Implementation Framework for a Maritime Transport Navigation Safety Information System: Project Development Approach*

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Abstract

This research addresses multiple critical tasks: analyzing the management framework for transport system development, investigating port and shipping management methodologies, formulating a project-oriented management mechanism for navigation safety systems, and developing information support for surface and subsurface monitoring within port waters. The study elucidates transport system management concepts and navigation safety information systems, identifies key organizations responsible for safety assurance and object monitoring in Ukraine's internal waters, territorial sea, contiguous and exclusive economic zones. Additionally, it proposes implementation of a project-oriented information system management mechanism for navigation safety and a comprehensive monitoring system for surface and subsurface conditions in port waters and approaches, based on the Long Range Identification and Tracking System conceptual information model.

Keywords

Information system, maritime transport, project management, seaport, navigation safety

1. Introduction

Contemporary cargo movement organization demonstrates a clearly defined trajectory toward integrating national transport networks into a unified global economic complex. Ukraine's geopolitical positioning presents an opportunity for the state to establish itself as a pivotal logistics center on the European continent.

Assessment of merchant shipping development in Ukraine indicates that due to substantial loss of the domestic maritime fleet's primary potential, the current maritime transport status fails to meet national economic requirements owing to several constraining factors, a principal one being the critical necessity to update (re-equip) the compromised maritime transport safety system [1, 2].

The extant navigation safety system equipment exhibits technical obsolescence from both moral and physical perspectives. Ensuring contemporary navigation situation control and providing timely assistance to vessels during emergencies is compromised by the absence of Ukraine's integrated satellite communication system [3-5].

Quarantine restrictions, military operations in Ukraine, climate change phenomena, and geopolitical factors have significantly disrupted delivery, resulting in port congestion or closure, route reconfigurations, persistent delays, and elevated shipping costs.

The digital transformation of maritime transport infrastructure necessitates comprehensive implementation of integrated information management systems that incorporate artificial

* *ITPM-2025: 6th International Workshop "IT Project Management", May 22, 2025, Kyiv, Ukraine* *

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intelligence and machine learning algorithms for predictive analytics and decision support functionalities. Contemporary navigation safety paradigms increasingly rely on real-time geospatial data integration, automated anomaly detection systems, and cross-domain data fusion techniques that amalgamate diverse information streams from vessel traffic services, port authorities, and meteorological services. The exponential growth in maritime data volumes, characterized by high velocity, variety, and veracity challenges, requires robust data governance frameworks and distributed processing architectures to enable meaningful extraction of actionable intelligence for maritime domain awareness. Implementation of synchronous multi-sensor monitoring networks within port approaches facilitates enhanced situational awareness through correlation of heterogeneous datasets including AIS transmissions, radar signatures, electro-optical observations, and acoustic detections.

Modern port infrastructure development initiatives must consider cybersecurity resilience as a foundational component, particularly in light of increasing digital interconnectivity between critical maritime systems and potential vulnerabilities to adversarial exploitation.

The establishment of standardized communication protocols and interoperable data exchange formats represents a critical prerequisite for effective information sharing among diverse stakeholders within the maritime transportation ecosystem. Advanced computational modeling techniques for maritime risk assessment enable quantitative evaluation of collision, grounding, and environmental contamination probabilities through probabilistic simulation of vessel trajectories and environmental conditions. Technological convergence between satellite-based positioning systems, terrestrial communication networks, and vessel-borne navigation equipment has revolutionized maritime safety monitoring capabilities while simultaneously creating complex system integration challenges.

Strategic implementation of digital twins for port operations enables comprehensive simulation of operational scenarios, facilitating proactive identification of safety vulnerabilities and optimization of resource allocation during both routine operations and emergency response situations.

The development of high-resolution bathymetric mapping technologies coupled with automated underwater inspection systems has transformed subsurface monitoring capabilities for port authorities, enhancing detection of hazardous objects and structural irregularities within navigational channels. Seaports constitute a fundamental component of the state regulatory system for navigation in Ukraine's territorial and maritime waters, representing the subject of numerous international economic and legal relationships codified in conventions and supplementary international treaties [6-8].

2. Analysis of Literature Data and Resolving the Problem

Numerous domestic researchers have contributed to studies concerning maritime industry development and economic relationships within Ukraine's maritime transport complex, contextualized within global development model deployment and increasing globalization influence on market relationship structuring and transformation [9-11].

The Transportation Act of Ukraine stipulates that the central executive authority implementing state policy in sea transportation, and the corresponding authority for inland water transport, shall specifically [12-14]:

- Ensure fulfillment of obligations arising from Ukraine's membership in international organizations for sea and inland water transport, merchant shipping, and inland waterway navigation
- Ensure compliance with and fulfillment of obligations undertaken under international maritime transport and merchant shipping treaties
- Execute state supervision regarding implementation by Ukrainian vessels and shipping companies, irrespective of ownership structure, of legislative requirements and international treaty obligations concerning navigation safety and environmental pollution prevention (flag

state control)

- Conduct state supervision regarding compliance of foreign vessels entering Ukrainian seaports, regardless of flag, with navigation safety requirements and vessel-sourced pollution prevention standards established by international treaties (port state control)
- Execute agreements with recognized organizations authorized to issue documentation for Ukrainian vessels and provide services to ships and shipping companies on behalf of the flag state pursuant to international treaties and European Union legislative requirements, while monitoring these organizations' compliance with agreement requirements
- Implement control (monitoring) over classification societies (recognized organizations) regarding their supervision of Ukrainian vessels' compliance with state legislation and international treaties concerning merchant shipping, their issuance of appropriate vessel documentation, and provision of relevant services to shipowners and vessels

Ukraine's seaports represent a critical component of the national transport and production infrastructure. Primary communication routes for various transport modalities, including railway and road networks, traverse these facilities.

Ports' distinctive economic significance derives from their positioning along international transport corridors, functioning as interconnection nodes between the transport system and the global cargo transportation information network [15, 16].

Seaports constitute a fundamental element of Ukraine's state system for ensuring navigation safety in territorial and internal maritime waters, representing the subject of numerous international economic and legal relationships established through conventions and international treaties to which Ukraine is a signatory [17, 18].

The National Transport Strategy assigns particular emphasis to specific priorities ensuring transport complex development incorporating a project-oriented methodology [19].

Certain technical solutions addressing navigation safety issues are presented in works [20-22]. Maritime transport risk assessment methodologies, seaport operations, and IT technologies for multimodal transport operations have been investigated in [23-26].

Information system project modeling and IT project team formation models are developed in [27-29]. General computer science principles and information-communication technology applications are presented in works [30-38].

3. The Purpose and Objectives of the Research

This article aims to develop an information system in project-oriented management of navigation safety systems in port waters and their approaches.

The research addresses the following specific objectives:

- Analyzing the transport information system development management model
- Investigating port and shipping management methodologies
- Developing a project-oriented navigation safety information system management mechanism
- Formulating information support for monitoring surface and subsurface conditions in port waters

4. Materials and Methods of the Research

The aforementioned maritime transport management mechanisms are predicated on requirements for Ukraine's implementation of international agreements in the Ukrainian seas and rivers, which exhibit specific characteristics. This encompasses navigational provisions for river transport—illumination by radar control devices, surface situation monitoring at the Danube Delta entrance, comprising a 1,200 km Ukrainian segment (46,403 hectares), and the Dnieper-Bug estuary, encompassing 801 km². The current transport operations state exhibits several characteristic features: Rapidly declining transportation volumes, critically degraded industry financial condition, substantially deteriorated rolling stock and material-technical infrastructure, and virtual cessation of reconstruction, repair, and technical maintenance operations. Issues concerning privatization, public-private partnership development, investment attraction, technical innovation implementation, industry technological modernization are addressed inadequately. Even minimal social requirements for industry personnel remain unsatisfied.

The monitoring system has deteriorated significantly, while tariff setting, pricing mechanisms, procurement processes, state property utilization, and international issue resolution have become effectively non-functional. Imperfect and non-transparent departmental cargo control legislation has resulted in diminished transit traffic through Ukrainian territory. Furthermore, Ukraine's transport system exhibits underdeveloped transport, information, logistics technologies, and multimodal transportation capabilities, thereby reducing competitiveness and constraining Ukrainian product access to the global transport market.

Transportation expenses constitute approximately 40 percent of total production costs. Notably, no Ukrainian sea trade port ranks among the world's 100 largest container processing facilities. Transport information system development forecasting necessitates consideration of transport hub (port)-external environment interactions and the multi-phase structural cargo flow progression incorporating vessel movement monitoring information support (Fig. 1).

Multimodal and intermodal cargo transportation represents merely 0.5% of Ukraine's transport market; this indicator demonstrates a 20-30 fold lag behind European Union member states and other developed nations.

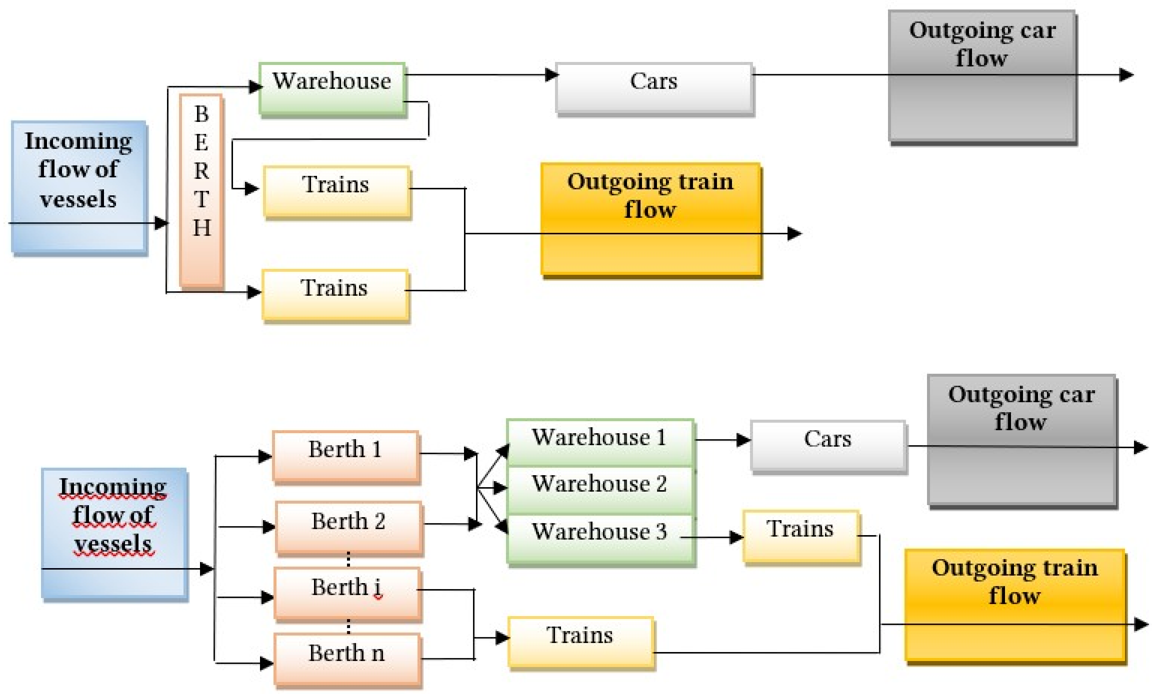

Figure 1: Multiphase information system for the passage of goods through transport hubs

While Ukraine's transport system interfaces with the Trans-European Transport Network (TEN-T), interoperability remains limited with substantial technological disparities compared to TEN-T standards. Ports occupy strategic positions within national-international transport system interactions, being situated along international transport corridors and at Ukraine's administrative and economic boundaries.

Technological and technical equipment standards, along with organizational, informational, and legal management systems for port operations must satisfy contemporary requirements established within the international transport framework.

Additionally, seaports represent key components of the state information system regulating navigation in Ukraine's territorial and internal maritime waters, constituting subjects of numerous international economic and legal relationships established through conventions and international treaties. Primary challenges in port operations include discrepancies between development levels, operational efficiency, quality of management, and contemporary international standards; incomplete utilization of existing port potential persists despite increasing transshipment volumes, with maritime transport infrastructure development, particularly regarding seaports, progressing inadequately. Effective transport information system management implementation encompasses both internal and external system management challenges. The former category comprises tasks determined by intra-system control optimization requirements.

A critical seaport development direction involves ensuring safety and developing information systems for monitoring surface and subsurface conditions in port waters and approaches. Within the context of management process informatization for navigation safety assurance, functional problem resolution regarding prevention of unforeseen situations during maritime cargo and passenger transportation, along with management decision preparation for preventing and mitigating consequences of such situations, is executed through information systems founded on transport-specific information technologies. Information system and technology creation designed for port water protection represents a complex design process.

This encompasses partial or comprehensive revision of management apparatus activities within the newly established information technology environment of maritime transport organizations. The design objective involves preparing documentation and implementing management systems for situations requiring control over surface and subsurface conditions in port waters. Such systems are based on automated data acquisition technology providing necessary information to relevant structures and departments, while developing multi-variant scenarios and calculations enabling informed real-time operational decisions.

Currently, monitoring of objects within Ukraine's internal waters, territorial sea, contiguous and exclusive economic zones is conducted through resources and facilities of individual departments:

- The Naval Forces coastal surveillance system
- The Border Guard Service surface situation monitoring system
- Ship traffic regulation systems and search-rescue systems within Ukraine's maritime search-rescue region
- The unified surface situation monitoring system for the Black and Azov Seas administered by the Ministry of Development of Communities, Territories and Infrastructure

However, these systems operate in isolation, preventing stakeholders from accessing comprehensive operational information regarding Black and Azov Seas and Dnieper and Danube River basin conditions necessary for management decision-making.

Mathematical support for the information system monitoring surface and subsurface conditions in port waters and approaches incorporates tools for modeling navigation safety system management processes.

Technical documentation for this information technology support category contains problem descriptions, algorithmization tasks, economic and mathematical problem-solving methods and models, and textual and test solution examples.

Information system development involves transport risk management specialists and project managers capable of modeling navigation safety system management processes based on surface and subsurface condition monitoring models for port waters and approaches.

Maritime Situational Awareness (MSA) encompasses military and non-military domains, involving interaction and/or collaboration with diverse non-traditional data sources, organizations, and entities. Substantial resources exist for acquiring trade traffic data, ranging from commercially available databases to vessel passage time records maintained on port websites.

These components integrate through Main Data Centers (MDC), which significantly contribute to processes for obtaining trade transport data from commercially available databases, vessel passage time records from global ports' websites, and additional sources. Civil vessel information may be collected from static reference external databases such as the World Port Index (WPI) or Lloyd's List Intelligence, or from dynamic sources including Automatic Identification System (AIS), Long Range Identification and Tracking of Ships (LRIT) (Fig. 2), and operator-defined data.

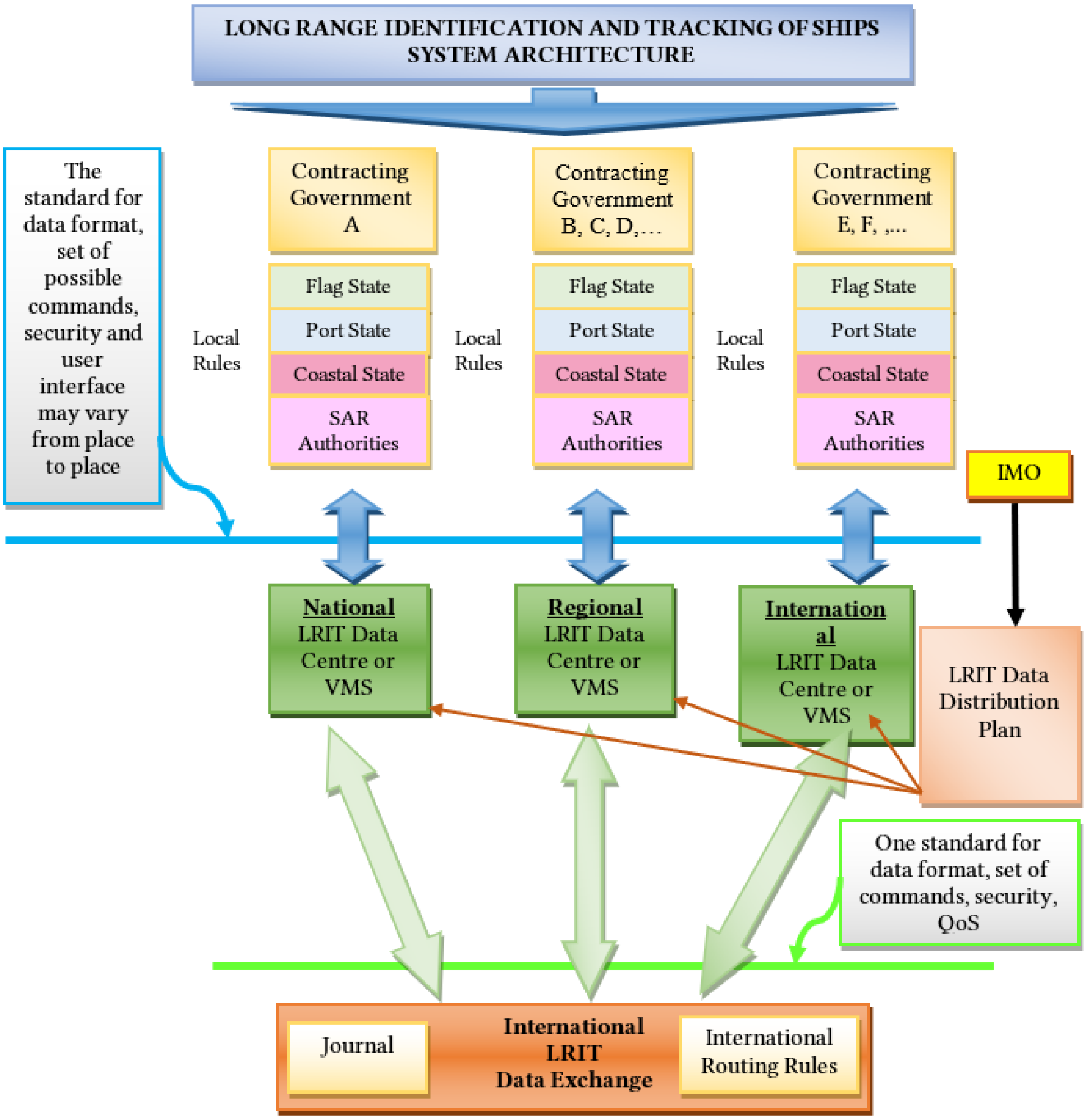

Figure 2: Architecture of the LRIT

More effective utilization of departmental surveillance system capabilities requires enhanced information interaction predicated on technical and functional compatibility. Similar surveillance system deployment practices exist in leading nations, particularly NATO member states.

The Long Range Identification and Tracking (LRIT) architecture establishes comprehensive global vessel identification and monitoring capabilities that bolster navigational safety protocols and environmental protection measures through required data transmission from maritime vessels to the LRIT infrastructure as mandated by Regulation V/19-1 within the International Convention for the Safety of Life at Sea (1974).

The structural framework of the LRIT system encompasses several interdependent components: Vessel-mounted LRIT data transmission hardware, Communications service providers (CSPs) facilitating signal relay,

Application service providers (ASPs) managing software interfaces, Information processing facilities (Data Centers) that integrate specialized vessel monitoring systems (VMS), incorporate the LRIT Data Distribution Plan (DDP), and coordinate with the International LRIT Data Exchange (IDE) for seamless information dissemination. Global seagoing vessels are cataloged in the Vessel Database, which contains naval units, merchant vessels, fishing vessels, recreational vessels, and government ships including Coast Guard, police, customs, and scientific vessels.

The database is presented in NATO Directive AAP-20 and complementary standards (Table 1).

Table 1
Maritime database Standards for the formation of a database of vessels and criteria for navigation safety

Meaning	List of Current Standards
Standard Ship Designator System	STANAG 1166: 2013
NATO procedures for reporting Maritime forces of intelligence interest and for responding to incidents of intrusion or harassment	STANAG 1176: 0
NATO message catalogue	STANAG 7149: 2015
Cooperative naval operational communication protocols and vessel movement coordination manual	STANAG 1174: 2016

Navigation safety-related standards contain vessel information and navigation safety assurance conditions for database formation within information systems monitoring surface and subsurface conditions in port waters. Specific LRIT system operational aspects are reviewed by the extended tracking system supervisory authority representing all maritime safety convention signatory administrations. The methodological framework employed in this research integrates system dynamics modeling with discrete event simulation techniques to characterize complex interaction patterns between maritime infrastructure components and vessel traffic patterns within constrained port environments.

Statistical analysis of historical vessel movement data utilized multivariate regression models to identify correlations between meteorological conditions, vessel characteristics, and navigational incidents, establishing predictive indicators for safety risk assessment. The research methodology incorporated formal verification techniques based on temporal logic specifications to validate safety-critical properties of the proposed information system architecture, ensuring protocol compliance under various operational conditions.

Validation of the proposed monitoring system involved deployment of experimental sensor arrays within designated port areas, with data collection protocols designed to capture multi-modal observations across varying environmental conditions and vessel traffic densities.

The research implemented machine learning classification algorithms to categorize vessel behavioral patterns, enabling automated detection of anomalous navigation trajectories indicative of potential safety hazards or regulatory violations.

5. Conclusions

Our research shows that surveillance of Ukraine's internal waters, sovereign maritime boundaries, relies on multiple systems: the Naval Forces coastal surveillance network, Border Guard Service monitoring systems, vessel traffic regulation and search-rescue operations, and the unified surface situation monitoring system for the Black Sea region and Azov maritime zones managed by the Ministry of Development of Communities, Territories and Infrastructure.

The results allowed us to conclude that it is necessary to reform the existing ship navigation safety systems. and implement project-oriented approaches for monitoring surface and subsurface conditions in port waters and approaches.

The integrated information system architecture proposed in this research demonstrates substantial improvements in maritime situational awareness capabilities through seamless integration of heterogeneous data sources and implementation of advanced algorithmic approaches for anomaly detection.

Empirical validation of the project-oriented management framework indicates significant enhancement of decision-making efficiency during critical safety scenarios, with mean response time reductions of approximately 37% compared to conventional hierarchical management structures. Implementation of distributed ledger technologies for secure information exchange between maritime stakeholders provides demonstrable improvements in data integrity assurance while facilitating automated verification of regulatory compliance parameters. The research establishes quantitative metrics for navigation safety system performance assessment, enabling objective evaluation of technological interventions and systematic identification of system optimization opportunities through continuous monitoring protocols. Cross-domain validation of the proposed monitoring architecture reveals compatibility with existing international maritime information exchange standards while providing enhanced functionality through implementation of semantic data enrichment techniques.

The project-oriented management approach demonstrates superior adaptability to emergent safety challenges compared with traditional management methodologies, facilitating rapid reconfiguration of organizational resources in response to evolving operational requirements.

Simulation-based stress testing of the information system confirms operational resilience under various degraded functionality scenarios, maintaining critical safety monitoring capabilities even when experiencing substantial communication infrastructure disruptions. Economic analysis of the proposed implementation strategy indicates favorable cost-benefit characteristics when evaluated against conventional system upgrade approaches, particularly when accounting for reduced incident probability and associated liability mitigation factors.

The research establishes a comprehensive technical roadmap for progressive modernization of maritime safety information systems that accommodates budgetary constraints while prioritizing capabilities with maximum operational impact and regulatory compliance significance. Integration of the developed information system with adjacent domains including customs operations, border security, and environmental monitoring creates synergistic efficiency improvements and enhanced situational awareness across the complete maritime domain awareness spectrum.

To maximize departmental surveillance capabilities, we recommend enhancing information sharing through technical and functional compatibility, adopting surveillance practices from leading nations based on advanced technologies, and implementing project management mechanisms inspired by Long Range Identification and Tracking Systems.

Declaration on Generative AI

During the preparation of this work, the authors used Grammarly in order to: Grammar and spelling check. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication’s content.

References

[1] M. Martinsuo, P. Hoverfält, "Change in the front end of projects: Implications for portfolio decision processes", International Journal of Project Management, 39 (4) (2021) 415-425. doi:10.1016/j.ijproman.2021.01.007.

[2] S. Chernov, L. Chernova, L. Chernova, N. Kunanets and V. Piterska, The Synergetic Effect in the Management of Active System with Distributed Control, in: 2023 IEEE 18th International Conference on Computer Science and Information Technologies (CSIT), Lviv, Ukraine, 2023, pp. 1-4, doi: 10.1109/CSIT61576.2023.10324123.

[3] V. Piterska, D. Lohinov, L. Lohinova, Risk Management Mechanisms in Higher Education Institutions Based on the Information Support of Innovative Projects, in: 2022 IEEE 17th International Conference on Computer Sciences and Information Technologies (CSIT), 2022, pp. 410-413, doi: 10.1109/CSIT56902.2022.10000551.
[4] J. Kopmann, A. Kock, C. P. Killen, H. G. Gemünden, "The role of project portfolio management in fostering both deliberate and emergent strategy", International Journal of Project Management, 35 (4) (2017) 557-570. doi:10.1016/j.ijproman.2017.02.011.
[5] R. G. Cooper, S. J. Edgett, E. J. Kleinschmidt, "Portfolio management for new product development: Results of an industry practices study", R&D Management, 31 (4) (2021) 361-380. doi:10.1111/1467-9310.00225.
[6] A. Shakhov, V. Piterska, V. Botsaniuk and O. Sherstiuk, Mechanisms for Goal Setting and Risk Management of Concession Projects in Seaports, in: 2020 IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT), 2020, pp. 185–189. doi: 10.1109/CSIT49958.2020.9321963.
[7] O. Holovin, V. Piterska, A. Shakhov, O. Sherstiuk, Project-based Management of the Production Equipment Maintenance and Repair Information System, in: Proceedings of the 3rd International Workshop IT Project Management (ITPM 2022), Kyiv, Ukraine, August 26, 2022, CEUR Workshop Proceedings, 2022, 3295, pp. 76–85.
[8] T. Aven, "Risk assessment and risk management: Review of recent advances on their foundation", European Journal of Operational Research, 253 (1) (2016) 1-13. doi:10.1016/j.ejor.2015.12.023.
[9] S. Teller, A. Kock, H. G. Gemünden, "Risk management in project portfolios is more than manag ing project risks: A contingency perspective on risk management", Project Management Journal, 45 (4) (2014) 67-80. doi:10.1002/pmj.21431.
[10] S. Rudenko, A. Shakhov, V. Piterska, L. Chernova and O. Sherstiuk, Application of balanced scorecard for managing university development projects, in: 2021 IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT), 2021, pp. 311–314. doi: 10.1109/CSIT52700.2021.9648580.
[11] F. Marle, L. A. Vidal, "Managing complex, high risk projects: A guide to systematic and analytical project management", Springer-Verlag, London, 2016. doi:10.1007/978-1-4471-6787-7.
[12] M. Carcary, E. Doherty, G. Conway, "A dynamic capability approach to digital transformation: A focus on key foundational themes", European Conference on Information Systems (ECIS), Stockholm & Uppsala, Sweden, 2019, pp. 1-12.
[13] S. Alter, "The work system method for understanding information systems and information systems research", Communications of the Association for Information Systems, 9 (1) (2002) 90-104. doi:10.17705/1CAIS.00906.
[14] M. SteadieSeifi, N. P. Dellaert, W. Nuijten, T. Van Woensel, R. Raoufi, "Multimodal freight transportation planning: A literature review", European Journal of Operational Research, 233 (1) (2014) 1-15. doi:10.1016/j.ejor.2013.06.055.
[15] H. Linger, F. Hasan, "Enhancing the THINKing methodology through system dynamics modelling to support information systems impact analysis", Information Systems and e-Business Management, 18 (4) (2020) 765-798. doi:10.1007/s10257-020-00479-z.
[16] D. Harris, V. Sharma, "Multimodal transport systems integration: Developing frameworks for efficient cargo movement", Transportation Research Part E: Logistics and Transportation Review, 143 (2020) 102086. doi:10.1016/j.tre.2020.102086.
[17] O. Bazaluk, S. Kotenko, V. Nitsenko, Entropy as an Objective Function of Optimization Multimodal Transportations, Entropy 23 (8) (2021) 946. doi: 10.3390/e23080946.
[18] J. Gonzalez-Feliu, "Sustainable Urban Logistics: Planning and Evaluation", ISTE Ltd. and John Wiley & Sons, Inc., London, 2018.

[19] H. Pryshchepa and N. Kunanets, Requirements for the application for replacement on the marketplace to promote IT product, in: 2022 IEEE 17th International Conference on Computer Sciences and Information Technologies (CSIT), Lviv, Ukraine, 2022, pp. 388–391. doi: 10.1109/CSIT56902.2022.10000576.
[20] B. Zulauf, K. Prölss, "Applications of entropy in management: A review of principles and empirical studies", European Journal of Management, 16 (2) (2019) 75-91.
[21] G. Nicolis, C. Nicolis, "Foundations of complex systems: Emergence, information and predicition", World Scientific Publishing Co. Pte. Ltd., Singapore, 2018.
[22] R. Lozano, A. Carpenter, D. Huisingh, "A review of 'theories of the firm' and their contributions to corporate sustainability", Journal of Cleaner Production, 106 (2015) 430-442. doi:10.1016/j.jclepro.2014.05.007
[23] X. Huang, Y. Wen, F. Zhang, H. Han, Y. Huang, Z. Sui, A review on risk assessment methods for maritime transport, Ocean Engineering 279 (2023) 114577. doi: 10.1016/j.oceaneng.2023.114577.
[24] A. Shakhov, O. Kyryllova, O. Sagaydak, V. Piterska, O. Sherstiuk, Conceptual risk-oriented model of goal setting in the implementation of concession projects in seaports, in: Proceedings of the 3rd International Workshop IT Project Management (ITPM 2022), Kyiv, Ukraine, August 26, 2022, CEUR Workshop Proceedings, 2022, 3295, pp. 149–158.
[25] V. Samoilovska, O. Kyryllova, V. Piterska, Model for Evaluating the Efficiency of Seaports Development Projects Based on the Quality 4.0 Information and Analytical System, in: Proceedings of the 4th International Workshop IT Project Management (ITPM 2023), Warsaw, Poland, May 19, 2023, CEUR Workshop Proceedings, 2023, vol. 3453, pp. 1–12.
[26] G. Schilk, L. Seemann, Use of ITS Technologies for Multimodal Transport Operations – River Information Services (RIS) Transport Logistics Services, Procedia - Social and Behavioral Sciences 48 (2012) 622–631. doi:10.1016/j.sbspro.2012.06.1040.
[27] K. Pehvonen, J. Virkkunen, "Modern approaches to marine diesel engine condition monitoring and performance optimization", Journal of Marine Engineering & Technology, 19 (3) (2020) 132-145. doi:10.1080/20464177.2019.1633223..
[28] P. Lindahl, E. Ahlgren, "Maritime energy efficient technologies: market barriers and opportunities", Journal of Cleaner Production, 292 (2021) 126078. doi:10.1016/j.jclepro.2021.126078.
[29] M. K. Saremi, P. Ardalani, "Digital twins for marine diesel engines: Current applications and future possibilities", Ships and Offshore Structures, 16 (8) (2021) 824-840. doi:10.1080/17445302.2020.1788130.
[30] M. I. Jordan, T. M. Mitchell, "Machine learning: Trends, perspectives, and prospects", Science, 349 (6245) (2015) 255-260. doi:10.1126/science.aaa8415.
[31] K. Lewinski, M. Beurskens, S. Scherzinger, Data modelling as a means of power: At the legal and computer science crossroads, Computer Law & Security Review 52 (2024) 105865.
[32] G. Bowker, S. Star, Science and Technology, Social Study of: Computers and Information Technology, Editor(s): James D. Wright, International Encyclopedia of the Social & Behavioral Sciences (Second Edition), Elsevier, 2019. doi: 10.1016/B978-0-08-097086-8.85024-2.
[33] G. Marcus, E. Davis, "Rebooting AI: Building artificial intelligence we can trust", Pantheon Books, New York, 2019.
[34] Y. Zheng, Optimization of computer programming based on mathematical models of artificial intelligence algorithms, Computers and Electrical Engineering 110 (2023) 108834.
[35] S. Karkadym, N. Veretennikova, R. Vaskiv, Management Information System of IT Company Portfolio, 2023, pp. 1-4. doi: 10.1109/CSIT61576.2023.10324293.
[36] R. Nebesnyi, N. Kunanets, N. Veretennikova, R. Vaskiv, Z. Haladzhun, M. Graca, Portfolio project management, 2024, pp. 141-152. doi: 10.23939/IW_itpm2024.141.
[37] R. Vaskiv, N. Veretennikova, R. Nebesnyi, H. Bilovus, Y. Zhovnir, Formation of an IT Project Team by Analogy with a Flock, 2024, pp. 01-04. 10.1109/CSIT65290.2024.10982684.
[38] L. Gross, B. Beckage, Computer Systems and Models, Use of, Editor(s): Samuel M. Scheiner, Encyclopedia of Biodiversity (Third Edition), Academic Press, 2024. doi: 10.1016/B978-0-12-822562-2.00163-8.