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Intelligent Information Technologies in Crisis Management of Multimodal Transport and Logistics Projects: Adaptation to Uncertainty, Turbulence, and Systemic Risks (Under Warmi Conditions)

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Abstract. The article investigates the application of intelligent information technologies in crisis management of multimodal transport and logistics projects in the WARMI environment. The directions of IIT adaptation are determined: monitoring, forecasting, risk assessment, scenario modeling and optimization. Their role in increasing the stability and adaptability of logistics projects is substantiated.
Keywords: *intelligent information technologies; crisis management; transport and logistics projects; intelligent analysis & analytics; multimodal transportation; uncertainty; turbulence; systemic risks; WARMI environment; adaptive management; optimization.*

INTRODUCTION.

The modern world economy (including the entire service sector) currently operates in complex conditions of dynamically increasing uncertainty [1], turbulence and systemic risks of the external environment [2], which requires constant adaptation of organizational, technological and management mechanisms [3]. The high dependence of the service sector on highly competitive changes in demand [4], infrastructure, technologies, financial and global supply chains - increases their vulnerability to external shocks [5]. In these conditions, innovative management [6] acquires special importance, which involves the optimal implementation and use of intelligent information technologies: which provide environmental monitoring, forecasting of changes, risk assessment and adaptive decision-making [7]. This problem is especially relevant for the transport and logistics industry as the most important component of the modern service sector.

Given the above, the modern transport and logistics system also operates in conditions of qualitatively more complicated external environment [8], which is characterized by accelerating changes, high uncertainty, turbulence, multiplicity of interconnected threats and increased systemic risks. Multimodal transport and logistics projects [9] are especially vulnerable to such influences, since their implementation involves the coordination of different types of transport, infrastructure facilities, operators, information systems, cargo flows, financial resources and regulatory requirements (and the violation of one element of such a system can cause a chain reaction and significantly change the parameters of the entire project). In such conditions, traditional methods of modeling the management of transport and logistics projects, which are based mainly on deterministic planning, fixed regulations and reactive decision-making, become insufficiently effective [10]. After all, crisis situations in the transport and logistics sector require not only an operational response to already occurring violations, but also the ability to identify potential threats in advance, predict the development of events, form alternative scenarios and dynamically restructure management decisions [11].

A special role in solving this problem is played by intelligent information technologies (IIT), which combine methods of artificial intelligence, machine learning, intelligent data analytics, forecasting [12], optimization, expert systems, intelligent decision support, digital twins and automated monitoring. Their application allows us to move from a predominantly reactive model of crisis management to a proactive and adaptive model [13], focused on early detection of threats, assessment of options for the development of the situation and operational redistribution of resources.

The relevance of the study is further enhanced in the context of the WARMI concept, which is considered in this work as a generalized characteristic of the external environment, in which volatility and variability, ambiguity and uncertainty, risk, multiplicity of interconnected influences and instability of system parameters are simultaneously manifested. In such an environment, intelligent information technologies must adapt not only to changes in input data, but also to changes in the very logic of the functioning of the transport and logistics system.

That is why the purpose of this article is to systematize the features, specifics and directions of adaptation of intelligent information technologies for crisis management of transport and logistics multimodal projects in complex conditions of uncertainty, turbulence and systemic risks of the external environment, which correspond to the WARMI concept.

MAIN PART.

A). Multimodal transport and logistics projects as an object of intelligent crisis management.

A multimodal transport and logistics project is a complex organizational, economic and technological system in which the movement of material flow is carried out using several types of transport for the needs of coordinated management of routes, terms, resources, infrastructure and information flows. Unlike autonomous logistics operations, a multimodal project has a pronounced systemic interdependence: changing the parameters of one element can lead to changing the parameters of other elements and, ultimately, to deviation of the entire project from the target indicators.

In crisis conditions, this interdependence becomes a source of the risk multiplication effect. A delay in one transport arm can lead to a violation of the overload schedule, downtime of rolling stock, an increase in storage costs, route changes, additional financial costs and violation of delivery terms. Therefore, crisis management should take into account not individual risks, but mutual influence and the possibility of forming cascading chains.

An essential feature of multimodal projects is also the high dynamism of the information environment. Data on transport flows, weather conditions, infrastructure status, route capacity, tariffs, stocks, delivery times and availability of vehicles are constantly changing. Therefore, a management solution that is optimal at time t may become ineffective after a short period of time.

This necessitates the formation of an intelligent management system capable of performing a continuous cycle: monitoring → detection of deviations → intelligent diagnostics → forecasting → generation of alternatives → scenario evaluation → decision selection → adaptation → result control.

B). Specificity of intelligent information technologies in crisis management.

Intelligent information technologies fundamentally differ from traditional information systems in that they are focused not only on collecting, storing and transmitting information, but also on its intelligent interpretation and use for forming management decisions.

In transport and logistics crisis management, IITs should be considered as an integrated technological basis for several interrelated functions.

The first function is intelligent monitoring. IITs provide processing of operational information flows and detection of deviations from regulatory or forecast parameters. This allows you to detect signs of a crisis before the violation becomes critical.

The second function is intelligent diagnostics. The system must determine not only the fact of a deviation, but also its possible causes, relationships and potential consequences. For example, an increase in delivery time may be associated not with one factor, but with a combination of infrastructure, weather, organizational and resource constraints.

The third function is forecasting. Machine learning, intelligent data analysis and scenario modeling methods allow you to assess likely changes in transport flows, delivery times, infrastructure load, cost and risk level.

The fourth function is intelligent optimization. In the event of a crisis, it is necessary to quickly determine alternative routes, types of transport, sequence of operations, resource allocation and priorities. In such conditions, heuristic and metaheuristic optimization methods become especially important, allowing to find acceptable solutions in complex multi-criteria search spaces.

The fifth function is decision support. An intelligent system should not simply provide a forecast, but form a set of management alternatives with an assessment of their consequences, risks, cost and sustainability.

Thus, IITs in crisis management act not as a separate digital tool, but as an integrated mechanism for increasing the adaptability of the transport and logistics system.

C). WARMI conditions as an environment for the adaptation of intelligent technologies.

WARMI conditions require revision of the traditional logic of information technology application. If in a relatively stable environment the main task of a digital system is to ensure the accuracy, speed and efficiency of pre-defined processes, then in a crisis environment the priority shifts to stability, adaptability, flexibility and the ability to function with incomplete and contradictory information.

For transport and logistics multimodal projects, it is advisable to characterize the WARMI environment through several interrelated features: dynamism of external and internal environment parameters; uncertainty of initial data and future states of the system; turbulence of processes and high speed of changing conditions; multiplicity of simultaneously acting factors and scenarios; interdependence of risks and elements of the transport system; instability of causal relationships; incompleteness and heterogeneity of information support; the need for prompt review of decisions.

As a result, the IIT architecture itself must become adaptive. It cannot be assumed that the same model, algorithm or system of criteria will be equally effective under different environmental conditions. Therefore, it is promising to use dynamically reconfigurable intelligent systems capable of changing model parameters, criteria weights, the set of data used, and decision-making algorithms depending on the current level of uncertainty and risk.

D). Adaptation of IIT to the dynamics of uncertainty and systemic risks.

A key feature of IIT adaptation is the transition from processing static data sets to dealing with continuously changing information flows. For this, mechanisms for automatic updating of models, detection of changes in data and detection of situations in which previously formed dependencies cease to be relevant are necessary.

Adaptive forecasting is of particular importance. In times of crisis, historical data do not always allow us to adequately describe the future state of the system, as the operating conditions themselves may change significantly. Therefore, the predictive model should take into account both the statistical regularities of the past and the current signals of environmental change.

Adaptive risk assessment is becoming an important direction. The risk of a transport and logistics project should be considered as a dynamic characteristic that depends on the current state of routes, infrastructure, resources, counterparties and external factors. This involves regular recalculation of the risk profile and determination of critical combinations of factors.

The next direction is script adaptation. IITs should ensure the formation of several possible scenarios of the development of the crisis: basic, adverse, critical and alternative. In this, the management system should evaluate both the expected outcome of each scenario and its resistance to further environmental changes.

Therefore, the most effective is the search for a single "optimal" solution, and the formation of a robust solution capable of maintaining acceptable efficiency when the initial conditions change.

E). Intellectual support for anti-crisis restructuring of multimodal routes.

One of the most significant application areas of IIT is dynamic reconfiguration of multimodal routes. When a crisis event occurs, the system must promptly evaluate available alternatives and determine the possibility of changing the transport arm, mode of transport, loading point, time parameters or sequence of operations.

In this case, the routing task becomes multi-criteria. Cost, time, reliability, throughput, probability of delay, resource constraints, environmental parameters and level of risk must be considered simultaneously.

In these conditions, it is advisable to integrate intelligent data analysis with heuristic and metaheuristic optimization methods. Intelligent analysis provides the formation of an up-to-date picture of the state of the system, and optimization algorithms allow you to quickly search for alternative solutions in the space of constraints that have changed.

An architecture in which IIT forms not a single route but a portfolio of alternative solutions ranked by sustainability, cost, time and risk is promising. This increases the quality of management choices and reduces the system's dependence on one forecast scenario.

F). Integration of IIT, digital twins and intelligent analytics.

An important direction in the development of crisis management is the integration of intelligent information technologies with digital twins of transport and logistics projects. A digital twin allows you to form a dynamic virtual representation of a real project and model the consequences of various management influences.

In crisis conditions, a digital twin can be used as an experimental environment for testing alternative solutions without direct intervention in the real transport system. For example, you can assess the consequences of changing the route, redistributing vehicles, changing consolidation points or switching to another mode of transport.

Integration of a digital twin with IIT forms a fundamentally new management mechanism: real system → data flow → digital twin → intelligent analysis → scenario modeling → management recommendation → impact on the real system → new data.

Such an architecture creates a closed adaptive control loop and provides the possibility of continuous system learning based on the results of decisions made.

G). Problems and limitations of the application of intelligent information technologies.

Despite the significant potential of IIT, their use in crisis management is associated with a number of limitations. First of all, this is the problem of the quality of the source data. Incomplete, untimely, contradictory or erroneous data can lead to erroneous forecasts and ineffective decisions.

The second problem is the dependence of intelligent models on the data structure and the conditions of their training. With a sharp change in the environment, the effect of reducing the accuracy of the model may occur, since the new conditions are significantly different from those under which it was formed.

The third problem is related to the clarity of decisions. In critical transport and logistics situations, the manager needs to understand not only the solution proposed by the system, but also the reasons for its formation. Therefore, a promising direction is the use of understandable artificial intelligence and hybrid models that combine machine learning, expert knowledge and formalized restrictions.

The fourth problem is cybersecurity and reliability of information infrastructure. The higher the level of digital integration of the transport and logistics system, the greater the potential surface of technological and information risks.

Finally, there is an organizational risk: an intelligent system should not completely replace human decision-making in crisis management. The optimal model is the human-in-the-loop, in which IITs collect, process, forecast and rank alternatives, and the final decision on critical issues is made by an authorized specialist.

CONCLUSIONS.

The analysis conducted allows us to conclude that crisis management of transport and logistics multimodal projects in the WARMI environment requires a qualitative change in approaches to the use of information technologies. The main problem is not only the need to increase the speed of information processing, but also to ensure the ability of the system to function under constantly changing initial conditions, incomplete data, high interdependence of risks and the occurrence of unexpected crisis events.

Intelligent information technologies form the technological basis of such a transition, ensuring the integration of monitoring, diagnostics, forecasting, scenario modeling, optimization and intelligent decision-making support. Their key advantage is the ability to transform large and dynamic information flows into management decisions focused not only on current efficiency, but also on the sustainability of the project.

The specificity of the application of IIT in multimodal projects is determined by the high interconnectedness of transport shoulders, infrastructure, resources and information flows. Therefore, intelligent management must take into account the cascading nature of risks and assess not individual violations, but systemic consequences.

Adaptation of IIT to WARMI conditions involves dynamic model updating, adaptive forecasting, constant risk reassessment, scenario modeling, use of robust solutions, and intelligent restructuring of routes and resources. Integration of IIT with digital twins, heuristic and metaheuristic optimization, intelligent analytics, and decision support technologies is particularly promising.

Thus, a promising model of crisis management of transport and logistics multimodal projects should be based on the principle of "anticipate - model - adapt - optimize - control - learn". This means a transition from reactive management of crisis consequences to proactive management of risk dynamics and stability of the entire transport and logistics system.

References:

[1] Ostapenko T., Onopriienko D., Hrashchenko I., Palyvoda O., Krasniuk S., Danilova E. (2022) Research of impact of nanoeconomics on the national economic system development. *Innovative development of national economies*: collective monograph. - Kharkiv: PC TECHNOLOGY CENTER, 2022. - pp. 46-70. URL: https://er.knutd.edu.ua/handle/123456789/23169

[2] Nevmerzhytska S. M. (2018). Formation of a strategy for the innovative development of enterprises in conditions of uncertainty. *Scientific Bulletin of the Kherson*

State University. Series: Economic Sciences. 2018. Vol. 32. pp. 99-103. URL: https://ej.journal.kspu.edu/index.php/ej/article/view/422/418.

[3] Naumenko, M. (2024). Methodology of determining factors of activity efficiency and competitive position of the enterprise on the market in crisis conditions. *Scientific innovations and advanced technologies*, № 7(35) (2024). DOI: https://doi.org/10.52058/2786-5274-2024-7(35)-648-665 [in Ukrainian].

[4] Hrashchenko, I. S., & Pryshchepa, N. P. (2016). Formuvannia konkurentnoho potentsialu pidpryiemstv za umov zrostannia mizhnarodnoi konkurentsii [Formation of the competitive potential of enterprises in conditions of growing international competition]. *Skhidna Yevropa: ekonomika, biznes ta upravlinnia - Eastern Europe: economics, business and management*, (4), 118-122.

[5] Hrashchenko, I. S. (2011). Problemy ta osoblyvosti prohnozuvannia na pidpryiemstvakh sfery posluh [Problems and features of forecasting at service enterprises]. *Ekonomichnyi visnyk Donbasu - Economic Bulletin of Donbass*, (3(25)), 175-179. https://www.evd-journal.org/download/2011/2011-3/Ek_visnyk_3_2011.pdf [In Ukrainian].

[6] Maksym Naumenko (2024). Modern concepts of innovation management at enterprises. *Scientific innovations and advanced technologies* No. 6(34) (2024). DOI: https://doi.org/10.52058/2786-5274-2024-6(34)-435-449

[7] Palyvoda O. O., Seliverstova, O. S. (2017). Management of innovative development of industry in the countries of the European Union based on the formation of cluster infrastructure. *Naukovyi visnyk Polissia*. 1(1(9). 185-191 [In Ukrainian].

[8] Остапенко Т.Г., Гращенко І.С., Прищепа Н.П. Транспортна система України як елемент глобальної транспортної системи. *Економіка та суспільство*. 2018. № 15. URL: https://economyandsociety.in.ua/journals/15_ukr/28.pdf

[9] Krasnyuk, M., & Kustarovskiy, O. (2017). The development of the concept and set of practical measures of anticrisis logistics management in the current Ukraine conditions. *Zarządzanie. Teoria i Praktyka*, Wyższa Szkoła

[10] Oksana Karpenko , Olena Palyvoda, & Olena Bondarenko (2018). Simulation modelling of strategic development of transport and logistics clusters in Ukraine. *Baltic Journal of Economic Studies*, 4 (2), 93-98. doi: 10.30525/2256-0742/2018-4-2-93-98

[11] Krasnyuk, M., Hrashchenko, I., Krasniuk, S., Kustarovskiy, O. (2019). Reengineering of a Logistic Company and its Information System Taking into Account Macroeconomic Crisis, Modern Economics, 13, pp. 141-153.

[12] Bondarenko, O., Palyvoda, O., & Kyrylenko, O. (2018). Development of a model for the estimation of financial processes in logistic systems at industrial enterprises. *Eastern-European Journal of Enterprise Technologies*, 5(1-95), 6-16. https://doi.org/10.15587/1729-4061.2018.142628

[13] Derbentsev, V. D., V. M. Soloviov, and O. V. Serdiuk (2005). Precursors of critical phenomena in complex economic systems. Modeling of nonlinear dynamics of economic systems. - Donetsk: DonNU, 1 (2005), (pp. 5-13) [in Ukrainian].