Information Technology for Logistics Infrastructure Based on Digital Visualization and WEB-Cartography Under the Conditions of Military Conflicts

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Abstract
Current trends and obstacles to the development of logistics infrastructure based on IT solutions in the conditions of military conflict were considered. Basic components of digital logistics infrastructure based on Industry 4.0 technologies were indicated. Digital Visualization and the inclusion of WCAG 2.0 include analytical tools, simulation models in the management of logistics chains. However, Ukraine currently does not have a ready-made solution that would take into account all aspects of managing logistics chains in the conditions of a military conflict. The concept of information technology for logistics infrastructure based on digital visualization and WEB-cartography in conditions of military conflict is proposed. The economic effect of the synergy of Digital Visualization and WEB-cartography for the proposed information technology for logistics infrastructure is highlighted and the organizational model of their implementation is presented.

Keywords [1]
Information Technology, digital visualization, WEB-cartography, logistics, IT solutions, military conflict.

1. Introduction

The initiated process of building and improving the quality of transport infrastructure in Ukraine on the basis of the adopted National Transport Strategy of Ukraine until 2030 provided for the implementation of the government program "Great Construction". This program became the basis for the large-scale transformation of the logistics infrastructure of Ukraine, including the construction and repair of transport corridors, roads, bridges, the reconstruction of local airport in Vinnytsia, Zhytomyr, Kryvyi Rih, Poltava, Rivne, Chernivtsi, and the Dnipro, the creation of new networks of transport connections and infrastructure objects of educational and medical institutions.

The war started by Russia on the territory of Ukraine stopped the initiated processes of modernization of the logistics infrastructure and caused a global collapse in the global food supply chains due to the direct destruction by military equipment and the detonation of ammunition of roads, warehouses, residential buildings, objects of social and transport networks, restriction of air and sea logistics by airspace bombing and occupation of seaports. As a result of such military aggression, the transport infrastructure of Ukraine, which provides a significant list of military, socio-humanitarian and economic tasks, namely: the movement of military equipment and other assistance to the front, the evacuation and relocation of the population from temporarily occupied regions, the delivery of humanitarian goods, experienced difficulties in functioning and limitations.

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Based on Kyiv School of Economics data, as of the end of April 2022, Russia destroyed and damaged about 30% of its infrastructure. And this indicator is growing daily. The damage caused by the enemy, according to experts, already exceeds 100 billion USD. In particular, more than 23,000 km of roads, 300 bridges, 10 military airfields, eight airports and two ports were damaged and destroyed during enemy attacks. The greatest losses of transport infrastructure facilities were experienced in the east and south of Ukraine, where active hostilities are taking place today and populated areas have been destroyed. At the same time, the logistics infrastructure of Ukraine adapted to the circumstances of the war and is working. Generalized trends in the functioning of the logistics infrastructure of Ukraine in the conditions of the military conflict with Russia are presented in Fig. 1

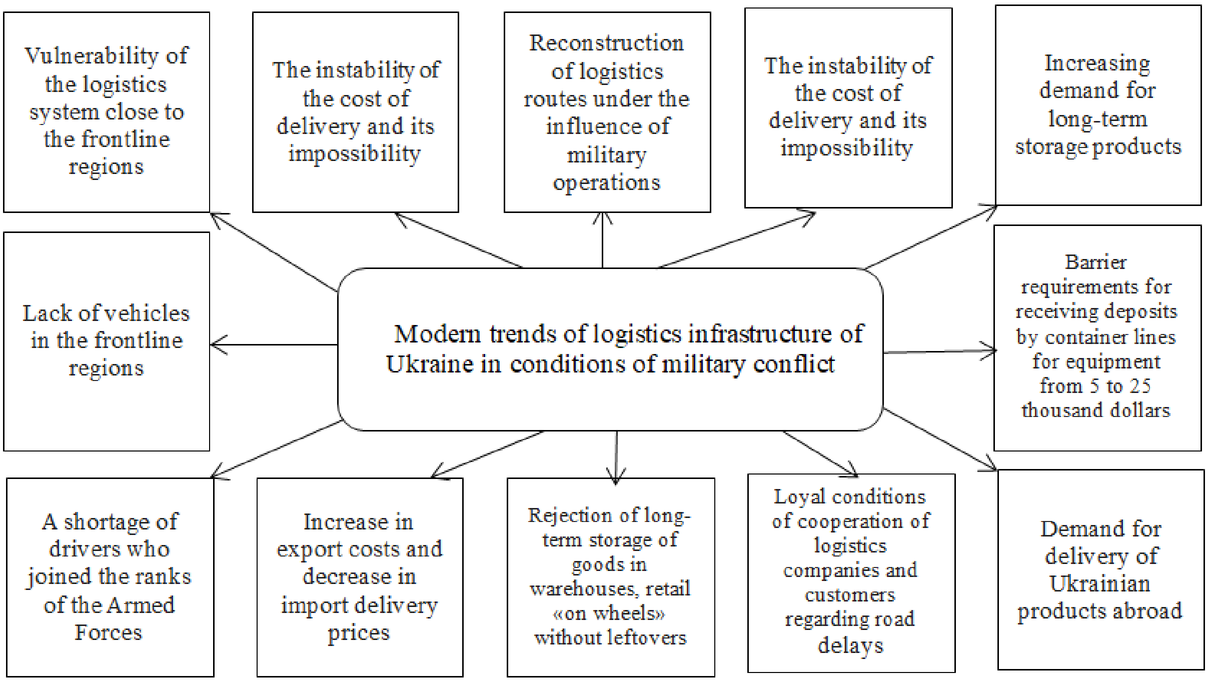

Figure 1: Modern trends of Ukrainian logistics infrastructure in the conditions of military conflict

In addition to everything listed in the organizational sense, it is important to mention the valuable aspect - the development of logistics infrastructure that survived military attacks and its digitalization based on the digitalization of operational and contractual processes. The military actions became a catalyst for the rapid application of information technologies in logistics with a wider application of digital solutions, expansion of interaction with customers through digital channels, expansion of opportunities for online marketing, reduction of business risks due to online payments, satisfaction of customer needs with the help of completely new services. Digital solutions have already gone beyond information and communication technologies. They help to create new business models, types of operations, services that can become new sources of income under the conditions of a military economy.

Modern IT solutions in Ukraine are already being implemented in all areas of the transport and logistics industry. According to experts' estimates, the total volume of the global 4PL logistics market is already over 200 billion dollars. Some 4PL-outsourcers are moving to 5PL-logistics, managing all components that make up a single chain of cargo supply using the Internet. Currently, the LPI index, which is calculated by the World Bank and determines the level of development of the country's transport and logistics complex from 1 to 5 points based on the assessment of six indicators: national customs, infrastructure, the system of international transportation, the system of regulatory and legal regulation of logistics activities, transportation, uninterrupted and the timeliness of the provision of logistics services in Ukraine cannot be rated in view of the war. At the same time, these indicators are benchmarks for the functioning of modern information systems and technologies in Ukraine:

– CALS AND CASE logistic business processes management and modeling technologies;

– electronic document management (EDI technologies);

– internet solutions, mobile and electronic business; systems for scanning bar codes and radio frequency identification of goods (RFID);

– voice technology for picking goods (Pick-by-Voice);

– satellite communication and navigation systems that allow tracking of goods and transport flows.

The position regarding the possibility of implementing digital innovations in the field of logistics is presented in the survey of the top management of logistics companies GT Nexus - Digital Transaction Chain Transformation, based on which 39% of managers recognize the lack of necessary technological skills and knowledge as the main barrier to business digitalization. To accelerate the implementation of digital workflows, 61% of companies are expected to rely on external partners - that is, outsourcing, technology and consulting providers of digital transformation. 25% of logistics and transport companies do not have a digital strategy. 48% of distribution companies rely on traditional technologies and outdated software to communicate with partners and manage workflows. Only a fifth of logistics managers admit that they have access to data from the extended supply chain and use it to make informed decisions. As a result, in fact, 41% of European Community enterprises still do not use digital technologies. That is why European countries direct their policies and pave the way for the development of key priority sectors in the direction of accelerating digital business transformations, encouraging the use of the latest digital technologies and building new business models.

According to survey based on the Google Form tool conducted in Ukraine among logistics enterprises of the Khmelnytskyi region in January 2022, the authors of this publication asked a number of questions, the answers to which made it possible to determine the positive and negative aspects in the development of logistics infrastructure based on IT solutions, the key of them was: "What is an obstacle in the implementation of IT solutions at the moment for you?" (Fig. 2).

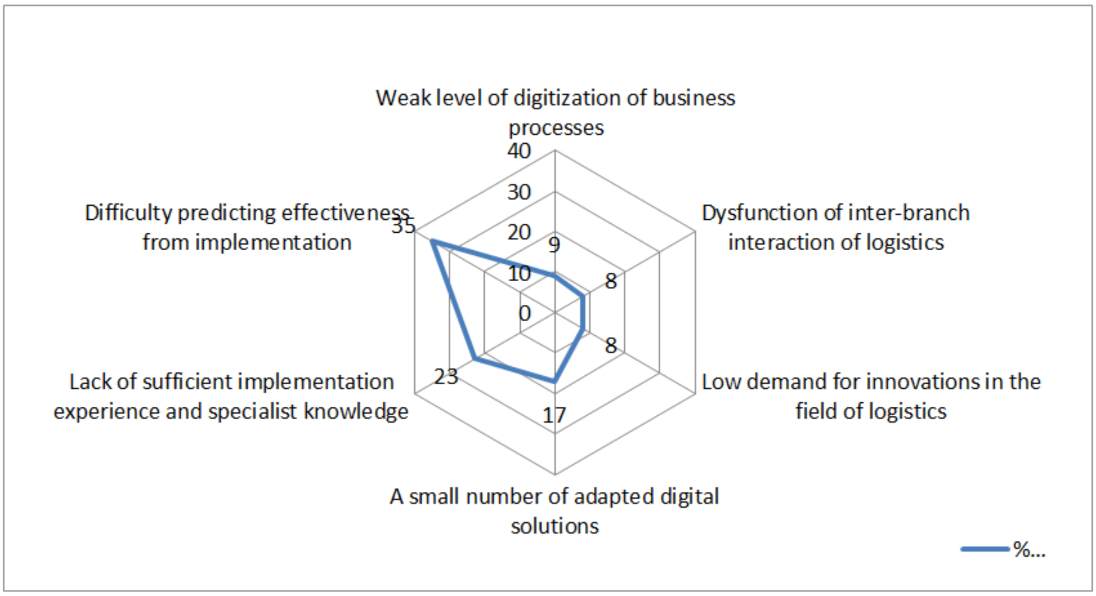

Figure 2: Obstacles to the implementation of IT solutions in the development of logistics infrastructure of Ukraine, % of respondents

This study showed that the further improvement and optimization of logistics solutions based on digitization indicates obstacles in view of the complexity of forecasting the effectiveness of the implementation of IT solutions (35% of respondents) and the lack of experience in using modern IT solutions (23% of respondents). Such survey results demonstrate the identity of the problems of perception and implementation of IT solutions for the development of the logistics infrastructure of Ukraine, which are similar to the obstacles identified by GT Nexus in European countries, and are based on the lack of cooperation between technology and business development teams in the field of logistics.

Therefore, taking into account the above factors, the issue of developing an information system for logistics infrastructure based on digital visualization and web cartography is currently relevant and important for the logistics industry.

2. Related works

The literature analysis and related works showed that in [1] the essence and tools of Blockchain IT technology from the point of view of digitalization of a typical logistics enterprise are presented. The paper [2] investigates the national logistics systems of developing countries in the context of their integration capabilities, but does not propose an IT-based solution. The source [3] considers the impact of the external factors on GPS operation, but does not consider its application for logistics infrastructure. The authors of [4] considered intellectual procedures for modeling the management of logistics information service system in the class of the problem and proposed method of the theory of queuing system. In [5] a complex big data L&I visualization network was established and the associations between information nodes were analyzed in detail. In [7] the authors propose a new DT design concept based on external service for the transportation of the Automatic Guided Vehicles (AGVs) which are being recently introduced for the Material Requirement Planning satisfaction in the collaborative industrial plant. The source [8] proposes a real-time IoT anomaly detection system to detect equipment failures and provide decision support options to warehouse staff and delivery drivers, thus reducing potential food wastage. The paper [9] deals with the problem of works transport organization in logistic center with the use of artificial intelligence algorithms. The presented approach is based on non-changeable path during travel along a given loop. A solution for semi-autonomous transport vehicles wherein the control system informs the driver about optimal route was presented. In the study [10], a Building Information Model (BIM), has been converted and displayed in 2D on Google Maps, and information on various sensors have been represented on the web with geographic coordinates in real-time. The report [11] provides an overview of what is currently possible in 3D cartography and what are the current challenges and possible solutions when creating three-dimensional maps. The research [12] intends to bring together for theoreticians and practitioners from academic fields, professionals and industries and extends to be visualizing cries such epidemic, votes, social Phenomena in spherical representation interactive model working in the broad range of topics relevant to multi - modal data processing and forensics tools developing. The source [13] presents digital twin-based services in the laboratory scale including feedback and interaction. In [14] a synergy of Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet Services (IS) and Smart Factory as a novelty approach in smart logistics is considered. In [15] a human-computer interface (HCI) efficiency description in production logistics has been developed based on an interdisciplinary analysis consisting of three interdependent parts: a production logistics literature review and process study, a computer science literature review and simulation study for an existing autonomous traffic control algorithm applicable to production logistics settings with the specific inclusion of human actors, and a work science analysis for automation settings referring to theoretical foundations and empirical findings regarding the management of workers in digital work settings. The authors of [16] discuss common definitions, characteristics, and functionalities of Digital Twins and outline current developments and implications from state-of-the-art implementation approaches, by using a systematic literature review. In [17], the authors analyze the current literature on digitization in the field of industrial logistics with a particular focus on action-oriented research findings and investigate recent studies on 1) technologies and technological concepts of digitalization in industrial logistics 2) enablers of digitalization in industrial logistics, 3) risks of digitalization in industrial logistics, and 4) opportunities for digitalization in industrial logistics. Based on the secondary-data-based content analysis, the authors identify promising areas of action for future research initiatives. The source [18] considers using the augmented reality technology for paving the routes in real time, but does not consider its application for logistics infrastructure.

The reviewed works mainly provide an overview of modern IT solutions application for smart industry and logistics area. However, none of the works proposes the development of Information Technology for Logistics Infrastructure based on synergy of Digital Visualization and WEB-cartography. Also, the above-mentioned works do not consider the impact of military conflict on the logistics sector operation.

Therefore, the issue of *developing Information Technology for Logistics Infrastructure based on Digital Visualization and WEB-cartography under the Conditions of Military Conflicts is relevant and important today*.

3. Basic components of Digital Logistics Infrastructure based on Industry 4.0 technologies

The implementation of the outlined LPI indicators regarding the digitization of the logistics infrastructure of Ukraine is ensured by technologies that are the core of the fourth industrial revolution - Industry 4.0. Digital transformation affects all areas of logistics and information technologies: both those directly related to IT technologies and those where they are not directly involved. The content of the digital transformation process involves a gradual transition from data digitization to the formation of a multi-component digital logistics infrastructure, the elements of which are summarized in Fig. 3.

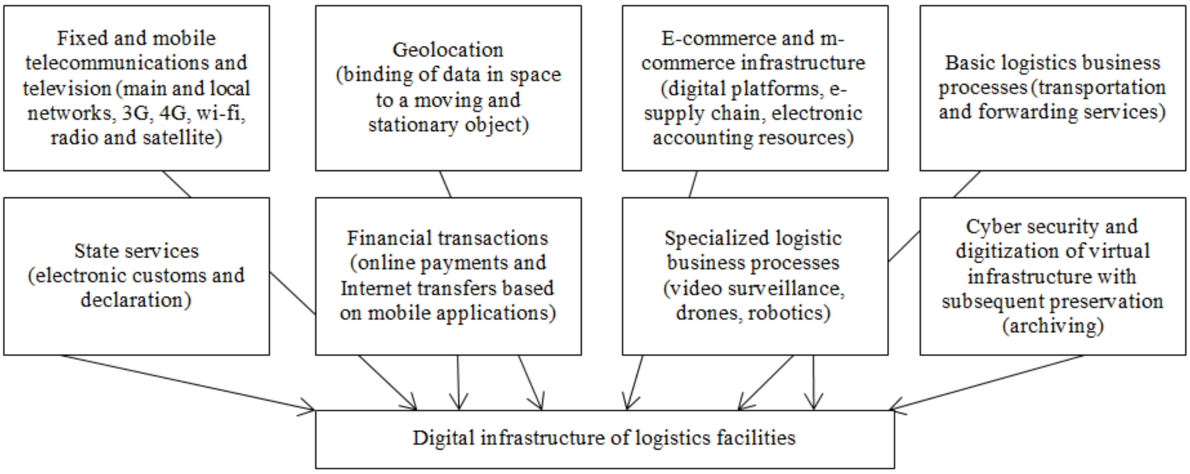

Figure 3: Basic components of the digital logistics infrastructure based on modern IT solutions

The presented basic components of the digital infrastructure of logistics based on modern IT solutions make it possible to significantly change traditional logistics business processes. In particular, they enable:

- automate the search for counterparties;
- switch to electronic document circulation;
- receive real, operational information in real time;
- synchronize all systems, including between individual counterparties;
- automation and robotization of processes;
- use digital doubles for modeling warehouses, ports, terminals.

Information about the location of goods plays a key role in supply chains and logistics. During military conflicts, this became even more apparent to many end users. However, products are not always in a warehouse, store or factory - they often move between these points. Therefore, combining internal logistics data with publicly available data, such as border waiting times and road congestion, can help track current inventory and make important decisions.

A digital twinning is an excellent solution in such conditions, because with the help of a double we can visualize the data, see the results of the impact, find out if additional measures are needed in unforeseen situations and if you need to speed up the delivery process. The concept of digital twinning has already become widespread in industrial production, but its advantages for the logistics industry are only beginning to be revealed. The DHL company in the review "Next generation wireless communication in logistics" identified digital twinning as a new direction for growth.

Essentially, a digital twin is a real-time model of a system that provides a virtual representation of physical assets. It allows you to manage both digital and physical assets as a single entity. Having a digital counterpart, such as a warehouse, can significantly improve operational efficiency. Every process that takes place at the facility and every piece of equipment will be reflected in a digital mirror, ensuring a constant flow of operational data. The advantages are many: inefficiencies in certain areas of cargo handling or equipment maintenance problems can be quickly identified before they affect throughput, which is extremely important in a wartime environment.

At the same time, modern trends dictate that without creating a single information system based on Industry 4.0 innovations, it is difficult to organize an effective IT infrastructure for logistics. Large volumes of logistics operations require significant control. One of the ways to use big data in the supply chain is to increase the speed of processing and delivery of goods and parcels. Companies in this sector use geo-analytics to simplify cargo tracking and eliminate waiting times that tire the customer. This solution is complemented by an electronic system for controlling the entry/exit of transport from sorting or storage points. Such a system allows facility operators to receive up-to-date information about the car, cargo, route, destination - in automatic mode. Data collection is carried out on the basis of:

– QR code reading systems (route, estimated time of arrival, type of cargo);
– video analytics systems (time of arrival and departure, autometer, car type, driver data);
– weighing systems (overload or shortage determination);
– systems for reading RFID tags for goods and parcels (nomenclature, dimensions, storage conditions, etc.).

Thus, the complex solution makes it possible to shorten the queues of motor vehicles in front of the logistics center, as well as to automate part of the processes during the inspection of motor vehicles, acceptance and processing of cargo. With this organization of work, costs for printing accompanying documentation and the burden on operators are reduced.

4. Digital Visualization and inclusion of WCAG 2.0: analytical tools, simulation models in logistics chain management

Digital visualization is one of the key trends in modern logistics. Business is moving from offline mode to online mode (ideally, combining them), and therefore there is a need for automatic tracking of stock balances, cargo movement and their display in real time, accurately and without errors with the most simplified perception of information and ergonomics of work.

Data visualization is based on the psychological perception of information. Viewing data in the tangible form of a chart or graph is the fastest way to instantly analyze data. Visuals are designed to tell a story. It sounds simplistic, but the most important benefit of using data visualization is the ability of the brain to process large and complex information in a much shorter period of time with the convenience of viewing it on almost any device.

Pre-attentive processing is the ability of our brain to subconsciously gather information from your environment and filter out what is important or stands out. Visualization of data relieves the brain from pre-attentive processing, maximizing its functions. Mindful processing requires a lot more work on behalf of the brain to focus and concentrate.

It is worth stating that the current European legislation establishes requirements for the accessibility of web content, in particular text, images, audio, video, coding and markup, forms and other types of media in digital visualization on the basis of inclusion, which are defined by the Web Content Accessibility Guidelines (WCAG), developed by World Wide Web Consortium (W3C). This Guideline applies to the design of objects, environments, programs and services and in the logistics infrastructure for use by all stakeholders without the need for adaptation or special design.

Accessibility aims to overcome a wide range of limitations: visual, hearing, physical, language, cognitive, cognitive and learning disabilities. The guideline has four basic principles:

1. Receptivity. Information and user interface components must be presented in such a way that they can be perceived by users.
2. Manageability. Navigation should be accessible to all users, including those using a keyboard or assistive technology.

3. Clarity. The content and design of the user interface must be understandable to each user.

4. Reliability. Content must be reliable and displayed on all devices and in all programs and applications that users use, including with the use of assistive technologies.

Data visualization improves the ability to monitor performance for many reasons. First of all, it saves time, and time is money. Knowing which metrics to focus on is vital in the data visualization process. Key Performance Indicators (KPI) are the foundation of business intelligence and data analysis. They are the most reliable indicator of business success. The current movement of logistics companies using powerful graphics processors allows the use of highly accurate and important indicators: shipment and delivery times; order accuracy; transport and storage costs; warehouse capacity; number of shipments; inventory accuracy and turnover; ratio of stocks to sales; percentage of damaged goods; driver safety indicators and incidents. The logistics industry is being transformed with the use of GPUs and data visualization techniques. This winning combination is changing the logistics landscape.

Digital visualization of processes in logistics is also formed under the influence of miniaturization of technical gadgets for logisticians to implement control functions. Mobile analytics is an example of this. Mobile analytics is one of the effective ways to keep all employees of the organization connected from anywhere and at any time. This allows users with limited computing power to use and experience the same or similar features, capabilities and processes as a desktop-based business intelligence software solution. This feature is becoming increasingly popular as people spend less time at their desks and become more mobile. Global companies need to be able to make data-driven decisions as they work.

Basic analytical tools are cluster analysis based on k-means, k-medoids, hierarchical clustering, regression models (linear, logistic, exponential, polynomial and multivariate), text analytics, statistical analytics, what-if scenario analysis, segmentation and cohort analysis, sentiment analysis, time series analysis and forecasting, statistical functions, support for Predictive Modeling Markup Language (PMML), advanced data analysis using Python and R, and presentation of data in the form of animations to show changes in multiple groups or time intervals (Fig. 4).

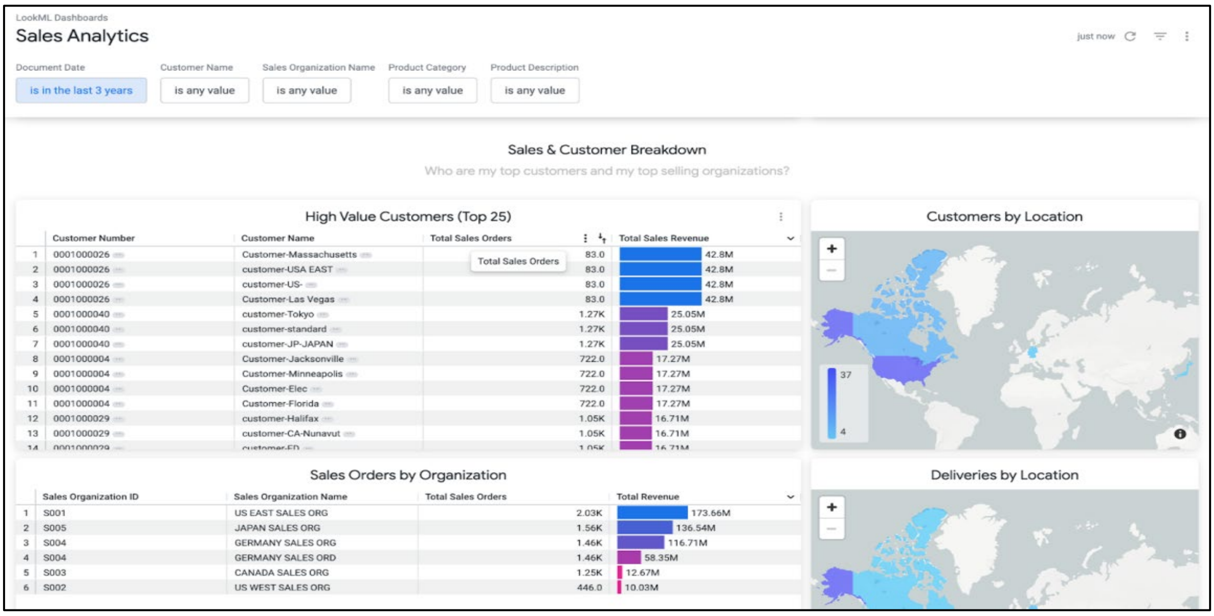

Figure 4: An example of basic analytical tools for visualizing sales logistics data in the e-commerce segment [19]

Modern analytical solutions combine and analyze several complex data sources, including structured, semi-structured and unstructured. With the ability to combine data from different sources into a single dashboard, these solutions provide a complete view of business performance. Today, Google Data Studio and Looker are dominant in terms of their functionality. Thus, the benefits of the visualization of logistics processes for the user are reduced to the following possibilities:

- obtaining the necessary data without burdensome and redundant information;
- their processing and analysis in real time;
- absence of capital costs for the creation of analytical infrastructure;
- clear data visualization.
- Web-access to the company portal of any employee online from any point;
- hierarchical situation center.

Visualization technologies, originally developed for safety purposes with their combination of process data and images, are now increasingly being used within logistics processes in the supply chain. One such tool is 3D visualization, which is a simulation modeling tool. Simulation modeling allows you to reproduce processes in time, which allows you to determine the state of the system in the future based on the input data. To analyze software products that can be used to build a simulation model of logistics infrastructure, a comparative table (Table 1) of simulation environments aimed at modeling business processes was created.

Table 1
Comparison table of similar products for creating an information technology model for logistics infrastructure

Characteristic	AnyLogic [20]	FlexSim [21]	AwSim [22]	Arena[23]	Enterprise Dynamics [24]	Simul8 [25]	Matlab (Simulink) [26]	ExtendSim [27]	Vensim [28]
3D visualization	+	+	+	+	+	+	+	+	-
Display of statistical data	+	+	+	+	+	+	+	+	+
Report creation	-	+	+	+	-	-	+	-	-
Databases integration	Access, SQL Server	SQL Server, MySQL, Oracle	Dbase, Access, FoxPro, Excel	FoxPro, Excel, Oracle, Informix, Access	Industry Specific Database	Excel, Access, Oracle, SQL Server	SQLite, Cassandra, MongoDB, Neo4j	ADO	Oracle, SQL Server
Functional extension using programming languages	+ Java	+ C++, FlexScript	+ C, Visual Basic	+ Visual Basic	+ 4Dscript	+ Visual Logic	+	+ ModL	+ Visual Basic, C, C++
Possibility of adaptation using analytic tools	-	+	-	-	+	+	+	-	-

The examples of visualization of logistics infrastructure elements based on Anylogic, Arena, Simulink and FlexSim tools are shown in Fig. 5.1-5.4 [20-21, 23, 26].

In general, the following advantages of simulation modeling for logistics can be distinguished: the costs of building a simulation model are limited by the cost of software and some services; compared to the physical model, the simulation is able to provide results in a shorter time; the variability of system parameter values makes it possible to conduct a large number of experiments; simulation modeling allows you to depict the system without mathematical formulas and dependencies; the graphic representation of the structure and processes of the system is more clear and easy to understand; a universal method of modeling any spheres of transport directions of logistics: container, railway, automobile, air etc.

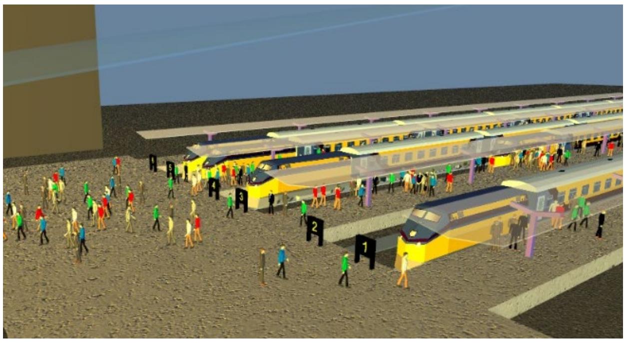

Figure 5.1: Example of model visualization in Anylogic [20]

Figure 5.2: Example of model visualization in Arena [23]

Figure 5.3: Example of model visualization in Simulink [26]

Figure 5.4: Example of model visualization in FlexSim [21]

The disadvantages of the presented analog products for building simulation models of the logistics infrastructure are reduced to the following: the simulation model does not always help to solve the issues; simulation of large and complex systems can take a lot of time; the model is not an absolutely exact copy of the real system; simulation modeling does not provide the same accuracy as mathematical modeling; modeling does not involve overlaying visualized models on maps or terrain in real time. The last shortcoming is one of the conceptually important in practical conditions regarding the most realistic simulation of a logistic operation in real time in critical execution conditions, in particular military conflicts. The optimization of such a shortcoming is based on geological studies formed at the border of geography and logistics. It was the concept of geology that defined the symbiosis of successful mapping and visualization in real time and on the ground.

Constructive simulation resources based on the JCATS (Joint Conflict and Tactical Simulation) simulation system have been created for the needs of the defense complex of Ukraine in a military situation (Fig.6).

The JCATS Simulation Modeling System (SMS) was created by the Simulation Modeling Laboratory at the Lawrence Livermore National Laboratory, USA, and is one of the most powerful systems on the structural simulator market today. JCATS provides opportunities to train troops for a range of tasks typical of the armed forces, to simulate combat tactics in individual groups and formations in various terrains, including urban areas.

JCATS SIM does not offer a set of pre-designed "static" scenarios. The system allows to adjust training scenarios directly in the simulation process. Scenarios can include multiple parties (shown in different colors) corresponding to different groups, associations or countries. At the same time, the types of relations between the participating parties must be determined. Such relations can be:

- hostile, when the participating parties act as adversaries to each other;

- friendly, when the participating parties act as member countries of a multinational alliance (for example, during peacekeeping operations);
- neutral, when the parties do not have relations with each other (for example, relations between participating parties and civilians who are the population of the country where the events take place).

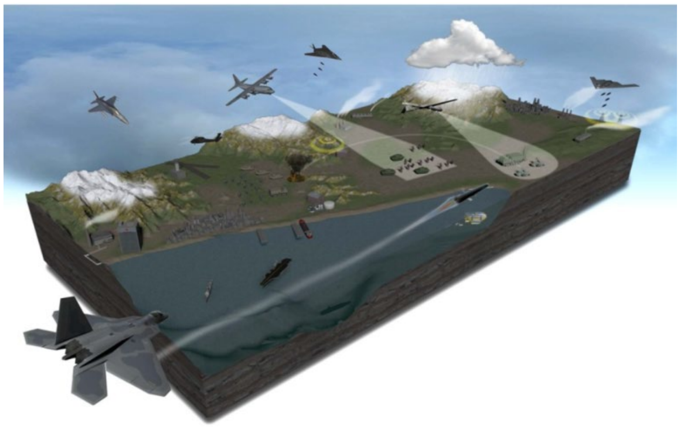

Figure 6: JCATS system simulation environment

5. WEB-cartography of Ukrainian logistics infrastructure in military conflict conditions

Cartographic support for logistics operations is based on: electronic maps, GPS monitoring systems and survey paper maps or a series of maps of different scales and different density to meet the needs of logistics. The details of the first two types are presented in Table 2.

The analysis of cartographic sources provides the conclusion that at first glance, cartographic sources are the most accessible and widespread, but in fact *there are no logistical wall maps in Ukraine*. Only the logistics map of Europe is available. This cartographic source in Ukraine is used by all logistics operators without exception, especially those specializing in international transportation. From the experience of the authors' work with logistics companies, it was found that most often forwarders and logisticians get out of the situation in this way: on an administrative map with as many settlements as possible with markers, pens, pencils, etc. the postal squares of the countries necessary for transportation planning are marked, sometimes the most frequently used border checkpoints and highways are highlighted for convenience. Sometimes transport maps are also used, depending on the type of transport (railway, sea, river, road transport, etc.). The given examples of primitivism in meeting the needs of logistics are *a significant gap in the number of cartographic product developments*, which must be filled with appropriate scientific justification and the skill and creative approach of a professional. Therefore *the development of Information Technology for Logistics Infrastructure based on Digital Visualization and WEB-cartography is currently an urgent task.*

Cartographic modeling allows logistics companies to organize transportation in a number of cases:

- if the place of dispatch of the cargo is located on both sides of large ports, it will make it possible to organize transportation from the place of departure to the transit port using road, sea transport (feeder or coastal lines) or inland waterways;

- calculate the cost of freight and related payments (bunker BAF, currency CAF, insurance ISPS and icebreaker ICE overheads, fees for ocean and feeder bills of lading, RELEASE FREE telex permits, fees for excessive use of containers owned by shipping lines DEMURRAGE DETENTION);

- organize delivery of the container for loading to the place of dispatch;

- create a storage scheme in ports;

- control the unloading with the calculation of cargo spaces and the execution of the act of acceptance/handover.

Table 2
Characteristics of electronic mapping and GPS monitoring systems for logistics needs

Type	Opportunities
Electronic maps for logistics, logistic GIS systems with cartographic content (ANTOR TerraMaster, XIT.tms, NaviTrans, Qguar TMS, TopLogistic)	- use of vector maps of different regions and cities; - the ability to edit maps and take into account traffic rules and different speeds on individual streets when laying out routes; - laying out optimal routes on maps and determining the length and duration of each route; - consideration of a significant number of conditions and restrictions; - automatic calculation of optimal routes; - simple integration with any accounting system; - formation of reports on the efficiency of the fleet for a certain period; - flexible setting for routing features; - communication with GPS sensors installed in fleet cars and the ability to observe their movement in the real-time system on the office computer.
GPS monitoring systems	- formation of a database of monitoring objects (transport and terminals). Entering information about controlled objects and the equipment installed on them; - connection of user databases (clients, addresses for product delivery, etc.); - the possibility of working with the directory of service firms and organizations of the developer of this software product; - vector electronic maps provide a wide range of possibilities for fast and convenient work of the cartographer: arbitrary scaling, search for an address and any cartographic objects, turning on/off thematic layers; - laying the route (finding the shortest route according to the sequence of given points). - saving the created route as a file; - editing of road conditions; - receiving data from trackers in real time, registering and saving the received information in the database, including in the form of a log file; - display of controlled objects on electronic maps in real time; - visual and audible notification of the operator about the arrival of a certain event: sensor activation, output of the controlled parameters of the object beyond certain limits (temperature, humidity), pressing of the alarm button by the driver, etc.; - changing the parameters of object monitoring (changing the interval of sending coordinates by the tracker); - settings for displaying information about monitored objects (time, mileage, coordinates, sensor status, etc.)

Under the current conditions in Ukraine, the issue of cartographic modeling of the military situation is the starting point for the correct formation of logistics chains. The American Institute for the Study of War (ISW) was one of the first to launch the Interactive Map of Military Operations in Ukraine to not only provide an accessible tool for understanding Ukraine's struggle against the

Russian invasion, but also to warn of the impossibility of logistical operations in the direction of military operations.

ISW's interactive map is an analogue of static maps of Ukraine, which ISW currently produces and distributes daily. Where possible, the interactive version allows for a high-precision assessment of the state of the war in Ukraine down to the street level, offering a powerful tool for investigations and briefings (Fig. 7.1-7.2)

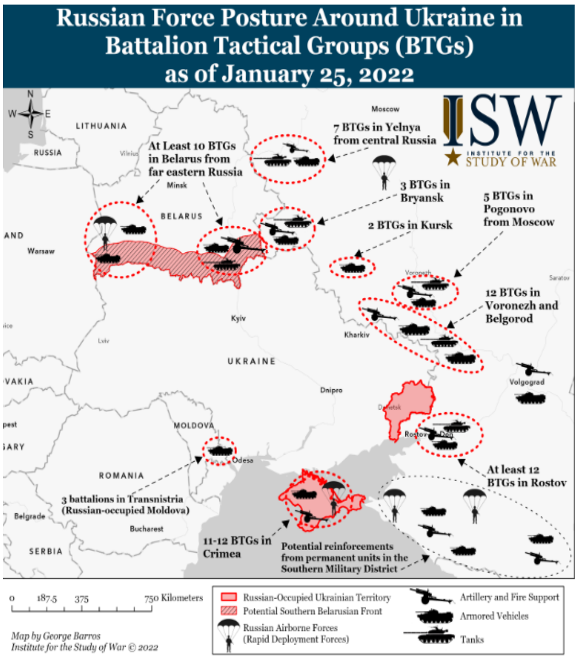

Figure 7.1: An example of an ISW interactive map with information on the composition of Russian tactical battalions

Figure 7.2: An example of an ISW interactive map with information on the territories temporarily occupied and controlled by Ukraine

The experience of the American Institute for the Study of War was implemented in domestic services in view of the need to assess the scale of destruction and damage caused by Russia's military aggression, one of which is the ReStart Ukraine project in cooperation with the UNDP Accelerator Lab in preparation for the reconstruction of Ukraine. The initiative of the project is to register and map all cases of destruction or pollution. Currently, several innovative online platforms are working on this in Ukraine. Some of them highlight the extent of the destruction in the media and stimulate the collection of funds for recovery funds.

First of all, it is worth mentioning the online service of state services "Diya". Even in the first months of the full-scale war, a function appeared in the system that allows citizens to report damage or destruction of their real estate, as well as the "Russia will pay" and "Map of destruction" projects. The feature of the latter is open data. Everyone can both declare destruction and view information about other objects (location, "before" and "after" photos). This map collects information about all civil infrastructure objects damaged or destroyed as a result of the Russian invasion of Ukraine, as well as information about restoration works. Each object on the map has information about its location (coordinates), address, estimated period of restoration, date of destruction, restoration estimate, photos before the destruction, the destruction itself and the restoration process and its completion, a link to the source of information about the event, about the company, which restored the object (Fig. 8).

The territories of Ukraine liberated from Russian troops still remain dangerous due to the large number of explosive ordnance left behind by the fighting. In order to protect the population from the risks associated with mine hazards in Ukraine, an interactive map of the territories that could potentially be contaminated with explosive ordnance was created.

The map in Figure 9 shows the places where explosive objects have already been found or are likely to be found, and the degree of threat from them according to the information available at the

State Emergency Service (localization error is up to 30 m). The map options also make it possible to quickly notify employees of the State Emergency Service about the detection of explosive objects, call sappers to neutralize dangerous finds.

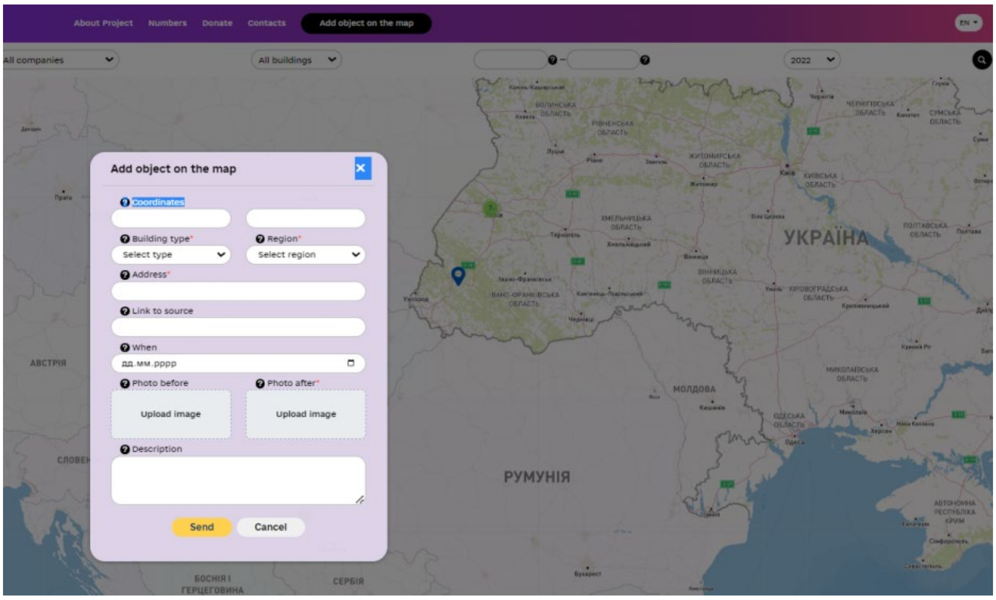

Figure 8: An example of an interactive map of the destruction of Ukraine with the functional possibility of filling it in online mode, the ReStart Ukraine project

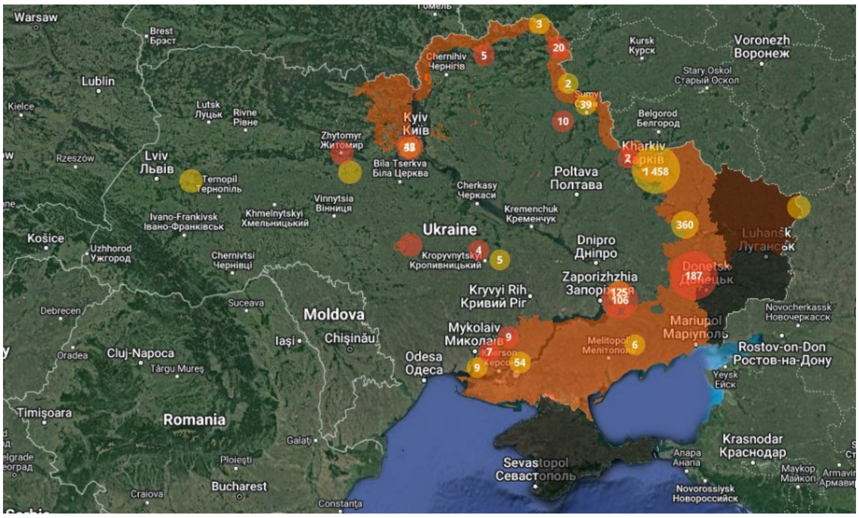

Figure 9: An example of an interactive map of the Emergency Situations of Ukraine regarding territories that could potentially be contaminated by explosive objects

Thus, the possibilities of web mapping ensure the conditional reliability of the functioning of the logistics infrastructure of Ukraine under the conditions of war, the detection and assessment of the extent of destruction and the possibility of making changes to the logistics routes in real time.

6. Results & Discussion

In order to calculate the economic effect from the implementation of the project decision of the logistics company regarding the implementation of the proposed information system based on digital visualization and WEB-cartography of the logistics infrastructure, the following options were determined:

Option 1: the logistics company uses the offered software without any modifications. Responding to changes in routes and changes in the location of warehouses in accordance with the appearance of the opportunity to familiarize yourself with third-party information resources and/or under intuitive or pragmatic self-control.

Option 2: the logistics company uses the proposed software with an implemented application overlaying all the informative fields of the interactive maps.

Responding to changes in routes and changes in the location of warehouses in accordance with the laid routes and with informative notification of changes on interactive maps describing the situation with the military situation, the possibility of operational control of a visual decision based on the real state of affairs in time.

Table 3 presents the initial data of various project options.

Table 3

Characteristics of the economic situation development scenarios

Estimated data	Pessimistic	Realistic	Optimistic
probability	0,23	0,56	0,21
change in expenses	+81%		-28%
change in income	-63%		+50%

Pessimistic scenario:

Option 1: 200*(1-0,63) – 175*(1+0,81) = -242,75

Option 2: 460*(1-0,63) – 325*(1+0,81) = -418,05

Optimistic scenario:

Option 1: 200*(1+0,5)-175*(1-0,28)=174

Option 2: 460*(1+0,5)-325*(1-0,28)=456

Let us create a matrix of possible profits from project implementation (Table 4) and a matrix of possible losses (Table 5).

Table 4

Matrix profits from project implementation, thousands of USD

Project implementation option	Profit from project implementation depending on the state of the economic environment, USD		
	pessimistic	realistic	optimistic
Option 1	-242,75	25	174
Option 2	-418,05	135	456

Table 5

Loss matrix from project implementation

Project implementation option	Losses from project implementation depending on the state of the economic environment		
	pessimistic	realistic	optimistic
Option 1	0	110	282
Option 2	175.3	0	0

By calculating the matrices, we will choose the optimal version of the project implementation, which contributes to achieving a better result under any scenario of the development of the economic situation.

When choosing the optimal option for project implementation, we will use the following criteria:

1. The "maximax" criterion - we choose a project option that allows us to maximize the maximum profit. So, the maximum profit is 456,000 USD, which corresponds to the 2nd option.

2. Criterion "maximin" (Wald`s) - we choose the project option that allows to maximize the minimum profit. So, judging by this criterion, option 1 of project implementation should be chosen - 25 thousand US dollars

3. Savage's criterion - we choose a project option that allows us to minimize the maximum possible costs. The calculation of the criterion consists of four stages:

We find the best result of each column (maximum aij).

1. We determine the deviation from the best result of each individual column, i.e. maxi aij – aij. The obtained results will create a matrix of risk (regret), because its elements are the forgone profit from unsuccessful decisions made due to a false assessment of the possible market reaction.

2. For each row of the regret matrix, we find the maximum value.

We choose a decision for which the maximum regret will be less than for other decisions.

According to this technology, a matrix (Table 6) was compiled with the best results corresponding to the maximum value of profit in each column.

Table 6

«Regret» matrix, thousands of US dollars

0	110	282
175.3	0	0

Thus, in Table 6, the maximum regret will be less than for other solutions, when implementing option 2.

On the basis of the Bayes rule (the rule of mathematical expectation optimization) for profit, the project option is chosen, which ensures the maximization of the expected profit. The selection criterion is the value of the mathematical expectation of the alternative. Let us reproduce the obtained matrix in table 7.

Option 1: M(x) : -242, 75 *0,23+25*0,56+174*0,21= -5,29

Option 2: M(x) : -418,05*0,23+135*0,56+456*0,21= 75,20

Table 7

Income matrix taking into account mathematical expectation, thousands of USD

Project implementation option	Pessimistic	Realistic	Optimistic	Mathematical expectation
Option 1	-242.75	25	174	-5.29
Option 2	-418.05	135	456	75.20

Thus, it can be concluded that option 2 will bring the most profit - the logistics company uses the existing software with an implemented application overlaying all informative fields of interactive maps.

Despite the fact that, at first glance, this option will incur greater losses, but due to the ability to respond to changes in routes and changes in the location of warehouses with an informative message about changes on interactive maps describing the situation with the military situation, the logistics company is able to get more benefit by avoiding losses from errors in the design of logistics chains.

Finally, an organizational model for the implementation of the information system of digital visualization and WEB-cartography of the logistics infrastructure based on modern IT solutions in the conditions of military conflicts was developed, which is presented in Fig. 10. Its elements include: the goal, tasks, influencing factors, priorities and tasks, long-term goals and indicators of achievements from its implementation and are implemented according to schematic connections according to the type of system approach.

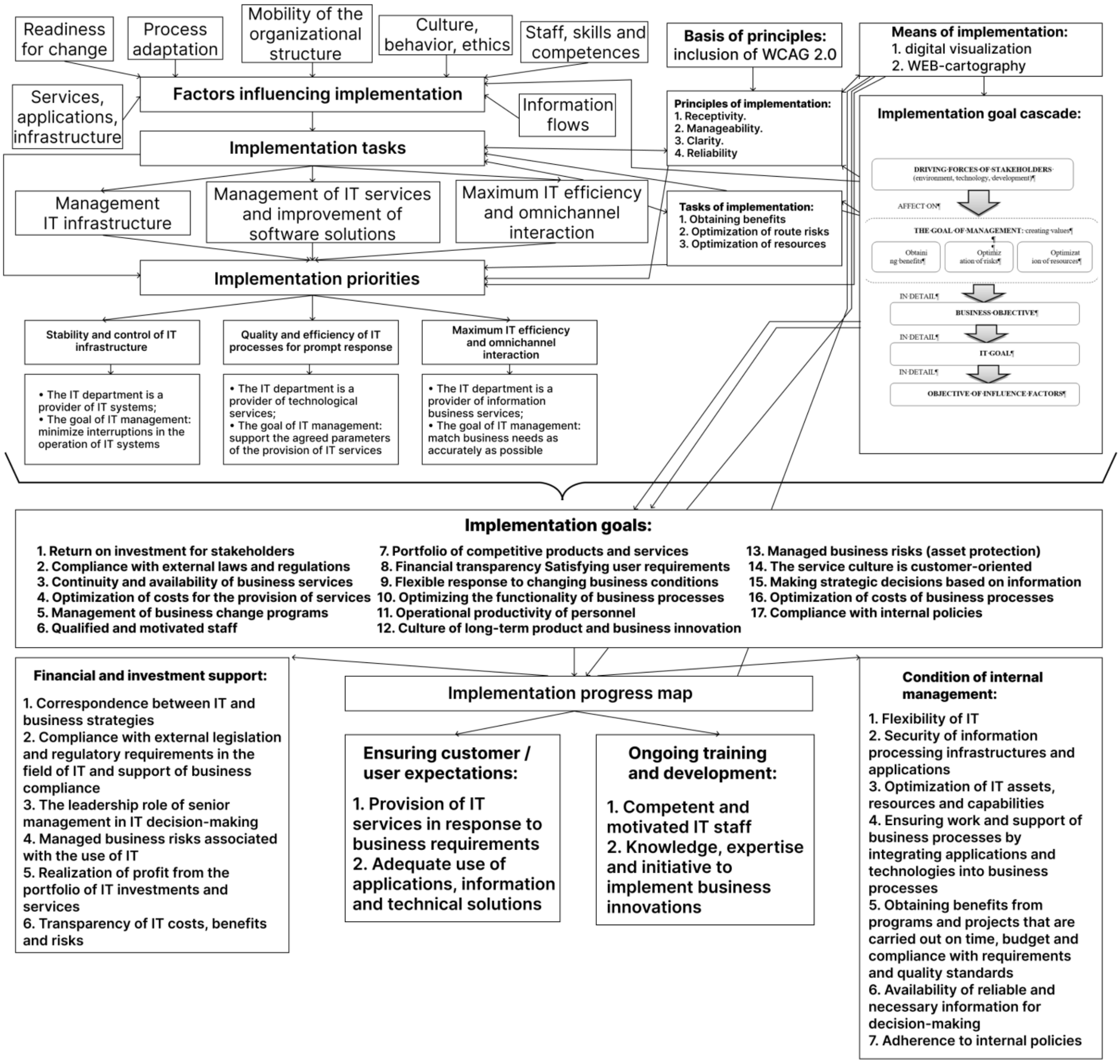

Figure 10: The structure of Information Technology for Logistics Infrastructure based on Digital Visualization and WEB-cartography under the Conditions of Military Conflict

7. Conclusions

The presented analytical studies proved the expediency of implementing digital visualization and web mapping in IT solutions for the needs of the logistics infrastructure of Ukraine under the conditions of military conflicts. An important role is played by the factors of inclusiveness of analytical tools and simulation models in the management of logistics chains, for which the requirements of WCAG 2.0 Guidelines have been implemented.

WEB-cartography of the logistics infrastructure of Ukraine in the conditions of a military conflict is based on the needs of documenting the damage caused to the logistics infrastructure and their assessment, informing about dangerous areas that can potentially be contaminated by explosive objects, obtaining the possibility of forming alternative routes for the delivery and storage of goods.

Currently, there are no IT solutions for the logistics infrastructure that would include software solutions with the overlay of all informative fields of interactive maps in a single application, which would allow for quick decisions and avoid errors when drawing up logistics routes.

For this purpose, we substantiated at the analytical level the expediency of supplementing the software products of logistics companies by including in the visual tools and simulation models interactive maps containing current information about the military situation according to the information load appropriate for the manager regarding the adoption of organizational and coordination decisions (a map of contamination by explosive objects - for drawing up logistics routes, a map of destruction - compensation for damages and their assessment, etc.).

In order to implement this information system at the organizational and economic level, we implemented the calculation of the economic effect based on the project decision of the logistics company regarding the introduction of digital visualization and WEB-cartography of the logistics infrastructure into the existing software solutions, and based on the results of the obtained positive effect, the concept of Information Technology for Logistics Infrastructure based on Digital Visualization and WEB-cartography under the Conditions of Military Conflicts was proposed and its organizational model of implementation was substantiated. Further investigation of the authors will be devoted to developing the method and algorithm of Information Technology for Logistics Infrastructure based on Digital Visualization and WEB-cartography and its implementation in the form of cross-platform mobile application.

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