%, in 2025 – by 19.4%, in 2026 – by 20.6%, and[197] the total cost of grain logistics will decrease by 10-20% due to an improvement in the ratio of supply and demand[198], which will significantly improve the global food situation in the world in general and the economic situation in Ukraine in particular.

These are prospects that still need to be worked on, but it can already be stated that the situation that has occurred in Ukraine is indicative of the whole world. The most important thing that can be learned from it in terms of logistics is that the country must be able to manage its logistics flows in emergencies. There should be risk management that will help cover logistics to a large extent. The war in Ukraine is changing the world order in the agricultural sector and forcing most countries to reconsider global strategies for providing the population with agri-food products. For example, top managers of large companies in Africa, Eurasia, North and South America, Japan, and Australia discuss at HBS the importance of increasing the share of domestic food production in order[199] to reduce

[196] Agrotimes. URL https://agrotimes.ua/article/chomu-kusayetsya-logistyka-zerna/

[197] Ekonomichna pravda. URL https://www.epravda.com.ua/news/2024/01/5/708431/

[198] Railinsider. URL https://www.railinsider.com.ua/u-2023-roczi-vartist-zernovoyi-logistyky-zmenshytsya-na-10-20-dumka/

[199] Bizagro URL https://bizagro.com.ua/zaminyat-globalizatsiyu-v-harveast-zayavili-shho-vijna-v-ukrayini-formuye-novi-trendi-u-svitovomu-agrobiznesi/

dependence on foreign markets and diversify relevant risks. This is also supported by the significant development of short food supply chain (SFSC) initiatives as an alternative to the globalized food chains typical of today's food industry[200].

In addition, even before the war in Ukraine, global logistics companies and carriers were looking for more flexible ways to build their own logistics chains, disrupted as a result of the coronavirus pandemic and the bans associated with it, when the market was left without the usual connections and air travel was unavailable for a long time, and ground transportation was carried out with serious delays. At this time, the logistics sector began to reform: from the concept of "deliver on time" [201] to the concept of "deliver as needed"[202]. Moreover, logistics companies around the world are increasingly using a dual sourcing approach, when the same product is delivered using two suppliers. This is another step towards reducing risks and increasing the resilience and flexibility of the entire logistics system.

Thus, businesses are forced to change the supply chains of agri-food products thereby increasing the complexity and cost of logistics operations in it. Four main factors have influenced the business processes related to the logistics of agri-food products in Ukraine.

1. Refusal to accumulate and store goods. If earlier the goods could be in the warehouses from which the shipment took place for a long time, now the business has begun to ship "from the wheels", trying to minimize the

[200] Paciarotti C., Torregiani F. The logistics of the short food supply chain: A literature review, Sustainable Production and Consumption, Volume 26, 2021, 428-442.

[201] Carvalho H., Naghshineh B., Govindan K., Cruz-Machado V. The resilience of on-time delivery to capacity and material shortages: An empirical investigation in the automotive supply chain, Computers & Industrial Engineering, Volume 171, 2022, 108375.; Li Z., Gu W., Meng Q. The impact of COVID-19 on logistics and coping strategies: A literature review, Regional Science Policy & Practice, Volume 15, Issue 8, 2023, 1768-1795.

[202] Kryshtal H. Role of Logistics in the Development of Agriculture of Ukraine in the War Conditions. Science and Innovation, 2023, 19(2), 73–82. https://doi.org/10.15407/scine19.02.073.; Ha N.T., Akbari M., Au B. Last mile delivery in logistics and supply chain management: a bibliometric analysis and future directions, Benchmarking: An International Journal, 2023, Vol. 30 No. 4, 1137-1170. https://doi.org/10.1108/BIJ-07-2021-0409.; Guzenko A., Guzenko N., optimization for last mile logistics, Transportation Research Procedia, Volume 63, 2022, 1700-1707. Wassen AM Mohammad P., Diab Y.N., Elomri A., Triki C. Innovative solutions in last mile delivery: concepts, practices, challenges, and future directions, Supply Chain Forum: An International Journal, 2023, 24:2, 151-169, DOI: 10.1080/16258312.2023.2173488

accumulation of balances so that in the event of a possible attack on warehouses there is no loss of goods.

2. Change of storage locations. Most of the granaries were located in the center and east of the country. Due to hostilities and changes in logistics routes, companies are forced to move goods to the west of the country, where there is a problem with warehouse capacity of the required size.

3. Abrupt and rapid change in warehouse conditions. Usually, it takes about three months to launch a warehouse: moving the warehouse, deploying an IT system and IT integration, setting up security systems, video surveillance, etc. In the conditions of war, companies do not have so much time, they are forced to migrate in a matter of weeks, or even days, to unknown areas.

4. Complications of logistics operations due to disrupted transport infrastructure, a huge number of checkpoints and inspections, and lack of clear rules of movement during the curfew (who could go at night and who could not).

As a result, it becomes unprofitable to maintain your logistics. Fixed costs, such as warehouse rent, electricity, utilities, and the salaries of couriers and logisticians, arise regardless of turnover. Companies are starting to look for fulfillment operators and pay them for each batch of goods, turning logistics into variable costs. In logistics, there is such a thing as the "last mile" – this is the last stage in the delivery of goods from the manufacturer to the client. It is at this stage of the supply chain that the greatest risks occur. It is believed that whoever is closer to the client wins. But maintaining that "last mile" has become more expensive and difficult today. Some companies have invented a way to streamline business processes and create collaborations and partnerships. By outsourcing logistics, companies are relieved of this burden and can rely on professionals with an already established supply chain[203].

If we analyze the main trends and innovations in the field of logistics and supply chains, they depend on global disasters (pandemics, wars, natural disasters) and significant changes caused by the introduction of

[203] Neubauer A. B., Voss A. The Structure of Need Fulfillment European Journal of Psychological Assessment 2016, 34, .220-228 URL.https://doi.org/10.1027/1015-5759/a000326

logistics technological solutions in business processes. Next-generation technologies in logistics aim to make global supply chains more customer-centric and sustainable. Thus, in 2023, Transmetrics analysts identified the TOP-10 important innovative logistics trends of our time and sorted them by importance.

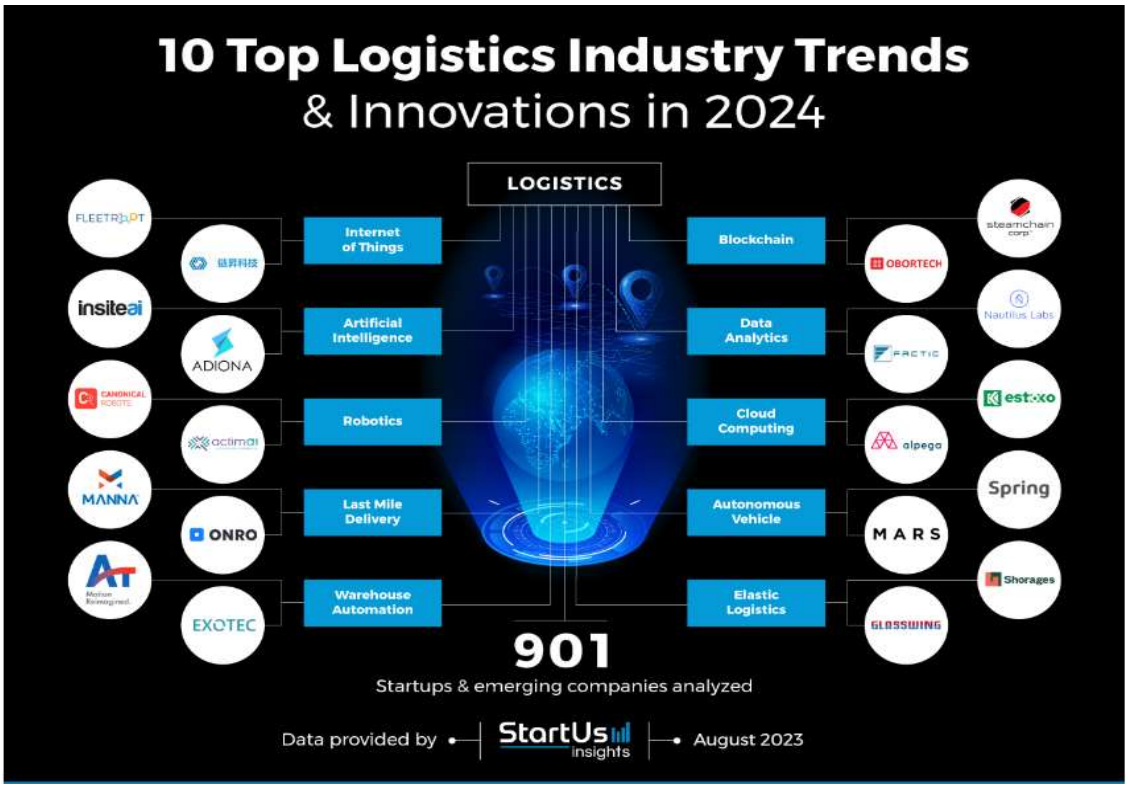



**Fig. 3.17. Top 10 Trends and Innovations in Logistics**

Source: Explore the Top 10 Logistics Trends in 2024 https://www.startus-insights.com/innovators-guide/top-10-logistics-industry-trends-innovations-in-2021/

These include, in order of importance for the business environment:

1. Internet of Things (Real-Time Supply Chain Management).
2. Artificial intelligence (demand forecasting, process optimization).
3. Robotics (robotization of warehouse operations).
4. Last-mile delivery (drones, smart boxes, etc.).
5. Warehouse automation (automated storage and retrieval system).
6. Blockchain (smart contracts, cargo tracking).

7. Data standardization and advanced analytics (creation of common information technology standards to improve the efficiency of the supply sector).

8. Cloud computing and digital twins (interaction with a digital model of a physical object or its parts).

9. Autonomous Vehicles (Autonomous Vehicle Fleet, Autonomous Vehicle Software).

10. Elastic logistics (on-demand warehousing, on-demand delivery vehicles).

The analysis of innovations and technologies in transport has identified key trends and identified important areas of development in the transport industry (see Table 3.5).

Table 3.5

**Global trends in the field of transport have been identified**

| Transport sectors | Directions | Technological solutions |
|---|---|---|
| Road transport | Clean decarbonized transport. Achieving zero CO2 emissions | Electric cars |
| | | Clean Vehicle Technologies and Their Infrastructure, including Their Interfaces |
| | | Technologies of a more systemic nature, which will concern the integration of clean vehicles and new available system services into the transport system. |
| | Implementation of Artificial Intelligence | Drones |
| | Automated transport | Internet of Things (IoT) |
| | | Interaction of automated vehicles with the environment, physical and digital infrastructure, interfaces with other modes of transport |
| | Satellite navigation | advanced satellite navigation services (Galileo / EGNOS) |

| | | |
|---|---|---|
| | | advanced EU satellite navigation/positioning technologies |
| Aviation | Ecologization of air transport | New aircraft configurations and new propulsion systems to dramatically improve greenhouse gas performance and fuel economy for the next generation of commercial aircraft technology |
| | Electrification of aviation | solutions that reduce the impact of non-CO2 emissions on the climate and the environment |
| | | introduction of climate-neutral fuels with low carbon content (including synthetic fuels, hydrogen) |
| | Autonomy | Drones |
| | Air Traffic Control (ATM) | Digitalization |
| | | Cybersecurity |
| | | Drone Traffic Management System |
| | | Satellite Navigation/Positioning |
| | | Інтеграція різних систем (літаки / ATM / аеропорти) |
| Railway | Decarbonization | |
| | Automatization | Digital Service Networks |
| | Digitalization | Satellite Navigation Technologies |
| | High-speed trains | |
| Water | Automation and digitalization of maritime transport | |
| | Ecology | Improving the performance of hybrid/full battery packs, fuel cell applications, low- |

| | | |
|---|---|---|
| | | carbon fuel drive systems, on-board renewable energy, and increased efficiency through changes in ship design and/or operations |
| | Energy Efficiency | Alternative Fuel and Electricity Supply and Use, Floating Ports, Capacity Management and Resilience in the Face of Mega Ships, Supply Chains, Port City Capabilities |
| | Connected Water System | Integrating waterborne freight and passenger solutions into spatial planning |
| Transport infrastructure | Digital | Big Data |
| | Connected Infrastructure | Мережа TEN-T |
| | Security | Protecting digital infrastructure, including cybersecurity aspects |
| | Traffic Management | Advanced Satellite Navigation Services (Galileo / EGNOS) |
| | | Implementation of next-generation multimodal NTM systems (including intramodal optimization and interface development) |
| | Connect | Integration of service networks with cooperation and vehicle connectivity to improve traffic management |
| | | Optimization of the movement of conventional, semi-automated, and unmanned vehicles in the multimodal NTM system |
| | | Implementation of comodal freight transport services within the European Union, connected to global supply chains, within a well-synchronized, smart and connected network |

| | | |
|---|---|---|
| | | Inclusion of provisions for soft/active mobility (bicycles + walking) |
| Freight transport (cargo transportation) | Цифровізація | New digital infrastructures and their interconnectivity and interoperability, also with EU satellite navigation |
| | Logistics Solutions | In the supply chain, utilization and management of grid capacity, as well as synchronous services |
| | | Multimodal logistics of freight transportation based on digital technologies and satellite navigation services |

*Source:* Bogomazova V.M., Kvasha T.K. Analysis of promising world scientific and technological areas of research on Sustainable Development Goal No. 9 in the transport sector using the tools of the platforms "Web of Science" and "Derwent Innovation": scientific and analytical note. Kyiv.: UkrISTEI, 2020. 33.

All these prospects are fully consistent with modern trends in the development of agri-food transport and logistics systems, but in Ukraine, they also have their characteristics, which include the following:

Firstly, while maintaining the volume of grain exports, it is necessary to comprehensively develop the logistics of processed products, finished products, and especially organic products. Regarding the latter, several models can be used to supply such crops from Ukraine to Europe:

– direct exports: this model involves the direct export of organic crops from Ukraine to buyers in Europe. In this model, the organic grain producer enters into a contract with the European consumer, which allows him to supply his products directly to the consumer. This method can be convenient if there are reliable contacts with consumers, and if it is possible to provide the necessary logistics and infrastructure for export.

– use of sales agents: this model involves the use of intermediaries to find buyers and organize the supply of organic crops from Ukraine to Europe. This method can be helpful if there are reliable sales agents with the right connections and experience.

– cooperation with distributors in Europe: this model involves the establishment of long-term partnerships with distributors of organic

cereals in Europe. This method can be convenient if it is possible to find a reliable distributor and agree on mutually beneficial terms of cooperation.

– development of its own retail sales network: this model envisages the development of its retail network of organic cereals in Europe. This method can be convenient if it is possible to create a network of stores specializing in the sale of organic products and provide the necessary logistics for the delivery of products from Ukraine.

Secondly: the development of agri-food logistics hubs with a focus on small and medium-sized agricultural and processing organizations. The creation of hubs that meet the requirements of modernity will significantly expand the opportunities for the development of domestic agricultural business, which will help increase the level of self-sufficiency of the region's population in quality products and contribute to strengthening Ukraine's food security[204].

Third: digitalization, which is becoming a necessity. In today's environment, the profitability of agribusiness is decreasing, and then the question immediately arises of reducing costs to achieve maximum efficiency. Therefore, the issue of digitalization is acute to control the situation with the promotion of agri-product products online and look for points to optimize the logistics processes of their supply.

To restore and fix the disrupted agri-food logistics, we need well-coordinated cooperation between farmers, the government of Ukraine, and neighboring countries, coordination between agricultural producers and logistics service providers to ensure an effective export flow; significant investments in the restoration of damaged transport and agricultural infrastructure, including warehouses, and the development of modern digital logistics technologies.

Many measures have already been implemented, but significant restoration work is still ahead. If the world needs Ukraine as one of the guarantors of food security, then we need to work together to find ways to help the agricultural sector withstand these ordeals.

[204] Kustrych, L. Agrologistic hubs as an integral part of the development of the agrarian sector of Ukraine. Economy and Society, 2022, (39). https://doi.org/10.32782/2524-0072/2022-39-14

## 3.3. The role and prospects of using digital technologies in agri-food logistics during the war

The shift in the interpretation of the efficiency of agri-food logistics from the utilitarian "minimum cost" to the urgent "increase in the usefulness of the processes of commodity supply and customer satisfaction" is associated with the breadth of changes affecting both the technological and the level of strategic management (adjustment of the development strategy, business operating model, etc.). Efficient food delivery requires balancing several goals, such as minimizing costs, reducing delivery times, reducing emissions, and maintaining their quality.

Traditional methods often focus on one goal without considering other important aspects. As we noted in the previous section, at the level of technology, promising directions for the development of agri-food logistics are fully consistent with modern logistics trends, where logistics services are evolving towards seamless, omnichannel, and digital logistics. This refers to the use of modern technologies that contribute to improving the quality of logistics processes, tracking the supply chains of agricultural products, and removing all kinds of obstacles to the market of the freshest and safest products.

A well-established and managed product supply tracking system helps provide greater transparency and control in the supply chain and reduce inventory reductions. A modern tracking system can distinguish between the destination of consignments and containers that include cargo. The most advanced tracking systems rely on state-of-the-art sensors for more detailed information about the status of each shipment.

Analysis of trends in the development and introduction of digital technologies allows us to point out those that can be implemented for the management of agri-food logistics and become catalysts for its further development. These, in our opinion, include the "Internet of Things", Blockchain technology, "smart systems" and "artificial intelligence" technology.

*The Internet of Things (IoT)* is the concept of a computing network of physical objects, for the use of which special technologies are built in, which

carry out interactions between objects or with the external environment. The introduction of the Internet of Things has become possible due to the widespread use of the Internet, smartphones, wireless networks, and the reduction in the cost of electronic components and data processing In practice, IoT systems usually consist of a network of smart devices and a cloud platform to which they Connected. They are adjacent to the systems for storing, processing, and protecting the data collected by the sensors.

According to a survey by BI Intelligence, the adoption of the Internet of Things in agriculture will reach 75 million in 2021, an increase of 20% annually. At the same time, the global smart agriculture market size is expected to triple to reach $15.3 billion by 2025 (up from just over $5 billion in 2016)[205].

In the logistics of the agro-industrial complex, the introduction of IoT technologies allows for solving such problems as reducing the cost of cargo transportation and delays, increasing the transparency of transportation, and minimizing the impact of the human factor. In practice, the issue of cargo safety in the process of its movement also remains relevant – the appropriate sensors allow you to fully track both the location and weight of the transported cargo, thereby practically eliminating opportunities for fraud.

The use of IoT can lead to significant cost reductions, as it will help to avoid product spoilage by constantly monitoring the cargo during storage and transportation, as well as reducing delivery times. As X. Zou points out, using the Internet of Things for tracking also allows you to "control and avoid cases of fraud in the food supply."[206]

Gupta & Rakesh[207] have developed a simple and efficient IoT system for monitoring impurities in food products. It can be used by several participants in the transport and logistics system of food supply (e.g.

[205] Singh K. J., Kapoor D., Sharma A., Thakur K., Bajaj T., Tomar A., Mittal S., Singh B., Agarwal R. Internet of Things in Agriculture Industry: Implementation, Applications, Challenges and Potential. 2023. 10.1007/978-981-99-0412-9_29.

[206] Zou X. Design and realization of pork anti-counterfeiting and traceability IoT system Acta Technica CSAV (Ceskoslovensk Akademie Ved), 61 (4) (2016),. 281-289.

[207] Gupta K., Rakesh N. IoT based solution for food adulteration Smart innovation, systems and technologies, Vol. 79 (2018), 9-18

farmers, consumers, and authorities) to detect falsification in the condition of the product. The system contains various sensors for temperature, oil, humidity, salt, metal, color, and viscosity. Another IoT system that prevents food fraud and that can used to monitor food quality in general, but can also be adapted to specific foods, was developed by S. Nirenjena et al[208]. The study used multiple sensors to measure temperature, humidity, and GPS location and detect food deterioration due to non-compliance. Scientists research[209] shows that the ability to monitor and track the process of cargo transportation online using IoT technologies is especially relevant in the organization of transport and logistics systems for the supply of food products.

In general terms, the Internet of Things technology can be considered as a global network infrastructure consisting of many connected devices that use sensors, communication, networks, and information technologies. The most commonly used communication technologies are the Internet, Radio Frequency Identification (RFID), and Wireless Sensor Networks (WSN)[210].

The core technology for the Internet of Things is RFID technology, which allows a microchip to wirelessly transmit identification information to readers. With RFID readers, people can identify, track, and monitor any objects automatically connected using RFID tags.

RFID technology is widely used in manufacturing, warehouse management, transportation logistics product authenticity measurements, etc. For example, IBM and the Colombian logistics operator AOS have

[208] Nirenjena S., Lubin Bala Subramanian D., Monisha M. Advancement in monitoring the food supply chain management using IoT International Journal of Pure and Applied Mathematics, 119 (14) 2018. 1193-1196.

[209] Jedermann R, Nicometo M, Uysal I, Lang W. Reducing food losses by intelligent food logistics. Philos Trans A Math Phys Eng Sci. 2014;372.; Nakandala D., Lau H., Zhang J. Cost-optimization modelling for fresh food quality and transportation, Industrial Management & Data Systems, 2016, Vol. 116 No. 3, 564-583. URL. https://doi.org/10.1108/IMDS-04-2015-0151; Kumar S., Tiwari P. & Zymbler M. Internet of Things is a revolutionary approach for future technology enhancement: a review. J Big Data 6, 111 (2019). URL. https://doi.org/10.1186/s40537-019-0268-2; Lee I., Lee K., The Internet of Things (IoT): Applications, investments, and challenges for enterprises, Business Horizons, Volume 58, Issue 4, 2015, 431-440,

[210] Bouzembrak Y, Klüche M., Gavai A., Marvin H., Internet of Things in food safety: Literature review and a bibliometric analysis, Trends in Food Science & Technology, 2019. Volume 94, 54-64.

implemented a platform that uses IoT to track and obtain information about each vehicle transporting goods. IBM Blockchain, Watson IoT, and IBM Cloud technologies were used to develop the system. AOS trucks are equipped with special IoT sensors for the assignment of RFID tags. Each label contains information about the carrier, the cargo, the location at a particular time, as well as the availability of space in the truck. The necessary information is recorded on the blockchain, which allows the company to quickly obtain it, while at the same time ensuring its reliable protection against unauthorized access. This IBM solution makes it possible to reduce the influence of the human factor and significantly speed up the process of information processing[211].

The second technology for IoT is Wireless Sensor Networks (WSN), which mainly use interoperable intelligent sensors (sensors) to work together and monitor. In general, WSN is a distributed, self-organized network of many sensors (sensors, motes). "mote" – a speck of dust, so named because of the tendency to miniaturization) and actuators connected using a radio channel. The coverage area of such a network can range from several meters to several kilometers due to the ability to relay messages from one element to another.

Motes usually include autonomous battery-powered microcomputers (controllers) and receivers, which allow them to self-organize into specialized networks, communicating with each other and exchanging data via radio communication. Their scope of application includes environmental monitoring, production control, traffic monitoring, etc.

Accordingly, the introduction of the Internet of Things technology into the practice of transport and logistics systems for the supply of food products will help improve their key aspects, namely:

1) the ability to track the origin, movement, location, and condition of products;

2) transparency of the supply process for all participants in the transport and logistics system;

[211] How the IoT is Improving Transportation and Logistics. Retrieved from https://ardas-it.com/how-the-iot-is-improving-transportation-and-logistics

3) constant monitoring of the product throughout the transport and logistics system.

1) Traceability is the ability to assess the origin, movement, location, and condition of products at all stages of supply (processing, production, and distribution) in the chain. An effective system should allow you to trace products down or up the supply chain and answer questions about the product you are interested in and where it came from, i.e. determine the origin of the product.

The key components of tracking are tracking and tracing. Tracking is a set of measures that allows you to identify products throughout the supply chain according to one or more criteria (for example, batch number or expiration date). Tracking makes it possible to track the route of movement of the desired product and/or batch of products as they move "to the bottom" along the supply chain. Tracking is used to determine the availability of goods, manage inventory, and for logistics.

Traceability of origin (tracing) allows you to determine the place of origin and related characteristics of a particular product at any point in the transport and logistics system of food supplies using several search criteria. So, by the batch number, you can find out what raw materials were used for the production of this product and the nature of its origin.

Tracing is used to identify the origin of the product and any problems related to product quality. In other words, tracing provides the ability to identify the origin of a given product in the direction "up" in the supply chain from the records made at the previous stages of its movement. Information and telecommunication tracking technologies operate based on processing large amounts of structured and unstructured data, inter-organizational interaction, and logistical coordination between supply chain counterparties, as well as the use of modern digital technologies that allow automatic, quickly and secure processing of customer orders to ensure the availability of goods to end consumers.

*Blockchain* is a common, immutable, and distributed ledger of information in which transactions are recorded. It is a peer-to-peer network in which nodes from different networks are connected but do not trust each other. The ledger of each node keeps track of transactions and ensures that

they are constantly synchronized. Data integrity, decentralization, and high reliability are the main characteristics of blockchain[212]. Blockchain technology offers a solution for a reliable single source of information distribution with improved information accuracy and efficiency, giving asset managers more opportunities to scale and use resources[213]. It marks the beginning of a new era and is a pioneering innovation in decentralized information technology, the main thesis of which for digital security is "trust, authentication, accounting of supply chain data related to every movement of global freight"[214].

The advantages of using blockchain technologies in transport and logistics systems for the supply of food products are:

– autonomy – independence from third parties when concluding a contract and negotiating;

– reliability of data – all transactions are encrypted with cryptographic code in a common distributed database, documents cannot be lost and cannot be edited;

– security – no possibility of hacking the database;

– data transfer speed – data transfer is carried out instantly if it is possible to automate the process of processing electronic documents;

– reduction of the amount of transmitted information – by reducing the use of EDI (electronic data interchange) by replacing it with encoded information in blocks;

– the ability to multi-use data in the supply chain/network – reduces errors and allows for synchronization of changes.

Blockchain technology, with its robust, secure, distributed nature, provides a controlled and managed solution for the entire agri-food supply chain from the production of raw materials to store shelves, with the participation of producers, consumers, suppliers, and regulators. and

[212] Pandey V., Pant M., Snasel V., Blockchain technology in food supply chains: Review and bibliometric analysis,

Technology in Society, Volume 69, 2022, 101954.

[213] Zagursky O.M. Basic principles of application of blockchain technology in supply chains. Computer Technologies and Mechatronics. Collection of scientific papers. Kharkiv, KhNAHU, 2020. 5-8.

[214] Smith J. Blockfreight™ the blockchain for global freight. Version : Public Release 2016. v 1.0.1 URL. http://blockchainlab.com/pdf/BlockfreightWhitepaperFinalDraft.pdf

significantly improve food[215] traceability. Additionally, with the help of smart contract technology, manufacturers can further reduce costs and improve the overall efficiency of the manufacturing industry. It is also important to note that the potential transparency provided by blockchain technology can also contribute to the development of a reputation-based trading system.

In the context of blockchain systems used in food supply chains, communication, and processes are usually presented as one-way. Figure 3.18 shows the process of the food supply chain in the blockchain system and the behavior of various participants.

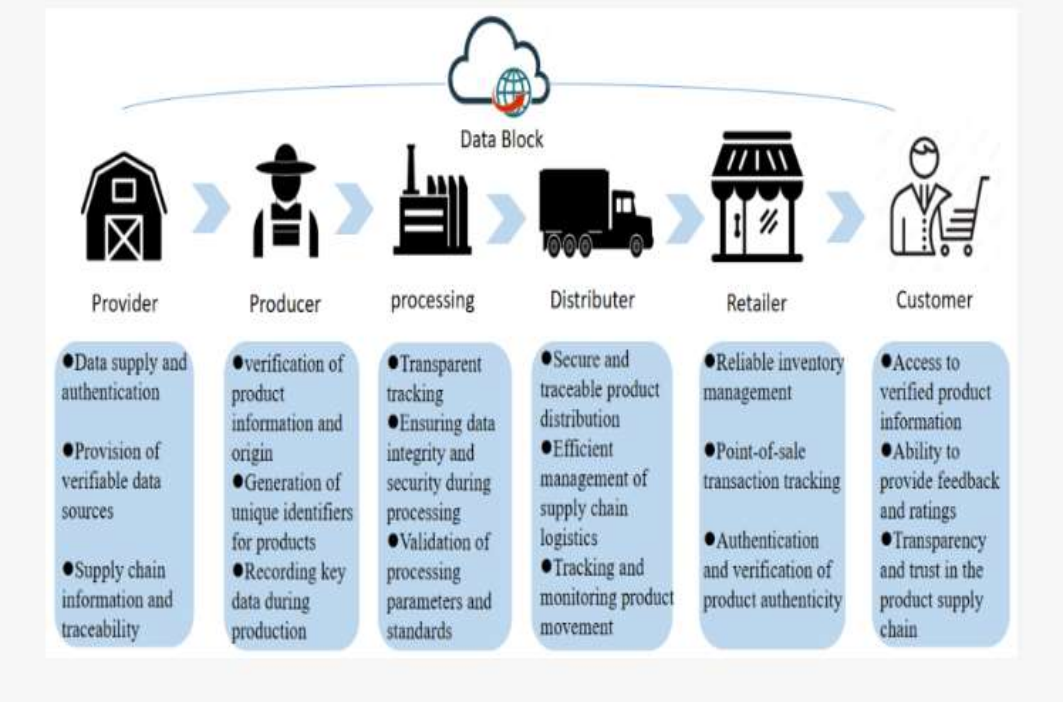



**Fig. 3.18. The process of the food supply chain in the blockchain system and the peculiarities of the behavior of different participants**

*Source:* Ding H., Tian J., Yu W., Wilson D.I., Young B.R., Cui X., Xin X., Wang Z., Li W. The Application of Artificial Intelligence and Big Data in the Food Industry. Foods 2023, 12, 4511. https://doi.org/10.3390/foods12244511

[215] Mao D.H., Hao Z.H., Wang F., Li H.S. Innovative Blockchain-Based Approach for Sustainable and Credible Environment in Food Trade: A Case Study in Shandong Province, China. Sustainability 2018, 10, 3149.; Smith B.G. Developing sustainable food supply chains. Philos. Trans. R. Soc. B-Biol. Sci. 2008, *363*, 849-861.

Accordingly, today, according to average estimates, 6 out of 10 food supply companies are looking for opportunities to apply blockchain technologies in their activities, as they have great potential for controlling food security in logistics and supply chain management. Major retailers such as Walmart, Unilever, and Nestlé are working with IBM to develop technology for the traceability of products throughout the supply chain and food disease control. This technology makes it possible not only to accurately identify contaminated products but also to exclude suppliers of such resources from the supply chain.

According to the World Health Organization, one in ten people falls ill annually in the world as a result of food contamination and about 420,000 people die. Usually, in an outbreak of foodborne diseases, it takes companies days and sometimes weeks to determine the source of supply of these products and remove them from the chain. When it is not possible to accurately identify the manufacturer of contaminated products, The government advises against consuming all products produced in a certain area. This leads to huge losses for all participants in the supply chain. The introduction of a transparent technology for tracking the origin of goods in the supply chain will simplify and reduce the time for removing only contaminated products from the supply chain. Therefore, along with Unilever, Nestle, and Walmart, seven other companies joined the project: meat manufacturer Tyson Foods, supermarket chain Kroger Co, fruit and vegetable manufacturer Dole, seasoning manufacturer McCormick & Company, food supplier Golden State Foods, fresh berry seller Driscoll's and trucking operator McLane Co[216].

Today, there are three main types of blockchain platforms – public, private, and consortium.

– Public blockchains are decentralized structures that allow any interested participant to log in, view information, make transactions, transfer assets, and participate in a consensus process, usually without

[216] IBM, "IBM announces major blockchain collaboration with Dole, Driscoll's, Golden State Foods, Kroger, McCormick and Company, McLane Company, Nestlé, Tyson Foods, and Unilever, and Walmart to address food safety worldwide," press release, IBM.com, August 22, 2017. URL. www-03.ibm.com/press/ us/en/pressrelease/53013.wss.

any special permission. Public blockchains, such as Ethereum, have no central admin or control, and information is available to everyone.

– private blockchains are centralized structures, the entry into which, and, accordingly, the implementation of transactions, is allowed only to a pre-approved set of participants. Therefore, they include members who know each other or whose identity has been verified and it meets certain predetermined criteria. Control in private blockchains is distributed only to the participants and no information is available to the outside public.

– Consortium blockchains are a hybrid of public and private platforms. They incorporate the decentralized nature of public blockchains and the permissive capabilities of private blockchains. Here, the entire network, along with the organization's validation rules and policies, is defined and regulated by members/nodes who can control every aspect of the blockchain, including transaction validation, adding nodes, managing node privileges, smart contracts, deploying chain codes, and more. In them, the identity of members must usually be verified before they can join the network, and some information about them must be made public. Such blockchains are customizable depending on the use case, including information that each participant has access to and what information the member can add.

With the use of blockchain technology in food transport and logistics systems, private or hybrid blockchains are more likely to be used than public ones.

2) Transparency is a level at which all its stakeholders have a common understanding of and access to the product-related information they request without loss, delay, or distortion. In the field of food, transparency can come in handy for a variety of needs. As J. Trienekens notes, "... In addition to improving market efficiency, improved information exchange throughout the supply chain, as well as continuously maintained food quality, product differentiation, logistics, and process optimization can help with operational management"[217].

[217] Trienekens J. Transparency in complex dynamic food supply chains , 2012 URL. https://proxy.library.spbu.ru:2069

Moreover, to ensure transparency and controllability in the transport and logistics systems of perishable food products, information must be transmitted between customers and suppliers in real time. Therefore, modern technologies such as sensors, radio frequency identification (RFID), and wireless networks are key components to ensure the visibility of each product throughout its lifecycle[218]. Transparency and traceability of the transport and logistics system are especially important in the supply of perishable food, where the quality and quantity of the product at the required level at the final link are maintained by controlling the temperature both in the production links and during transportation. With the increasing demand for organic agricultural products, companies can increase customer confidence by providing them with the ability to trace the origin of a product. Transparency also facilitates inventory management, lowers operating costs, and speeds up delivery times. The Internet of Things helps to identify weaknesses in the transport and logistics system, which allows you to make the necessary changes following accepted standards.

3) Monitoring technologies include a number of technologies related to tracking various factors influencing food products (such as, for example, temperature or humidity) and tracking the location of the product in the transport and logistics system. This is primarily necessary to ensure the supply of goods before a certain shelf life and, accordingly, increase the efficiency of the entire supply chain. For the transportation of food products, It is necessary to implement a monitoring and notification system for critical conditions of products (e.g. related to unacceptable temperature conditions), as well as to inform all participants about ensuring compliance with regulatory requirements.

In recent years, advances in Internet of Things technologies such as radio frequency identification (RFID), sensor technology, communication modules, microprocessors, and special sensors have expanded the range of applications of the Internet of Things. This trend is particularly pronounced in the use of sensor technology, which can be used to intelligently control temperature and humidity during the transport or storage of products. For

[218] Aung M., Chang Y. Temperature management for the quality assurance of a perishable food supply chain. Food Control. Elsevier, 2014. 40. 198-207.

example, a company can monitor the temperature of its products and track them throughout the supply chain, instead of the traditional approach in which the main processes are performed separately using a temperature logger, barcode scanner, and document scanner. Also, technologies such as RFID tags will allow you to control the expiration time of the product both in large production facilities and during transportation.

The development of information and communication technologies (ICT) is constantly changing the devices used in IoT, so sensors are being replaced by radio frequency identification of animals and food products (RFID), actuators, and even intelligent packaging (IP)[219]. It should be noted that food packaging plays a very important role, both to preserve the quality of the product and to ensure its safety for the consumer.

Traditional packaging mostly fulfills only the first function and is intended only to protect food from environmental changes such as temperature, humidity, light, gas emissions, or microbes.

Active packaging systems (APS) contain special additives (gas and moisture absorbers, flavors, antimicrobials, enzyme preparations, etc.) that have an interactive connection between the food products packaged in them and the packaging medium to regulate the microbiological balance inside and ensure the protection and extension of the shelf life of the products. With the help of active ingredients, APS protects packaged foods by releasing or absorbing the necessary substances in/out of the product. They contribute to the improvement of the presentation and preservation of the organoleptic properties of food products, that is, signs that affect the human senses.

Intelligent (smart) packaging systems (IPS), unlike APS, do not contain active ingredients, but they have intelligent devices that "communicate" with observers or consumers about the quality of the current state of food[220]. Intelligent (smart) packaging devices are divided into two types. The first type is data carriers, such as barcode labels and radio frequency identification (RFID) tags. The second type includes

[219] Fang Z., Zhao Y., Warner R. Johnson S. Active and intelligent packaging in meat industry. Trends in Food Science and Technology. 2017. 60-71.

[220] Biji K. B., Ravishankar C. N., Mohan C. O., Gopal T. K. S. Smart packaging systems for food applications: a review, J Food Sci Technol, 2015. vol. 52, 6125-6135.

packet indicators used for environmental monitoring (time, temperature gas indicators, etc.). Such systems analyze the impact of the environment on the state of the product and inform the consumer about this condition.

Thus, the consumer receives information about the expiration of the goods or non-compliance with the requirements of the conditions of its storage or transportation. In addition, consumers using smartphones can get more detailed information from the packaging that is already on it (for example, about the ingredients, allergens, or nutritional value of the product), as well as information about the quality of the product, its freshness, its origin or whether pesticides were used in its production. In addition to consumers, retailers can also benefit from this system by predicting the shelf life of products and comparing it to the actual date suitability to improve their logistics.

It should be noted that most modern warehouse complexes are already equipped with warehouse management systems (WMS), which receive data from scanning barcodes and RFID tags placed on the packaging of goods. A more advanced level is Warehouse Control Systems (WCS): warehouse equipment, not just goods, are equipped with sensors, and systems have this data.

Also, some warehouses are equipped with Building Automation Systems (BAS). Such systems, with the help of special sensors, can monitor and control lighting, air conditioning, and ventilation, as well as ensure the operation of security subsystems and access control to the warehouse. For example, when it comes to the storage of agricultural products that require special temperature conditions, the BAS system can track temperature fluctuations in the warehouse area through sensors. If it has reached a critical value, send a signal to the WMS system, and that, in turn, inform warehouse workers about the situation.

In the future, IoT is expected to grow rapidly towards the development of wireless sensor networks for contextual data collection. At the same time, experts note that today, due to the lack of standardized communication protocols, data received by IoT devices is difficult to interpret, transmit, and exchange.

In the future, as more and more IoT devices adhere to the Fair Trade (FAIR) guidelines, it will be possible for the Internet of Data and services that assist data and algorithms to become available for sharing by all participants in perishable food supply transportation and logistics systems[221].

The use of smart systems and *artificial intelligence* is proving to be a key factor in optimizing logistics processes in a world where speed and efficiency are critical to food supply.

Artificial intelligence (AI) is a set of technologies that mimic human intelligence and allow computers to mimic aspects of human thinking and behavior to achieve autonomous learning, reasoning, planning, and decision-making. Artificial intelligence is based on machine learning, deep learning, natural language processing, computer vision, and other technologies that can be applied in various fields and industries[222].

AI is one of the most promising technologies of our time, which has significant potential for the transformation of various fields of activity, including logistics. Thus, one of the examples of the use of AI in the transportation of products is the system for optimizing transportation routes. Such a system can use data on the traffic situation, weather conditions, and other factors to determine the most optimal route for cargo transportation. This can lead to lower transportation costs and increased transportation efficiency.

Another example of the use of AI in the transportation of products is a cargo flow planning system, where the system can use data on the current state of warehouses, customer orders, and other factors to plan the optimal placement of goods in warehouses and their shipment to customers[223]. This can lead to an increase in the efficiency of the use of

[221] Wittenburg, P, et al. The FAIR Funder pilot programme to make it easy for funders to require and for grantees to produce FAIR. 2019. Data. arxiv:1902.11162. URL: http://arxiv.org/abs/1902.11162

[222] Ding H., Tian J., Yu W., Wilson D.I., Young B.R., Cui X., Xin X., Wang Z., Li W. The Application of Artificial Intelligence and Big Data in the Food Industry. Foods 2023, 12, 4511. https://doi.org/10.3390/foods12244511

[223] Lechtenberg S., Hellingrath. B. Applications of artificial intelligence in supply chain management: Identification of main research fields and greatest industry interests, 2021, ERCIS Working Paper, No. 37, Westfälische Wilhelms-Universität Münster, European Research Center for Information Systems (ERCIS), Münster

warehouse space and a reduction in the delivery time of goods to customers. In general, in the supply chain,

AI can be used to solve a variety of tasks, including:

– optimization of transportation routes;

– planning of cargo flows;

– warehouse management;

– traffic safety, etc.

In Table 3.6, we summarize all the concepts considered, taking into account various artificial intelligence technologies and their use in transport and logistics systems.

Table 3.6

**The main directions of the use of artificial intelligence in transport and logistics systems of agri-food products**

| Areas of activity | AI Technologies | | | |
|---|---|---|---|---|
| | ANNs | GAs | FL | ЕП |
| Traffic Flow Management | 6 | 9 | 6 | 2 |
| Control and forecasting | 12 | 5 | 8 | 1 |
| Road Safety and Accident Prediction | 6 | 4 | 7 | 3 |
| Just | 24 | 18 | 21 | 6 |

*Source:* Machin M., Sanguesa J. A., Garrido P., Martinez F. J. On the use of artificial intelligence techniques in intelligent transportation systems, 2018 IEEE Wireless Communications and Networking Conference Workshops (WCNCW*)*, Barcelona, Spain, 2018, 332-337, doi: 10.1109/WCNCW.2018.8369029.

Analysis of literature sources shows that artificial neural networks (ANNs) are considered most widely in works on AI, followed by genetic algorithms (FL) and fuzzy logic (GAs). Expert systems (EMs) turned out to be less popular.

Research conducted by foreign scientists is aimed at developing new methods and technologies to improve the efficiency and reliability of food delivery. They have the potential to solve problems such as preserving

food quality, reducing food loss, and improving food safety. So Iowa State University scientists Liu Y.[224] and Wang H[225].

A machine learning-based algorithm is proposed to optimize food delivery routes, taking into account two goals: minimizing transportation costs and reducing greenhouse gas emissions. Researchers use the NSGA-II multi-criteria optimization algorithm, which can find trade-offs between conflicting goals. They collect real-world data from a Chinese food delivery company, including information about routes, costs, emissions, and other factors. The algorithm is trained on this data to forecast costs and emissions for new routes. The algorithm then uses these predictions to find optimal routes that minimize both targets at the same time. As a result, the study demonstrates that the proposed algorithm can generate routes that are 10-15% shorter than traditional ones, which significantly reduces transportation costs and greenhouse gas emissions by 10-15%, which contributes to the environmental friendliness of supplies and effectively balances between economic and environmental goals.

Other scientists, S. Wang, H. Wang, H. Liu, J. Yu, [226] and R. Xu, Q. Liu, Y. Wu[227], focused the study on the multi-deposit problem of vehicle routing (MDVRP) with time windows. In this problem, several vehicles placed in different depots serve a certain number of customers, having time and capacity constraints. Delivery must be done in such a way as to minimize the total distance or time while respecting all constraints. To solve MDVRP, researchers use Deep Reinforcement Learning (DRL), allowing the model to learn from data and make decisions in a dynamic environment. It proposes the creation of a new neural network called "MDVRP-DQN", specifically designed for MDVRP. This network takes into account customers' time windows and distances between different points. The

[224] Liu Y. An optimization-driven dynamic vehicle routing algorithm for on-demand meal delivery using drones, Computers & Operations Research, Volume 111, 2019, Pages 1-20.

[225] Wang X., Wang L., Dong C., et al. Reinforcement Learning-Based Dynamic Order Recommendation for On-Demand Food Delivery. *Tsinghua* Science and Technology, 2024, 29(2): 356-367. https://doi.org/10.26599/TST.2023.9010041

[226] Wang S., Wang X., Liu X., Yu J. A Bi-Objective Vehicle-Routing Problem with Soft Time Windows and Multiple Depots to Minimize the Total Energy Consumption and Customer Dissatisfaction. Sustainability 2018, 10, 4257. https://doi.org/10.3390/su10114257

[227] Xu P., Liu Q.; Wu Y. Energy Saving-Oriented Multi-Depot Vehicle Routing Problem with Time Windows in Disaster Relief. Energies 2023, 16, 1992. https://doi.org/10.3390/en16041992

performance of MDVRP-DQN is compared to traditional MDVRP-solving methods such as metaheuristics and precision algorithms.

The MDVRP-DQN model achieved better results in terms of total time and distance compared to traditional methods in most test cases. It can take into account customers' time windows and deliver without violations. MDVRP-DQN demonstrated a better ability to adapt to changes and uncertainties in the environment, such as dynamic road traffic. This research demonstrates the potential of using DRLs to solve complex logistics and planning problems such as MDVRP. The developed DRL model can be used to optimize vehicle routes in real-time, improving delivery efficiency and reducing costs. The study paves the way for the further development of DRL techniques for other logistical challenges.

Yong-Sung Oh, Seung-neo Son[228] paid attention to the problem of vehicle routing (VRP) with a heterogeneous fleet. This means that the available vehicles have different characteristics, such as payload capacity, speed, and fuel consumption. Traditional VRP methods may not be effective in these situations because they do not account for these differences. Researchers propose a new graph neural network (GNN)--based deep learning model to solve VRP with a heterogeneous park. GNN is capable of handling structured data such as road networks and stop sequences, making it well-suited for this problem. The model takes into account the different characteristics of vehicles when planning routes, and assigning appropriate tasks to each vehicle. The GNN-RL model achieved better results in terms of total time and distance compared to traditional VRP methods in most of the test cases. The model efficiently distributed tasks among different vehicles, taking into account their characteristics. The GNN-RL model showed a better ability to adapt to changes and uncertainties in the environment, such as dynamic road traffic.

The analysis of the work carried out by foreign scientists makes it possible to form relevant directions for further research:

[228] Son S., Lee J., Cho Y., Park J., So J.. A Study on the Development of Urban Roads Convoy Driving Service and Effect Analysis. The Journal of The Korea Institute of Intelligent Transport Systems Vol.21 No.1. 51-63

– the development of AI algorithms that can take into account additional factors, such as the type of food;

– storage conditions and delivery requirements;

– development of AI algorithms that can work in real-time;

– the development of AI algorithms that can adapt to changing conditions.

In addition, by anticipating changes and trends in consumer demand, agro-industrial companies can rationally plan production and supply and avoid situations of excess or lack of goods in stock[229]. Forecasting models and machine learning algorithms can use historical sales data, market trends, and other relevant factors to build accurate demand forecasting models. By analyzing data and learning from it, these models and algorithms can automatically detect and capture demand patterns, make predictions, and provide targeted recommendations and decision support. By applying big data analysis in supply chain management, as well as predictive models and machine learning algorithms to forecast demand, food companies can more accurately understand the supply chain situation and consumer demand, achieve supply and demand matching, and improve operational efficiency and customer satisfaction. This will help optimize supply chain management and production planning, as well as increase the competitiveness of companies[230].

Since food safety is a top priority, expert systems are applied in food production, quality testing, and food risk assessment. In addition, the food industry also uses databases of intelligent expert systems[231] for automatic control of product quality indicators, expert systems based on fuzzy logic models[232].

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[229] Djekic I., Sanjuán N., Clemente G., Jambrak A.R., Tonda A. Review on environmental models in the food chain-Current status and future perspectives. J. Clean. Prod. 2018, 176, 1012-1025.

[230] Bronson K., Knezevic I. Big Data in food and agriculture. Big Data Soc. 2016, 3, 2053951716648174.

[231] Blagoveshchenskiy, I.; Blagoveshchenskiy, V.; Besfamilnaya, E.; Sumerin, V. Development of databases of intelligent expert systems for automatic control of product quality indicators. In *Journal of Physics: Conference Series*; IOP Publishing: Bristol, UK, 2020; p. 012019.

[232] Zagursky O.M. Application of fuzzy logic techniques in assessing investment attractiveness. Problems and prospects for the development of technical and bioenergy systems of nature management. XVIII International Conference of Scientific and Pedagogical Workers, Researchers and

In the coming years, knowledge-based expert systems will be combined with techniques such as fuzzy logic and neural networks for improved management processes in the food industry, management modeling, and multivariate and nonlinear processes. In particular, the ability of fuzzy logic to overcome uncertainty in hybrid fuzzy expert systems can bring significant benefits. In the food industry, the application of knowledge-based expert systems can help companies reduce production costs, increase productivity, optimize product quality, and increase market competitiveness.

Thus, artificial intelligence is no longer a novelty and is beginning to be practically used to optimize and automate logistics processes, including agri-food logistics. Thus, Ukrainian NIBULON uses a software solution that allows you to manage all processes at the elevator, in particular. to keep a full-fledged quantitative and qualitative accounting with the selection and fixation in the system of batches and samples of accepted crops. Thus, The management of the elevator has a convenient tool for prompt receipt of information on batches of accepted crops and further operations with them.

In addition, the system allows you to automatically carry out calculations (for example, the main indicator when accepting grain to elevators is the test weight, the system determines it according to the Duval formula[233]), as well as charge penalties for the supply of a low-quality product.

Among the main advantages of this solution are the following:

– grain quality control before unloading to the elevator;

– reducing the risk of obtaining a low-quality product, respectively, reducing the risk of financial losses;

– exclusion of the human factor in calculations;

Postgraduates: Collection of Abstracts. Kyiv, Ukraine, March 26–30, 2018. Kiev. 2018. 3-5.;Hernández-Vera B., Aguilar Lasserre A.A., Gastón Cedillo-Campos M., Herrera-Franco L.E., Ochoa-Robles J. Expert system based on fuzzy logic to define the production process in the coffee industry. J. Food Process Eng. 2017, 40, e12389

[233] It is used to calculate the percentage of moisture/weed reduction during grain acceptance at an elevator or grain processing plant.

– flexibility of the technical solution (the system can contain the formulas necessary for the user if they adopt a method where instead of the Duval formula there will be another, and there will be no problems);

– automatic registration of electronic documents. The driver arrives at the weighing station with a consignment note, which has already been entered into the system and goes through all the processes of acceptance and unloading. At the exit from the elevator, he is given a package of documents and on the back of the invoice, they indicate information about the quality of the grain received and at what price it was accepted.

Kernel was the first in agribusiness to switch all logistics to digital rails[234]. Business Logic helped to bring the concept of smart logistics to life. The idea was for artificial intelligence to calculate the entire crop transportation chain, from the field to its loading at the port. An innovative simulation model based on the available data from accounting systems allows you to analyze the past and future seasons, and mistakes made, take into account changes, and make several options for the movement of grain from the field to the port in just half a day. It independently offers various alternatives, and the decision is made by the team of managers, which lies in the plane of the chosen strategy: minimization of logistics costs, priority in the delivery of its grain to the company's elevators, speed of grain delivery to the port, etc. After analyzing all the indicators, the Kernel simulation model offers several logistics scenarios, including the date, the field to which warehouse it is better to take the harvested crop, and how much needs to be shipped from warehouses to accept the entire crop and maximize the turnover of the elevator.

The simulation model allows you to calculate different scenarios and choose the most optimal and profitable solutions. This means that it makes the company even more financially successful and profitable in the global market of the agricultural industry. It allows you to identify bottlenecks and calculate options in advance on how to avoid collapse or redistribute traffic flows so as not to create unnecessary load. The program also takes into account technical and other constraints, takes into account the

[234]Stack-systems URL. https://stack-systems.ua/blog/iskusstvennyj-intellekt-idet-v-polya-novaya-era-v-logistike-agrobiznesa

available data, and as a result, makes recommendations for preparing the company for the start of the season. For example, to build an elevator or introduce new equipment, or to increase the reception, cleaning, drying, and so on."

However, it is more important for us to explore the role of AI in improving transport and logistics processes in the supply of agri-food products during the war. After all, the use of AI in this context can not only increase the efficiency of logistics but also ensure the safety and accuracy of management in conditions of military uncertainty. Among such areas, we have identified ten main ones.

1. Logistics planning and routing. Artificial intelligence can help develop effective plans and routes for the transportation of agri-food products under martial law. Machine learning algorithms can take into account a variety of factors, such as conflict zones, traffic restrictions, possible threats, and escape routes. This will maximize delivery efficiency and minimize risks.

2. Autonomous vehicles. The use of autonomous vehicles based on artificial intelligence can ensure productivity and safety in a military conflict. Autopilot systems capable of analyzing the environment and responding to changes in real-time make the transportation of products less dependent on human intervention.

3. Tracking and Security. Artificial intelligence can provide highly accurate tracking and monitoring of vehicles transporting products. Video surveillance systems, sensors, and analytics allow you to quickly respond to any threats or incidents that may arise during martial law.

4. Adaptability and strategic planning. Artificial intelligence can analyze situations in real time and provide recommendations for strategic transportation planning. The ability to adapt to a rapidly changing environment and make data-driven decisions allows you to optimize logistics processes.

5. Cryptographic data protection. The protection of information about transported products becomes critically important in wartime. Artificial intelligence can use cryptographic techniques to protect data from unauthorized access and ensure the confidentiality of information.

6. Human factor and cooperation. In wartime, the key element is the interaction between artificial intelligence and humans. Humans ensure the need to make strategic decisions by responding to unforeseen situations and solving problems that are beyond the capabilities of AI systems.

7. Ethics and Safety. An important aspect of the use of artificial intelligence in the transportation of products is compliance with ethical standards. The development of systems that do not violate human rights and take into account humanitarian aspects determines the success and acceptance of these technologies in society.

8. Sustainability and responsibility. When considering the use of artificial intelligence in the transportation of agri-food products during martial law, the importance of sustainability and responsibility should be emphasized. Technologies must be reliable and ready to work in extreme conditions, as well as be accountable for their actions.

9. Integration with modern military technologies. Artificial intelligence must be integrated with existing military technologies to maximize efficiency and ensure interoperability with other means and systems in wartime.

10. Technological analysis and foresight. Artificial intelligence can be used to gather and analyze information, which helps to identify potential threats and risks to the transportation of products. This allows you to plan appropriate safety measures and adapt transportation strategies.

In addition, the implementation of AI in traffic management and the harmonious integration of intelligent transport systems (ITS) during martial law in the transportation of agri-food products is crucial to ensure the efficiency, safety, and reliability of logistics operations. In such circumstances, it is important to create integrated and automated traffic management solutions to ensure that products are moved quickly and safely to their designated locations via

– route optimization – AI can analyze a variety of factors, such as road conditions, potential threats, and other circumstances, to automatically optimize product transportation routes. This avoids hazards and ensures efficient use of transport networks.

– automated alarm control – the use of AI to control traffic lights and road infrastructure ensures fast and safe traffic, including the transportation of agri-food products. Effective traffic regulation helps to avoid traffic jams and emergencies.

– *monitoring and reporting systems* – the use of AI to create monitoring systems that provide real-time information about the movement of transport and the movement of products. This allows operators to efficiently manage logistics operations and respond to possible challenges on time.

– *security and encryption* – ensuring a high level of security for information about the transportation of products through the use of encryption and protection against unauthorized access.

– Geofencing and control – the use of geofencing to identify safe areas and control the movement of products along certain paths, which avoids dangers and possible attacks.

– *the use of drones and video surveillance* – the use of AI to control drones and video surveillance systems, which allows you to obtain objective information about the movement of agricultural products in the frontline areas and respond to events in real-time.

The introduction of AI in traffic management and the harmonious integration of ITS during martial law are designed to ensure the reliability and efficiency of transport operations, reduce risks, and ensure the safety of product transportation. Intelligent Transport Systems (ITS), which use information and communication technologies, are aimed at improving the efficiency, safety, and reliability of transport networks. Figure 3.19 shows the most common applications of ITS.

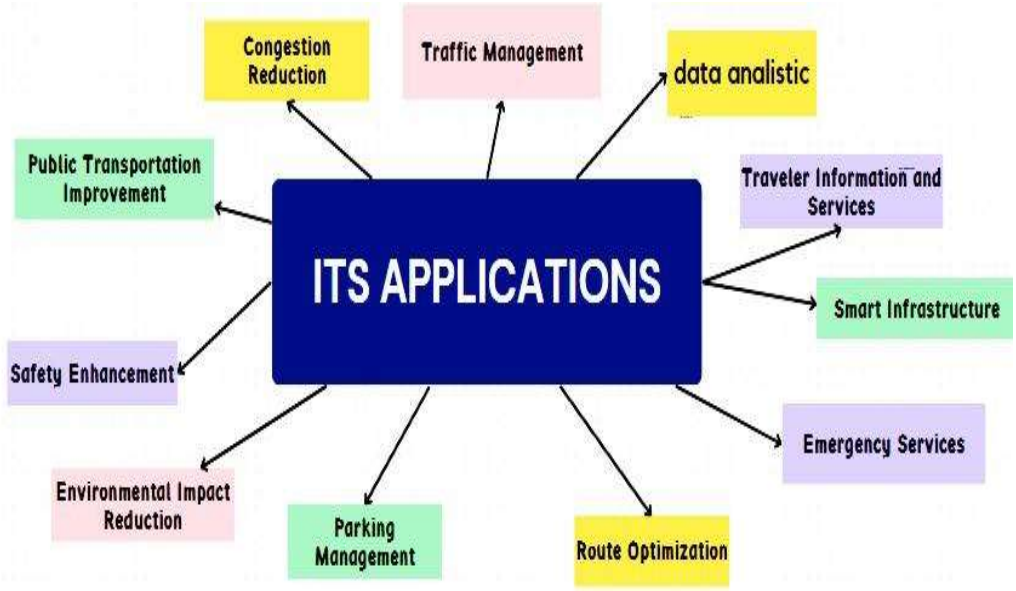


**Fig. 3.19. The most common ITS applications**

*Source:* Rashad M. F., Ali Q. I. Advancements in Intelligent Transportation Systems (ITS) and Roadside Unit (RSU) Design: A Comprehensive Review. International Journal of Advanced Natural Sciences and Engineering Researches, 2023, 7(9), 209-221.

ITS aims to improve the safety of transportation in all modes of transport and increase the capacity of the country's transport system[235]. It is believed that ITS is the most effective method of solving transport problems and is one of the scientific fields that combines economics, technology, and telematics. ITS was initially implemented in the United States, Europe, and Japan, and according to the European Commission, its application has led to a 15-20% reduction in travel time, a 12% reduction in

[235]Katerna O. Intelligent transport system: the problem of definition and formation of classification system, Economic Analysis 2019, 29, 2, 33-43. Garg T., Kaur G. A Systematic Review on Intelligent Transport Systems. Journal of Computational and Cognitive Engineering, 2022, 2(3), 175-188. https://doi.org/10.47852/bonviewJCCE2202245

energy consumption, and most importantly, a 10% reduction in emissions[236].

In wartime, when transporting agricultural products, the most important thing is to save lives and provide food to the area where hostilities are taking place. Roadside blocks (RSUs) can be used for this purpose. These are devices that collect traffic data from a static sensing zone along the road. Such data may be used for a variety of purposes, including traffic monitoring, traffic management, and providing information on road conditions. In wartime, RSU can be used to transport products in a variety of ways. Thus, in wartime conditions in Ukraine, the use of roadside blocks (RSU) and intelligent transport systems (ITS) can provide several important advantages in the field of transportation of agri-food products, namely:

– Prediction of road conditions: RSUs can collect data on weather, road conditions, and other factors that can affect road conditions. This data can be used to predict road conditions, which can help transportation companies plan their routes and avoid dangerous road sections, which can help them reduce delivery time and costs.

– Ensuring safety: The RSU can be used to identify potential hazards on the roads, such as accidents, traffic jams, and dangerous objects. This data can be used to alert transportation companies to potential hazards, which can help them avoid accidents.

– Traffic monitoring: RSUs can record traffic and provide real-world traffic data. This allows the authorities and the military to effectively monitor and control the movement of vehicles, ensuring the safety of the transportation of products.

– Rapid Emergency Response: Real-time data collection and analysis allows you to respond quickly to emergencies such as traffic accidents or other unforeseen events that may affect transportation.

– Infrastructure monitoring: RSUs can be used to monitor the condition of roads, bridges, and other infrastructure facilities. This allows

[236] Rashad M. F., Ali Q. I. Advancements in Intelligent Transportation Systems (ITS) and Roadside Unit (RSU) Design: A Comprehensive Review. International Journal of Advanced Natural Sciences and Engineering Researches, 2023, 7(9), 209-221.

you to detect possible damage in time and carry out repair work to ensure the safety of transportation8.

– Resource saving: The use of ITS allows for the optimization of traffic, which can lead to fuel and resource savings when transporting products.

In addition, RSUs can be used within Intelligent Transport Systems (ITS).

Roadside Units (RSUs) collect and record traffic data in static sensing zones close to roads and transmit this data to traffic control devices and the traffic control center. These devices are a source of information for intelligent transportation systems, which are responsible for collecting predictive traffic information.

Figure 3.20 shows the benefits of using edge computing in roadside units.

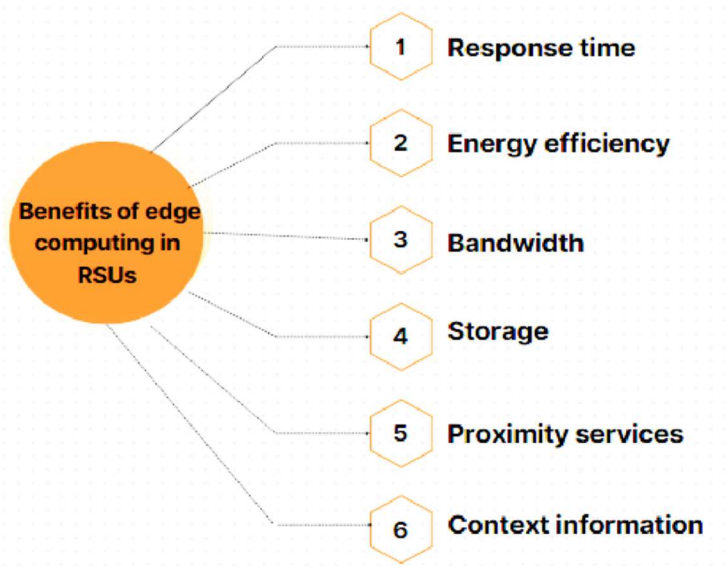


**Fig.3.20. Benefits of edge computing in RSUs**

*Source:* Rashad M. F., Ali Q. I. Advancements in Intelligent Transportation Systems (ITS) and Roadside Unit (RSU) Design: A Comprehensive Review. International Journal of Advanced Natural Sciences and Engineering Researches, 2023, 7(9), 209-221.

The RSU obtains traffic data using a variety of methods. One such method is triangulation, which uses mobile phones as anonymous traffic sensors. Phones send signals about their presence on the mobile network, which RSU can detect. The collected network data is analyzed through

triangulation and converted into traffic flow information. This method works for all kinds of vehicles as long as they have their mobile phone turned on.

Another method is vehicle re-identification, which uses unique identifiers from on-board devices such as Bluetooth MAC addresses or paid RFID tags. As the vehicle moves, multiple RSUs identify a specific vehicle and record a timestamp. This information is transmitted and analyzed to determine speed, travel time, and traffic on a stretch of road. This method requires technology in the car to transmit a unique identifier. Conveniently, most modern vehicles use wireless communication between components, which can be used to identify the vehicle.

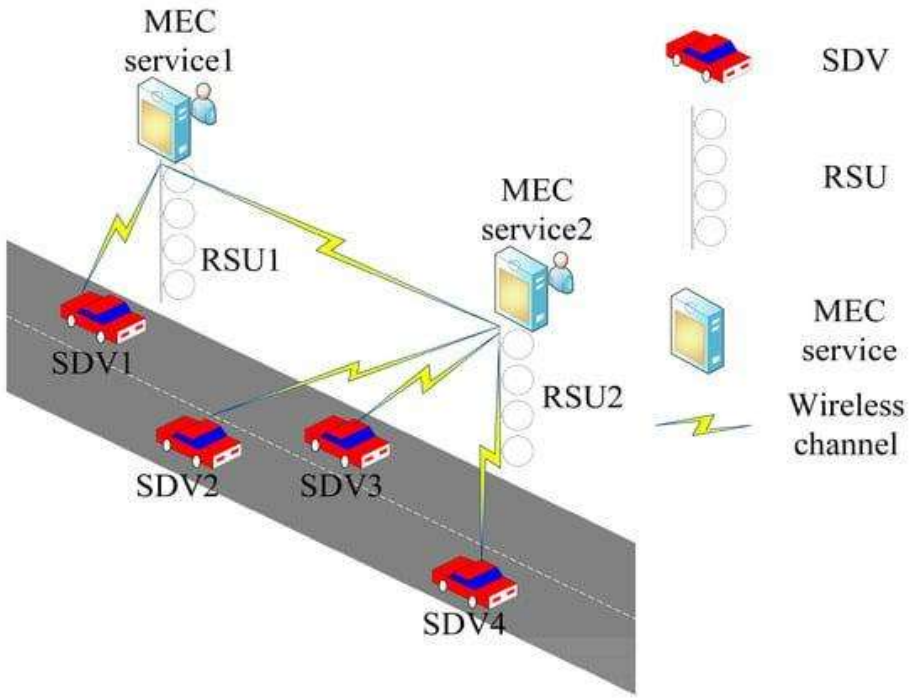


**Fig. 3.21. Example of smart integration**

Source: Li Y., Qi F., Wang Z., Yu X., Shao S. Algorithm for unloading distributed edge computing based on deep learning with amplification. IEEE Access 2020, 8, 85204-85215.

Finally, the use of V2I communication provided by intelligent transport systems makes it possible to collect data on traffic flows. Various methods can be used for this, such as two-way GPS or satellite navigation, inductive loop detection, traffic cameras, and acoustic analysis.

The RSU uses information from a variety of sources to create an accurate picture of the type of traffic flow on a particular stretch of road, using approaches based on combining data to intelligently combine information. These data aggregation methods contribute to a more accurate representation of traffic than any single measurement method8.

In the importance of road traffic research, roadside units (RSUs) play an important role by capturing and analyzing traffic data. Various methods of obtaining information, such as triangulation and vehicle reidentification, allow RSU to get an accurate and complete picture of traffic. Collecting and analyzing data from various sources allows for an integrated understanding of traffic flow, which is a key element for the development of intelligent transport systems.

When using an RSU for traffic research, information can be collected and used in real-time. This can be useful for improving traffic management, warning of traffic accidents, and optimizing traffic flows. Obtaining accurate traffic information is an essential element in creating safe, efficient, and integrated transportation systems. In a military setting, it is important to ensure the efficient and safe functioning of supply chains, and the use of ITS and RSU can be an important tool to achieve these goals.

Therefore, artificial intelligence is an important tool for optimizing and improving the efficiency of agri-food logistics processes during the war. Thanks to the use of innovative AI technologies, it is possible to develop implemented systems that provide a high level of security, accuracy, and efficiency in managing emerging logistics challenges. AI can analyze and process large amounts of data to predict optimal routes and identify safe zones for transporting products. This not only saves time and resources but also helps to maintain product quality, especially in important war conditions. Additionally,

AI systems can prove themselves to be useful tools for monitoring and managing temperature conditions and other factors that affect the quality of food during transportation. This makes effective resource management possible, which is a key aspect in wartime environments where resources can be limited.

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## IN CONDITIONS OF UNCERTAINTY

*Monograph*

**ISBN 978-83-66567-62-7**

Academy of Applied Sciences Academy of Management and Administration in Opole
45-085 Poland, Opole, ul. Niedzialkowskiego 18 tel. 77 402-19-00/01.




978-83-66 567-62-7