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Українська асоціація управління проєктами
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# ІНТЕГРОВАНЕ СТРАТЕГІЧНЕ УПРАВЛІННЯ, УПРАВЛІННЯ ПОРТФЕЛЯМИ, ПРОГРАМАМИ, ПРОЄКТАМИ

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## LIST / ЗМІСТ

# AI-DRIVEN INNOVATION IN PROJECT MANAGEMENT - A STRATEGIC IMPERATIVE FOR FUTURE SUCCESS

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Artificial Intelligence (AI) is fundamentally reshaping the landscape of project management, transcending mere automation to drive profound innovation in decision-making, efficiency, and strategic outcomes. This transformation necessitates a proactive and ethically informed integration approach. This report explores the pervasive impact of AI across project lifecycles and methodologies, detailing its practical applications, tangible benefits, inherent challenges, ethical considerations, and the evolving role of project managers in an AI-augmented environment.

The capabilities of AI, particularly its capacity to rapidly process vast datasets, predict future trends, and automate routine operational tasks, extend beyond simple efficiency gains. This equips project managers with real-time, data-driven intelligence that facilitates proactive adjustments and strategic reorientations. This dynamic responsiveness directly enhances organisational agility, enabling quicker and more informed reactions to fluctuating market conditions, emergent risks, and evolving stakeholder requirements. Consequently, AI transforms project management from a predominantly reactive oversight function into a proactive, strategic enabler that directly contributes to the achievement of overarching organisational objectives.

Traditionally, project success has often been narrowly defined by adherence to triple constraints. on-time, on-budget, and within-scope delivery. However, the integration of AI is shifting this focus significantly, emphasising superior benefits realisation and higher return on investment (ROI). An AI-driven environment allows for continuous optimisation efforts aimed at maximising business benefits. Therefore, project success is increasingly being redefined by the achievement of strategic outcomes, value creation, and long-term organisational impact, rather than solely by the efficiency of execution. This represents a profound conceptual evolution in how project performance is measured, evaluated, and managed.

The rapid advancement of Artificial Intelligence has fundamentally revolutionised numerous industries, with Project Management (PM) being a prominent example. This transformation is driven by AI's enhanced functionality, including faster data analysis, increased storage capacity, and improved algorithms. Organisations are increasingly confronting heightened complexity in managing intricate tasks, diverse teams, and dynamic resources, making the strategic integration of AI tools not merely advantageous but often indispensable. AI has matured from a futuristic, theoretical concept to a practical, actionable asset within the project management domain, demonstrating its tangible utility in real-world scenarios. The embrace of modern technology, particularly AI, is occurring with increasing boldness and a pronounced drive for innovation within PM practices.

Innovation in an AI-driven project management environment is characterised by the strategic leveraging of AI's advanced capabilities – specifically its prowess in data processing, predictive analytics, and automation – to facilitate faster, more accurate, and ultimately more strategic decision-making throughout the entire project lifecycle. This integration inherently leads to substantial increases in operational efficiency, significant reductions in project risks, and a demonstrably higher success rate for the development and launch of new products and services.

The «Stages and Gates» process, often described as a cornerstone of innovation management, traditionally implies a structured, linear, and somewhat mechanistic approach to innovation. However, the integration of AI is consistently presented as redefining, revolutionizing, and marking a pivotal shift in these processes, leading to next-generation AI-powered innovation. AI's capabilities in real-time data analysis, predictive modelling, and dynamic adjustment fundamentally transcend merely making existing processes faster. Instead, they enable continuous feedback loops, proactive adaptation, and iterative optimisation throughout the entire innovation lifecycle. This signifies a profound shift from a rigid, sequential innovation model to a more fluid, adaptive, and continuously optimising paradigm, where innovation is not a discrete outcome but an ongoing, dynamic process of refinement directly driven by AI-generated information.

This transformation extends beyond simply enabling innovation within project management tasks, such as better scheduling. The discussion of «innovation management powered by Artificial Intelligence» and the emergence of "next generation AI-powered innovation phases and gates processes" indicates that AI is fundamentally innovating *how innovation itself is managed and executed*. By automating and enhancing critical stages like ideation, concept testing, market analysis, and design, AI is transforming the very process of innovation. This represents a meta-level innovation – an «innovation of innovation» – where AI optimises the mechanisms and frameworks used to create new products and services, making the entire innovation pipeline more efficient, predictable, and ultimately more successful.

AI fundamentally transforms project management by significantly improving efficiency, effectively reducing risks, and profoundly enhancing decision-making across the entire project lifecycle. This integration enables a critical paradigm shift from reactive management to proactive, foresight-driven leadership.

The research highlights a dichotomy. Agile frameworks naturally integrate AI due to their adaptive nature, while Traditional (Waterfall) methods, despite initial challenges, can also achieve significant enhancements through AI, especially in strategic forecasting and process optimisation. This observation suggests that AI is not merely favouring one methodology over another but acts as a unifying technological force. It bridges the gap between these seemingly opposing paradigms by infusing data-driven information and automation into both. AI allows traditional approaches to gain a degree of agility and responsiveness typically associated with Agile, while potentially making Agile even more efficient and predictable. This implies AI is a methodological agnostic enabler, pushing all project management approaches towards greater data-driven optimisation and hybrid models.

Overall, AI-driven project management tools have become indispensable across both Agile and traditional frameworks as organisations globally strive to improve project outcomes. Real-world implementations consistently showcase how organisations leverage machine learning algorithms, natural language processing, and intelligent automation to enhance overall efficiency. The research underscores AI's growing influence on decision-making, forecasting, and project execution, highlighting its profound potential to redefine the future trajectory of project management. Future projects are increasingly advised to consider adopting combined management systems that effectively unite systematic planning methods with AI capabilities to meet evolving adaptation needs.

The detailed breakdown of AI's pervasive impact across all core PM functions – planning (resource forecasting, adaptive scheduling), execution (task prioritisation, automation), monitoring (real-time dashboards, predictive outcomes), and risk management (proactive identification, automated mitigation) – reveals a comprehensive, integrated influence rather than isolated applications. AI is not just optimising individual project management functions; it is enabling a new, holistic paradigm of «Intelligent Project Lifecycle Management.» In this model, every stage of a project is interconnected, continuously informed, and dynamically optimised by AI, leading to a much more fluid, responsive, and self-correcting project ecosystem. This goes beyond simple «automation» to «intelligent automation» that learns, adapts, and proactively guides the project from conception to completion.

Numerous sources emphasise AI's unparalleled ability to process vast amounts of data. However, the critical and innovative outcome consistently highlighted is not merely data processing, but the provision of «actionable information» and «actionable recommendations». This distinction reveals a fundamental shift. AI transforms raw, often overwhelming data into clear, prescriptive intelligence that directly informs strategic decisions and immediate actions. The innovation lies in AI's capacity to bridge the gap between data availability and effective utilisation, moving project management beyond descriptive reporting (what happened) to predictive (what will happen) and prescriptive (what should be done) guidance.

Applications such as AI assisting in brainstorming risks, creating time estimates, and drafting communications extend beyond simple automation of repetitive tasks. These functionalities suggest that AI is actively augmenting the:

- *cognitive functions* of a project manager. By identifying potential risks that a human might overlook due to cognitive biases like «tunnel vision», or by generating a diverse range of creative design options, AI is not merely performing tasks
- *for* the manager, but is helping the manager *think more effectively, comprehensively, and creatively*. This implies that AI is evolving into a cognitive partner, expanding the project manager's mental capacity, analytical reach, and innovative potential, rather than serving solely as a tool for administrative relief.

AI Applications in Project Management – Capabilities and Benefits are presented in Table 1.

Table 1 – AI Applications in Project Management- Capabilities and Benefits

| **Application Area** | **Core AI Capabilities** | **Key Functionality** | **Primary Benefit to Project Management** |
|---|---|---|---|
| Automated Task Scheduling | Machine Learning Algorithms, Data Analytics | Optimising complex schedules, Prioritising tasks based on dependencies and deadlines | Increased operational efficiency, reduced time-to-market |
| Project Forecasting & Budgeting | Machine Learning Algorithms, Predictive Modelling, Data Analytics | Forecasting timelines, resource requirements, and budgetary needs; Identifying potential budget overruns | Enhanced data-driven decision-making, Optimised resource utilisation, Proactive financial management |
| Optimised Resource Allocation | Machine Learning Algorithms, Data Analytics | Matching skills to tasks, Dynamic reallocation based on real-time changes, Workload balancing | Optimised resource utilisation, Higher task efficiency, Improved team satisfaction |
| Proactive Risk Management | Machine Learning Algorithms, Predictive Modelling, Data Analytics, Natural Language Processing (NLP) | Identifying potential risks, Simulating scenarios, Continuous monitoring and alerts | Proactive problem-solving and risk mitigation, Reduced project disruptions |
| Enhanced Communication & Collaboration | Natural Language Processing (NLP), Generative AI | Drafting communications, Chatbots for routine inquiries, and Sentiment analysis in team interactions | Improved team collaboration and stakeholder engagement, Streamlined information flow |
| Intelligent Decision Support | Machine Learning Algorithms, Data Analytics, Predictive Modelling | Providing real-time, data-driven information, identifying patterns and correlations | Enhanced data-driven decision-making, Strategic guidance |
| Performance Monitoring & Evaluation | Machine Learning Algorithms, Data Analytics, Natural Language Processing (NLP) | Tracking KPIs, Identifying performance patterns, Analysing feedback for improvement | Superior project outcomes and continuous improvement, Real-time project health overview |
| Quality Assurance & Control | Machine Learning Algorithms, Data Analytics | Detecting anomalies in project data, Prioritising testing efforts, and Ensuring compliance | Higher quality deliverables and reduced errors, Early issue detection |
| Creativity Enhancement | Generative AI, Machine Learning Algorithms | Generating design options, organising brainstorming ideas, and transforming raw ideation into actionable steps | Fostered innovation and creative solutions, expanded creative capacity |

The integration of AI into existing project management frameworks and organisational structures is not without its challenges. Implementation complexity is a notable concern. Key considerations include ensuring seamless compatibility with existing legacy systems, optimising ease of use for diverse project teams, guaranteeing scalability to meet evolving project demands, and managing the associated costs of AI tool acquisition and integration.

A significant challenge also lies in workforce adaptation. As AI increasingly automates routine and repetitive tasks, a certain degree of workforce disruption becomes inevitable. To mitigate negative impacts, organisational leaders must proactively plan to support displaced staff through comprehensive transitional assistance programs, robust upskilling and reskilling initiatives, opportunities for job rotation, and effective change management strategies. The overarching goal is to elevate team members into more rewarding and strategic roles, rather than causing undue hardship or fostering mistrust.

A foundational principle for effective AI systems is that their insights are only as reliable as the data they process. Ensuring high-quality, relevant, valid, and correct data is paramount for generating accurate information. This necessitates defining precise data requirements aligned with AI objectives, implementing robust data governance policies, conducting regular data audits to identify and correct inconsistencies, and utilising automated tools for streamlined data collection and updates, which significantly reduces human error and ensures real-time accuracy. Integrating data from diverse sources offers a comprehensive view, further enhancing the effectiveness of AI models. Furthermore, there can be inherent trust gaps in algorithmic recommendations, especially when AI systems are perceived as black boxes. AI tools must be viewed as collaborators that augment human capabilities, rather than as replacements. The synergistic combination of human creativity and AI's analytical power forms a formidable force for innovation.

***Conclusions.*** The integration of Artificial Intelligence represents a profound transformation, not merely an incremental improvement, in project management. AI is redefining innovation within this domain by enabling faster, more informed, and strategic decision-making, enhancing predictive capabilities, and significantly improving operational efficiency across the entire project lifecycle. This shift moves project management from a predominantly reactive function to a proactive, value-driven strategic imperative.

AI serves as a powerful bridge between traditional and agile methodologies, infusing data-driven optimisation into both and fostering the emergence of an «Intelligent Project Lifecycle Management» paradigm. Its applications span automated scheduling, precise forecasting, optimised resource allocation, proactive risk management, and enhanced communication, transforming raw data into actionable intelligence and augmenting the cognitive functions of project managers.

The tangible benefits of AI adoption are evident in quantifiable improvements in productivity, on-time project delivery, benefits realisation, and return on investment, demonstrating a compounding return on investment. This signifies a fundamental shift towards a «value-centric project management» approach, where strategic and financial returns are prioritised alongside traditional project constraints.

Despite its immense potential, AI integration presents significant challenges related to implementation complexity, workforce adaptation, and, critically, ethical considerations. The paradox of AI efficiency versus ethical overhead underscores the necessity of robust governance, comprehensive training, and meticulous data management to mitigate risks such as algorithmic bias, privacy breaches, and lack of transparency. Successfully navigating these ethical landscapes will become a key competitive differentiator, building trust and reputation in an increasingly AI-driven world.

Ultimately, AI will not replace project managers but will fundamentally augment their capabilities, leading to the emergence of the «augmented project manager.» This evolution necessitates a re-humanisation of the role, allowing project managers to focus on uniquely human competencies such as strategic leadership, emotional intelligence, complex problem-solving, and ethical stewardship. The synergy between AI's analytical power and the Project Management Professional (PMP) principles will define the future of successful project delivery, emphasising collaboration and continuous learning as cornerstones for navigating the complexities of the AI era.

# FORMATION OF A RISK STRATEGY IN THE MANAGEMENT OF INVESTMENT PROJECTS UNDER CONDITIONS OF AN UNSTABLE EXTERNAL ENVIRONMENT

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The investment climate of a country is a key factor in investors' decision-making and is determined by political stability, transparency of legislation, tax policy, and incentive systems. While developed countries already possess a well-established investment image, a number of states are still in the process of forming it by improving their legislative frameworks in order to enhance investment attractiveness.

This article examines the main principles of forming risk strategies when investing in regions where the external environment remains turbulent. The economic development and sustainable growth of countries participating in an investment program based on direct investments in various sectors of the economy are achieved through the following key directions:

- strategic objectives of investors;
- mechanisms for achieving investment goals;
- tasks of investment activity;
- development of mutually beneficial partnerships;
- improvement of the investment climate in the regions where projects are implemented;
- development of entrepreneurial activity;
- formation of integrated production and logistics chains.

At the same time, an important task of direct financing of investment projects is the proper formation of a risk strategy, which involves defining the overall level of risk appetite at the level of the investment program and cascading it into specific limits for the portfolio and individual investments. Each risk category is considered separately.

**Risk Appetite: Program Level**

Within the implementation of the investment program, a prudent and balanced approach is applied when selecting investment targets, based on four key principles:

- investment in existing low-volatility industries;
- diversification of the investment portfolio;
- cooperation with experienced and successful management teams;
- direct financing of projects without transferring responsibility for investment decision-making to third parties.

**Risk Appetite: Portfolio Level**

At the portfolio level, it is necessary to ensure sufficient diversification in order to avoid a high concentration of investments.

For concentration risk:

- sectoral diversification allows investments of no more than 20% of the maximum authorized capital;

- diversification by project type permits investment in companies scaling their activities using existing business models and infrastructure;
- the maximum size of a single transaction shall not exceed 5% of the maximum authorized capital.

**Risk Appetite: Deal Level**

At the level of each transaction, the project office must manage a group of risks in accordance with a moderate risk appetite.

*In the case of reputational risks:*

- investments in industries;
- investments in companies that may contribute to reputational risk;
- restriction of any questionable transactions.

*In the case of regulatory risks:*

- investment in projects that comply with regulatory requirements;
- exclusion of transactions that violate legally established norms.

*In the case of debt risks:*

- investments under conditions where Debt/Equity > 1.5, Debt/EBITDA > 3, and DSCR < 2;
- analysis of the company's credit history.

*In the case of financial risks:*

- efficiency assessment taking into account currency and country risks;
- presence of a strong project team;
- partnership-based investment approach.

*In the case of operational risks:*

- establishment of a minimum investment threshold;
- ensuring access to the necessary data and expertise.

From the above, the following conclusions can be drawn:

The analysis of these global indicators enables investors to assess the investment climate in different countries. High index values attract major financial players to a region, stimulating economic growth while ensuring high investment returns with minimal risk.

As a characteristic feature of uncertainty-driven investment climates, investors are increasingly interested not in short-term speculative stocks or long-term real estate investments, but in investments in modern businesses. High values of DB, WCI, ES, and WGI in regions with uncertain climates make local business activity one of the most secure ways to generate profit, which explains the growing demand for such investments.

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# THE ROLE OF LOCAL AUTHORITIES IN SUPPORTING SOCIAL ENTREPRENEURSHIP: IMPACT ON THE SELF-EFFICACY OF SOCIAL ENTREPRENEURS

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Social entrepreneurship is a relatively new social and economic phenomenon, although examples of social enterprises can be found throughout the history of entrepreneurship. Evidence of the relative novelty of social entrepreneurship can be found in the statistics of a number of developed countries, where only in recent decades has the contribution of social enterprises to GDP and employment been clearly noted.

At the same time, there is a visible increase in research interest in social entrepreneurship, as evidenced by the growing number of publications in recent decades.

Among the research questions in the field of social entrepreneurship, an important place is occupied by the issue of supporting this type of entrepreneurship, determined by the main problem that the social entrepreneur faces – achieving a balance between two conflicting goals in nature – those of business and social goals.

Social entrepreneurship is also gaining new importance for central and local government policies aimed at solving social problems that the relevant authorities have difficulty dealing with. In this context, local governments play a major role, at least for the following reasons: their proximity to community problems, the control they have over local resources, and their responsibility for maintaining local well-being.

In the presented study, attention will be focused on two types of support that local authorities have the capacity to provide to social entrepreneurs – material (physical) and informational. Of course, these two types of support will be considered in the broader context of the role of local authorities, namely, as creators of the social entrepreneurship ecosystem and builders of social entrepreneurship capacity at the local level.

Special attention in the study is paid to the role of local authorities as a factor determining the level of self-efficacy perceived by social entrepreneurs. The concept of self-efficacy was proposed back in 1977 by psychologist Albert Bandura as an explanation of the decision to make or not make the necessary efforts to achieve certain goals. In its shortest definition, self-efficacy is expressed in the confidence of the individual that he has the necessary capacity to carry out activities necessary to achieve certain goals. In the context of entrepreneurial activity, the concept of “entrepreneurial self-efficacy” appears, which expresses the confidence of the individual that he has the necessary capacity to perform roles and tasks aimed at achieving entrepreneurial results. An important feature of the self-efficacy of the social entrepreneur, compared to the traditional one, is the conviction in the ability to achieve positive social change (Broccia, Dias & Pereira, 2022), and the presence of high self-efficacy would lead to the creation of greater social value (Smith & Woodworth, 2012).

The hypothesis, which the analysis of a representative array of empirical data from a survey conducted at the end of 2025 in Bulgaria aims to test, is that the content of the support provided by local authorities to social entrepreneurship plays a significant moderating role in relation to the level of entrepreneurial self-efficacy.

In testing the hypothesis, instruments for measuring entrepreneurial self-efficacy tested in previous studies were used, including those relating to social entrepreneurs (Chen et al, 1998; DeNoble et al, 1999; McGee et al, 2009; Barakat et al, 2014; Urban, 2015), as well as instruments for measuring support from local authorities.

It is envisaged that the expected results of the study, which also contains the verification of other hypotheses regarding the role of local authorities in supporting social entrepreneurship, will be incorporated as elements in recommended models for interactions between local authorities and social entrepreneurs, which will ultimately lead to sustainable solutions to social problems at the local level with the help of social entrepreneurship

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# FORMATION OF A PROJECT TEAM USING FUZZY INTERVALS TO ASSESS COMPETENCIES

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Selecting candidates for project teams is a responsible task. The success of the project largely depends on this decision. In most cases, such selection is carried out quite subjectively. The level of technical competence of candidates is rather uncertain. Consider how a group of teachers listens to a student's presentation and then tries to give a final assessment. A number of circumstances must be taken into account. First, the presentation does not fully reflect the entire scope and quality of the student's work.

A student could prepare a mediocre presentation based on excellent work. Or, conversely, the presentation exaggerates and embellishes what has been done, and the student has skilfully presented very imperfect work. Secondly, the examinee's answers may relate to different subject areas. This raises the problem of assessing the importance of knowledge and skills in different subject areas. Thirdly, the assessment that forms in the teacher's mind is vague. Fourthly, teachers' perceptions of the presentation may differ significantly, and in practice this happens very often. When giving a final assessment, teachers' opinions sometimes differ significantly. Disputes among members of the commission when giving a final assessment are not uncommon. Nevertheless, in this situation, they must give a single clear assessment.

A similar situation can be observed when assessing candidates' competencies. In addition, each candidate may have several competency assessments – these may be exam results, test results, interviews, certificates of advanced training, etc. Thus, when forming a project team, it is necessary to take into account multiple assessments of certain competencies and their vagueness.

To reflect the opinion of the teacher or examiner regarding the competence of the student or candidate for the team, it is proposed to use fuzzy intervals, whose membership function is shown in Figure 1. This function is a piecewise linear approximation of more complex real membership functions. For simplicity, a trapezoidal fuzzy interval can be used, although it provides fewer opportunities to reflect the examiner's opinion of the candidate's level of competence.

The influence of team composition on its effectiveness has been studied by many scientists. The work of R. M. Belbin, who identified nine roles that team members must perform for a project to be successful, has gained wide recognition. He developed a questionnaire that allows candidates to be assessed in terms of their readiness to perform a particular role. In addition to self-assessment, R. M. Belbin suggested that individuals be assessed by at least four people who have worked with them for at least three months. As a result, anyone can obtain percentile scores for each team role on R. M. Belbin's website, based on self-assessment and the cumulative perception of observers. Thus, a candidate's ability to perform certain roles is assessed by at least two evaluations. To reflect these assessments, the fuzzy interval shown in Fig. 1 can be used.

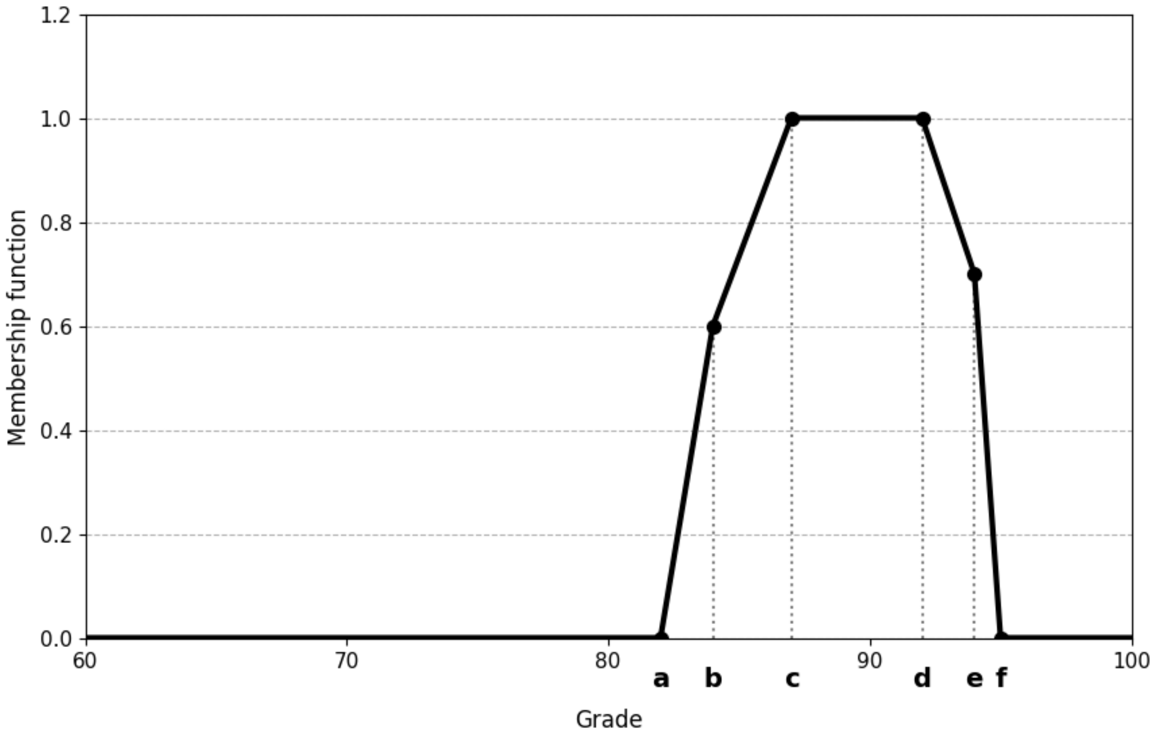


Fig. 1. Fuzzy membership function of a candidate's assessment

In addition to technical competencies and the ability to perform specific roles, the personal qualities of team members are important for the success of a project. When studying the influence of personality traits included in the Big Five personality traits, the authors [1] found that the higher the level of agreeableness in teams and the more similar team members are to each other in this respect, the higher their productivity. The exception in terms of the influence of this factor was student teams, whose work was characterised by shorter periods of interaction. The higher the average level of conscientiousness in a team and the closer the team members are to each other in terms of this indicator, the higher the team's performance. Student teams are an exception.

The other personality traits included in the Big Five were not identified as important for team performance. Neither extraversion nor its variability affect team performance. Increased emotional stability and openness to new experiences do not correlate positively with team performance.

A method for optimising the composition of a project team is proposed, which is based on representing the competencies of candidates and their abilities to perform certain roles in the form of fuzzy intervals, shown in Fig. 1. The requirements for the competencies of candidates are specified by fuzzy sets. Compliance with the requirements is verified by calculating the area $S$ of the intersection of the membership functions of competence and requirements. Next, a constraint is set: the ratio of the area $S$ to the area of the competence membership function $S_{comp}$ must be at least $q$, where $0 < q \leq 1$. For example, q can be equal to 0.8. If this constraint is satisfied, then the competence requirement is also satisfied.

The objective function of the task is introduced, which is calculated as follows. The sum of the abscissa values of the centres of mass of the membership functions of a specific type of competence for all candidates included in the team composition under consideration is determined. Next, these sums are added up for all competences. This objective function is maximised for all team composition options. The second objective function reflects the costs of the selected team composition option. It is minimised across all team composition options. The third objective function aims to maximise the agreeableness and conscientiousness of team members. The model contains constraints that take into account the workload, the fulfilment of competency requirements, and the cost of the team's work [2].

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# TECHNOLOGY FOR MASKING SPATIALLY DISTANCED SPATIAL-TIME SERIES DATA

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Today, the problems of defining a forecast of the occurrence and development of accidents and/or emergencies of a natural or man-made nature on the engineering infrastructure of the city and the region as a whole are of particular importance [1,2]. This issue is highly relevant for electricity supply networks, given the modern conditions of operation of electricity consumption networks, which are maximally complicated by the changing external environment, which generates additional uncertainties and challenges of significant negative impact. It should be noted that the formulated problem (let us call it as Problem 1, and note that this problem is the inverse one of the task of forecasting the uninterrupted supply of produced electricity) is an integral component of the generalized task of maintaining a constant balance between electricity production and consumption in the region, together with such basic tasks as: Problem 2 – forecasting electricity production in the region [3]; Problem 3 – forecasting electricity consumption in the region (Fig. 1).

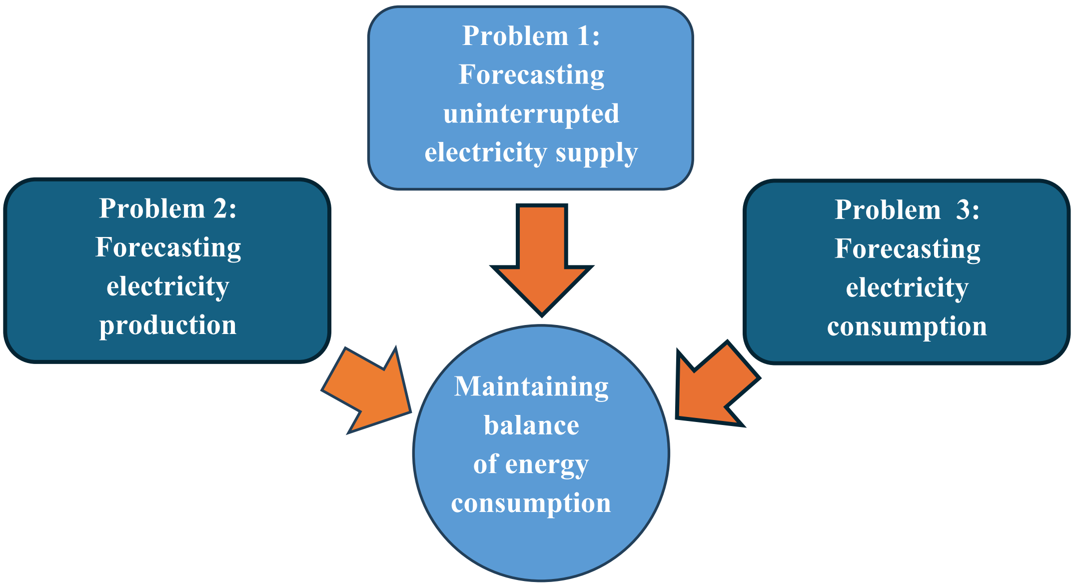


Fig.1. Hierarchy of forecasting problems

Modeling and solving problems 1-2 should also use weather forecast data, historical data characteristics – seasonal and temporal patterns, characteristics of electricity supply sources, and electricity demand characteristics as exogenous parameters.

The specified problems require the interpretation of large volumes of available data for their solution. Analysis and further use in forecasting events of this kind necessarily involves the use of a powerful apparatus of neural networks of various types [4, 5], which makes it possible to process large volumes of data and identify complex nonlinear dependencies.

Thus, the spatio-temporal series G, which is the initial one for Problem 1, has the form:

$$G=\{v_i, r_i(v_i), t_i\}_{i=1,2,\ldots I},$$

where $v_i=(x_k,y_j)$, k=1,2,…,K, j=1,2,…J, is a two-dimensional matrix (usually a regular grid) of the coordinates of the network links, on which the value of the severity of the accident at time $t_i$ is given.

Analysis of the key existing neural network architectures for processing spatio-temporal data series, such as recurrent neural networks (RNN) and more complex architectures Long Short-Term Memory networks (LSTM) and GRU (Gated Recurrent Unit), convolutional neural networks (CNN) and their hybrid variants (CNN-RNN, ConvLSTM), allowed us to identify the ConvLSTM architecture as the most promising among them, which combines the capabilities of convolutional neural networks (CNN) and long-term memory (LSTM).

The ConvLSTM architecture interprets the spatio-temporal series as a set of maps $r_i(v_i)$, where each map provides the severity of the accident at different points in the network at time $t_i$, i=1,2,…I.

To create and train ConvLSTM models, the study used the TensorFlow/Keras libraries of the Python programming language in the Google Colab environment with the connection of an appropriate specialized graphics processor. T4 GPU.

As the initial (raw) data, model (randomly generated) data according to the principle set out in [6] and publicly available data in the form of CSV files were used.

The ConvLSTM architecture theoretically allows you to preserve the spatial structure of the data (considering neighboring sections of the power grid).

Experimental studies on parametric identification of the ConvLSTM architecture and forecasting have shown that this architecture should be significantly supplemented with a set of masks that prohibit the influence of forbidden zones of the grid, where there are no network links (buildings, natural obstacles, etc.). At the same time, forbidden zones and network links that are not active at the moment of time, that is, do not bear signs of an accident, are distinguished by marking in the constructed neural network architecture.

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# THE ROLE OF DATA ANALYTICS IN IMPROVING PROJECT MANAGEMENT EFFECTIVENESS

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The increasing scale and complexity of projects in modern organizations, along with the growing uncertainty of the market environment, necessitate the adoption of more flexible, systematic, and well-substantiated approaches to project management. Traditional project management methods often have limited capacity to respond promptly to changing conditions and to identify risks in a timely manner. In this context, data analytics emerges as a critical and strategic tool for enhancing project management practices. This article examines the integration of data analytics into project management processes and its role in improving the effectiveness of decision-making mechanisms. Within the scope of the study, the strengths and weaknesses of traditional project management approaches are analyzed and compared with data-driven management models. By applying analytical methods and statistical indicators, the study evaluates the potential for early prediction of project risks, optimization of time and cost performance, efficient allocation of resources, and real-time monitoring of project performance. The findings indicate that the structuring and systematic analysis of large volumes of data enable project managers to move away from subjective judgments and adopt more accurate, objective, and evidence-based decision-making practices. Furthermore, the article proposes a conceptual framework and practical mechanisms for the application of data analytics across the planning, execution, and control phases of project management. The use of analytical tools positively contributes to the timely and budget-compliant implementation of projects, improvement of quality indicators, and increased transparency of project outcomes. Overall, the systematic and consistent integration of data analytics into project management accelerates the achievement of organizational strategic objectives and significantly increases the overall probability of project success.

In the contemporary era, the increasing complexity of projects and the dynamic nature of organizational environments have made project management a more challenging and strategically significant field. The timely and budget-compliant execution of projects, efficient utilization of resources, and effective risk management are key criteria for organizational success [1,2]. Traditional project management approaches often fail to place sufficient emphasis on data analysis and objective forecasting, which may reduce the likelihood of project success. In this regard, data analytics serves as a critical tool in project management by supporting decision-making processes, enabling early risk identification, and enhancing overall project performance [3,6].

The purpose of this article is to examine the role of data analytics in project management, assess its application potential, and identify the challenges associated with its implementation. In project management, data analytics is widely used as an effective means to improve project performance, detect risks at an early stage, and manage resources more efficiently. Empirical studies indicate that big data analysis, predictive analytics, and real-time monitoring contribute significantly to preventing project delays and budget overruns [1,2]. Data-driven approaches facilitate proactive decision-making and enable dynamic planning and risk analysis capabilities that are not achievable through traditional methods. At the same time, challenges such as data quality issues and the lack of analytical skills hinder the widespread adoption of data analytics in project management. Overall, existing research demonstrates that the integration of data analytics into project management is essential for improving project efficiency and creating new opportunities for future research. The purpose of this article is to examine the role of data analytics in enhancing the effectiveness of project management. The study evaluates the potential of data-driven approaches to improve decision-making processes, ensure resource optimization, manage risks, and monitor project performance in real time [1,2]. The article demonstrates that data analytics is widely applied across the planning, execution, and control phases of project management. Through the analysis of large-scale data and the use of predictive analytics, project risks can be identified at an early stage, resources can be allocated more efficiently, and performance can be continuously monitored in real time [3]. The application of analytical tools enables the prevention of project delays and budget overruns, facilitates task prioritization, and optimizes decision-making processes. However, barriers such as data quality issues, lack of standardization, and insufficient analytical skills may negatively affect the effectiveness of implementation [5]. Consequently, the systematic integration of data analytics into project management significantly increases the probability of project success and supports organizations in achieving their strategic objectives. The findings of the study indicate that data analytics serves as an effective tool for risk management, resource optimization, and real-time performance monitoring in project management. Analytical approaches contribute to mitigating project delays and budget overruns, improving decision-making quality, and enhancing task prioritization [4]. Nevertheless, limitations related to data quality and analytical capabilities may influence the efficiency of adoption. Future research may focus on the integration of advanced analytical tools, such as artificial intelligence and machine learning, into project management practices. In particular, exploring real-time forecasting and advanced risk analysis techniques could further enhance the likelihood of project success.

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# PROJECT PORTFOLIO SELECTION AND OPTIMISATION IN ENTERPRISES

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In the presented study, strategic approaches and models in both local and global contexts are analysed comparatively. The integration of projects into the organisational strategy serves as the fundamental basis for effective resource management. Project portfolio management, as a centralised management process, involves not only the execution of projects but also the appropriate allocation of resources in line with strategic objectives and the selection of the right projects. Based on the analysis of various academic sources, researchers emphasise that the project selection process, regardless of individual perspectives, should be transformed into a multi-stage decision-making mechanism. In this context, extensive research demonstrates that focusing solely on financial indicators (NPV, ROI) leads to the marginalisation of strategic innovations and causes imbalances within the project portfolio.

In the local context, based on the author's conclusions, project portfolio selection should not be considered merely an economically significant decision but rather a strategic step that defines the organisation's future vision. Portfolio optimisation should be carried out based on the principle of the "added value" that each project brings to the organisation. Therefore, according to researchers at both local and global levels, modern optimisation models should simultaneously take into account economic efficiency, long-term competitive advantage, as well as strategic objectives. Accordingly, this paper provides a comprehensive analysis of portfolio theories, mechanisms for aligning projects with organisational strategy, various optimisation models, and several existing contradictions in this field [2].

In the modern corporate environment, several challenges, including rapid technological transformations and competitive pressures, compel organisations to seek more effective management methods to achieve their strategic objectives. Therefore, according to the PMI (2017) standards, Project Portfolio Management (PPM) plays a crucial role both in defining organisational priorities and in managing processes within a centralized system. Observations based on practical experience indicate that weak strategic alignment leads not only to delays in project execution but also to the fragmentation of resources across various directions. One of the primary proposed solutions to this problem is the implementation of a multi-stage selection system. The existing model applies the principle of a strategic filter, minimises subjectivity, and allows each project, in addition to its individual benefits, to contribute to the overall balance of the portfolio and to the organisation's long-term vision [1].

In the formation of a project portfolio, it is essential to define the selection criteria correctly. Organisations often prioritise financial metrics, assessing the current value of a project; however, it should be noted that considering this factor alone is not sufficient to ensure the project's sustainability. Observations from researchers' portfolio theories indicate that they develop specific concepts for financial assets, balancing risk and return while appropriately adapting available resources to the project portfolio [3]. The primary objective here is to establish an optimal frontier that minimizes the overall portfolio risk, thereby considering not only the risk of individual projects but also their interactions within the portfolio.

Based on literature reviews, it can be concluded that in the domestic market environment of Azerbaijan, economic profitability, the development of local human capital, and local market risks must be taken into account. Moreover, not only tangible assets but also intangible assets, such as intellectual capital, represent specific factors that a project contributes to the organisation, and these factors constitute a fundamental part of the selection process. [2].

Once the selection criteria are established, optimal models such as multi-criteria decision-making and linear programming methods are used to identify the most effective combination of projects within limited resources. These methods play a crucial role not only in prioritizing projects and eliminating subjectivity but also in incorporating specific constraints into the models, thereby providing solutions that optimize the objectives.

A key point is that the optimisation process is not static; as certain market conditions change over time, project portfolios are transformed, updated, and developed within a dynamic environment. However, portfolios that remain unchanged may, over time, diverge from the organisation's strategic initiatives and goals. Therefore, during portfolio execution, optimisation models should be applied, projects with diminished effectiveness should be halted, and their resources should be reallocated to more suitable and promising directions based on the principle of strategic renewal [1,2,3].

Based on the conducted analyses, one of the key management mechanisms for ensuring an organisation's strategic resilience is the selection and optimisation of project portfolios. Research at both global and local levels indicates that mathematical models and strategic vision approaches should be synthesised and applied, directing resources toward value-creating initiatives. Furthermore, to achieve a competitive advantage in a dynamic market environment, project portfolios must be regularly updated and aligned with forthcoming strategic objectives.

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# STRATEGIC AUTOMATION OF BCBS 239 COMPLIANCE: A GRAPH NEURAL NETWORK APPROACH TO ADAPTIVE DATA LINEAGE

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***Introduction***. The management and governance of data assets in the financial industry are plagued by inflexible regulatory environments: the Basel Committee on Banking Supervision's standard number 239 (BCBS 239) (Basel Committee on Banking Supervision, 2013) defines requirements for an effective risk data aggregation and risk reporting. When financial institutions are moving from monolithic data warehouses to scattered ecosystems of Data Lakes, Spark clusters, cloud solutions, it is increasingly complex to have a comprehensive knowledge of the movement of data (Data Lineage). Manual documentation and rule-based systems for metadata management are not able to cope with the new speed of developments of the complex architectures, exposing investment institutions to compliance and operational threats.

***Problem Statement***. Current data lineage tools tend to store lineage information on common static graph databases (ex. Neo4j, natively in Oracle, etc.) or proprietary tools that crawl through SQL scripts. Despite their immense utility, these tools depend on the predefined knowledge of individual source-to-target lineage rules for retrospective lineage aggregation, reporting, or impact analysis. They cannot offer a «what-if» analysis to suggest how a change made to a schema in a source system (say a new Oracle transaction table) would impact a downstream regulatory reporting job within a Data Mart without rule definition in advance. They cannot discover «hidden» lineage relationships within a server log or source code penned in a dynamic programming language such as Python using Pandas etc.

***Proposed Methodology***. In this paper, we presented a new GNN based data lineage artifact called LineageGNN that can perform the job of extracting and evolving data lineage automatically. LineageGNN stores data as a heterogeneous graph with nodes of different granularity including entities such as tables and columns and processes such as ETL jobs and API calls, and edges defined by data flow. Deep learning methods have been used to the data ecosystem graph (Scarselli et al., 2009) to address two important strategic problems:

1. Automated Lineage Discovery: Through learning from query logs, execution plans (DAGs), and API access patterns, the GNN model learns to infer the presence of an edge between nodes, despite lack of explicit metadata. This facilitates the retrieval of lineage within «black box» processes.
2. Predictive Impact Analysis: The model utilizes link prediction algorithms to propagate the probability of failure across the graph.

***Strategic Implications***. Automated data lineage has potential as an adaptive «strategic» tool rather than just a reactive compliance requirement. In a typical organization, McKinsey estimates that solution lineage may cut data documentation costs by 40-60% (McKinsey & Company, 2019). This course of action would allow a bank to re-align data engineering efforts to new problem domains without compromising documentation integrity. Additionally, «LineageGNN» would also empower a bank to actively maintain a transparent audit-ready data architecture.

***Conclusion***. Using machine learning, in particular Graph Neural Networks, to improve data lineage is an excellent way to advance our data analytics infrastructure. This work proves that automation of this kind is really a competitive advantage (not only a technical improvement) that allows financial institutions to do more by following the rules.

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# PROJECT MANAGEMENT OFFICE MATURITY ON PROJECT SUCCESS IN CONSTRUCTION AND INFRASTRUCTURE PROJECTS

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***Abstract***. Construction and infrastructure projects are characterized by high complexity, long implementation periods, and a high level of uncertainty. Achieving project success in such environments requires not only effective project-level management but also mature organizational mechanisms that support informed decision-making. The Project Management Office (PMO) plays a critical role in this context by ensuring the selection, adaptation, and standardization of project management methodologies. This paper examines the impact of PMO maturity on project success in construction and infrastructure projects. The study is based on the methodology selection approach proposed by I. Kononenko and A. Kharazii and the project portfolio management maturity level selection method developed by I. Kononenko and M. Kpodjedo. The analysis shows that higher PMO maturity enhances project success by enabling systematic methodology selection and strategic alignment across project portfolios.

***Introduction***. Construction and infrastructure projects represent some of the most challenging project types due to their scale, technical complexity, regulatory constraints, and involvement of numerous stakeholders. Despite the widespread use of project management standards, many organizations continue to experience delays, cost overruns, and quality issues. These problems often arise from the misalignment between project characteristics and the applied project management methodologies.

The Project Management Office (PMO) has emerged as an organizational response to these challenges, providing coordination, governance, and methodological support. However, PMOs vary significantly in their maturity levels. While low-maturity PMOs typically focus on administrative functions, high-maturity PMOs support strategic decision-making and portfolio-level alignment.

This paper explores how PMO maturity influences project success in construction and infrastructure projects by enhancing the organization's ability to select appropriate project management methodologies and maturity levels.

***Methodology***. The methodological foundation of this study integrates two complementary approaches proposed by I. Kononenko and co-authors. The first is the project management methodology selection approach developed by I. Kononenko and A. Kharazii, which emphasizes that project success depends on the alignment between project characteristics and the selected management methodology. This approach uses structured criteria to evaluate and compare alternative methodologies rather than relying on universal or predefined solutions.

The second approach is the project portfolio management maturity level selection method proposed by I. Kononenko and M. Kpodjedo. This method focuses on selecting an appropriate maturity level for an organization based on its strategic objectives, portfolio complexity, and management capabilities.

In this paper, PMO maturity is viewed as an organizational mechanism that enables the practical application of both approaches. A mature PMO provides the necessary data, competencies, and governance structures to support systematic methodology selection at both project and portfolio levels.

***Results***. The analysis indicates a strong relationship between PMO maturity and project success in construction and infrastructure projects. Organizations with low-maturity PMOs often apply a single project management methodology across all projects without considering differences in complexity, uncertainty, or stakeholder requirements. According to I. Kononenko and A. Kharazii, such an approach reduces adaptability and negatively affects project outcomes.

In contrast, higher-maturity PMOs enable organizations to apply differentiated methodology selection based on project characteristics. Furthermore, the maturity level selection logic proposed by I. Kononenko and M. Kpodjedo allows organizations to align their portfolio management practices with strategic goals.

As a result, mature PMOs contribute to improved schedule performance, enhanced cost control, better risk management, and stronger alignment between projects and organizational strategy. These factors collectively increase the likelihood of project success in complex construction and infrastructure environments.

***Scientific Innovation***. The scientific contribution of this paper lies in the combined application of project management methodology selection and project portfolio management maturity level selection to the analysis of PMO maturity. While previous studies have considered these approaches separately, this paper highlights PMO maturity as a key organizational prerequisite for integrating them effectively.

By linking PMO maturity with both methodology selection capability and portfolio-level maturity, the study provides a conceptual framework that is particularly relevant for organizations managing large construction and infrastructure project portfolios.

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# A STUDY OF THE FUNDAMENTAL SOLUTIONS OF EQUATIONS BY MEANS OF MATHEMATICAL ANALYSIS METHODS IN AGGRESSIVE ENVIRONMENTS

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***Abstract.*** The study of processes occurring in aggressive environments solely through experimental methods is often costly and not always feasible. Therefore, the development of mathematical models and the derivation of fundamental solutions hold significant scientific and practical importance. Mathematical analysis provides the primary methodological framework for this field, enabling the investigation of essential system properties such as boundedness, convergence, stability, and uniqueness. This work presents an examination of the fundamental solutions of differential equations formulated for aggressive environments using advanced methods of mathematical analysis.

***Introduction.*** In modern industry, engineering, and materials science, the precise modeling of processes occurring under the influence of aggressive environments is one of the main directions of scientific research. These processes typically develop under the combined effects of chemical corrosion, high temperature variations, mechanical stress, and biological impacts. Such complex influences necessitate the mathematical description through differential equations and the development of mathematical analysis methods, as the behavior of the system often exhibits nonlinear, non-stationary, and multi-dimensional characteristics.

Processes modeled in aggressive environments are widely applied across various industrial sectors, particularly in oil and gas, chemical industry, metallurgy, construction materials engineering, energy, and biotechnology. Proper management of these processes enhances the durability of materials and reduces production errors and the risk of accidents.

Mathematical models in aggressive environments often possess the following characteristics:

**1)** Nonlinearity: the system coefficients depend on variables such as the temperature, density, and chemical composition of the environment;

**2)** Non-stationarity: time-dependent parameters complicate the analysis of the process;

**3)** Multidimensionality: both spatial and temporal variables must be taken into account;

**4)** Stochasticity: real processes are often influenced by random noise and fluctuations.

Consequently, the relevance of the topic is associated both with the development of theoretical mathematical problems and with the need for practical engineering applications.

***Mathematical Modeling of Aggressive Environments.*** The most widely used models for regulating processes in aggressive environments are based, in part, on differential equations. The chemical activity of the environment can be modeled as follows, we present the formula here

$$\frac{\partial u}{\partial t} = \nabla(k(x,t)\nabla u) + f(u,x,t)$$

$u(x,t)$ – a function of temperature, concentration, or stress, $k(x,t)$ - a variable diffusion coefficient depending on the aggressiveness level of the environment, $f(u,x,t)$ – a nonlinear function describing the chemical and thermal effects of the environment. The propagation of cracks in corroding materials is described by equations of the following type:

$$\Delta u + q(x)u + g(x)$$

$q(x)$ – the aggressiveness index of the environment.

***Results***. The conducted studies show that:

1. Equations formulated for aggressive environments are often more complex than classical models and require high-precision mathematical analysis.
2. Constructing fundamental solutions for variable coefficients reflects the real physical behavior of the system more accurately.
3. Spectral methods are highly efficient for predicting the long-term effects of aggressive environments.
4. The application of variational methods provides optimal results for nonlinear models.

Approximate methods (FEM, FDM) serve as effective tools for practical engineering applications.

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# INTEGRATED MANAGEMENT APPROACH TO BUSINESS PROCESS OPTIMIZATION

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***Abstract***. Digital transformation requires organizations to improve business processes and adopt new digital capabilities. Many initiatives fail because they are not aligned with strategic objectives. This paper proposes an approach to business process optimization based on integrating strategic management with portfolio, program and project management (SP3M). The method strengthens alignment, improves prioritization and supports consistent implementation of redesigned processes [1, 2].

***Introduction***. Business process optimization plays a central role in digital transformation. However, organizations often struggle to translate strategic goals into actionable initiatives. BPM research shows that process improvement efforts frequently remain isolated and lack governance mechanisms [1]. Project management literature highlights a similar challenge in aligning organizational strategy with project execution [2].

This paper examines how an integrated SP3M framework can improve coherence between strategy and implementation. Strategic goals shape the transformation direction, portfolios help prioritize initiatives, programs coordinate interrelated efforts, and projects deliver process changes. Such a system enhances transparency, resource allocation and benefit realization [2, 3].

***Research Problem and Objective***. Digital transformation efforts are frequently fragmented. Organizations launch multiple projects that are poorly justified or unrelated to strategic objectives, resulting in weak process improvements and limited value. BPM and process mining studies emphasise the need for structured, end-to-end governance of process optimization [1].

The objective of this study is to develop a compact method for business process optimization that uses SP3M integration to ensure strategic alignment, improve decision-making and support measurable realization of transformation outcomes [2].

***Methodology***. The method integrates following components:

- Strategic management tools. SWOT, PESTEL, digital maturity models and OKR/BSC are used to identify priorities for process optimization and define transformation goals [2].
- Portfolio, program and project management standards. PMI standards offer governance mechanisms for evaluating initiatives, coordinating related efforts and managing benefits across the SP3M hierarchy [3, 4].
- Business process optimization techniques. BPMN modeling, Lean, process mining and simulation support diagnosing current processes and designing improved workflows [1, 5].
- KPIs and benefit realization metrics link strategic objectives with the outcomes of implemented projects.

***Proposed Integrated Method***. The method includes five stages:

1) Selecting target processes according to strategic goals and digital maturity [2].

2) Forming a transformation portfolio, prioritizing initiatives based on alignment and expected value [4].

3) Coordinating initiatives through programs when multiple interdependent projects are required [3].

4) Executing optimization projects using hybrid project management approaches to refine redesigned processes [2].

5) Monitoring and benefit realization, using metrics and feedback loops to adjust actions and support continuous improvement [5].

***Results and Discussion***. Application of the SP3M-based method shows improved prioritization, reduced duplication of initiatives and more consistent implementation of redesigned processes. Organizations also report better decision-making and clearer evaluation of transformation benefits. These observations align with BPM and portfolio management research confirming the effectiveness of integrated governance models [1, 4].

***Conclusion***. Business process optimization becomes far more effective when supported by structured SP3M integration. The proposed method ensures alignment with strategic goals, supports consistent implementation and enables better measurement of transformation outcomes. Future work will include development of quantitative decision models and empirical validation in organizational settings [1, 5]

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# INTELLIGENT TECHNOLOGIES IN QUALITY MANAGEMENT OF URBAN INFORMATION SYSTEMS WITHIN DIGITAL DEVELOPMENT PROGRAMS

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Modern processes of urban digital transformation lead to an increasing role of urban information systems in the implementation of strategic development programs, which has become particularly relevant in the context of the full-scale war in Ukraine. Military actions have resulted in infrastructure destruction, disruption of information flows, increased cyber threats, and higher requirements for the resilience, reliability, and continuity of urban information systems. Under these conditions, the problem of managing the quality of urban information systems within digital development programs and portfolios becomes critically important for ensuring urban viability and supporting managerial decision-making.

Within digital development programs, urban information systems act not only as technical tools but also as strategic assets, the quality of which determines the achievement of planned socio-economic outcomes. As noted in contemporary research, the development of a «smart city» is considered one of the global trends in urban development, where the city is formed as a complex socio-economic and cultural ecosystem integrating infrastructure, technologies, and human capital [1]. Insufficient data quality, fragmentation of information resources, lack of unified standards, and weak system integration lead to reduced effectiveness of managerial decisions and complicate the implementation of digitalization programs.

Studies emphasize that data quality is critical for building reliable and effective artificial intelligence systems, as the use of incomplete or outdated data may result in erroneous managerial decisions and reduced effectiveness of digital development programs [3]. Research also highlights that even highly digitalized cities often have fragmented smart services due to the absence of systemic strategies and integrated management platforms [1]. Traditional approaches to information system quality management, primarily based on regulatory and static control methods, do not meet the dynamic nature of the urban environment.

In this context, the application of intelligent technologies in managing the quality of urban information systems represents a promising direction.

Artificial intelligence enables automated analysis of large datasets, detection of anomalies, failure prediction, and real-time assessment of information process quality. In particular, the use of machine learning and deep learning algorithms supports pattern recognition in data and facilitates scenario forecasting for urban system development [2].

The Internet of Things ensures continuous monitoring of urban facilities and systems, forming an up-to-date information base for managerial decisions. The combination of IoT with artificial intelligence technologies (AIoT) allows real-time data processing and enhances the efficiency and functionality of urban information systems [2].

Big Data technologies enable the integration of heterogeneous information sources and support comprehensive assessment of urban information system performance.

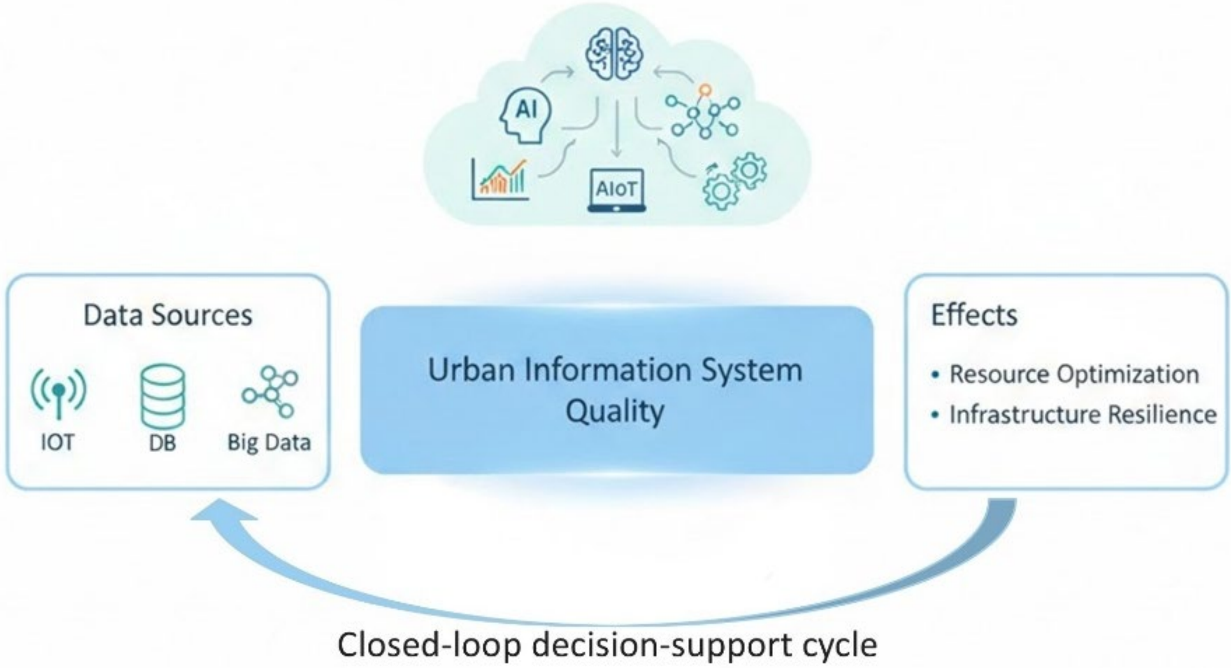


Fig. 1. Conceptual scheme «Intelligent ecosystem for Quality Management»

The conceptual scheme presented in Figure 1 illustrates the integration of data sources, intelligent technologies, and feedback mechanisms that together form an intelligent ecosystem for managing the quality of urban information systems within digital development programs.

The use of intelligent technologies creates prerequisites for the transition to adaptive quality management of urban information systems within digital development programs. The integration of solutions such as Urban Brain and Urban Digital Twin ensures the combination of real-time analytics with strategic forecasting and forms a closed-loop decision-support cycle within digital development programs and portfolios [2]. Such approaches allow alignment of strategic urban development goals with digital project portfolios, ensure transparency in program implementation, and increase the justification of managerial decisions. Intelligent decision-support systems contribute to resource optimization, risk reduction, and improved effectiveness of digital transformation programs.

Thus, the integration of intelligent technologies into the quality management of urban information systems is an important factor in enhancing the effectiveness of digital development programs and strategic urban governance. Further research should focus on the development of intelligent quality management models for urban information infrastructure, taking into account the specifics of urbanized territories and the requirements of sustainable development.

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# MANAGEMENT OF PORTFOLIOS, PROGRAMS AND PROJECTS INTEGRATION IN ACCORDANCE WITH THE STRATEGY OF THE SYSTEM DEVELOPMENT

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***Introduction***. The modern IT industry is characterized by a shift from single-project management to concurrent multi-project environments. In practice, software companies frequently manage multiple projects with shared, limited resources, leading to competition for qualified personnel. The Software Multi-Project Scheduling (SMPS) problem involves assigning employees to tasks across various projects to optimize objectives such as duration, cost, and resource utilization [1].

Effective resource management is widely recognized as a critical factor for project success, particularly in the processes of estimating and acquiring resources [2]. A key challenge in this domain is ensuring that the assignment of team members aligns with both the project schedule and the organizational constraints. Ineffective distribution leads to resource bottlenecks, where some teams are overloaded while others remain idle, ultimately causing project delays and budget overruns.

***Relevance and Problem Statement***. The problem of distributing IT projects among development teams is complicated by the need to balance competing resource demands. Traditional manual allocation based on subjective managerial experience is often time-consuming and prone to errors. Recent studies indicate that integrating AI-based optimization methods with Project Management Information Systems (PMIS) can significantly reduce planning time and operational costs [3]. However, existing Decision Support Systems (DSS) rarely provide comprehensive integration of flexible organizational structures with advanced optimization techniques, such as Genetic Algorithms or Machine Learning ensembles, for effective team formation [4]. Furthermore, decision-making in this area is often complicated by uncertainty regarding project start times and the availability of specific competencies [5]. Therefore, the development of models and methods that support decision-making in such complex multi-project environments represents a relevant and timely scientific challenge.

The aim of the research is to enhance the efficiency of IT project management by developing a DSS for the distribution of projects among development teams, considering modern organizational approaches and industry standards. To achieve this aim, an analysis of multi-project environment features and risk assessment processes was conducted, which allowed for the identification of potential bottlenecks and resource constraints.

Based on these findings, the team formation process has been formalized through the development of a mathematical model for assigning executors to development teams. The model defines team formation criteria, including platform compatibility, application domain, and technology stacks, as well as operational constraints such as project deadlines, budget limitations, and team workload balance.

The objective functions are focused on optimizing team composition, skill complementarity, and overall resource utilization in IT projects [6].

In addition, standard project management principles have been systematically integrated into the team formation decision-making model. These principles cover resource availability, levels of competence, role suitability, and experience matching, ensuring that all assignments comply with established industry best practices and organizational standards, and provide a practical framework for effective team management [2].

Given the NP-hard nature of the team formation and scheduling problem in multi-project environments, meta-heuristic and data-driven optimization approaches have been investigated. In particular, the applicability of Genetic Algorithms, Random Forest models, and their hybrid combinations has been analyzed to obtain near-optimal team formation solutions under conditions of uncertainty and dynamically changing project parameters [3, 4].

***Conclusion***. The proposed research addresses the critical issue of development team formation and allocation in multi-project software development environments. By integrating structured team formation approaches, standard project management methodologies, and modern optimization algorithms, the developed information support methods will enable IT companies to improve the effectiveness of team composition, ensure balanced utilization of development teams, and reduce project planning time. The further research focuses on analyzing the risks associated with development team formation and assignment, taking into account the qualification and competencies of individual developers. This includes identifying potential bottlenecks, skill mismatches, and uncertainties related to project start times, workloads, and employee availability, as well as organizational, technical, and human-related risks..

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# RESILIENCE OF URBAN INFORMATION INFRASTRUCTURE IN STRATEGIC AND PORTFOLIO MANAGEMENT

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Under conditions of urban digitalization, information infrastructure acts as a strategic asset of a city, as it determines the effectiveness of governance, the accessibility of public services, and the level of security. [1] Ensuring its long-term viability requires a systematic management approach that takes external risks into account.

Within the traditional perspective, resilience is interpreted as the ability of a system to recover after disruptions. However, the growing scale of technological, cyber, and military threats necessitates a shift toward a managerial paradigm in which resilience is treated as a controllable parameter combining recovery, adaptation, and anticipatory response capabilities. [2, 3]

As an object of management, resilience has its own life cycle, requires adequate resource support, and is integrated into the city development strategy. Its management is cyclical and encompasses assessment, planning, implementation, and validation of results.

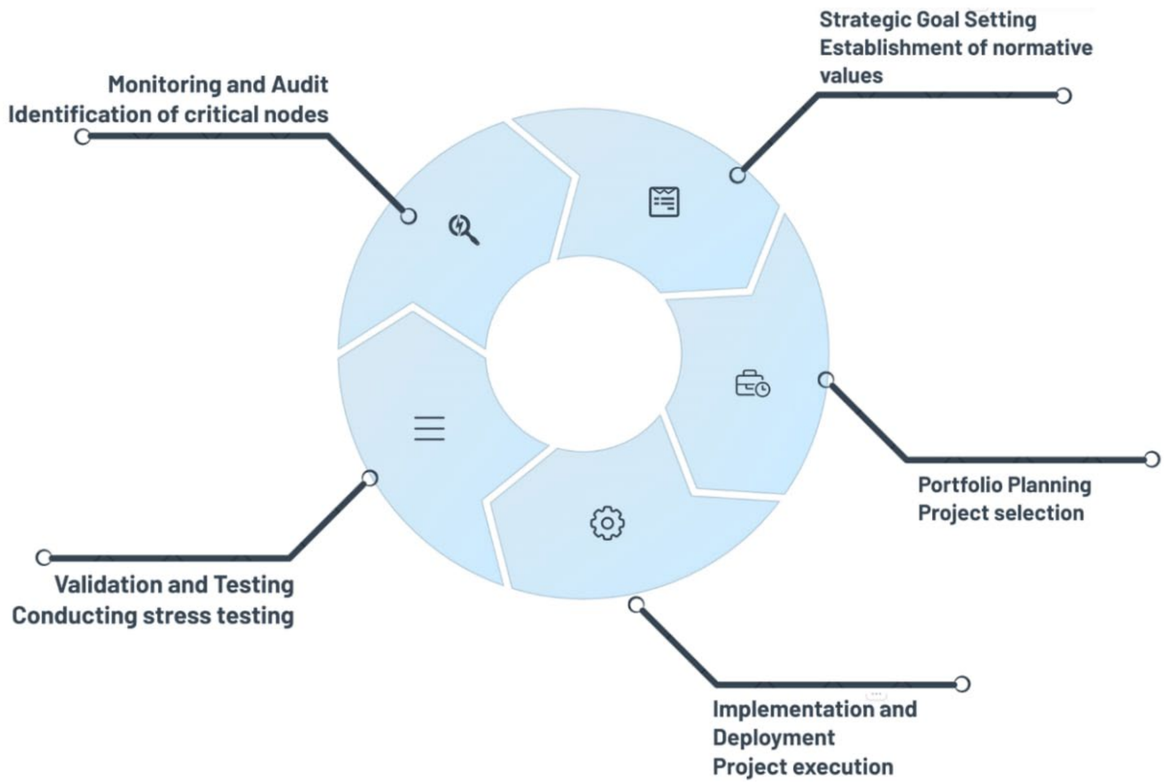


Fig. Resilience management cycle of urban information infrastructure

According to the authors, the resilience of urban information infrastructure constitutes an integral component of overall urban resilience. Urban resilience is a concept that has been actively developed by researchers in recent years and has gained particular relevance in the context of accelerating global urbanization. Current studies primarily focus on such dimensions of resilience as natural, economic, social, physical, and institutional resilience [4]. Information and communication technologies and artificial intelligence–based innovations are considered within this framework, but mainly as enabling tools for achieving an acceptable level of urban resilience through smart city development [5]. However, under contemporary decision-making conditions – where management quality critically depends on the degree of external uncertainty and the level of informatization of governance processes – the problem of urban information infrastructure resilience becomes evident and requires the urgent development of dedicated analytical and managerial instruments. To integrate the resilience of urban information infrastructure into management practice, it is advisable to introduce its quantitative assessment, which enables comparative analysis, monitoring, and substantiation of managerial decisions.

At the strategic level, resilience is defined as the foundation of urban security within the Resilient Smart City concept, where information infrastructure is regarded as a strategic asset. Governance acquires a risk-oriented character and is institutionally formalized through the integration of international standards, particularly ISO 22301, into municipal development strategies [6].

For the practical measurement of resilience, a multidimensional resilience index $I_R$ is applied. This index accounts for the magnitude of functional performance degradation of infrastructure components $\Delta P$ and the actual recovery time $T_{rec}$ of specified components in relation to the target level of functionality $P_{target}$ and the maximum allowable downtime $T_{max}$. An increase in $\Delta P$ and $T_{rec}$ leads to a decrease in the value of $I_R$, reflecting a decline in system resilience relative to predefined target parameters.

The integration of the resilience concept into portfolio project management (PPM) is a critical prerequisite for the development of urban information infrastructure under uncertainty. Portfolio formation is based on balancing economic efficiency with each project's contribution to system reliability, adaptability, and recovery speed.

Key implementation mechanisms include:

- *selection and prioritization:* projects are evaluated based on their ability to minimize vulnerabilities and ensure the continuity of critical systems;
- *technological stack:* deployment of decentralized data solutions, cloud-based architectures, and AI/ML-driven automated response systems;
- *social factor:* training and adaptation of personnel for crisis response as an essential component of system survivability.

The coordinated realization of these initiatives within a unified portfolio transforms resilience from an incidental property into a predictable outcome of managerial decision-making.

The transition from understanding resilience as a desirable attribute to treating it as a managed object of strategic and portfolio governance establishes a foundation for a proactive urban security policy and targeted investment in the long-term viability of urban information infrastructure.

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# THE PLACE OF IT PROJECTS IN THE ORGANIZATION'S PORTFOLIO

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Despite the fact IT projects are connected to some organizational changes, modern scientific publications, as well as those with a practical focus, generally prefer to consider change management and software development project management issues separately. These publications tend to consider IT issues in isolation from business process development and organizational changes. This is largely understandable, since software development and the implementation of organizational changes require project teams to possess completely different competencies. Exceptions include publications on IT service management (ITSM) based on the ITIL framework library and service-oriented technology management in organizations [1]. However, ITSM and service-oriented technology management are only indirectly related to project management.

A significant portion of research devoted to information technology considers issues of flexible management of software development (Agile Development) and project management (Agile Project Management). The effectiveness of agile methodologies in managing software development projects is largely due to the fact that agile methodologies have tools that allow them to cope with the phenomenon of «requirements creep».

A development of these studies is research devoted to the issue of organizational flexibility (organizational agility), i.e. the construction of such organizational structures that allow the organization to quickly adapt to constant changes in the business environment [2]. With regard to these studies, it is worth noting that, despite the fact that the concept of organizational agility is a continuation and development of agile software development and project management, extending the same principles that apply at the project level to the organizational level, these studies, nevertheless, completely lose sight of the IT component, focusing exclusively on the construction of adaptive processes [3] and adaptive organizational structures [4].

In relation to IT projects, development organizations can be classified into product-oriented ones, those engaged in the development of so-called «out-of-the-box» products, i.e. products that can be replicated multiple times and sold to various consumers unchanged or with minimal customization, and organizations that engage in custom development, carried out once for a specific customer. In the second case, the product can also be replicated if it is an integral part of the customer's product being replicated.

Accordingly, the client's portfolio may include projects for the implementation of out-of-the-box products or custom development of IT products to address a specific business case. The presence of IT projects in the client's portfolio always implies the implementation of some organizational change or a whole complex of organizational changes that constitute a business transformation program.

If an IT project is being implemented to achieve organizational change, its measurable objectives can be expressed by specifying the magnitude of the desired change. These objectives may be related to reducing the labor, cost, or time required to execute the business processes of the IT project's consumer, or to improving the quality of the company's services, as expressed through metrics and indicators for these services.

The greatest challenge in setting the goal of an IT project is the transition from the parameters of the organizational change being implemented with the support of the IT project to the specific requirements of the product being developed. This transition is significantly simplified by using a service-oriented approach [5], since IT service metrics can be directly linked to the parameters of the IT service consumer's business processes. The models and methods developed in this paper are also based on the use of a service-oriented approach.

In order to describe the IT project management system, it is necessary to consider:

- the project's organizational structure;
- relationships with other projects and connection to the organization's strategy;
- project roles and responsibilities;
- project management processes;
- product metrics and process metrics.

According to the ITSM ideology, the following general goals of IT projects are identified:

- improving business processes;
- reducing enterprise costs;
- increasing the use of information and analytics in decision-making;
- increasing the productivity of the enterprise's labor resources;
- attracting new and retaining existing customers;
- creating innovative products and services.

The organizational structure of an IT project thus includes a client-side project team and a contractor-side project team. The client-side project team implements the organizational change supported by the IT project. The contractor-side project team, in turn, implements a software development project (or the refinement of a universal solution to meet the needs of a specific customer). To set the goals of an IT project, it is necessary to understand how the goals of the organizational change itself are determined. These goals, in turn, follow from the business case, which, in turn, can be developed (but not necessarily) as part of a business transformation program [6].

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# MANAGEMENT METHODS FOR CROSS-PLATFORM GAME PROJECT DEVELOPMENT PROCESSES

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**Introduction.** The global video game market has reached a valuation of over $180 billion in 2024, with a projected growth to $250 billion by 2030. Within this dynamic segment, strategy games play a crucial role as they foster critical thinking and decision-making skills. Modern industry standards demand cross-platform compatibility, allowing players to access products on PCs, consoles, and mobile devices simultaneously. The development of such projects requires sophisticated management methods to handle high complexity and multi-platform synchronization [2]. The research is aimed at grounding management decisions and architectural models within the development of a cross-platform strategic game with an advanced system of player interaction. The object of the research is the video game development process as an IT project, while the subject includes management methods, information, and mathematical models.

**Market Analysis and Project Rationale.** The strategy game genre is a significant part of the creative economy, offering not only entertainment but also acting as «management simulators» that model complex economic and social processes [1]. Current market analysis shows that global gaming audience has exceeded 3 billion people, with a growing demand for intellectual challenges and deep system simulations. Key industry trends emphasize the necessity of cross-platform accessibility, as players increasingly expect a seamless transition between desktop and mobile environments.

However, the development of sophisticated strategic products faces several critical issues: high resource intensity of ensuring cross-platform compatibility across different hardware architectures; intense market competition from established global studios that hold significant audience shares; technical challenges in maintaining multiplayer stability, particularly regarding connection lag and data synchronization; the problem of «overwhelming complexity», where complex game systems may become a barrier for new users.

To address these challenges, this project proposes the integration of advanced project management methodologies and specific architectural solutions. The use of a host-server model is justified as a rational approach to minimize infrastructure costs while providing robust multiplayer functionality. This strategic rationale ensures that the project remains competitive and technically viable in the current market landscape.

**Mathematical Modeling of Project Subsystems.** To ensure the stability and predictability of the game environment, the project involves the formalization of key processes through mathematical modeling. This approach allows for the creation of a balanced system of rules that are manageable from a development perspective.

1. Resource Balance Optimization. The economic component is described by a system of equations for the resource vector $R_c(t)$, which includes energy, minerals, production, and population3. The balance is calculated as follows:

$$R_c(t+1) = R_c(t) + G_c(t) - C_c(t)$$

Where $G_c(t)$ represents resource growth (extraction, trade) and $C_c(t)$ represents expenditures (maintenance, consumption). The management goal is to maximize the utility function $U_c = \sum \alpha_i R_i$, which is solved using linear programming methods.

2. Spatial Navigation Model. The game space is modeled as a weighted graph $G = (V, E)$, where vertices are sectors and edges are paths. To find the optimal route between points $v_s$ and $v_t$, the following minimization is used:

$$\min_{p \in P(v_s, v_t)} \sum_{e \in P} w(e)$$

This ensures efficient unit movement across the cross-platform environment using $A*$ and Dijkstra algorithms [3].

3. Diplomatic Interaction. Interactions between corporations are modeled using game theory. The payoff function for corporate strategies (alliance, trade, war) is determined through Nash equilibrium to maintain gameplay balance.

**Information Support and Software Implementation.** The project's information architecture is designed to handle large volumes of data in real-time. The conceptual model includes entities such as Player, Corporation, Planet, and Fleet [4].

For software implementation, Unreal Engine 5 was selected due to its advanced networking capabilities and cross-platform support. The host-server model was chosen as the primary architectural solution. In this model, one player's machine acts as the server, which significantly reduces infrastructure costs and simplifies deployment for independent developers. Data consistency is ensured by using PostgreSQL for multiplayer synchronization and SQLite for local storage.

**Conclusions.** The study justifies the development of a cross-platform strategy game through the lens of integrated project management. It is demonstrated that the combination of Agile methodologies (for development flexibility) and robust mathematical modeling (for economic and navigation balance) significantly reduces the risks associated with multi-platform deployment. The transition to a host-server architecture is proven to be a cost-effective solution for independent studios, ensuring multiplayer synchronization without heavy infrastructure investment. Future research will focus on the implementation of adaptive AI systems for diplomatic modeling and the optimization of network migration protocols to enhance user experience across different devices.

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# CONCEPT OF A HYBRID APPROACH TO PROJECT MANAGEMENT IN SHIPBUILDING

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Ship design has long been recognised as one of the most complex engineering processes due to its interdisciplinary nature and long life cycle.

The existing project management methodology in shipbuilding, the traditional ship design spiral (TDS) by J. H. Evans [Evans, 1959], is becoming outdated and requires digital adaptation. It has become iconic because it presents design as an iterative process. The integration of systems engineering (SE), Model-Based Systems Engineering (MBSE) methods, and Agile approaches [Beck et al, 2001] opens up new opportunities for improving the efficiency and manageability of shipbuilding projects. The study analyses modern technologies used in project management in software and civil engineering, including MBSE, Digital Twin and Agile System Engineering (Agile SE) principles as a more flexible form of systems engineering [INCOSE, 2015].

The hybrid concept can be formulated as the integration of TDS with modern methodologies for managing complex engineering systems, namely MBSE, Digital Twin, and Agile SE principles. The advantages and disadvantages of each component of the hybrid concept were analysed. It is shown that a hybrid approach can significantly improve the efficiency of design processes, reduce time and ensure flexibility in rapidly changing conditions. It is noted that the transition to a hybrid concept (especially Agile SE) in shipbuilding requires changes in management, organisational implementation of MBSE and Digital Twin, as well as adherence to the architectural discipline of modularity.

An analysis of literary sources on the research topic and a comparison of project approaches based on key criteria were conducted. The analysis shows an increase in the number of works supporting digitalisation in engineering fields, particularly in shipbuilding.

The implementation of the hybrid TSP / Agile SE / MBSE / Digital Twin approach involves the following stages:

– Initiation and architectural hypotheses: the scope of tasks (capability epics) and system ‘stories’ (user stories) are determined; alternative architectures with interfaces for optional modules are developed;

– Competitive prototyping: parallel prototypes/models are launched for key risks (module compatibility, etc.); the results are promptly entered into the model;

– Integration increments: every 6–8 weeks – system demonstrations (model in the loop, HIL/software stands), clarification of requirements and agreements with suppliers/shipyards;

– Architectural solutions for modularity: standardised foundation locations and connectors for connecting systems are developed, reserves for mass and centering are established, and module certification test templates are created;

– An updated spiral is formed: sequential stages of the TSP are integrated with the MBSE architecture; each iteration reduces uncertainty; V-links provide the ability to verify requirements [Dahlke et al., 2023].

The results confirm the following:

1. Evans' TDS remains valuable as a structural basis for systematic ship design.
2. Modern digital technologies (MBSE, PLM, Digital Twin) reinforce the spiral, increasing traceability and adaptability. The ship design spiral and flexible systems development can be successfully integrated to create a more effective design methodology.
3. The use of Agile SE in shipbuilding enables faster iterations, flexibility, and greater team engagement.
4. A hybrid approach combines the best aspects of classical and digital design, reducing risks and increasing the robustness of solutions.
5. Significant productivity improvements: integrated approaches demonstrate significant improvements in design efficiency, stakeholder satisfaction and project outcomes, with the potential benefits far outweighing the risks.
6. Growth in industry adoption: Leading shipbuilders are increasingly adopting integrated approaches with positive results. Navantia, Rolls-Royce, and Hyundai demonstrate the real-world effectiveness of SE and Agile integration.
7. The effectiveness of the agile approach will be greatest for complex, integrated ship projects (passenger, car-passenger and high-speed car-passenger ships, gas or oil processing ships, ships for transporting large and heavy cargo, multi-purpose rescue, diving and other ships).

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# CYBER RISK MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF HUMAN RESOURCE MANAGEMENT PROCESSES

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Digitalization of management processes has made it possible to increase the efficiency of management decision-making, which is important for ensuring the sustainable development of the organization. But along with the numerous advantages of using a single information space, creating a project portal and using artificial intelligence tools, the question of ensuring cyber resilience of management processes arises [1].

Human resource management in a multi-project environment is associated with the use of a large amount of data from different projects [2]. The use of a single information environment involves simultaneous work with data (in particular, corporate templates) in several projects and the need to implement roles related to ensuring the cybersecurity of the multi-project environment [3].

Among the potential cyber threats in a multi-project environment, the most influential are:

- technical, related to cyberattacks, hacks and malicious injections;
- organizational, caused by the influence of the human factor;
- project, arising as a result of project management problems in a multi-project environment, access conflicts between projects;
- legal, caused by violation of legislation;
- biased or uncontrolled AI solutions.

Since machine learning systems within a single corporate system were trained according to the same rules, there is a risk of information leakage, training data leakage, data poisoning, which will affect the predictability of forecasting results, on the basis of which management decisions are made.

Human resources, especially top management, are becoming nodes of data, access and management decisions.

The use of shared platforms, corporate control over correspondence, reuse of accounts and unauthorized access to information between projects can cause critical cyber risks in human resources management in projects and programs. Integration of project management systems with HR management systems must be secure from the point of view of Sensitive HR Data.

A typical problem is the availability of access to redundant resources, in particular to the personnel database, the level of competencies (including information with limited access) at the level of the entire multi-project environment. Privilege Creep as a result of the accumulation of excessive access rights, in particular in top management, reduces the cyber resilience of the system.

A low level of information management development or excessive decentralization leads to an insufficient level of monitoring of changes related to information flows. For example, when changing roles in a project, the levels of access to information change, which requires reviewing the employee's information profile.

Monitoring the relevance of access to corporate mail, inclusion in mailing lists, auditing permissions and rights will allow you to respond to changes in the employee's status:

- removed from the project;
- accepted into the project;
- transferred to the bench;
- dismissed from the organization.

Transferring an employee to a resource pool, with the possibility of further involvement, and leaving them in the system, as well as information about contractors and stakeholders with whom they collaborated in past projects, are also potential causes of information leakage.

Auditing inter-project resource intersections that arise when applying the donor-acceptor approach to resource redistribution and program management, from the point of view of information flows and access rights, will reduce the risk of unauthorized data distribution.

Thus, cyber resilience of management processes is a critical factor of sustainability, as it reflects the trust and effectiveness of digitalization processes. Ensuring cyber resilience should combine technical protection mechanisms, organizational policies and ethical principles of using artificial intelligence, which should ensure compliance with modern cybersecurity standards.

Comprehensive cyber risk management should be integrated both into elements of a multi-project environment and at the PMO level, which should contribute to the prediction of the emergence of cyber risks, response to them, adaptation and recovery of management processes after cyber incidents.

The study is being conducted within the framework of the research project 2025.07/0038 of the National Fund of Ukraine on the topic «Scientific Foundations for the Formation and Management of Human Capital in a Multi-Project Environment to Support the Sustainable Development of Ukraine's Recovery Programs».

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# INNOVATIVE DEVELOPMENT OF THE CONSTRUCTION COMPLEX OF UKRAINE

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The construction business is an investment business with long payback periods and low profitability, which is affected by any slightest fluctuations in financial markets. It directly depends on the business activity of domestic markets, the purchasing power of the population, stable and economically justified for business economic legislation. The annual profitability of the construction business does not exceed 6-8%, but the development of more than 35 industries in Ukraine depends on the dynamics of its development, it employs 30% of the working population of Ukraine. Financial dependence makes it a business for managing financial flows that are subordinate to construction technology and distinguishes it from operating businesses [1].

Construction can and should become the locomotive of Ukraine's economy's exit from the crisis. World practice shows that $1 invested in construction entails investments of $10 in the building materials industry, related industries, transport and infrastructure. In conditions of economic crisis, for the survival and development of an enterprise in innovative activity, investment and financial activities become particularly relevant, as the basis for increasing the competitiveness and efficiency of the main operating activity through innovations. The implementation of innovations by the enterprise is carried out periodically or once, as a rule, through investment projects that affect operational activities and require accounting for the consequences in the financial results of the enterprise.

When making a decision on the implementation of an innovative project, the cost of capital attracted from various sources at different stages of the life cycle of the innovative project and the expected profit from the sale of innovative products should be taken into account.

An innovative investment project is a system of documented targeted actions and necessary resources for the creation and implementation in the future of an innovative product and (or) products.

At an operating enterprise, the leading place in investment activity is occupied by projects related to innovative organizational and technical solutions that ensure optimization of solutions and provide for:

- development of production: production output and diversification;
- saving of all types of resources;
- labor and environmental protection.

The implementation of a project depends on its life cycle - the time between the moment of its appearance (documented) and its liquidation (until the appearance of a new project).

All innovative and investment projects in construction today can be conditionally divided into the following areas:

- building materials and their production;
- assembly devices (means of connecting building materials);
- constructive solutions;
- technical means and production technologies;
- methods of interior and exterior decoration;
- means of restoration, reconstruction or repair;
- architectural solutions;
- innovations that affect labor productivity;
- innovations in the operation of the finished object;
- construction management and organization systems;
- innovations in design.

In the construction of Ukraine, most innovations belong to the first five areas. In design, innovations are more relevant in the form of digital technologies and require the implementation of new software.

The construction industry is considered the most conservative in terms of implementing innovations, due to the long operating periods of buildings and structures, through which innovations have not passed. Designers do not risk implementing them without sufficient regulatory and technical support. There is no specialized market innovation infrastructure (licenses, options, leasing, auctions, startups, etc.), investment funds with the participation of the state and private capital.

In these conditions, the following areas of development of innovative business can be distinguished:

1. Purchase of domestic and foreign:

- patents, know-how, licenses for organizing own production of new products, building materials, application of progressive technologies;
- new equipment, modern building materials, automated systems for organizing and managing design and production.

2. Services of foreign construction companies in performing construction work using new technologies.

3. Implementation of own research and innovation developments by special research and design departments and groups.

4. Training of enterprise personnel in new technologies, skills in working with new equipment and building materials in accordance with international quality standards ISO-9001.

5. Financing of innovative activities at the expense of own funds, credit resources, state budget.

Innovative development of the construction complex of Ukraine is a key factor in ensuring economic development. To achieve this goal, it is necessary to overcome existing barriers, intensify the implementation of modern technologies, and create favorable conditions for investment. This is especially important in the context of the need to restore the Ukrainian economy.

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# CONSTRUCTİON OF THE GREEN FUNCTİON OF SOME DIFFERENTIAL EQUATIONS WITH NORMAL OPERATOR COEFFICIENTS

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***Abstract.*** The construction of the Green's function for higher-order differential equations is considered in this work. The Green's function of the operator defined by a differential equation and boundary conditions whose coefficients are specified at an arbitrary point taken from the half-axis is sought in the form (5).

Suppose that, $H-$ is a separable Hilbert space. Let's denote by $H_1 = L_2[[0,\infty);H]$ the Hilbert space consisting of all strongly measurable functions $f(x)\,(0 \le x < \infty)$ whose lie in the Hilbert space $H$, such that

$$\|f\|_{H_1}^2 = \int_0^\infty \|f(x)\|_H^2\, dx < \infty,$$

and the scalar product of any function $f(x), g(x) \in H_1$ is defined by

$$[f(x), g(x)]_{H_1} = \int_0^\infty (f(x), g(x))_H\, dx \cdot$$

Let's consider the operator in the space $H_1 = L_2[[0,\infty);H]$ defined by the differential expression

$$l(y) = (-1)^n y^{(2n)} + \sum_{j=2}^{2n} Q_j(x) y^{(2n-j)} \tag{1}$$

and the boundary conditions

$$y^{(l_1)}(0) = y^{(l_2)}(0) = \ldots = y^{(l_n)}(0) = 0, \quad 0 \le l_1 < l_2 < \ldots < l_n \le 2n-1. \tag{2}$$

***Construction of the Green's function of the operator $L_1$.***

Assume that "$\xi$" is an arbitrarily fixed point taken from the half-interval $[0,\infty)$. Consider the operator $L_1$ defined by the differential expression

$$l_0(y) = (-1)^n y^{(2n)} + Q(\xi)y + \mu y \tag{3}$$

in which the coefficient $Q(x)$is «rozen» at the point "$\xi$", together with the boundary conditions

$$y^{(l_1)}(0) = y^{(l_2)}(0) = \ldots = y^{(l_n)}(0) = 0 \tag{4}$$

We seek the Green's function $G_1(x,\eta,\xi,\mu)$ of the operator $L_1$ is the form

$$G_1(x,\eta,\xi,\mu) = g(x,\eta,\xi,\mu) + V(x,\eta,\xi,\mu) \tag{5}$$

Here $g(x,\eta,\xi,\mu)$ is the Green's function of the corresponding equation $l_1(y) = 0$on the whole real axis.

It's known from [2] that

$$g(x,\eta,\xi,\mu)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}\left[s^{2n}+Q(\xi)+\mu E\right]^{-1}e^{is(x-\mu)}ds=$$

$$=\frac{1}{2ni}\cdot K_{\xi}^{1-2n}\cdot\sum_{\alpha=1}^{n}\omega_{\alpha}e^{i\omega_{\alpha}K_{\xi}|x-\eta|}. \qquad (6)$$

the function $V(x,\eta,\xi,\mu)$ appearing in equality (5) is the bounded solution of the problem

$$\begin{cases} l_1(y)=0 \\ V^{(l_1)}(x,\eta,\xi,\mu)\Big|_{x=0}=-g^{(l_1)}(x,\eta,\xi,\mu)\Big|_{x=0},\ j=1,2,...,n \end{cases} \qquad (7)\ (8)$$

Under the condition $x\to\infty$.

Based on the work [1], we obtain that this solution has the following form:

$$V(x,\eta,\xi,\mu)=\frac{K_{\xi}^{1-2n}}{2ni}\sum_{\alpha=1}^{n}A_{\alpha}(\eta,\xi,\mu)e^{i\omega_{\alpha}K_{\xi}x}. \qquad (9)$$

As a result, we obtain the equality

$$V(x,\eta,\xi,\mu)=\frac{1}{2ni}K_{\xi}^{1-2n}\sum_{\alpha=1}^{n}\omega_{\alpha}e^{i\omega_{\alpha}K_{\xi}(x+\eta)}.$$

Substituting the obtained expression for $V(x,\eta,\xi,\mu)$ into equality (5), we obtain the following expression for the Green's function $G_1(x,\eta,\xi,\mu)$

$$G_1(x,\eta,\xi,\mu)=\frac{1}{2ni}K_{\xi}^{1-2n}\sum_{\alpha=1}^{n}\omega_{\alpha}e^{i\omega_{\alpha}K_{\xi}|x-\eta|}-\frac{1}{2ni}K_{\xi}^{1-2n}\sum_{\alpha=1}^{n}\omega_{\alpha}e^{i\omega_{\alpha}K_{\xi}(x+\eta)}. \qquad (10)$$

Taking this into account, the obtained expression for the function $G_1(x,\eta,\xi,\mu)$ can be written in the following form

$$G_1(x,\eta,\xi,\mu)=\frac{1}{2ni}K_{\xi}^{1-2n}\sum_{\alpha=1}^{n}\omega_{\alpha}e^{i\omega_{\alpha}K_{\xi}|x-\eta|}\left[E-\sigma(x,\eta,\xi,\mu)\right]=$$

$$=g(x,\eta,\xi,\mu)\left[E-\sigma(x,\eta,\xi,\mu)\right]. \qquad (11)$$

Here, under condition $\mu\to\infty$, the uniform $\xi$ with respect to the variable $\|\sigma(x,\eta,\xi,\mu)\|_H=o(1)$ is valid.

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## OPTIMIZATION OF AGILE-SUPPORTED PROJECT MANAGEMENT USING A MULTI-CRITERIA APPROACH

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***Abstract***. In modern project environments characterized by uncertainty and frequent change, organizations face increasing challenges in selecting effective project management methodologies. Although Agile approaches are widely recognized for their flexibility and adaptability, their actual contribution to project success is not always clear, particularly in hybrid and non-IT organizational contexts. This study focuses on the evaluation and optimization of Agile-supported project management using a structured multi-criteria approach.

***Introduction.*** The growing complexity of projects and dynamic external conditions have limited the effectiveness of traditional plan-driven project management approaches. As a result, Agile methodologies have gained significant attention as an alternative that emphasizes adaptability, iterative development, and stakeholder collaboration. However, organizations often struggle to assess the real advantages of Agile-supported approaches compared to predictive methodologies in a systematic and evidence-based manner. This issue highlights the need for structured evaluation models that support informed decision-making in project management.

***Methodology.*** This study applies the two-stage evaluation and optimization methodology developed by I. Kononenko and A. Kharazii, which provides a structured framework for comparing project management approaches from both qualitative and quantitative perspectives.

At the first stage, a qualitative evaluation is carried out using a Likert-scale questionnaire designed to capture expert judgments regarding the relative effectiveness of Agile-supported and predictive project management practices. The assessment focuses on key managerial activities, with higher scores reflecting a stronger perceived advantage of the Agile-supported approach.

At the second stage, a quantitative evaluation is conducted based on a set of project success criteria that reflect operational performance and outcome effectiveness. These criteria include time efficiency, cost performance, risk exposure, quality, and stakeholder satisfaction. Risk assessment follows PMBOK principles and is based on a probability–impact approach, ensuring a consistent and transparent representation of uncertainty.

The empirical analysis is conducted as a single organizational case study at PMO.az. Multiple training programs are treated as repetitive project cycles implemented within a unified management framework. Empirical data are obtained from internal documentation, semi-structured interviews with coordinators and trainers, and direct operational observations within the organization.

***Results.*** The results of the empirical evaluation indicate that the Agile-supported project management approach demonstrates superior overall performance when compared to the predictive approach within the studied organizational context.

The analysis shows that Agile-supported practices contribute to smoother project execution by improving coordination mechanisms and increasing transparency across project activities. Enhanced visibility of tasks and responsibilities supports faster response to emerging issues and reduces dependence on manual control procedures. These factors positively influence the stability of project processes, even in environments characterized by frequent change. In addition, the findings suggest that Agile-supported management practices strengthen interaction among project participants and support more effective feedback exchange throughout the project lifecycle. While predictive elements remain relevant for maintaining structure and documentation, the results indicate that greater flexibility and iterative coordination play a decisive role in improving overall project performance. The outcomes of the multi-criteria comparison further confirm that Agile-supported and hybrid project management models are better aligned with the needs of dynamic, service-oriented organizations such as PMO.az.

***Scientific Innovation***. The scientific innovation of this study lies in the application of the multi-criteria methodology proposed by I. Kononenko and A. Kharazii to evaluate Agile-supported project management within a real organizational context in Azerbaijan. In contrast to predominantly descriptive or conceptual studies, this research offers a structured empirical comparison of project management approaches based on real operational data and clearly defined success criteria. In addition, the study demonstrates how qualitative expert assessments and quantitative performance indicators can be integrated into a unified analytical framework. The proposed evaluation model extends the practical applicability of the methodology by enabling evidence-based comparison and optimization of Agile-supported, predictive, and hybrid project management approaches. As a result, the framework can be used by practitioners as a decision-support tool when selecting or adapting project management methodologies in similar organizational environments.

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# APPLICATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN PROJECT MANAGEMENT WITHIN THE CONTEXT OF CYBER-PHYSICAL SYSTEMS: AN ANALYTICAL PERSPECTIVE ON DECISION SUPPORT SYSTEMS

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As a result of the integrated application of technologies such as the Internet of Things (IoT), cloud computing, and Artificial Intelligence (AI) brought about by the Fourth Industrial Revolution, a highly automated cyber-physical environment has emerged in modern industry. In this environment, AI-based decision support systems (DSS) analyze data collected from sensors to optimize operations, increase productivity, and enable proactive maintenance of equipment. This thesis analyzes, in an academic manner, the role of AI and Machine Learning (ML) applications in project management within this context, as well as the capabilities of DSS.

Cyber-physical systems are complex ecosystems in which numerous devices and subsystems operate in an interconnected manner. Managing projects within such systems requires the processing of large-scale data and coordination across multiple disciplines to a much greater extent than traditional projects. For this reason, the development of project management information systems integrated with AI and ML technologies has become highly relevant. These systems enable real-time monitoring of project progress, support dynamic decision-making, and reduce the workload of human managers by providing accurate and timely information.

Current trends indicate that the use of AI tools in projects related to cyber-physical systems is increasing rapidly. For example, a survey conducted in the United Kingdom showed that 70% of project professionals reported that AI is already being used in projects within their organizations. In other words, AI has entered project management very rapidly within a short period of time (PMI, 2023). 29% of respondents stated that their organizations plan to implement AI in the near future, while only 1% indicated that AI use is neither currently planned nor expected in the future. The application of AI technologies in project management has led to significant transformation, reshaping planning, execution, and control mechanisms. Studies show that AI reduces the operational workload of project teams by automating repetitive and time-consuming management tasks, while also enabling more accurate resource optimization and risk assessment.

Systematic literature reviews also confirm the practical outcomes of integrating AI into project management. Extensive studies published in 2025 report that AI applications improve forecasting accuracy, reduce risks, enhance collaboration with stakeholders, and positively impact safety management. However, these studies also emphasize several challenges associated with AI adoption, including difficulties in integrating with legacy systems, shortcomings in data quality, and organizational resistance to change.

DSS and AI Applications. Decision Support Systems are software solutions designed to help project managers evaluate alternatives and make optimal decisions based on complex data. While traditional DSS rely on databases and modeling tools to perform scenario analyses, AI and ML strengthen their intellectual foundation and elevate them to a new level. With AI, DSS can rapidly process both structured and unstructured data (such as sensor streams, textual reports, and images), detect trends and anomalies, and provide scenario outcomes at a scale that exceeds human computational capacity.

The effectiveness of DSS equipped with ML algorithms is observed across various cyber-physical domains. In the energy sector, AI-based simulation tools enable comparison of investment and operational scenarios and support the selection of optimal strategies under multiple variables. In construction projects – particularly road construction–neural networks learn from historical data to predict costs more accurately and improve budget planning, thereby increasing the reliability of investment decisions. Furthermore, criteria-based AI mechanisms assist in project selection by evaluating critical success factors, helping to allocate resources more rationally in portfolio management. In Industry 4.0 and smart manufacturing, AI-enhanced DSS are widely used in supply chain optimization, energy consumption management, quality control, and production planning (Bagheri, 2015). Through real-time data analysis, it becomes possible to detect failures in advance and plan preventive maintenance, which reduces costs and improves operational continuity (Bagheri, 2015).

Benefits and Challenges. According to survey results, 84% of project managers report increased project effectiveness after implementing AI, while 44% note an improvement in decision-making quality. In an APM survey, 50% of respondents stated that they benefit from AI in functions such as scheduling, resource planning, and risk analysis. On the other hand, APM data from 2025 identify key challenges in AI adoption, including a lack of technical knowledge and training (49%), data security and privacy concerns (44%), integration difficulties (42%), and issues related to the reliability of outcomes (41%) (APM, 2025). These findings highlight the importance of validating AI-generated results through human judgment rather than relying on them blindly.

In conclusion, the integration of AI and ML into project management within the context of cyber-physical systems is a strategic direction that enhances the accuracy and efficiency of decisions across planning, execution, and control phases. However, successful implementation requires high-quality data, appropriate infrastructure, well-prepared personnel, and a sensitive approach to ethical and privacy standards. The future of project management does not lie in AI replacing humans, but in the proper establishment of human–AI collaboration.

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# FUZZY AHP-BASED THEORETICAL MODEL FOR INTERNATIONAL MARKET ENTRY STRATEGY SELECTION

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When companies decide to expand beyond their domestic borders, they are immediately confronted with a defining strategic puzzle: how to enter a foreign market effectively. While classical decision-making tools like the AHP have been widely applied, our analysis suggests they often fall short in practice. The integration of fuzzy logic, pioneered by Zadeh (1965), with the AHP framework offers a promising path forward. In this paper, we propose a tailored theoretical model that leverages Fuzzy AHP to navigate this very uncertainty. Our primary aim is to move beyond a generic methodology and provide a structured, yet adaptable, framework that mirrors the real-world complexities managers face.

Our model sits at the intersection of two well-established fields: international business strategy and advanced decision science. From the strategy side, we draw on the classic typology of IME modes – such as Exporting, Franchising, Joint Ventures, and FDI – each presenting a distinct trade-off between control, risk, resource commitment, and reward (Root, 1987). Interestingly, it is precisely in evaluating these trade-offs that traditional AHP (Saaty, 1980), for all its merits, shows limitations. It forces crisp numerical judgments onto what are often vague, linguistic assessments. This is where our approach diverges. By employing Fuzzy AHP (Buckley, 1985; Chang, 1996), we translate qualitative expert opinions into triangular fuzzy numbers (e.g., representing "medium importance" as a range rather than a single value). This shift is crucial; it allows our model to absorb the inherent imprecision of human reasoning, making the output not just mathematically sound but also pragmatically credible.

The heart of our proposal is a practical, three-level hierarchy designed for direct application. At the top sits our Goal: Selecting the optimal IME strategy. The Criteria level (Level 2) is where managerial judgment is formally structured. We propose five core dimensions, synthesized from both theory and common strategic concerns: Market Potential (C1): Beyond just size, this includes growth trajectory and sustainable profitability; Risk Exposure (C2): A composite of political, economic, and operational uncertainties; Resource Commitment (C3): The tangible and intangible investments required; Control Level (C4): The degree of command a firm can exert over operations and strategy; and Flexibility & Speed (C5): Often overlooked, this criterion assesses adaptability and time-to-market. The Alternatives (Level 3) are the concrete strategic options to be evaluated: Exporting (A1), Franchising (A2), Joint Venture (A3), and Foreign Direct Investment (A4).

The operational steps of our model follow a logical, iterative process: Expert Elicitation: A diverse panel of managers and experts provides pairwise comparisons using a linguistic scale (e.g., «Strategy A is moderately more preferable than Strategy

B regarding Control»). Fuzzification: These linguistic terms are converted into Triangular Fuzzy Numbers (TFNs), creating fuzzy pairwise comparison matrices. Consistency Validation: We check the logical coherence of judgments by calculating a consistency ratio for the defuzzified matrices, discarding inconsistent inputs. Weight Aggregation: Using the geometric mean, we aggregate individual fuzzy judgments. The fuzzy weights for both criteria and alternatives are then computed via the extent analysis method (Chang, 1996). Synthesis and Defuzzification: The final fuzzy scores for each alternative are calculated by combining the weights across the hierarchy. These fuzzy scores are then converted into crisp values using the Center of Area method, yielding a clear, ranked order of the IME strategies.

By explicitly accommodating vagueness, it produces results that seasoned managers find more trustworthy and reflective of actual decision-making contexts. Secondly, its structured hierarchy forces a comprehensive evaluation, ensuring that critical factors like «Flexibility» are not sidelined by more obvious criteria like «Market Potential.» For practitioners, this model is not a black box but a transparent framework that facilitates dialogue, challenges assumptions, and builds consensus among decision-making teams. It transforms a potentially contentious strategic debate into a disciplined, evidence-informed discussion. Theoretically, our contribution is a focused adaptation of a powerful MCDM tool to a specific, perennial challenge in international business, thereby bridging a notable gap in the applied literature.

Selecting an international market entry strategy remains a daunting task under the best of circumstances. The theoretical model we propose here, grounded in Fuzzy AHP, is designed to bring clarity and robustness to this process. We believe this framework offers a significant step toward more resilient and defensible internationalization choices. Looking ahead, the true test will be in its application. We see promising avenues for future research in applying this model to detailed industry case studies, comparing its strategic recommendations with real-world outcomes, and perhaps integrating it with other fuzzy decision-making techniques for even greater analytical depth.

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# AN APPROACH TO UNIVERSITY RESOURCE PLANNING BASED ON GENETIC ALGORITHMS AND NONLINEAR PROGRAMMING

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In the context of growing global competition among higher education institutions, improving universities' positions in international rankings, in particular the QS World University Rankings, has become a strategic objective and requires scientifically grounded approaches to development management. Achieving target values of ranking indicators under conditions of limited financial, human, and organizational resources necessitates the formalization of the resource planning problem using modern mathematical methods. This paper considers an approach to university resource planning based on a combination of nonlinear programming and genetic algorithms, building on the authors' previous research on modeling the impact of key QS WUR indicators on the strategic development of higher education institutions [1].

The resource allocation problem is formalized as a quadratic optimization model with Boolean variables and linear constraints, where the objective function minimizes the weighted quadratic deviation between current and target values of ranking indicators. Each indicator can be improved through the implementation of alternative managerial actions that require different amounts of resources, making the model discrete and nonlinear in nature. The presence of multiple criteria, interdependencies among indicators, and incomplete input data significantly complicates the application of classical nonlinear programming methods and limits their ability to find globally optimal solutions.

Given these limitations, the use of a genetic algorithm as a metaheuristic optimization method capable of efficiently exploring the feasible solution space is justified. Genetic algorithms are widely applied to constrained multi-criteria optimization problems and demonstrate high robustness to nonlinearity and the structural complexity of objective functions [2]. Within the proposed approach, each chromosome is interpreted as a scenario of resource allocation across the main areas of university activity, while the fitness function is defined by the value of the objective function of the mathematical model subject to resource constraints. The selection, crossover, and mutation operators enable the generation of a set of alternative managerial decisions and support an effective search for optimal scenarios.

An experimental study was conducted to evaluate the effectiveness of the proposed approach based on a genetic algorithm and a nonlinear optimization model using the National Technical University «Kharkiv Polytechnic Institute» as a case study. The experiments employed up-to-date QS World University Rankings indicator values corresponding to the current state of NTU «KhPI», as well as realistic constraints on the possible annual growth of indicators and the total volume of available resources. The modeling was performed for the problem of maximizing the integral QS Score under fixed resource units while accounting for nonlinear dependencies. The experimental results showed that the genetic algorithm enables an increase in the overall QS Score of more than 5% compared to the initial value, generating alternative resource planning scenarios and demonstrating high flexibility in strategic analysis tasks. The use of the nonlinear optimization model made it possible to obtain well-grounded solutions with the most efficient use of available resources, confirming the adequacy of the proposed model and its suitability for practical application in strategic university development planning.

The combination of nonlinear programming methods with the heuristic capabilities of genetic algorithms provides model flexibility, adaptability to changes in weighting coefficients of ranking indicators, and support for scenario analysis.

The practical application of this approach allows for evaluating the efficiency of different university development strategies and formulating recommendations on the priority use of limited resources to improve positions in international rankings. The effectiveness of genetic algorithms for constrained optimization problems is also confirmed by contemporary research in this field [3]. The obtained results can be integrated into a decision support information system for strategic management of higher education institutions' development.

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# THE INVERSE PROBLEM FOR THE NONLINEAR EQUATION OF OSCILLATIONS OF A THIN PLATE

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Our needs to find the pair of functions $(u,v) \in U \times U_{ad}$ from the relations

$$\rho\frac{\partial^2 u}{\partial t^2} + \Delta(D\Delta u) + (1-\nu)\left(2\frac{\partial^2 D}{\partial x\partial y}\frac{\partial^2 u}{\partial x\partial y} - \frac{\partial^2 D}{\partial x^2}\frac{\partial^2 u}{\partial y^2} - \frac{\partial^2 D}{\partial y^2}\frac{\partial^2 u}{\partial x^2}\right) + u^3 = v(x,y)f(t),$$

$$(x,y,t) \in Q, \tag{1}$$

$$u(x,y,0) = \varphi_0(x,y), \frac{\partial u(x,y,0)}{\partial t} = \varphi_1(x,y),$$
$$(x,y) \in \Omega, \tag{2}$$

$$u(0,y,t) = 0, \frac{\partial u(0,y,t)}{\partial x} = 0,$$
$$u(a,y,t) = 0, \frac{\partial u(a,y,t)}{\partial x} = 0,$$
$$0 \le y \le b,\ \ 0 \le t \le T,$$
$$u(x,0,t) = 0, \frac{\partial u(x,0,t)}{\partial y} = 0,$$
$$u(x,b,t) = 0, \frac{\partial u(x,b,t)}{\partial y} = 0,$$
$$0 \le x \le a,\ \ 0 \le t \le T, \tag{3}$$
$$\int_0^T K(x,y,t)u(x,y,t)dt = g(x,y \tag{4}$$

where $(x,y) \in \Omega = \{(x,y): 0 < x < a, 0 < y < b\}$, $t \in (0,T)$, $Q = \Omega \times (0,T)$, $\rho(x,y)$ is a density of the mass at the point $(x,y)$, $h(x,y)$ is the heath thickness of the plate in the point $(x,y)$, $u(x,y,t)$ - is deflection of the plate in the point $(x,y)$ at the moment $t$, $\Delta$ is Laplace operator with respect to $x$, $y$, $D = \frac{Eh^3}{12(1-\nu^2)}$- cylindrical rigidity, $\nu\left(0 < \nu < \frac{1}{2}\right)$- Poisson's coefficient, $E > 0$-Young's modulus,

$$U = \left\{u | u(x,y,t) \in C[0,T]; \overset{o}{W}{}_2^2(\Omega), \frac{\partial u}{\partial t} \in C[0,T]; L_2(\Omega)\right\},$$
$$U_{ad} = \{v(x,y) \in L_2(\Omega): \mu_0 \le v(x,y) \le \mu_1 a.\text{e.on } \Omega\}$$

$f(t) \in L_2(0,T)$, $\varphi_0(x,y) \in \overset{o}{W}{}_2^2(\Omega)$, $\varphi_1(x,y) \in L_2(\Omega)$, $K(x,y,t) \in L_\infty(Q)$, $g(x,y) \in L_2(\Omega)$ are given functions, $h(x,y)$ -is sufficiently smooth given function, $a$, $b$, $T$ are given positive numbers, $\mu_0$, $\mu_1$ given numbers.

This problem we reduce to the following optimal control problem: to find the minimum of the functional

$$J_0(v) = \frac{1}{2}\int_\Omega \left[\int_0^T K(x,y,t)u(x,y,t;v)dt - g(x,y)\right]^2 dxdy, \qquad (5)$$

subject to (1)-(3). The function $v(x,y)$ is called a control. By $u = u(x,y,t;v)$ we denote the generalized solution of the problem (1)-(3) corresponding to the control $v(x,y)$.

We regularize the problem (1)-(3), (5) by the following way: instead of the functional (6) consider the next one

$$J_\alpha(v) = J_0(v) + \frac{\alpha}{2}\int_\Omega v^2(x,y)dxdy, \qquad (6)$$

where $\alpha > 0$ is a positive number.

Let's assume that by any fixed control $v(x,y)$ boundary problem (1)-(3) has unique generalized solution from $U$.

The following theorems were proven in the article:

***Theorem 1.*** Under the imposed conditions on the problem data, there exists an optimal control in problem (1)-(3), (6).

***Theorem 2.*** Let’s the conditions of the Theorem 1 be satisfied. Then functional (6) is continuously Frechet differentiable on $U_{ad}$ and its differential in the point $\forall v \in U_{ad}$ at the increment $\delta v \in L_2(\Omega)$, $v + \delta v \in U_{ad}$ is defined by the expression

$$\langle J'_\alpha(v), \delta v\rangle = \int_\Omega \left[\alpha v(x,y) - \int_0^T f(t)\,\psi(x,y,t)dt\right]\delta v dxdy.$$

***Theorem 3.*** Let’s the conditions of the Theorem 1 be satisfied. Then for the optimality of the control $v_* \in U_{ad}$ in problem (1)-(3), it is necessary fulfilment of the inequality

$$\int_\Omega \left[\alpha v_*(x,y) - \int_0^T f(t)\psi(x,y,t)dt\right] \times$$
$$\times\,(v(x,y) - v_*(x,y))dxdy \ge 0$$

for arbitrary $v = v(x,y) \in U_{ad}$.

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# STRATEGIC PROJECT MANAGEMENT: ALIGNING PROJECT STRATEGY WITH BUSINESS GOALS

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This article explores the concept of project management, demonstrating that in modern organizations, project management is not only about completing projects on time and on budget, but also about aligning the business strategy with the strategy. The article examines the role of strategic project management in project portfolio management, resource optimization, and organizational governance and leadership development. The results show that strategy-aligned projects increase business value, leverage resources, and strengthen an organization's competitive advantage.

Key words: Strategic project management, organizational objectives, leadership and competencies, project prioritization, business value creation, long-term planning

In modern organizations, project management is not only based on technical indicators; projects must also be aligned with the company's long-term business strategy. This approach focuses project managers and decision-making processes not only on technical indicators, but also on strategic values. In other words, the project is viewed not only as a work in progress, but also as a mechanism that contributes to the company's strategic goals [1].

Strategic project management is built on three main components:

1. Strategic alignment: Projects should serve the long-term goals of the organization and contribute to the implementation of the business strategy. This approach is a key criterion in the processes of selecting, prioritizing projects, and allocating resources.

2. Project portfolio management: The assessment and coordination of several projects within an organization in terms of strategic goals. This approach ensures the efficient use of resources and minimizes conflicts between projects.

3. Organizational skills and leadership: Strategic project management is not possible with technical skills alone; project managers must be armed with strategic thinking and business understanding. Leadership and strategic vision are the main conditions for the successful implementation of projects [1].

A study by Fereshtéh Bahman Taheri [2] tests the strategic project management framework in a real business environment. The thesis shows that when there is no alignment between project portfolio management and corporate strategy, the following problems arise: Project misprioritization, inefficient use of resources, and selection of projects that do not serve strategic objectives.

Taheri also finds that the success of portfolio management depends on factors such as coordination, control, resource balance, and alignment of projects with strategic objectives. This approach validates DyReyes' theoretical framework from a practical perspective and shows that project management can create real business value for an organization [2].

Oudeh, Ghazimoradi, and Safehian [3] present a conceptual framework for aligning a project portfolio with strategic objectives. They emphasize that a project portfolio is not just a collection of activities that are executed, but that it must be managed in a structured manner to impact strategic objectives and create business value.

This framework involves prioritizing projects in accordance with strategic objectives, monitoring portfolio performance, and optimizing resources. The theoretical and empirical approaches presented are integrated into a conceptual framework by Oudeh et al. [3]. In the absence of strategic alignment, projects use resources inefficiently and do not create business value; in the presence of alignment, projects are both executed and contribute to strategic objectives, increasing the competitive advantage of the organization.

Portfolio management ensures that projects are evaluated, prioritized, and allocated in a strategic context, maximizing the organization's business value. As a result, the organization derives maximum business value from projects.

Strategic project management is not achieved through technical skills alone; project managers must both complete projects and make strategic decisions to manage them in line with long-term goals. This approach increases the business value of projects, allows for measurement of their impact, uses resources efficiently, and strengthens the organization's competitive advantage [1,2,3].

Strategic project management does not just improve project performance; it also serves as a critical mechanism that supports the implementation of business strategy. This approach encourages project managers and the organization to think strategically, ensures that projects are aligned with the company's overall strategic goals, and creates the basis for the efficient use of resources. As a result, strategic project management becomes the key management framework that ensures both sustainable development and competitive advantage for organizations.

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# STRATEGIC DEVELOPMENT OF ADAPTIVE KARATE IN AZERBAIJAN: PROJECT MANAGEMENT AND SOCIAL INTEGRATION

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The article examines the strategic aspects of integrating adaptive karate into the national sports system of Azerbaijan from a project management perspective. The implementation of para-karate programs is presented as a complex project involving resource planning, stakeholder engagement, and performance monitoring. The study highlights the role of the National Karate Federation in program management, coordination with state structures, and international benchmarking. Key success factors, challenges, and strategic directions for scaling adaptive sports initiatives are identified.

***Introduction.*** The development of adaptive sports in Azerbaijan is a state priority aimed at social inclusion and improving the quality of life for persons with disabilities. Para-karate, as one of the disciplines, requires a systematic approach to planning, implementation, and evaluation. This study analyzes the experience of Azerbaijan in managing para-karate programs through the lens of project and strategic management.

***Methodology.*** The research is based on a systemic analysis of the para-karate development program in Azerbaijan, including documentary analysis, stakeholder interviews, and benchmarking with international federations (Japan Karate Federation, Federazione Italiana Karate). A project management framework was applied to assess planning, execution, and outcomes.

***Results and Discussion***. The strategic integration of para-karate in Azerbaijan includes:

1. Program design and goal setting – development of adapted training methodologies, competition systems, and coach education programs.
2. Resource management – state and public funding, infrastructure development, international partnerships.
3. Stakeholder engagement – collaboration among the National Karate Federation, Ministry of Youth and Sports, educational institutions, and NGOs.
4. Monitoring and evaluation – tracking athlete performance, social impact assessment, and program scalability analysis.

A comprehensive analysis revealed several strategic factors. The program's strengths include state priority status, active federation involvement, and established international partnerships. Key opportunities lie in growing global interest in adaptive sports and potential digitalization. However, challenges persist: lack of unified methodological standards, insufficient materials, and limited funding infrastructure. Threats include high dependence on state funding and potential coach shortages.Challenges identified:

- lack of methodological standards for coaches;
- insufficient methodological materials;
- need for increased financial and infrastructural support.

***Conclusion***. The case of para-karate in Azerbaijan demonstrates the effectiveness of applying project and program management principles in adaptive sports. Strategic planning, stakeholder coordination, and continuous improvement are critical for sustainable development. Future directions include developing unified methodological standards, expanding international cooperation, and integrating digital tools (e.g., athlete progress tracking platforms, online coach certification systems) for enhanced program management and scalability.

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# DATA-DRIVEN PORTFOLIO SELECTION AND OPTIMIZATION IN GOVERNANCE, RISK AND COMPLIANCE MANAGEMENT

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The complexity of regulatory requirements and organizational risks demands structured, data-driven Governance, Risk, and Compliance (GRC) decision-making (Avianti & Handoyo, 2025). Traditional qualitative and fragmented approaches often fail in dynamic environments (Papazafeiropoulou & Spanaki, 2015). This study proposes a portfolio-based optimization framework for GRC, integrating portfolio theory with risk analytics to improve compliance effectiveness and reduce organizational risk exposure.

Governance, Risk, and Compliance (GRC) has become a strategic function due to regulatory pressure, digital transformation, and complex risk environments (Avianti & Handoyo, 2025). Organizations must allocate resources across multiple initiatives while balancing risk appetite and obligations. Traditional GRC approaches remain reactive, relying on isolated controls and subjective judgments that often miss interdependencies between risks (Papazafeiropoulou & Spanaki, 2015; Maf'ul Taufiq, 2023). Data-driven decision-making can enhance GRC by converting risk and compliance data into actionable insights (Zhu, 2019). Portfolio selection theory offers a framework to optimize decisions under uncertainty, balancing expected outcomes and risk exposure (Markowitz, 1952). Integrated, analytics-based GRC systems improve transparency and compliance performance (Avianti & Handoyo, 2025), with big data enhancing risk assessment and proactive mitigation (Theodorakopoulos et al., 2025). Portfolio optimization models, including Bayesian approaches, address uncertainty and multi-objective constraints, making them suitable for GRC (Boyd et al., 2024; Nguyen et al., 2021; Bauder et al., 2018). This study models GRC initiatives—compliance programs, internal controls, and governance reforms—as portfolio assets defined by cost, expected risk reduction, compliance impact, and uncertainty. Data from organizational systems are analyzed to estimate effectiveness, and portfolio optimization identifies the best combination of initiatives aligned with risk appetite and resource constraints (Papazafeiropoulou & Spanaki, 2015; Boyd et al., 2024). This framework allows continuous adjustment as regulatory and risk conditions evolve.

Overall, data-driven portfolio selection and optimization provide a rigorous, practical approach to GRC management, enhancing compliance effectiveness, reducing risk exposure, and supporting informed governance decision-making (Avianti & Handoyo, 2025). The approach offers a focused, scalable, and analytically grounded framework for strategic GRC management..

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# OF PRODUCTION DEVELOPMENT OF DIGITAL PROTOTYPE PROJECT

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Customer clustering of an IT company is an important problem in marketing and detailed and realistic representation of the expected system. This process helps to evaluate the product before starting real production [1]. Digital computer prototyping tools allow you to visually see the experiments performed on the model of the control object and monitor the results.

CPN Tools is a software-instrumental system that can simulate the control object. Here, certain attributes can be assigned to various structural elements [2]. CPN Tools uses Petri net (PN) techniques, which are used for dynamic, connected and parallel modeling.

The PN is mathematically defined as a set $N = (P,T,F,H,\mu^0$ [3]. Here $P=\{p_1 , p_2 ,\dots,p_n\}$, $n>0$ – a non-empty finite set of positions; $T=\{t_1 ,t_2 ,\dots,t_m\}$, $m>0$ – a non-empty finite set of transitions; $F:P\times T\to\{0,1,2,\dots\}$ and $H:T\times P\to \{0,1,2,\dots\}$ – are the incidence functions of the sets of positions and transitions, respectively; $\mu_0 :P\to \{0,1,2,\dots\}$ –- is the initial marking of the network.

The graphical representation of the PN consists of circular vertices representing positions, rectangular vertices representing transitions, and edges connecting them.

The control object under consideration is a typical mechanical machining center consisting of an industrial robot (IR), a personal input keeper (IK), two identical devices (D1 and D2) performing the same operation on different identical workpieces, and a personal output keeper (OK).

The IR places the raw product from the individual input holder at the input of the 1st or 2nd free device and after the operation is completed, it places the part in the output holder. When both devices are free, a conflict situation arises between them. The conflict is resolved by selecting one of the devices based on the appropriate parameters and partially parallelizing and queuing it. When the operation is completed, the IR takes the part from the output of the device and places it in the output holder.

The states are described as the positions of the PN, and the possible events are described as the transitions of the PN. In the simulation model built with the help of the colored PN (Fig. 1), the states of the processing center module are described by the following positions:

$P_1$ – IR is free; $P_2$ − There are workpieces in IK; $P_3$ – IR has taken the workpiece; $P_3$ – D1 is free; $P_5$ – D2 is free; $P_6$ – the workpiece is in the working area of D1; $P_7$ – the workpiece is in the working area of D2; $P_8$ – D1 is machining the workpiece; $P_9$ – D2 is machining the workpiece; $P_{10}$ – the workpiece has been machined in D1; $P_{11}$ – the workpiece has been machined in D2; $P_{12}$ – IR has taken the part; $P_{13}$ – the part is in the OK.

The possible events in the machining center module are described by the following transitions:

$t_1$ – IR takes the workpiece from the IK; $t_2$ – IR places the workpiece in D1; $t_3$ – IR places the workpiece in D2; $t_4$ – machining of the workpiece begins in D1; $t_5$ – machining of the workpiece begins in D2; $t_6$ – machining of the workpiece ends in D1; $t_7$ – machining of the workpiece ends in D2; $t_8$ – IR takes the finished part from D1; t9 – IR takes the finished part from D2; $t_{10}$ – IR places the part in the OK.

The visualization of the model was carried out in the CPN Tools system (Fig. 1).

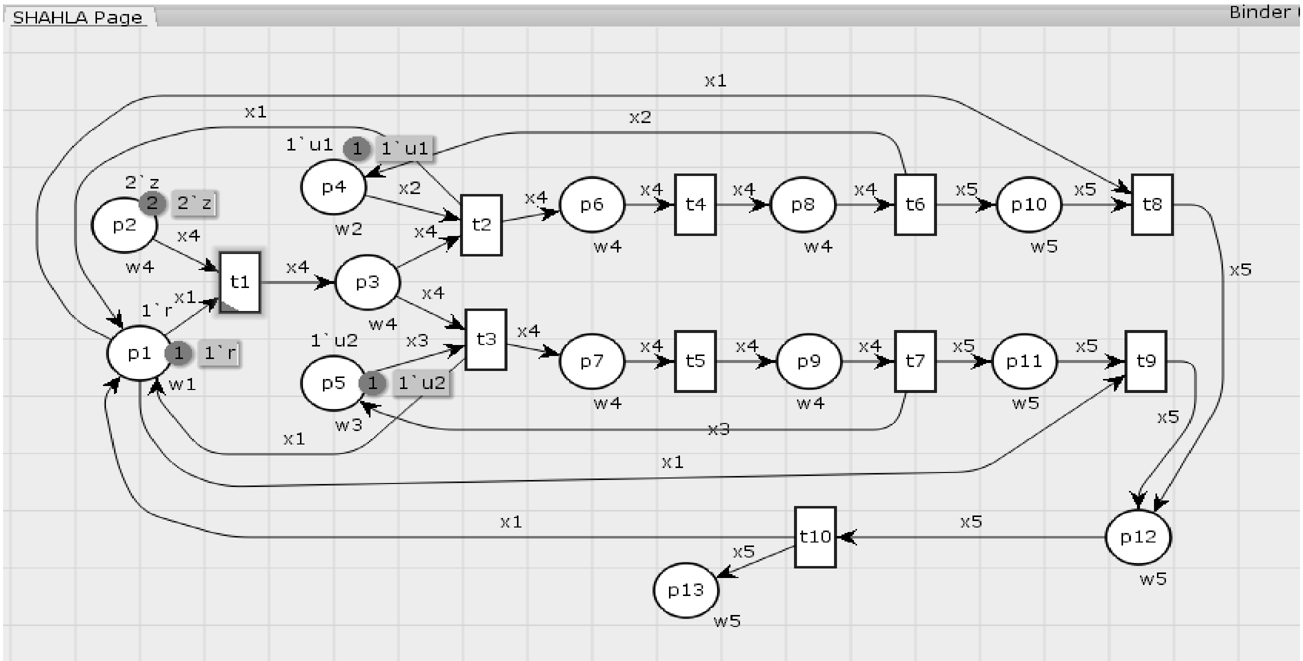


Fig. 1. Graph model of a machining center module in an manufacturing system.

During the simulation, an optimal trajectory was selected that eliminated random delays. As a result, it can be said that the created digital prototype allows you to save time and costs before operation by identifying errors at the initial stages of design.

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# DEVELOPMENT OF A BASIC MODEL FOR CHOOSING INFORMATION SYSTEM CLOUD MIGRATION STRATEGY

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Cloud migration of information systems (IS) in digital transformation is increasingly seen as a comprehensive change in the management of resources, risks and costs, and not just the technical transfer of components to the cloud. Therefore, pre-migration planning becomes key, where goals, KPIs, constraints and assumptions regarding workload and costs are determined; Without a formalized approach, the strategy is often chosen incorrectly, which increases the risk of technical and financial errors. The relevance is growing due to the strengthening of regulatory and security requirements and the complexity of IS architectures, which makes fragmented planning ineffective. The existing approaches are mostly developed at the level of individual instruments but are not sufficiently integrated into the reproducible procedure of transparent strategy selection [1].

The purpose of the work is to formalize the task of optimizing resources at the pre-migration stage of planning cloud migration of IS by developing and justifying a KPI-oriented (Key Performance Indicators) approach that provides a transparent comparison of alternatives for the business, and a formalized choice of strategy based on measurable performance indicators with reproducible results. To achieve the goal, the work focuses on two applied tasks: building a KPI-oriented model for choosing a strategy and experimental approbation of the model on the example of comparing alternatives.

The basic hypothesis is that for the reproducible choice of the optimal strategy at the pre-migration stage, it is not enough just to fix the «before/after» KPIs; It is necessary to form a quantitative model, where load characteristics and resource/architectural dependencies are translated into a set of normalized KPIs and financial indicators and supplemented by risk and constraint assessments, after which alternatives can be compared in a single procedure as a multi-criteria compromise [2].

The state of the IS before migration is described by a set of key performance indicators, and the acceptability of the result after migration is determined by the achievement of specified target thresholds. Heterogeneous metrics are agreed by normalizing and bringing them to a single direction of interpretation, which makes it possible to correctly compare alternatives. For each strategy, the expected impact on indicators is set, which can be adjusted by the migration conditions (context). Generalized business priorities are considered by metric weights, and non-compliance with target requirements is reflected by a penalty for not meeting thresholds. At the same time, the cost component is considered as an assessment of the complexity/labor intensity of the strategy implementation; The final choice is formalized by an integral criterion that combines «quality» in terms of KPIs and costs and is minimized to obtain a recommendation.

The model was tested using the example of comparing three cloud migration strategies: Lift-and-Shift, Re-platforming, and Re-engineering, using the specified base KPIs, normalization reference limits, and target thresholds. For each strategy, a projected post-migration profile of indicators was formed and the degree of compliance with the minimum acceptable requirements due to deficits relative to thresholds was determined. The results showed that Lift-and-Shift has the highest probability of not reaching part of the threshold requirements, Re-platforming in most cases ensures their fulfillment, and Re-engineering demonstrates the most complete compliance in terms of KPIs but is accompanied by higher complexity of implementation. The integral criterion, which combines the penalty for not achieving the KPI and the cost component with a manageable trade-off parameter, provided a reproducible ranking of alternatives and identified Re-platforming as the most balanced option under the conditions of the example.

Thus, the proposed KPI-oriented model sets a reproducible procedure for choosing a cloud migration strategy in conditions typical for pre-migration planning: limited time, incomplete data, the need for explainability for business stakeholders. At the practical level, the approach is aimed at reducing uncertainty and decision-making costs at the pre-migration stage, by reducing the time and financial costs of preparing the evidence base, increasing the reproducibility of estimates and reducing the likelihood of wrong choice of strategy, which reduces the risks of budget overruns, missed deadlines and accumulation of technical debt after migration. The theoretical value lies in the formalization of the «strategy» as a manageable multi-criteria compromise, which simultaneously considers the achievability of threshold requirements for KPIs and the resource/cost component through the structure of the integral criterion.

It is advisable to associate the further direction of research with the empirical calibration of model parameters on real migration cases and the expansion of the observation base for different classes of information systems and domains. The development of the contextual part of the model by expanding the list of factors and checking their impact on the accuracy of recommendations, as well as integrating the approach with load profiling tools and automated collection of metrics, is also promising.

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# GOVERNANCE BY PROJECTS AS A METHODOLOGICAL FRAMEWORK FOR THE STRATEGIC DEVELOPMENT OF EDUCATIONAL AND SCIENTIFIC INSTITUTIONS IN UKRAINE

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The transformation of Ukraine's higher education system under European integration, decentralization of governance, and wartime uncertainty requires universities to shift from rigid administrative management toward adaptive, results-oriented governance. This paper substantiates governance by projects as a methodological framework for the strategic development of educational and scientific institutions in Ukraine. The approach integrates governance theory, project and portfolio management, interactive and responsive governance mechanisms, systems analysis, and formalized modeling.

The study argues that strategic university development should be operationalized through a portfolio of projects, where projects serve as organizational units for implementing transformation initiatives (digitalization, internationalization, research capacity building, infrastructure recovery). In this paradigm, governance by projects provides strategic alignment, transparency, and stakeholder coordination while preserving flexibility under constraints.

A key contribution of the research is the clarification of the dual nature of project governance in higher education: (1) external governance through institutional portfolio rules, prioritization and oversight, and (2) internal governance within temporary project organizations based on responsibility distribution, communication, trust and decision-making procedures. Such a structure supports coherent strategy execution in complex multi-stakeholder environments.

The research also emphasizes the need for pluralistic governance mechanisms in strategic projects, combining contractual governance (formal agreements and risk allocation), relational governance (trust, collaboration culture), and governmental governance (regulatory and coordination functions). Balanced interaction between these mechanisms increases governance performance in terms of transparency, decision timeliness, and stakeholder satisfaction.

An essential part of the study is the development of a mathematical model for adaptive governance of a university project portfolio. The model formalizes the dynamic relationship between strategic objectives, portfolio configuration, resource constraints and external uncertainty. It enables quantitative assessment of how individual projects contribute to target strategic indicators, comparison of alternative development scenarios, and implementation of adaptive decision gates (review, reprioritization, resource reallocation, stopping or scaling initiatives) based on monitoring results. In this way, the model supports a transition from declarative strategic planning to controlled portfolio-based implementation of change.

The results have practical value for Ukrainian universities in conditions of systemic transformation and post-war recovery. Governance by projects may serve as an operational architecture for strategy implementation, integrating institutional autonomy with accountability and evidence-based decision making.

Keywords: governance by projects; project governance; strategic development; portfolio management; adaptive governance; responsive governance; higher education.

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# APPLICATION OF TRANSFORMER MODELS AND INTELLIGENT DOCUMENT ANALYSIS METHODS FOR AUTOMATED MEDICAL DOCUMENTATION PROCESSING

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The rapid digitalization of healthcare information systems has significantly increased the demand for automated processing of medical documentation. Laboratory test results are commonly distributed in PDF format and are characterized by substantial variability in layout, structure, language, and document quality. This heterogeneity complicates the reliable extraction of structured information and limits the direct integration of laboratory data into clinical databases and decision support systems.

In earlier studies conducted by the authors, the modeling of medical center business processes and decision support mechanisms was examined with the aim of improving operational efficiency in healthcare institutions. These works emphasized that the quality, completeness, and structure of primary medical data play a critical role in ensuring the reliability of analytical outcomes and managerial decisions. This observation highlights the importance of developing effective methods for transforming unstructured medical documents into structured, machine-readable data suitable for further analysis.

Recent studies have demonstrated a growing interest in intelligent clinical information systems and automated decision support tools in healthcare. Research on web-based clinical decision support systems emphasizes the role of digital platforms in improving the personalization and effectiveness of medical services by integrating heterogeneous clinical data into routine workflows [2]. In parallel, contemporary studies in the field of artificial intelligence for healthcare underline the potential of intelligent decision support systems to enhance diagnostic and analytical processes by leveraging structured and semi-structured medical information [3]. These findings indicate that reliable document analysis and data extraction methods represent a critical technological foundation for the successful deployment of such systems.

The present study addresses the problem of automated recognition and extraction of laboratory test data from heterogeneous medical PDF documents. A representative laboratory report containing analytical results such as test names, measured values, measurement units, and reference ranges was used as a test case. Several text recognition approaches were analyzed, including classical OCR systems based on recurrent neural networks and modern transformer-based models. Within the scope of the study, the LayoutLM architecture was examined in detail, as it integrates textual, visual, and spatial information to model relationships between elements of medical forms. The processing workflow included a stage of preliminary noise filtering and image binarization, which improved the accuracy of subsequent character recognition by neural networks. Particular attention was paid to self-attention mechanisms in transformer models, which enable effective identification of contextual dependencies between test names and their corresponding numerical values in complex tabular structures.

In addition to text recognition, special attention was given to the task of structured data extraction required for database storage. Rule-based methods relying on predefined patterns were evaluated as a baseline approach. To validate the extraction results, a set of heuristic rules for data type checking was developed based on medical standards for acceptable value ranges. Machine learning-based extraction methods, including named entity recognition models and layout-aware document understanding architectures, were also examined. The scalability of the proposed approach is ensured through the use of containerization for model components, enabling seamless integration of the technology into existing cloud-based medical information systems.

The experimental analysis demonstrated that modern OCR approaches provide more stable text recognition results when processing documents with complex layouts and numerical information. It was observed that transformer-based methods reduce the frequency of recognition errors in numerical values and measurement units. Furthermore, layout-aware extraction models showed improved robustness in identifying relevant analytical fields across variations in document structure. An important aspect is the generalization capability of intelligent models, which allows them to correctly process documents from new laboratories without the need for manual template creation. The results also indicate that improvements at the text recognition stage do not always lead to proportional gains in structured data extraction accuracy, emphasizing the necessity of a holistic, end-to-end approach to document processing.

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# TOWARDS DEVELOPING A RECOMMENDATION SYSTEM FOR FAMILY PHYSICIANS IN FORMING A TREATMENT PLAN

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Modern medicine operates under conditions of rapid growth in the volume of clinical information, continuous updates of medical protocols, and expansion of diagnostic and therapeutic methods. The decision-making process is particularly complex at the level of primary healthcare, where the family physician plays a key role in forming diagnostic and treatment plans for patients. In everyday practice, physicians must simultaneously consider symptoms, medical history, results of previous examinations, comorbidities, individual patient characteristics, and current evidence-based medicine guidelines. This creates a significant informational burden and increases the risk of erroneous or excessive clinical decisions.

According to scientific studies, a substantial proportion of laboratory tests are prescribed without sufficient clinical justification, leading to inefficient use of healthcare resources, increased financial costs, and delays in establishing accurate diagnoses. In this context, the implementation of intelligent clinical decision support systems becomes particularly relevant, as such systems can assist physicians in structuring clinical data, improving the rationale behind medical decisions, and reducing the number of unnecessary examinations.

One of the promising directions in the development of such systems is Health Recommender Systems (HRS), which belong to the class of Clinical Decision Support Systems (CDSS) [1]. Unlike traditional rule-based expert systems, HRS utilize artificial intelligence, machine learning, and deep learning methods, enabling the generation of personalized recommendations that take into account the specific context of individual patients. These systems are applied to the selection of diagnostic tests, therapeutic strategies, risk assessment, and support of clinical decision-making.

At the same time, an analysis of recent scientific publications indicates that most existing medical recommender systems are either narrowly specialized or primarily oriented toward patients rather than general practitioners. One of the key challenges is the lack of algorithm explainability, where systems function as “black boxes” and fail to provide justification for their recommendations. This reduces the level of trust among medical professionals and complicates the integration of such systems into real clinical practice.

Of particular importance in medical recommender systems is the concept of Explainable AI [2], which enables the explanation of decision-making logic used by artificial intelligence algorithms. For physicians, it is essential not only to receive recommendations but also to understand the reasons behind them, as responsibility for clinical decisions ultimately lies with the medical professional. In addition, international regulatory requirements, including GDPR and HIPAA, impose strict demands regarding transparency, ethics, and security in the processing of personal medical data.

Considering the above, this paper proposes an approach to designing a recommendation-based clinical decision support system for family physicians aimed at assisting in the formation of patient treatment plans. The objective of the study is to improve the quality and validity of clinical decisions by combining artificial intelligence algorithms, evidence-based medical knowledge bases, and explainable analytics principles. The proposed system analyzes patient symptoms, electronic health record data, results of previous examinations, and clinical guidelines to generate a list of recommended laboratory tests accompanied by explanations for each recommendation.

To generate recommendations, the system employs machine learning methods, particularly a Multilayer Perceptron (MLP) neural network. This method was selected due to its ability to model nonlinear relationships between symptoms, anamnesis data, and clinical recommendations. The MLP model supports multi-label classification, which is appropriate for simultaneously generating multiple laboratory test recommendations. The input to the model consists of a structured set of clinical features, while the output is a list of recommended tests with associated weighting coefficients [3].

To enhance transparency and trust in the results, Explainable AI techniques are incorporated to identify the influence of individual input features on the generated recommendations. This ensures physician control and verification of decision outcomes and promotes the safe application of artificial intelligence in medical practice.

Within the scope of this research, an architectural model of the system was developed, including data input modules, an artificial intelligence analytical module, an explainability module, a knowledge base, and a reporting component. Context, functional, behavioral, and component diagrams were constructed to illustrate interactions between the physician, the recommendation system, and the patient's electronic health record. Active physician involvement in the decision-making process is ensured, with options for editing and approving generated recommendations.

The proposed recommendation system is designed for practical application in family medicine and does not replace the physician, but rather serves as an intelligent decision support tool. Its use enables a reduction in unjustified examinations, improves diagnostic planning accuracy, optimizes healthcare resource utilization, and ensures transparency in clinical decision-making processes. The application of Explainable AI principles enhances trust in the system and aligns with contemporary ethical and regulatory requirements for the use of artificial intelligence in medicine.

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# HALLUCINATIONS OF LARGE LANGUAGE MODELS IN INSURANCE ANNUITY SALES

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In the context of the rapidly increasing use of Large Language Models (LLMs) in financial advisory and insurance sales, the problem of AI hallucinations becomes particularly critical. Unlike general informational applications, errors generated in the domain of insurance annuities may result not only in misinformation, but also in regulatory non-compliance, incorrect risk assessment, and distorted financial expectations of clients.

The approach proposed in this paper differs from traditional methods of evaluating AI reliability [1]. Instead of external benchmarking or post hoc error analysis, LLMs are directly queried about their own limitations, uncertainty zones, and typical scenarios in which they may generate incorrect or incomplete information during annuity sales processes. This meta-analytical approach makes it possible to investigate not only *where* models tend to fail, but also *how* they conceptualize their own cognitive and informational constraints.

The following analysis is based on a comparative examination of responses provided by four contemporary LLMs (GPT, Gemini, Claude, and Grok) and aims to identify common and divergent patterns of self-described hallucinations in the context of annuity products, regulatory environments, and actuarial calculations (see Table 1).

Table 1 – Comparison of hallucination characteristics in major LLMs

| Characteristic | GPT | Gemini | Claude | Grok |
|---|---|---|---|---|
| Source of hallucinations | Employs a clear three-component framework: data insufficiency, limitations of logical inference, and regulatory uncertainty. | Focuses on data obsolescence, logical miscalculations, and regulatory opacity; introduces the concept of feature blending. | Emphasizes pattern-matching, generating plausible but non-existent attributes based on training examples rather than actual product prospectuses. | Identifies weaknesses in excessive generalization of shared patterns and the lack of dynamic updates to static datasets. |
| Product-specific risk | Notes the risk of misinterpreting roll-up rates as actual investment returns. | Refers to the benefit base as a “phantom number” and warns about incorrectly promising its liquidity. | Provides a detailed description of hallucinated distinctions between the benefit base and account value. | Highlights the tendency to cite outdated historical rates (e.g., 3–4% as a standard), ignoring current market conditions. |

| Characteristic | GPT | Gemini | Claude | Grok |
|---|---|---|---|---|
| Regulatory context | Acknowledges the tendency to merge distinct standards (NAIC Suitability and SEC Reg BI) into a single conceptual framework. | Warns against jurisdictional overgeneralization, where "best interest" standards are attributed to states that have not adopted them. | Demonstrates relatively high awareness of state-specific regulations (e.g., New York, California, Florida). | Introduces an international dimension, noting the risk of erroneous harmonization between EU and U.S. regulatory frameworks. |
| Mathematical and actuarial reasoning | Characterizes its numerical comparisons as linguistically coherent but actuarially invalid. | States that multi-step actuarial reasoning frequently results in confidently incorrect dollar amounts. | Admits reliance on approximate arithmetic and an inability to consistently distinguish between simple and compound interest in rider calculations. | – |
| Linguistic overconfidence | – | Describes a "default user bias," providing advice without considering age or tax status. | Identifies the use of professional jargon without explanation and the absence of caveats when presenting numerical values. | Points to an authoritative tone and lack of hedging language that conceals reasoning errors. |
| Mitigation strategies | Prompt-Level Controls: Instructing the model to state uncertainty and use sensitivity ranges. | Technical Guardrails: Utilizing RAG and Python scripts for math. | Verification Protocols: Explicitly forcing the model to show uncertainty and request caveats. | Tool Integration: Using web search for real-time rates and code execution for actuarial modeling. |

The obtained results indicate that, despite differences in their self-analytical structures, all examined models converge on a common conclusion: their primary function is to generate linguistically plausible outputs rather than to provide actuarial or regulatory authority. In the context of annuity sales, LLMs therefore function more effectively as reasoning support and hypothesis-generation tools than as reliable sources of factual information about financial products. In addition, the results of the analysis provide a foundation for the informed selection of a model depending on the specific stage of the annuity sales process. The identified differences in hallucination profiles and competency domains across LLMs make it possible to determine which model is more appropriate for particular business processes, ranging from prospect identification to annuity issuance and post-sale engagement.

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# MODEL OF THIRD-PARTY LIBRARY SELECTION BASED ON DEMPSTER–SHAFER THEORY OF EVIDENCE

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Third-party libraries – such as libraries, SDKs, frameworks, services, and plugins – are essential components of the technology stack in IT projects. The selection or migration of these libraries should be justified using key indicators that characterize their usage within a project. These indicators include effort, costs, quality, risks, and technological effect. In practice, data for these indicators is often imperfect or comes from various sources, leading to uncertainty and potential inconsistencies. Therefore, it is important to formalize the library selection process, which should (1) rely on these indicators, (2) consider project constraints, and (3) facilitate decision-making in the presence of imperfect data, including uncertainty and conflicts.

The selection issue should be approached as a multi-criteria problem, where libraries (referred to as alternatives) are evaluated based on the five indicators mentioned. Each indicator can be further broken down into specific components. For example, the effort required for an alternative includes: (1) learning effort, (2) implementation effort, (3) the effort needed to remove the existing library being replaced, and (4) the effort necessary to use the alternative after implementation. This effort can be calculated for a typical usage life cycle or as an average annual effort.

The project environment imposes constraints on resources and on acceptable levels of the indicator components, defined by specific thresholds. An approach is considered that treats thresholds not as rigid «cutoffs» that eliminate alternatives, but rather as flexible criteria that gradually decrease the support for an alternative as it deviates further from the threshold. To implement this mechanism, a sigmoid (S-shaped) curve can be used to represent a smooth transition from acceptable to unacceptable values of a component.

Let $\Theta = \{ A_j \}_{j=1}^{n}$ be the set of alternatives, where $n$ is the number of alternatives considered. Consider $K$ indicator components of the alternatives. For each component $k$, $k = \overline{1,K}$, and each alternative $A_j$ an estimated value $X_{k,j}$ is known. The task is to transform $X_{k,j}$ into a belief (support) mass $m_k(A_j)$ for the hypothesis of choosing the alternative, in accordance with Dempster–Shafer evidence theory.

For indicators to be minimized — effort, costs, and risks—the support degree $S_{k,j}$ should decrease as $X_{k,j}$ increases:

$$S_{k,j} = \frac{1}{1+e^{\alpha_k \times (X_{k,j} - X_{k,max})}}, \quad (1)$$

where $X_{k,max}$ is the target constraint (threshold) for component $k$.

$\alpha_k > 0$ is the sensitivity coefficient for component $k$, which determines how critical exceeding the threshold is for that component $k$.

When $X_{k,j} = 0$ (the ideal value), the support degree $S_{k,j}$ reaches its maximum. Within the proposed model, such values are interpreted as full support for the alternative.

The choice of the coefficient $\alpha_k$ should be linked to a business metric reflecting risk tolerance (i.e., the admissible exceedance of the target constraint). An allowable deviation $\Delta_k$ **from the target constraint** $X_{k,max}$ is introduced. In particular, it is required that when the threshold is exceeded by $\Delta_k$, the support degree $S_{k,j}$ decreases to the minimum acceptable level $S_{k,min}$:

$$\alpha_k = \frac{1}{\Delta_k} \times \ln\left(\frac{1-S_{k,min}}{S_{k,min}}\right). \tag{2}$$

For indicators to be maximized — quality and technological effect — the support degree $S_{k,j}$ should decrease as $X_{k,j}$ decreases. In (1), the term in the exponent is replaced with $X_{k,min} - X_{k,j}$, where $X_{k,min}$ is the target constraint (minimum threshold) for component $k$. Accordingly, when calibrating the sensitivity coefficient $\alpha_k$ in (2), the parameter $\Delta_k$ is interpreted as the allowable decrease of the indicator relative to the threshold $X_{k,min}$, at which the support drops to the level $S_{k,min}$.

The belief mass $m_k$ for any subset of hypotheses $H \subseteq \Theta, H \neq \emptyset$, is computed as the product of the support degrees of the alternatives included in $H$ and the residual term that captures the risk of falsely excluding an optimal alternative due to imperfect input data:

$$m_k(H) = \left(\prod_{\forall A_j \in H} S_{k,j}\right) \times \left(\prod_{\forall A_j \in G} (1 - S_{k,j})\right), \tag{3}$$

where $H$ is the set of alternatives that the hypothesis considers compliant with the project requirements; for these alternatives, the support degree $S_{k,j}$ is included in the computation.

$G$ is the set of alternatives rejected by the hypothesis as non-compliant, $G = \Theta \backslash \mathrm{H}$; for these alternatives, the term $(1 - S_{k,j})$ is used in the computation.

The proposed approach enables the construction of a set of belief masses (hereafter, evidence) for the indicator components across all hypotheses in the set $\Theta$. The obtained masses are combined while accounting for potential conflicts between information sources. Given the typical presence of contradictory evidence regarding alternatives and indicator values, it is reasonable to consider the Dubois–Prade disjunctive consensus rule for combination, which interprets conflict as uncertainty and does not perform a “forced” redistribution among alternatives.

As a result, generalized belief masses are obtained for all combinations of hypotheses in $\Theta$, on the basis of which confidence intervals are computed for the corresponding hypotheses. The interval width is interpreted as a measure of evidence imperfection: the wider the interval, the less definite—and therefore less reliable—the conclusion. The final selection decision may be based on comparing hypotheses by two components of the confidence interval: (1) the maximum guaranteed support and (2) the maximum possible support.

Thus, the proposed model: (1) incorporates constraints on the indicators and their components; (2) enables transforming observed component values into degrees of support for alternatives while accounting for incomplete data; and (3) allows combining evidence in the Dempster–Shafer evidence theory, with the ability to form both mutually exclusive and composite hypotheses.

# THE ROLE OF MODERN MARKETING STRATEGIES IN COMPETITIVE ADVANTAGE

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Competitive advantage is the ability of a company, organization, or country to achieve a superior market position through more efficient and effective use of resources, processes, and strategic capabilities. As digital technologies transform the market, traditional marketing is less effective. Modern marketing strategies –driven by technology, data analytics, and consumer behavior –are now essential for building and sustaining competitive advantage. This article demonstrates how modern marketing strategies shape and sustain competitive advantage in a dynamic, digital marketplace.

The Essence of Modern Marketing Strategies. The development of technology, digital transformation, and global market conditions requires businesses not only to offer high-quality products but also to employ strategic, innovative, and flexible marketing approaches. Competitive advantage depends not only on the differentiation of products and services but also on how a company positions itself in the market, how it builds relationships with customers, and how it strengthens its brand image. From this perspective, modern marketing strategies have evolved not only as a means of increasing sales but also as a fundamental tool for building brand sustainability and fostering a loyal customer base.

Marketing strategy serves as a comprehensive roadmap that guides organizations in identifying, anticipating, and fulfilling customer needs while achieving long-term business objectives. In today's rapidly evolving business environment, companies face unprecedented challenges – ranging from technological disruptions and changing consumer preferences to heightened global competition and economic fluctuations. As a result, a well-designed marketing strategy is no longer optional; it has become a crucial element for survival and growth (Ayinaddis, S. G. 2023).

A marketing strategy represents the totality of activities planned by a business to present its products and services in the market, reach target audiences, and strengthen customer relationships. Modern marketing strategies combine traditional and digital tools, enabling broader and more interactive outcomes. These strategies mainly aim to:

– Increase brand visibility and market recognition;
– Strengthen customer engagement;
– Increase sales and revenue;
– Differentiate from competitors and ensure long-term market advantage.

Modern marketing approaches enable companies to respond quickly to market changes, allocate resources efficiently, and align team members with strategic objectives.

Modern marketing strategies, by focusing on digital technologies, data analytics, and customer experience, encompass concepts such as target market selection, the creation of competitive advantage, relationship marketing, and STP (Segmentation, Targeting, Positioning). At the same time, they adapt traditional elements such as the classic 4Ps (Product, Price, Place, Promotion) to the digital environment, track each step of the customer journey, analyze consumer preferences, and design activities aimed at meeting customer needs. The main modern marketing strategies include content marketing, social media marketing, search engine optimization (SEO), influencer marketing, artificial intelligence and marketing automation, personalization, and data analytics.

The Role of Marketing in Creating Competitive Advantage. Modern marketing strategies provide a competitive advantage in several key directions:

-Brand Awareness. Strong marketing campaigns increase brand recognition in the market and help brands remain memorable to consumers. Social media platforms, short-form videos, influencer collaborations, and interactive campaigns play an important role in this area.

-Strengthening Customer Relationships. Analyzing customer behavior and creating personalized experiences are essential for long-term loyalty. Hyper-personalization and data analytics make it possible to accurately identify customer needs and offer tailored services.

-Innovation and Differentiation in the Market. Innovative marketing strategies enable companies to differentiate themselves and gain superiority over competitors. Brand repositioning, technological integrations, interactive campaigns, and the introduction of new products are particularly important in this regard.

-Active Presence on Digital Platforms.

Digital marketing enables real-time interaction with customers through social media, SEO, email campaigns, and mobile applications. This not only increases sales but also ensures that the brand remains relevant.

The Impact of Modern Marketing on Business. Modern marketing strategies provide the following advantages to businesses:

– Customer Satisfaction and Loyalty: Personalized experiences strengthen customer attachment to the brand.

– Growth in Sales and Revenue: Targeted campaigns increase sales and attract new customers.

– Competitive Advantage: Innovative and flexible approaches differentiate companies from their competitors.

– Long-Term Brand Value: Strengthening brand image ensures business sustainability in the market.

Additionally, modern consumers increasingly value authenticity, sustainability, and social responsibility. Therefore, marketing strategies must integrate ethical considerations, transparent communication, and community engagement to foster long-lasting relationships. An effective marketing strategy also requires regular performance evaluation and adaptation to environmental changes, ensuring continued relevance and impact (Adrian, 2025).

Conclusion. Modern marketing strategies are a fundamental tool for creating competitive advantage. They are used not only to increase sales, but also to build customer loyalty, enhance brand awareness, and achieve differentiation in the market.

To succeed in a competitive environment, companies must implement strategic, innovative, and flexible marketing approaches.

The analysis conducted shows that modern marketing strategies no longer merely serve the function of promoting products and services; rather, they have become one of the main strategic instruments that determine a company's position in the competitive environment. Under conditions of accelerated digitalization, changing consumer behavior, and global market integration, competitive advantage is no longer limited to price and quality factors alone. It is increasingly shaped by brand value, customer experience, innovation capability, and data-driven decision-making mechanisms.

Modern marketing strategies enable businesses to respond flexibly to market changes, identify customer needs more accurately, and offer personalized solutions. Hyper-personalization, active use of digital platforms, socially responsible initiatives, and the integration of technological innovations into marketing processes support not only short-term sales objectives but also long-term sustainable development. These approaches strengthen emotional bonds with customers, increase trust in the brand, and create advantages that are difficult for competitors to imitate.

At the same time, the effectiveness of modern marketing strategies depends on their systematic and integrated implementation. The random use of isolated tactics does not produce sustainable results. Competitive advantage is reinforced only when marketing strategies are aligned with the overall business strategy, integrated into organizational culture, and supported by a continuous innovation approach.

In conclusion, modern marketing strategies act both as a catalyst and as a protective mechanism in the formation of competitive advantage. They enable companies not only to strengthen their existing market positions but also to create new sources of value, enter new markets, and ensure long-term sustainability in a dynamic business environment. From this perspective, the adoption and strategic-level implementation of modern marketing approaches should be regarded as one of the main conditions for achieving competitive advantage.

This article provides a comprehensive overview of key marketing strategy concepts and their practical implications, offering valuable insights into developing effective frameworks for competitive advantage (Cepeda-Carrion, I. Ortega-Gutierrez, J.Garrido-Moreno 2023).

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# MODELS AND METHODS FOR PROCESSING TEXTUAL BUSINESS RULES IN DECISION SUPPORT SYSTEMS

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This research addresses the challenge of converting unstructured natural language business rules into executable Decision Model and Notation (DMN) structures within decision support systems. The investigation proposes a computational framework integrating probabilistic language models with deterministic validation mechanisms. The proposed approach encompasses three foundational models: semantic identification of business rule components, automated generation of DMN decision tables, and test-oriented validation of formalized structures. Experimental evaluation demonstrates highly-promising convergence across iterative refinement cycles while reducing computational costs by 6.06% compared to static validation approaches.

Contemporary decision support systems increasingly rely on explicit business rules defining decision logic within complex organizational contexts. The Decision Model and Notation standard provides formal representation of such logic through executable decision tables. However, business rules are typically formulated in natural language, and their transformation into formal DMN models requires substantial manual effort and remains error-prone [1].

Large Language Models demonstrate fundamental challenges in structured data generation despite excellence in semantic coherence. Transformer architectures frequently lose track of long-range dependencies in XML structures or fail to maintain type consistency across decision tables [2]. Empirical analysis reveals that directly generated DMN tables contain semantic drift and structural violations when validated against deterministic execution engines, rendering unmediated generation unreliable for enterprise deployment [3].

The research addresses defect propagation cost through early error detection mechanisms [4]. The proposed framework comprises three integrated models addressing distinct phases of business rule processing. Semantic identification model formalizes the mapping from textual business rules to structured representations. Given textual rule t, data schema S comprising attributes, domains, and type mappings, plus domain context C, the model produces rule interpretation r* satisfying $f: (t, S, C) \rightarrow r^*$. The model extracts conditions, actions, and dependencies while incorporating available data schema, addressing the fundamental challenge of grounding natural language semantics in deterministic type systems. DMN generation model constructs decision table structure D comprising input attributes I, output attributes O, rules R, hit policy H, and condition-result mapping σ. The model satisfies semantic equivalence where for all valid input states x, the rule semantics equals decision table semantics: $[\![r]\!](x) = [\![D]\!](x)$. Schema Injection works by dynamically incorporating data structure specifications into generation prompts. This method effectively constrains the model's output space by enforcing formal syntactic rules. Validation model synthesizes test coverage Ξ comprising test cases ξ = (x, O(x)) where expected results O(x) derive from Oracle(T, S, C; x). The critical innovation lies in independent generation: tests are derived from primary business rule artifacts rather than extracted from generated tables, enabling detection of semantic deviations invisible to structural validation alone.

The framework implements hybrid architecture where probabilistic generation operates within deterministic control structures. The Dispatcher component, formalized as Cost-Colored Petri Net PN = $(P, T, F, W, M_0)$, functions as intelligent resource arbiter managing state transitions between generation, validation, and regeneration phases [5]. Petri Net formalism enables precise modeling of concurrency, state accumulation, and retry budget enforcement, mathematically guaranteeing system termination. The architecture employs test-first generation: the system initially synthesizes validation criteria as JSON test cases utilizing Schema Injection and Retrieval-Augmented Generation, subsequently grounding DMN logic generation in these pre-validated scenarios. RAG integration reduces semantic errors from 14% to 1% by enriching prompts with domain-specific knowledge retrieved from enterprise knowledge bases. The research introduces simultaneous regeneration of both DMN tables and test cases upon validation failure. When both artifacts regenerate together, the model reinterprets the rule set holistically, reducing persistent misalignment probability.

Controlled experimental analysis across 200 generation cycles evaluated two error-recovery strategies: independent DMN regeneration versus joint regeneration of DMN and test cases. Quantitative results demonstrate joint regeneration achieves 6.06% reduction in total cost and 8.44% reduction in token consumption while maintaining 100% convergence rate with zero irrecoverable failures. The validation framework successfully identified all error categories through deterministic execution, with semantic errors detected exclusively through test-based validation [6].

This research resolves the modeling bottleneck in business rule automation through systematic integration of probabilistic generation with deterministic verification. The proposed dual-stream architecture transforms validation from post-production manual review into pre-production automated cycle.

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# DEVELOPMENT OF AN INFORMATION SYSTEM FOR SUPPORTING PART-TIME AND DISTANCE LEARNING PROCESSES

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In the current conditions of digitalization of education, part-time and distance learning have become an integral part of the educational process in higher education institutions. The quarantine restrictions caused by the COVID-19 pandemic significantly accelerated the implementation of distance learning technologies, which led to their widespread use in higher education institutions worldwide [1]. In Ukraine, starting from 2022, part-time and distance education have gained particular importance due to the introduction of martial law, which has necessitated ensuring the continuity of the educational process regardless of the location of students and teachers. Under these conditions, higher education institutions actively use various digital platforms and services, including Moodle, Google Classroom, Zoom, and Microsoft Teams.

At the same time, practical experience with these solutions has revealed several organizational and technological problems related to supporting part-time and distance learning. Difficulties arise in managing student enrollment, monitoring the implementation of curriculum, tracking academic progress, organizing examination sessions, and accounting for academic arrears. This is because traditional Learning Management Systems (LMS) are primarily focused on synchronous interaction and do not always consider the specifics of part-time education, which requires flexible schedules, student autonomy, and asynchronous access to learning materials [2].

As a result, to ensure comprehensive support for part-time and distance learning, higher education institutions are forced to use a combination of several disparate information systems and services. This complicates administration, increases the risk of errors, and requires additional time and human resources. These problems arise due to the lack of integrated automated solutions that could, at a minimum, facilitate the support of educational processes and, at the maximum, fully optimize them by reducing staff workload and improving learning efficiency.

The aim of this work is to develop an information system to support part-time and distance learning processes that integrate functionality for the effective support of both forms of education, considering the specific needs of students. This aim is achieved through the development of a multi-module web application which, unlike classical LMS solutions, is oriented not only toward learning content but toward the full cycle of part-time student support-from enrollment to the completion of examination sessions and the processing of academic documentation.

The scientific novelty of this work lies in the development of an approach to designing an information system focused on the comprehensive support of part-time and distance learning, covering not only educational content but also administrative, organizational, and analytical processes of a higher education institution within a unified information environment.

The practical value of the work consists in the possibility of using the developed system in the activities of higher education institutions to reduce the administrative workload on dean's offices and teaching staff, increase transparency and manageability of the educational process, and improve access to educational and organizational resources for part-time and distance learning students.

Thus, the future system is designed as a modular solution comprising the following components: a student enrollment and curricula module; a courses and learning content module; an assignments and assessment module; a communication and support module; a schedule and events module; an examination sessions and academic arrears module; a documents and applications module; an analytics and reporting module; as well as an administrative module.

The modular architecture of the system enables the integration of new subsystems with the existing information system of the university, ensuring continuity of operation and minimizing risks during implementation.

The server-side component is developed with consideration of the software solutions already used to support the educational process, using the PHP programming language. This approach allows the expansion of the functionality of the existing system by adding new modules without the need for its complete redesign. For data storage and processing, the PostgreSQL database management system is used, which is already employed at the university and has proven to be a reliable and productive solution for handling large volumes of structured information. The use of a unified DBMS ensures compatibility with new modules with existing data and simplifies their integration.

The selected technological solutions also consider the availability of specialists responsible for maintaining and developing the university's current information systems, which helps reduce the costs of implementation, maintenance, and further scalability of the developed system.

An important aspect considered in the development of the system is the need for its integration with other information systems of the university, including electronic databases and library systems. This ensures a unified information space and reduces the administrative burden for both students and teachers [3].

The system is primarily intended for use at the National Technical University «Kharkiv Polytechnic Institute» to improve the quality of support for part-time and distance learning students. As a result of this work, an improvement in the quality of educational services for part-time and distance learning students is expected, contributing to the competitiveness of the university in the context of education digitalization.

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# TRANSFORMATION OF HR-MANAGEMENT IN THE CONTEXT OF DIGITALIZATION OF THE PUBLIC SECTOR

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Digital technologies enable security-oriented systems to provide more responsive, accessible, and innovative public services. For example, with the introduction of an electronic office, personnel can access online services, reduce bureaucracy, and improve service quality. In addition, technologies such as big data can be used to improve the monitoring and management of public resources. Digital technologies enable personnel to participate in decision-making and policy planning. Through participation platforms, personnel can contribute and collaborate with government agencies to formulate policies that are more inclusive and responsive to current needs. This strengthens the principles of democracy, transparency, and accountability. The transformation of governance also involves closer cooperation between government agencies, departments, and personnel. Digital technologies facilitate effective partnerships and interactions between these entities. Thus, the impact of digital technologies on governance transformation is significant. These changes have created new opportunities to increase efficiency, improve service quality, and enhance public participation.

Engaging employees in change. Change affects every employee in the organization. This means that for a successful digital transformation, all stakeholders, from employees to managers, must be effectively engaged and communicate to consider all the pros and cons of civil protection HR management transformation.

Identifying digital tools. Today, technology is available to help the public sector optimize its work, improve the experience, and automate processes. But before choosing to upgrade, it is necessary to evaluate the available digital tools and technologies, aligning them with the goals of government agencies in the field of human resource management.

Implementation. Gradually implement the selected HR technology until it is fully integrated with existing data and HR systems. The goal is not to disrupt the existing system, but to make gradual changes that are easy to adapt to. Implementing the software will help measure and optimize the organization's performance.

Focus on digital culture. HR technology is not the only condition for the transformation of HR in government structures; it is the digital transformation of the entire organization. It is vital to prioritize the experience of personnel to ensure that the plan meets their needs and provides sufficient information about the changes. Get feedback periodically and understand the mindset of the entire organization. This will create a culture of a healthy government system.

In the context of government organizations, digital transformation directly affects both HR professionals and the entire institutional structure. It changes the roles and functions of human resources departments, increases the requirements for professional competencies of employees, and requires the formation of a new organizational culture focused on flexibility, openness to innovation, and continuous learning. At the same time, the process of implementing digital changes is accompanied by a number of risks, including staff resistance to change, insufficient digital literacy, limited resources, and threats to information security and personal data protection.

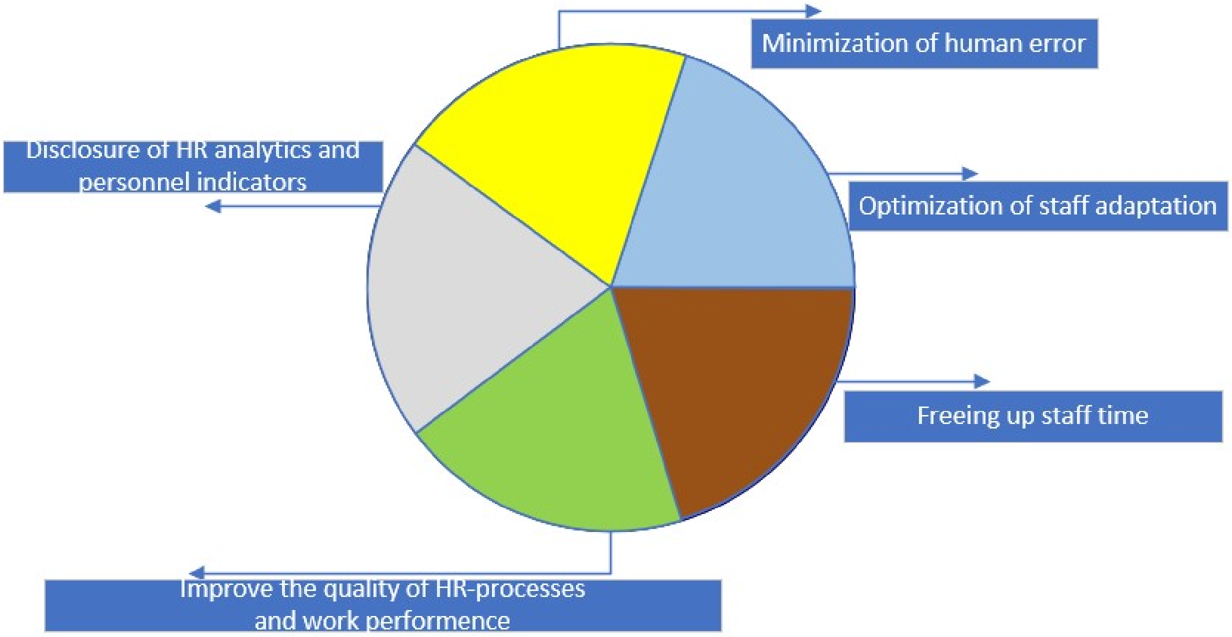


Fig. Digitization of key trends in human resource management

Such risks are characteristic of periods of transformation in public administration, especially in the context of reform and crisis situations. That is why the role of human resource management specialists is growing significantly. They must not only accompany the technical implementation of digital tools, but also ensure effective change management, communication with staff, and support for employees in the adaptation process. Therefore, successful digital transformation of HR in the public sector is impossible without systematic training and retraining of personnel.

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# A NOVEL APPROACH FOR E-GOVERNMENT SERVICES WITH ARTIFICIAL INTELLIGENCE USING ARTIFICIAL NEURAL NETWORKS

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Artificial intelligence (AI), especially the rapidly growing field of artificial neural networks (ANNs), is an exciting and emerging area of computer science which has a very broad scope and can replicate and enable human decision making in the form of intelligent processors of information. As AI technology grows, there is a major concern/consideration for the requirement of public services in every walk of life, ranging from health to education to social welfare. This paper aims at the exploitation of AI technology in the development of public services (specially e-government) which can provide an intelligent decision making layer that can be beneficial to the populace. E-government is basically the employment of ICT (Information and Communication Technology) to exchange information and services in the public sector. This is kind of a revolution from the current manual and paperwork oriented public sector and provide round the clock services to the citizens. Govt. of any nation implements various decisions and projects them as policies for the benefit of the public. Then these public sectors have various institutions that provide services to the public. With time, information technology has also revolutionized the way the public gets access to these policies and services. E-government services have been an evolution from the last decade and have definitely made the governance simpler, cheaper, and quicker. But the services provided are more kind of an information exchange and the public has to make a lot of decisions (which services to choose to accomplish a task, what are the implications, and can he find the best possible solution) regarding those services that can be confusing. Also, there can be cases where the policies are not very well understood to have any services behind them as govts do not want to take a decision considering their implications and also implementing the decisions which are best for the public. There is a vast scope of simulation here, the decisions, the policies, an intelligent environment which can be a very good test bed for policies and which can provide the implications verified at the best interest of the public. Now this is a perfect ground for an intelligent environment which can be in the form of an intelligent agent or a knowledge base, but we are focusing on the employment of AI technology which is still an improvement from the previous decade

# MANAGEMENT OF FIXED-BUDGET IT PROJECTS UNDER CONDITIONS OF NONLINEAR DYNAMICS OF THE EXTERNAL ENVIRONMENT

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Fixed-budget IT projects operate under conditions of nonlinear external dynamics, including market volatility, technological uncertainty, and regulatory changes, which limit the effectiveness of traditional linear project management approaches. This paper explores adaptive management of fixed-budget IT projects based on forecasting nonlinear environmental impacts and systems analysis. A conceptual management framework is proposed to support informed decision-making and improve project controllability while maintaining fixed budget constraints.

***Introduction***. Fixed-budget IT projects, particularly in outsourcing, face nonlinear external dynamics such as technological change, market volatility, and regulatory uncertainty, which reduce the effectiveness of traditional linear management approaches. Adaptive strategies integrating forecasting and systems thinking can improve decision-making and enhance project controllability under these dynamic conditions.

***Methods***. The study employs a multi-level methodological approach combining systems analysis, nonlinear modeling, and forecasting techniques to address the challenges of managing fixed-budget IT projects under dynamically changing external environments. The first step involves identifying key sources of nonlinear impact, including market volatility, technological evolution, regulatory changes, and shifts in stakeholder expectations. These factors are analyzed in terms of their potential influence on project constraints such as cost, schedule, and scope.

Next, predictive models are developed to quantify the effects of nonlinear environmental dynamics on project performance. These models incorporate historical data, trend analysis, and scenario-based simulations to forecast potential deviations and risk escalation. The methodology also integrates adaptive management mechanisms, allowing project managers to adjust strategies proactively based on forecasted outcomes.

Finally, a conceptual framework is formulated that combines forecasting results with decision-support tools, enabling real-time monitoring of project performance and facilitating informed managerial interventions. This integrated approach ensures that fixed-budget constraints are respected while improving resilience to unpredictable external influences and enhancing the likelihood of successful project completion.

***Results***. The application of the proposed framework demonstrates improved management of fixed-budget IT projects under nonlinear external dynamics. Predictive models enable early identification of critical deviations in cost, schedule, and scope, allowing managers to implement corrective actions before risks escalate. Scenario-based simulations show that integrating forecasting with adaptive decision-making significantly reduces the likelihood of budget overruns and schedule delays compared to traditional linear management approaches.

Furthermore, the framework provides a structured mechanism for monitoring environmental changes and adjusting project strategies in real time. This increases project resilience, enhances controllability, and supports more informed decision-making under conditions of uncertainty. The results indicate that combining forecasting techniques with adaptive management can substantially improve the success rate of fixed-budget IT projects in outsourcing environments..

***Discussion***. The findings emphasize the importance of integrating forecasting and adaptive management in fixed-budget IT projects under nonlinear external dynamics. Predictive models and scenario-based simulations help managers identify risks early, take proactive actions, and maintain performance within budget constraints. The proposed framework enhances controllability, resilience, and timely strategic adjustments, highlighting the value of adaptive, forecast-driven approaches in high-uncertainty IT projects.

***Conclusions***. Managing fixed-budget IT projects under nonlinear external dynamics requires adaptive, forecast-driven approaches. Integrating predictive models with systems-oriented management improves early detection of deviations, decision-making, and project controllability. The proposed framework enhances resilience, reduces budget and schedule risks, and supports strategic adjustments, highlighting the importance of forecasting and adaptive mechanisms in high-uncertainty IT projects..

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# ASSESSMENT OF PROJECT ACTIVITY AND DEVELOPMENT PERSPECTIVES

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Abstract. Project activity is a crucial component in organizational growth and innovation. Evaluating project performance enables managers to identify strengths, weaknesses, and future development opportunities (Mammadov, 2020). This study examines current methods of project assessment and proposes strategies for improving project efficiency and sustainability. The research emphasizes the integration of modern project management tools, training programs, and sustainability considerations as essential for achieving long-term project success (Brown & Green, 2022).

Introduction. Project activity involves the planning, execution, and monitoring of tasks to achieve specific objectives (Mammadov, 2020). Effective assessment allows organizations to optimize resource use, increase productivity, and ensure long-term success (Huseynli, 2021). With rapid technological advances and increasing competition, project management has become a key factor in organizational development (Smith, 2019). Proper evaluation of projects ensures that organizations can identify potential risks, allocate resources efficiently, and adopt best practices (Brown & Green, 2022).

The purpose of this paper is to explore key methods of project assessment and to present development perspectives that enhance project outcomes. Special attention is given to modern software tools, training programs for project teams, and sustainability integration as crucial components of contemporary project management (Johnson, 2021).

Methods of Project Assessment. Methods of project assessment vary according to organizational objectives, project size, and the complexity of tasks involved, and they collectively aim to determine how successfully a project has been executed. One of the most widely applied approaches is the use of Key Performance Indicators (KPIs), because measurable criteria such as time, cost, and quality enable managers to monitor efficiency and identify deviations from planned targets at an early stage (Mammadov, 2020). KPIs make the evaluation process more concrete and provide clear benchmarks for assessing project success. Another important method is the Balanced Scorecard approach, which examines not only financial indicators but also non-financial dimensions including customer satisfaction, internal operational efficiency, and innovation capacity (Smith, 2019). This approach offers a comprehensive understanding of how a project contributes to the organization's strategic goals. Project audits represent a further significant evaluation method, as they involve detailed reviews of both project processes and final outcomes, allowing organizations to detect weaknesses, inefficiencies, and areas requiring improvement (Brown & Green, 2022). Audits strengthen accountability and help teams extract valuable lessons from completed projects. Overall, combining quantitative and qualitative assessment techniques enables organizations to gain a holistic view of performance and supports more informed strategic decision-making (Huseynli, 2021).

Development Perspectives. Development perspectives in project management focus on enhancing project efficiency, strengthening organizational capabilities, and ensuring long-term sustainability, reflecting the importance of both short-term results and broader strategic impact. One of the main strategies involves integrating modern project management software, as tools such as Microsoft Project, Jira, and Asana streamline workflows, improve team coordination, and allow real-time monitoring of project progress (Johnson, 2021). These digital solutions automate reporting, reduce human error, and help teams work more efficiently. Another essential development strategy is training and capacity building, since continuous professional development increases team competence, fosters knowledge sharing, and enhances adaptability in complex or rapidly changing environments (Mammadov, 2020). Incorporating sustainability principles into project management is equally important, with ESG standards guiding organizations to align their initiatives with environmental, social, and governance objectives; such practices reduce potential risks and strengthen corporate reputation (Brown & Green, 2022). Looking ahead, development perspectives increasingly highlight the use of artificial intelligence and predictive analytics to improve resource allocation, anticipate project outcomes, and enhance decision-making quality (Johnson, 2021). As a result, organizations that combine innovative technologies with traditional project management approaches are more likely to achieve sustainable development and maintain a competitive advantage.

Conclusion. Regular assessment of project activity is essential for organizational growth, productivity, and competitiveness (Huseynli, 2021). Combining traditional evaluation methods such as KPIs and audits with modern strategies like software integration, training programs, and sustainability considerations ensures that projects remain efficient, adaptive, and socially responsible (Mammadov, 2020; Brown & Green, 2022). Future research should explore the integration of digital tools and methodologies, and assess their impact on project performance and long-term sustainability (Johnson, 2021).

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# MATRIX FOR SELECTION A PROJECT MANAGEMENT APPROACH IN HYBRID PROJECTS

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Modern project management is undergoing substantial intensification of complexity driven by two trends: the proliferation of megaprojects, which are characterized by a large number of stakeholders, interdependent subsystems, and extended supply chains; and the growing prevalence of hybrid projects that combine heterogeneous work types, different forms of uncertainty, and multiple decision-making regimes. In such projects, practitioners increasingly blend tools and practices drawn from different methodologies, because a «single approach» often fails to ensure controllability across all workstreams.

This situation amplifies the demand for models that enable a justified selection of management practices not only at the aggregate project level, but also in a differentiated manner – for distinct subproblems and project contours that may operate within different activity environments. Accordingly, a key question emerges: which approaches should be applied when a single hybrid project simultaneously spans multiple environments and therefore requires not one, but several mutually aligned management practices.

Within both professional practice and scholarly discourse, two widely used frameworks for selecting management approaches under uncertainty are the Cynefin framework and the Stacey matrix. Cynefin is valuable because it helps determine the domain in which a system operates and supports the selection of a management regime. The Stacey matrix is traditionally used to position situations along two dimensions of uncertainty («what is needed» and «how it can be implemented»), thereby informing the choice between more plan-driven and more adaptive approaches.

However, for hybrid projects and megaprojects, both frameworks exhibit notable limitations. First, they insufficiently capture situations in which the decisive factors are not only requirements or technological complexity, but also increasing environmental volatility and turbulence, as well as constraints in fundamental resources. Second, these models are less effective as instruments for hybrid configurations in which different parts of the work require different regimes. Consequently, there is a need for an additional descriptive lens that links the choice of approach to a system's resource capacity to learn and to produce solutions under constraints of time and search scale.

The methodology selection model proposed in this study builds on two conceptual foundations. The first is the evolutionary design spectrum, within which solution-generation regimes range from traditional design to various forms of guided experimentation and evolutionary selection of solutions [1]. The second foundation is the economic tetrad, within which space and time are treated as fundamental resources of a system's existence and activity [2].

To support decision-making regarding the selection of project management approaches, the model proposes a matrix defined by two axes:

1. Time axis (T): time available for learning through iterations. This dimension reflects the realistically available number of cycles (sprints, iterations, prototype generations) as well as the temporal buffer before a deadline. High values of T indicate the possibility of repeatedly refining solutions through feedback, whereas low values imply a need to decide quickly with a minimal number of learning loops.
2. Space axis (S): the volume of search/experimentation space available to the system. This dimension captures the capacity for parallel exploration and verification of options: how many hypotheses/alternatives the team can test per unit of time, what degree of parallelism is feasible, and how quickly feedback can be obtained. High values of S imply high experimental throughput; low values indicate constraints on the number of trials and alternatives.

Within this two-dimensional space, zones emerge, each corresponding to a characteristic management regime:

Traditional Design (low T, low S). This zone reflects situations with a shortage of time and a low capacity to test alternatives. Management tends toward expert-driven design, detailed specification, and change minimization, because errors are costly and feedback is slow or expensive.

Combinatorial Design (intermediate T and/or S). This regime corresponds to contexts in which combinations of solutions can be explored – for example, feature variants, configurations, or architectural alternatives. Management is appropriately framed as organizing a design space: forming a portfolio of alternatives, managing dependencies, and accumulating knowledge.

Continuous Evolution (high T and high S). This is a mode of continuous evolution: many iterations combined with high verification speed. Management becomes product-oriented, emphasizing continuous discovery and delivery, metrics, system learning, regular data-driven selection of solutions, and governing evolution through rules and constraints rather than a static plan.

Trial and Error (no knowledge). The critical meaning of this zone is not the endorsement of chaos but the risk of legitimizing it: if an organization generates many trials without building knowledge (i.e., without hypotheses, measurement, and inference), costs increase without corresponding progress. In project terms, this manifests as proliferating activity without managed learning.

As a result, a hybrid project is interpreted not as a "compromise" between methodologies, but as a configuration of regimes in which each work area is governed by a logic aligned with the team's resource capacity: whether repeated learning is feasible (T), whether parallel testing is feasible (S), and whether knowledge accumulation is sufficient to shift activity from "blind trials" to guided selection.

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# NUMERICAL SOLUTION OF A PROBLEM OF DETERMINING THE RIGHT HANDSIDE FOR A STRING VIBRATION EQUATION

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The paper considers the inverse problem of determining the right-hand side of the string vibration equation. This problem reduces to the problem of minimizing a functional constructed using additional information. The problem is solved numerically using the gradient projection method.

***1. Problem statement***

Let us consider a problem of finding of the pair $(u(x,t),\upsilon(t))$ from the following relations:

$$\frac{\partial^2 u}{\partial t^2}=\frac{\partial^2 u}{\partial x^2}+\upsilon(t),\ (x,t)\in Q=(0,\ell)\times(0,T), \tag{1}$$

$$u(x,0)=u_0(x),\ \frac{\partial u(x,0)}{\partial t}=u_1(x),\ 0\le x\le\ell, \tag{2}$$

$$u(0,t)=u(\ell,t)=0,\quad 0\le t\le T, \tag{3}$$

$$u(x_0,t)=p(t),\qquad 0\le t\le T \tag{4}$$

here $u_0(x), u_1(x),\ p(t)-$are the given functions, $0<x_0<\ell$.

Let us reduce this inverse problem to the following optimal control problem:
Find the minimum of the functions

$$J_\beta(\upsilon)=\frac{1}{2}\int_0^T[u(x_0,t;\upsilon)-p(t)]^2dt+\frac{\beta}{2}\int_0^T[\upsilon(t)-\omega(t)]^2dt \tag{5}$$

at within the constraints (1)-( 3) and for

$$\upsilon(t)\in V=\left\{\upsilon(t)/\int_0^T\upsilon^2(t)dt\le r^2\right\} \tag{6}$$

where $\omega(t)-$is a given function, $r>0-$is a given number.

It is assumed that all the data of the problem are rather regular.

For numerical solution at this problem we can use various minimization methods, for example, the method of gradient projection, the method of conditional gradient.

In brief, we stop on the gradient projection method. For the problem (1)-(3),(5),(6) the gradient projection method is reduced to constructing the minimization sequence $\{\upsilon_k(t)\}$ by the rule

$$\upsilon_{k+1}(t) = \begin{cases} \upsilon_k(t) - \alpha_k J'_\beta(\upsilon_k), \\ \int_0^T \left[\upsilon_k(t) - \alpha_k J'_\beta(\upsilon_k)\right]^2 dt \le r^2 \ for, \\ \dfrac{r\left(\upsilon_k(t) - \alpha_k J'_\beta(\upsilon_k)\right)}{\left(\int_0^T \left[\upsilon_k(t) - \alpha_k J'_\beta(\upsilon_k)\right]^2 dt\right)^{\frac{1}{2}}}, \\ \int_0^T \left[\upsilon_k(t) - \alpha_k J'_\beta(\upsilon_k)\right]^2 dt > r^2 \ for, \end{cases}$$

where $\alpha_k > 0$ is chosen by one of the rules described in [1] §4, p.2 $J'_\beta(\upsilon)-$ is the gradient of the functional (5) and determines

$$J'_\beta(\upsilon) = \psi(x,t;\upsilon) + \beta[\upsilon(t) - \omega(t)]$$

$\psi(x,t;\upsilon)-$ is determines as the solution of the problems (1)-( 3), (5), (6)

$$\frac{\partial^2 \psi}{\partial t^2} = \frac{\partial^2 \psi}{\partial x^2} + (u(x,t;\upsilon) - p(t))\delta(x - x_0)(x,t) \in (0,\ell) \times (0,T), \tag{7}$$

$$\psi(x,T) = 0, \frac{\partial \psi(x,T)}{\partial t} = 0, \ 0 \le x \le \ell, \tag{8}$$

$$\psi(0.t) = 0, \psi(1,t) = 0, \qquad 0 \le t \le T \tag{9}$$

being the adjoint of (1)-( 3), (5), (6).

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# HYBRID NEURO-FUZZY DECISION SUPPORT MODEL FOR SELECTING AI-TOOLS IN PROJECT MANAGEMENT

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The rapid development of Artificial Intelligence (AI) technologies has expanded their application within project management environments. Modern organizations employ AI-based tools to support planning, monitoring, collaboration, and decision-making activities. However, the diversity and functional heterogeneity of available AI solutions complicate the process of selecting tools aligned with established project management frameworks. In practice, project managers often rely on subjective judgment, simplified evaluation criteria, or vendor-driven recommendations.

This study proposes a hybrid neuro-fuzzy decision support model aimed at assessing and predicting the relevance of AI tools to the knowledge areas defined in the Project Management Body of Knowledge (PMBOK). The proposed approach integrates fuzzy clustering, neural network classification, and cognitive interpretation mechanisms. The model combines quantitative prediction with explainable reasoning, thereby supporting informed managerial decision-making.

Recent research highlights the increasing role of AI in enhancing project management efficiency through automation, predictive analytics, and collaboration support [1–3]. Systematic reviews confirm a steady growth of AI adoption across software engineering and project lifecycle phases, emphasizing the strategic importance of intelligent decision support systems [4].

The object of the research is the process of project management under conditions of active integration of artificial intelligence technologies. The subject of the research are models and methods of decision support based on neural networks, fuzzy logic, and cluster analysis applied to the selection and evaluation of AI tools.

The main scientific contributions are:

1. A hybrid model integrating Principal Component Analysis (PCA), Fuzzy C-Means (FCM) clustering, and Multilayer Perceptron (MLP) neural networks for AI tool relevance assessment.
2. An ANFIS-like (Adaptive Neuro-Fuzzy Inference System) interpretation mechanism enabling the transformation of latent technical factors into linguistic decision rules.
3. A cognitively oriented DSS (Decision Support System) concept combining predictive accuracy with explainable reasoning, conceptually aligned with current trends in explainable and LLM-assisted (Large Language Model) DSSs [5, 6].

A dataset comprising 37 AI tools was constructed using Gartner Peer Insights, G2, and vendor documentation. The feature set included functional indicators (automation, analytics, generative capabilities), business parameters (cost, reviews), and quality metrics. Fuzzy C-Means clustering was subsequently performed in the latent feature space.

Cluster validity analysis indicated that a two-cluster structure provides the most stable partition. The identified clusters were interpreted as:

1. Operational-Analytical AI tools for monitoring, automation and integration.
2. Cognitive-Generative AI tools for analytics and content generation.

The study proposes a hybrid decision support architecture in which neural networks ensure predictive scalability, while fuzzy logic provides interpretability. An additional conceptual LLM-based reasoning layer is introduced.

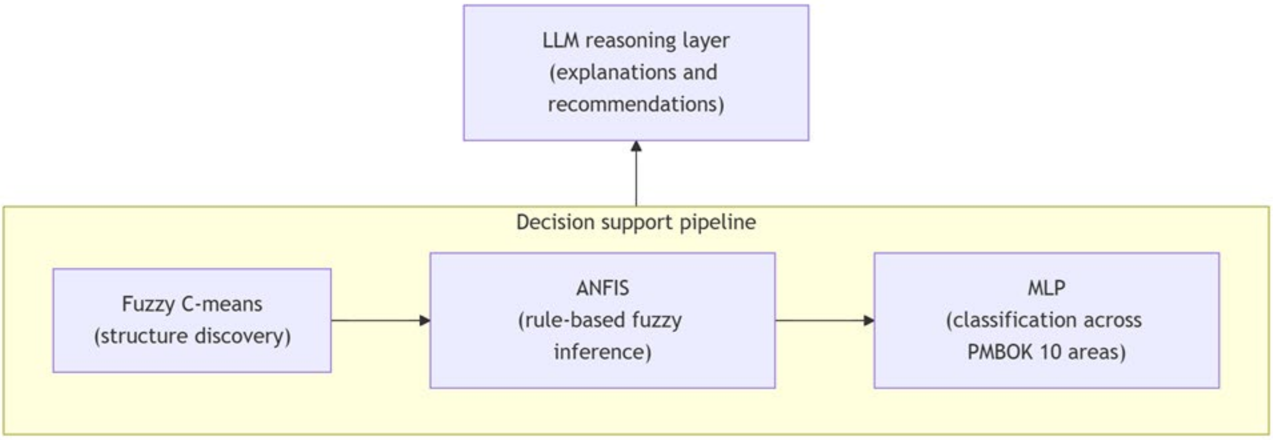


Fig. 1. Hybrid decision support pipeline for selecting AI tools in IT-project management

Formally, this pipeline is defined as $P = \langle X, C, F, M, L \rangle$, where $X$ is the set of project feature input vectors. First, FCM assigns each input vector to multiple clusters with different memberships, $C: X \rightarrow \{C_1, \dots, C_k\}$. Further, clustered data is processed by ANFIS – $F$, formalized by a rule base $R \subseteq U \times V$ and a set of membership functions $\mu: X \rightarrow [0,1]$, which transforms clustered inputs into a fuzzy feature space. Next, MLP is applied – $M: V \rightarrow Y$, where output $Y = \{y_1, \dots, y_{10}\}$ corresponds to the 10 PMBOK knowledge areas. Finally, the LLM-based reasoning layer is applied – $L: Y \rightarrow E$, where $E$ denotes the set of generated explanations and recommendations.

As a result of the study, a three-module decision support system architecture was developed. The architecture integrates an ANFIS-FCM module for fuzzy rule generation and cognitive interpretation, an MLP module for accurate and scalable prediction and an LLM-based reasoning layer for logical explanation and recommendation generation.

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# INTEGRAL APPROACHES TO MANAGING TRANSPORT SYSTEM DEVELOPMENT PROJECTS

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In the context of sustainable development, transport systems must be integrated with environmental, social, and economic objectives, as defined in the United Nations Sustainable Development Goals. This includes emission reduction, optimization of freight delivery systems, and risk management. The contemporary transport sector is undergoing a period of intensive transformation driven by the rapid advancement of digital technologies and the necessity to adapt to the evolving demands of society. In this context, project management in the transport industry faces new challenges that require a revision of traditional approaches to planning and implementing solutions aimed at improving the efficiency of freight delivery systems.

Integrated project management methods, which combine elements of traditional and agile methodologies, represent a promising solution for the transport sector. They enable the preservation of the required level of structural rigor while simultaneously ensuring flexibility and adaptability to change. Traditional project management approaches, focused on detailed upfront planning, often prove inadequate in conditions of rapid technological change in the transport sector, unpredictable regulatory shifts, the need to integrate new digital solutions, increasing sustainability requirements, and the involvement of diverse stakeholders.

Mathematical models for sustainable development in freight forwarding and logistics activities include risk-based models, such as multimodal transport risk models with stochastic parameters [1, 2]. Bifurcation analysis in traffic flow models demonstrates transitions to instability induced by risk parameters [3, 4].

Recent studies in the field of integrated project management in transport emphasize the integration of strategic and project management. For instance, study [5] on integration in transport enterprises highlights the necessity of strategic planning for sustainable operational development.

Integrated project management methods represent a combination of elements from various methodologies adapted to the specific characteristics of a given project or organization. The main types of integrated approaches in managing transport development projects include: phased integration, which involves the application of different methodologies at different project stages, for example, employing a traditional approach for planning freight delivery systems and Agile methods for implementing transport development projects; functional integration, which implies the allocation of methodologies across functional domains of a transport project, such as traditional methods for managing transport infrastructure and Agile approaches for IT components of freight delivery systems; system integration, which focuses on the development of a unified methodology combining elements of various approaches across all aspects of managing freight delivery system development projects.

The integration of transport systems into sustainable development requires a multimodal approach, in which transport is aligned with economic, social, and environmental objectives.

Within the framework of forming an integrated model for transport system development, it is proposed to apply technical criteria (level of compliance with technical requirements, efficiency of technical solutions, degree of innovation adoption in transport system development projects), economic criteria (degree of adherence to the project budget, return on investment in transport system development projects, efficiency of resource utilization), process criteria (level of compliance with project implementation schedules, responsiveness and flexibility to changes, level of information interaction), and project stakeholder criteria (customer satisfaction level, project team engagement level, and the social impact of the project).

The conceptual model of sustainable development in implementing transport system development projects within a risk-oriented approach constitutes an integrated system of interrelated components ensuring a balanced achievement of economic, environmental, and social objectives while minimizing project risks. The model is based on the Triple Bottom Line concept of sustainable development, adapted to the specific characteristics of transport projects, with the integration of risk-oriented management principles across economic, environmental, and social dimensions.

First, optimization of the life cycle of transport system development projects is performed, ensuring the financial sustainability of transport systems, improving resource efficiency, and establishing stable funding sources while accounting for financial risks. Second, the model focuses on minimizing negative environmental impacts, implementing environmentally friendly technologies, reducing greenhouse gas emissions, and managing environmental risks in accordance with the principles of the circular economy within the operation of transport systems. Third, accessibility of transport services is ensured, quality of life is improved, employment opportunities are created, and social risks, including impacts on local communities, are effectively managed.

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# MANAGING PROJECTS IN THE DEVELOPMENT OF MOBILE APPLICATIONS

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Project management as a mobile application involves structured and strategic planning, design, development, and maintenance of digital products that efficiently operate within the means and capabilities. It requires a synthesis between technical know-how, user-centered design principles and rapid management methodologies to ensure the final application is both functional and appealing for its intended audience.

For mobile application project management to bear fruit, goals, requirements and success criteria must be explicit. Given the variety of user groups served by mobile apps and their complex interactions, project managers have to carefully gather and analyze user needs, market trends, and competitive landscapes. The early stages usually include defining user personas, identifying core features – and through prototypes and wireframes shaping product vision for software later down the line. This provides a basis on which technical and commercial objectives can be kept in check throughout the project life cycle.

The management of a mobile app project involves heavy use of iterative development cycles. Agile frameworks such as Scrum, or Kanban can be used to enable work to be sliced into manageable increments, prioritize features based upon their value and refine the product continuously through feedback loops. Short release cycles help verify assumptions early on, recognise usability problems, and when used regularly can allow for the adaptation of development plans as user expectations change or new constraints crop up from platform updates.

Technical issues are a key factor in managing such projects. Choices made about native, cross-platform, or hybrid development have an impact on performance, scalability, and long-term maintainability. Managing project managers need to work closely with technology leads to ensure that architectural decisions are appropriate for the app's purpose and expected user loads-integration with back-end services, API performance, data security and adherence to mobile operating system guidelines are all key aspects of technical design.

The experience of the user is equally important. It becomes a decisive factor for mobile application success. The screen is small and operated by tapping your finger. The interface must be intuitive. It must also respond to the user's input quickly while being easily accessible. In this context, project management means that close collaboration is required among designers, developers and quality assurance engineers, all of whom need to ensure that UI/UX standards are upheld consistently. User tests and usability studies help improve the flow of navigation, give sight precedence over any other measure, and remove friction points from users' journeys. The necessity of quality assurance and risk management in mobile app projects, However, cannot be overlooked. The diversity of devices of all kinds, operating systems with their own special features, screen resolutions that vary widely and hardware configurations that deviate significantly from one another therefore suggest extra layers of complexity. Procedures for testing must include functional tests, performance evaluations, compatibility checks, security advisory statements, as well as real device testing. Effective risk management ensures that problems such as data breaches, bottlenecks in performance or system failures of other kinds will be discovered earlier and resolved ahead of completion before the application is rolled out.

Deployment and management within the mobile app lifecycle are also key to successful projects. Publishing in app stores requires adherence to platform-specific rules, version control and scheduling strategic timing for releases. Post-launch activity includes identifying user feedback, reviewing statistics, rectifying bugs and continuously updating the application to enhance it. Continuous improvement makes sure the app is always competitive yet able to flex with changing user needs and technology trends and that it remains competitive. But really, it is an unchanging fact of mobile applications! In conclusion, project management in the context of a mobile application is a multilayered process. It involves strategic planning, technical decisionmaking and user-centered design with agile thinking as an amalgam. Multidisciplinary teams' coordination, management of risks and the placing members of development groups for maximum effect. Organizations that are able to follow these principles stand a good chance of creating mobile solutions which not only deliver sustainable results and possess technological stakes, but come to influence international standards in a rapidly developing mobile world.

Ultimately, effective project management in the format of a mobile application ensures not only the successful delivery of a functional digital product, but also its long-term relevance, adaptability, and ability to meet the evolving expectations of modern users. By integrating strategic planning, agile development, user-centered design, and continuous improvement practices, organizations can transform a mobile application from a simple technological tool into a sustainable, high-value solution that supports business goals and enhances the overall user experience. This holistic approach strengthens the application's competitiveness on the market and allows it to evolve alongside technological innovations. When managed effectively, a mobile app becomes not just a product, but an adaptable platform capable of continuous growth, user engagement, and long-term impact.

# OPTIMAL CONTROL PROBLEMS WITH VARIABLE STRUCTURE DESCRIBED BY VOLTERRA-TYPE INTEGRAL EQUATIONS

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This thesis addresses an optimal control problem with a variable structure described by Volterra-type integral equations. The research develops mathematical models for systems whose dynamics depend on historical states, emphasizing the construction of optimal control strategies. Analytical methods for solving Volterra integral equations with variable structure are studied, including conditions for existence and uniqueness of solutions. Computational techniques for practical implementation of the proposed control strategies are also discussed. The results provide a theoretical and practical framework applicable to engineering, economics, and other fields involving dynamic systems with memory effects. This work contributes to a deeper understanding of optimal control in complex systems and offers tools for further research and applications.

Suppose that the controlled process is described by two Volterra-type integral equation systems over different time intervals

$$x(t)=\int_{t_0}^{t} f(t,\tau,x(\tau),u(\tau))d\tau, \qquad t\in[t_0,t_1], \tag{1}$$

$$y(t)=\int_{t_0}^{t} g(t,\tau,y(\tau),v(\tau))d\tau + G(x(t_1)), \qquad t\in[t_1,t_2]. \tag{2}$$

Here $f(t,\tau,x,u)$ $(g(t,\tau,y,v))$ – a given n-(m)-dimensional vector function, continuous with respect to all variables along with its partial derivatives with respect to $x(y)$ up to the second order inclusive, $t_0, t_1, t_2$ - are given, $G(x)$ – a given twice continuously differentiable *m*-dimensional vector function, $u(t)$ $(v(t))$ – an r (q) – dimensional piecewise-continuous (with a finite number of first-kind discontinuities) vector of control inputs taking values from a given nonempty and bounded set U (V),

$$\begin{aligned} &u(t)\in U\subset R^r, \qquad t\in[t_0,t_1],\\ &v(t)\in V\subset R^q, \qquad t\in[t_1,t_2]. \end{aligned} \tag{3}$$

We assume that for every admissible control, the system of equations (1)–(2) admits a unique continuous solution.

Let us $T_i\in[t_0,t_1]$, $i=\overline{1,k}$ $(t_0<T_1<T_2<...<T_k\le t_1)$, $\theta_i\in[t_1,t_2]$ $(t_1<\theta_1<\theta_2<...<\theta_k\le t_2)$, $i=\overline{1,k}$ the given points.

On the solutions of the system of equations (1)–(2) generated by all admissible controls, we define a functional.

$$S(u,v)=\varphi_1\left(x(T_1),\dots,x(T_k)\right)+\varphi_2\left(y(\theta_1),\dots,y(\theta_k)\right). \tag{4}$$

Here $\varphi_1(x_1,\dots,x_k)$, $\varphi_2(y_1,\dots,y_k)$ – given twice continuously differentiable scalar functions

This study establishes an analogue of Pontryagin’s maximum principle [1] and subsequently investigates the case of its degeneration. n this context, a modified version of the increment method proposed in [1] and further developed in [2] et al. is employed.

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# INTERCULTURAL COMPETENCE AS AN EFFECTIVENESS FACTOR OF PROJECT TEAM

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In the modern world, where artificial intelligence increasingly takes over routine tasks, the question arises: which skills and abilities make project team members truly indispensable and unique? In addition to technical knowledge, the value of soft skills – abilities based on human experience, intuition, and interpersonal competence – is growing [1]. They not only enhance the effectiveness of team work during project implementation but also give specialists a competitive advantage in the labor market.

Key soft skills necessary for participants in international teams are presented in Table 1. In this context, intercultural competence occupies a special place. It is the ability to interact effectively with representatives of different cultures and is a critical professional skill in a globalized environment. It includes cultural awareness, sensitivity, communication skills, adaptability, respect, and empathy. Project team members should act in an interculturally competent manner, understand the cultural differences of each participant, avoid misunderstandings, and build strong relationships with all stakeholders.

Intercultural competence consists of various components, including empathy; tolerance and openness; communication skills, which imply culturally sensitive, respectful, and clear communication; language competence; self-reflection, or awareness of one’s own cultural influence; flexibility and adaptability; and teamwork and conflict resolution skills, allowing productive collaboration despite differing values and norms.

These competencies are not innate; they can be developed through education, training, and personal experience. Teams formed with cultural diversity have the potential to increase creativity and generate innovative solutions. Diverse experiences and ways of thinking broaden perspectives on contemporary challenges, positively influencing the team’s problem-solving abilities, enhancing project productivity, and overall organizational adaptability. Intercultural competence is especially important in the context of the ongoing military actions in Ukraine, where many specialists are forced to integrate into foreign labor markets. In such conditions, the ability to interact effectively with representatives of different cultures becomes essential for realizing the potential of diverse teams and achieving the strategic goals of organizations.

**Table 1. Key professional competencies and their scientific rationale in project team performance**

| № | Competency | Core Aspects | Scientific Rationale | Project Team Application |
|---|---|---|---|---|
| 1 | Emotional Intelligence | Self-awareness; self-regulation; empathy; social skills | A high level of emotional intelligence enhances interpersonal interaction and team productivity | Ensures effective communication, prevents conflicts, and supports team morale. |
| 2 | Creativity | Thinking outside of the box; generating unconventional ideas; willingness to experiment; interdisciplinarity | Creativity is key for innovation processes, enabling the development of new approaches and solutions to complex problems | Promotes idea generation, process optimization, and innovative solutions within the project |
| 3 | Critical Thinking | Information analysis; source evaluation; rational approach; evidence-based decisions | Ensures accurate assessment of information and improves decision-making based on facts | Helps objectively evaluate project data, make informed decisions, and minimize risks |
| 4 | Adaptability | Openness to new experiences; positive attitude towards change; lifelong learning | Enables effective responses to technological and social changes | Provides flexibility in managing project changes and rapid adaptation to new conditions |
| 5 | Communication skills | Persuasiveness; active listening; nonverbal communication; transparency | Facilitates conflict avoidance, increases work productivity, and improves collaboration quality | Ensures clear information exchange, reduces misunderstandings, and improves team coordination |
| 6 | Teamwork | Team orientation; constructive conflict resolution; responsibility | Enables achieving collective goals, effective task distribution, and enhances group performance | Supports interaction among team members, ensures collective task completion, and achieves shared collective results |
| 7 | Leadership Competencies | Leading by example; motivational abilities; decision-making skills | Contributes to organizational stability, boosts team motivation, and enhances decision-making quality | Helps coordinate team work, motivate participants, and make timely project decisions |
| 8 | Intercultural Competence | Openness and respect; adaptability to cultural context; cultural awareness | Ensures effective interaction in a globalized environment and minimizes cultural misunderstandings | Promotes productive collaboration among team members with diverse cultural backgrounds, strengthening team |

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# FEATURES OF KNOWLEDGE MIGRATION IN MARITIME INDUSTRY PROJECT TEAMS UNDER CONTEMPORARY CONDITIONS

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Knowledge migration within maritime project teams is becoming increasingly crucial amid globalisation, digitalisation, and dynamic changes in the global economy. The maritime industry is characterised by high technological complexity, the international nature of its activities, and the need to adhere to strict safety standards, making knowledge transfer and preservation crucial to the successful implementation of projects.

Unlike land-based industries, maritime teams face unique challenges, including prolonged physical separation, limited communication windows at sea, and the critical nature of decisions where errors can result in catastrophic consequences [1]. Furthermore, the transition to green technologies and alternative fuels necessitates rapid knowledge acquisition and dissemination across geographically dispersed teams.

To understand the mechanisms of knowledge migration in this industry, it is advisable to use an adapted version of the SECI (Socialisation, Externalisation, Combination, Internalisation) knowledge spiral that accounts for the specificities of the maritime environment (Fig.1).

***Socialisation*** involves transferring tacit knowledge through observation and joint practice [2]. In the maritime industry, this occurs through joint watches where junior officers observe experienced captains, mentoring during complex manoeuvres, simulator training, and informal crew exchanges. Critical elements include intuitive understanding of vessel behaviour, quick decision-making skills, and equipment expertise that are difficult to formalise.

***Externalisation*** transforms tacit knowledge into an explicit form, which is essential given high staff turnover [3]. This includes incident documentation, procedure checklists, Lessons Learned reports, video instructions, digital knowledge bases, and navigation charts. International conventions (STCW, ISM Code) reinforce documentation standards.

***Combination*** systematises explicit knowledge from multiple sources. Maritime projects integrate operational data across fleets, compile cross-project reports, establish corporate standards, implement cloud-based document management, develop Best Practices databases, and create digital vessel twins. Digitalisation enables Big Data analytics and decision-support systems.

***Internalisation*** converts formalised knowledge into practical expertise through simulator training, studying STCW procedures, structured onboarding programmes, supervised application of instructions, and ISM Code training. Effectiveness depends on quality externalisation – better formalised procedures enable faster learning and integration.

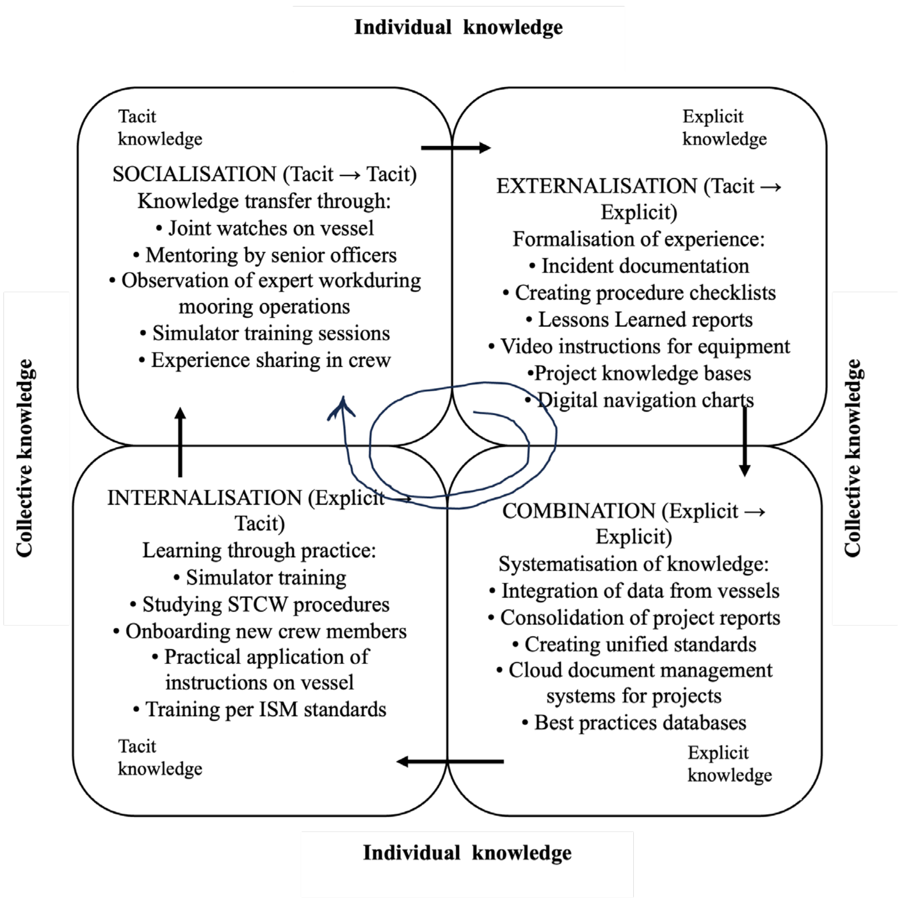


Fig. 1. Knowledge migration spiral in maritime project teams

The SECI knowledge spiral provides a comprehensive framework for managing knowledge migration in maritime project teams. Each stage addresses specific industry challenges: geographical dispersion, crew rotation, multicultural environments, and regulatory requirements. Successful knowledge migration requires systematic attention to all four stages, supported by digital technologies and an organisational culture that values continuous learning.

The cyclical nature of the SECI model is particularly relevant for maritime operations, where knowledge must continuously evolve through repeated iterations as crews rotate, technologies advance, and operational contexts change.

As the maritime industry undergoes ecological transformation and technological advancement, effective knowledge migration becomes a key competitive advantage, enabling organisations to preserve expertise, accelerate adaptation, and maintain safety standards in increasingly complex operational environments.

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# A PRIVACY-PRESERVING BLOCKCHAIN ARCHITECTURE FOR DISTRIBUTED MANAGEMENT SYSTEMS

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Modern supply chain management systems increasingly adopt distributed architectures to improve transparency, integrity, and trust among participants. Blockchain technology provides a solid foundation for such systems; however, conventional consensus mechanisms are associated with high computational overhead, energy inefficiency, and limited data confidentiality. These challenges are especially critical for small and medium-sized enterprises (SMEs) with constrained computational and financial resources. At the same time, the intrinsic properties of blockchain systems, such as immutability and public verifiability, complicate regulatory compliance and the protection of commercially sensitive information [1–6]. Recent studies therefore emphasize privacy-by-design approaches that integrate cryptographic primitives, including zero-knowledge proofs, secure multi-party computation, and homomorphic encryption, into blockchain architectures in order to enable verifiable privacy-preserving computing [1–3].

This paper proposes a private, dockerized blockchain architecture for supply chain management that integrates the Proof of Friendship (PoF) consensus mechanism with Zero-Knowledge Proofs (ZKP). PoF extends Proof of Stake by incorporating socially oriented trust metrics into the validator selection process. Instead of relying solely on financial stake, validators are evaluated using a composite trust factor derived from their historical transaction success rate and geographic distribution, which discourages regional monopolization, promotes consistent participation, and reduces the risk of validator centralization. By ranking validators according to this trust factor and limiting the number of active participants, PoF reduces synchronization overhead and computational load, making it suitable for SME-oriented blockchain deployments.

To preserve data confidentiality while maintaining auditability, the proposed architecture integrates Zero-Knowledge Proof mechanisms. Confidential transaction data are processed off-chain by a dedicated ZK-Prover module deployed as a Docker container, which generates succinct cryptographic proofs, such as zk-SNARKs. These proofs are verified on-chain via a smart contract, while only the verification results are stored in the distributed ledger. This approach mitigates transaction correlation and metadata leakage risks commonly associated with transparent blockchain systems and aligns with architectural patterns based on consent-aware access control, channelized ledgers, and regulatory-compliant data governance [5], [6]. Evidence from high-load domains, including healthcare, IoT, and federated learning–based decision support systems, confirms that similar hybrid architectures can significantly reduce latency and energy consumption without compromising confidentiality [1], [4], [7].

The solution is implemented as a dockerized private blockchain system that supports modular deployment and seamless integration with existing enterprise infrastructures. The architecture separates request routing, transaction mediation, blockchain interaction, and cryptographic proof generation into isolated components coordinated by a mediator server, preventing sensitive data from being stored in plaintext on the ledger and limiting attack surfaces. Simulation-based evaluation demonstrates that the proposed approach significantly reduces vulnerability to Sybil attacks and validator centralization through trust-based selection, while overall transaction latency is primarily influenced by validator synchronization rather than ZKP overhead due to off-chain proof generation. The system achieves stable throughput suitable for private supply chain applications.

The results indicate that integrating Proof of Friendship with Zero-Knowledge Proofs enables a resource-efficient, privacy-preserving blockchain architecture that enhances cybersecurity and data confidentiality while maintaining acceptable performance. The proposed approach is well suited for SME-oriented supply chain management systems and provides a foundation for further research on trust-aware and privacy-preserving distributed management platforms.

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# BEHAVIORAL COMPETENCIES IN HIGH-STRESS SITUATIONS

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For Ukrainian PMs, the full-scale invasion by the Russian Federation became a factor that added military and infrastructure risks directly affecting the basic needs, safety, and daily performance of the team to the usual professional stressors (lack of time, budget, changing requirements, stakeholder conflicts). According to an analytical report by the Verkhovna Rada of Ukraine on IDP employment, as of mid-2024, there were 4.7 million internally displaced persons in Ukraine, and more than 2 million of them were of working age [1]; at the same time, some IDPs needed employment and turned to employment centers. These statistics matter for the project environment because they show the scale of migration and shifts in staff availability, while official reports from the Ministry of Social Policy indicate that as of the end of 2024, about 4.6 million IDPs were registered in Ukraine and more than 6.8 million Ukrainians remained abroad [2], which for PMs translates into a sustained reality of distributed teams, time-zone gaps, uneven stress exposure, and legal/domestic/resource constraints that must be managed as a new normal rather than exceptions.A separate powerful stress multiplier of war is energy instability. An official statement by the Cabinet of Ministers of Ukraine noted that as a result of a series of massive enemy attacks on the power system, more than 9 GW of capacity was lost [3]. For project management, this is not just an «inconvenience» but a systemic risk: unstable connections, disruptions in synchronous communications, the inability to work within the usual time frames, and a drop in the throughput of approval and quality control processes. In such conditions, PMs are forced to design their teams' work to be resistant to interruptions: with backup channels, asynchronous protocols, and planning in «short sprints of productivity».

In everyday practice, war adds a number of stress factors to PM that go beyond classic «project pressure». For PM in Ukraine, these are primarily security interruptions, alarms, and shelling, as well as the need to simultaneously organize work and maintain life support (heat, power, internet). For PMs «in Ukraine», this means managing a team where some members are periodically forced into survival mode (searching for heat/power/communication), and the manager has to quickly reconfigure the plan without destroying trust or creating guilt for «inefficiency». For PMs abroad, the stress profile is different, for example, adapting to a new social and legal environment, restoring basic stability (housing, documents, family work, school/kindergarten for children), as well as anxiety for loved ones in Ukraine. At the same time, the PM's responsibility as a leader does not disappear: on the contrary, there is a growing need for clear communication, empathy, and process discipline, as the team works in heterogeneous conditions and has various limitations. That is why the topic of anti-crisis PM logically focuses on behavioral competencies, which in a crisis determine not only the psychological climate, but also the speed of decision-making, the quality of coordination, and the ability of the team to remain operational.

The IPMA ICB competency system (People Competencies) [4] separately highlights the elements of self-reflection and self-management, communication, leadership, teamwork, as well as conflict and crisis management competencies. These competencies are most «vulnerable» to the effects of high stress, and the military context exacerbates both acute (incidental) and chronic (background) stress. From a scientific point of view, this is to be expected: review and experimental studies show that acute stress can impair decision-making and lead to less advantageous choice strategies [5]. More recent data also describe acute stress as being associated with impaired working memory, cognitive flexibility, and planning – functions that are directly at the heart of PM activities (prioritization, testing assumptions, plan restructuring, and compromise coordination) [6]. It is also important to note that the combination of stress and time pressure can lead to a decline in the quality of decisions – a typical situation for crisis «windows» when teams have little time, incomplete data, and a high cost of error.

At the behavioral level, this often looks like this: (1) self-management «slips» due to sleep disturbances, overload, and anxiety, and PM begins to make decisions reactively; (2) communication becomes either too directive or too vague – both options undermine transparency and trust; (3) leadership shifts from service-oriented to controlling, which increases tension and conflict; (4) conflict management becomes more difficult because people have less «emotional resources» for compromise. In project studies, PM emotional intelligence is associated with better project performance (including through mechanisms of commitment and quality of interaction), making EI an important anti-crisis resource [7]. In addition, empirical work in the International Journal of Project Management shows that psychological distress among employees can negatively affect project success [8].

This leads to the practical conclusion that anti-crisis PM must simultaneously manage the project and maintain people's working capacity. This means that «war-induced stress» must be integrated into management as a separate class of risks: security risks, energy and communication gaps, forced displacement, uneven availability of participants, emotional exhaustion. Since these factors are recurring, they must be reflected in the risk register, communication rules, and «process architecture» (asynchrony, redundancy, clear escalation channels).

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# METHODS AND MODELS OF COLLABORATIVE BUSINESS INTELLIGENCE

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The increasing complexity of contemporary business environments necessitates advanced approaches to collective decision support and knowledge management. Modern decision-making processes require not only access to reliable analytical data but also mechanisms that expand contextual understanding through collaboration among users, systems, and intelligent agents. Numerous studies confirm that Business Intelligence (BI) technologies enhance decision quality by transforming raw data into actionable knowledge [1]. At the same time, vast volumes of routine, user-generated information are continuously produced in social networks, online platforms, and thematic communities. Although such data are inherently fragmented and weakly structured, their aggregation and semantic interpretation constitute a critical foundation for Collaborative Business Intelligence (CBI).

This study focuses on the development of methods and models for collaborative BI, emphasizing the formalization of collaboration within analytical processes rather than domain-specific optimization. The main scientific contribution of the work is the design of a multi-agent collaborative BI framework that integrates collective intelligence principles, knowledge graphs, OLAP-based analytical models, and large language model (LLM)–based agents to support decision-making for non-professional users. The tourism domain is employed as a case study for prototyping and experimental evaluation, due to its high data heterogeneity, intensive use of unstructured content, and dynamic decision-making context [2].

Collaboration in decision support systems is analyzed through the perspectives of Collaborative Business Intelligence, collective intelligence, and crowdsourcing. CBI is considered an evolution of traditional BI that enables cooperative execution of analytical tasks and knowledge sharing across organizational and user boundaries, forming a virtual collaborative analytical space [1]. Collective intelligence emerges when coordinated contributions from multiple participants and intelligent agents lead to analytical outcomes that exceed individual capabilities. Crowdsourcing complements this paradigm by enabling large-scale acquisition of distributed knowledge through open participation mechanisms supported by digital platforms and social technologies [3].

Despite the increasing adoption of CBI solutions in various industries, their application in domains oriented toward non-professional users remains limited. Existing systems are often focused on technically skilled analysts and depend heavily on the continuous availability of human experts, which constrains scalability and accessibility. Similar limitations have been identified in collaborative medical decision-support systems, where the absence of specialists can significantly reduce system effectiveness [4].

To address these challenges, the proposed framework incorporates LLM-based agents acting as virtual collaborators within the CBI process. These agents support semantic interpretation of user intents, automated generation of analytical queries, and validation of results against a graph-based knowledge base. A multi-stage self-verification mechanism is introduced to improve the reliability of automatically generated Cypher queries by ensuring their syntactic and semantic consistency with the structure of the knowledge graph [5]. This approach reduces the dependence on human experts while maintaining analytical accuracy.

From a theoretical standpoint, the framework formalizes: (1) a collaborative multi-agent model for query generation and validation over a knowledge graph, (2) a graph-based recommendation model that exploits semantic relationships between business entities, and (3) a feedback-driven knowledge acquisition model that captures user interactions with the system. These interaction traces form the foundation of the knowledge graph and enable continuous enrichment of the system's collective intelligence. Experimental results obtained in the tourism case study confirm the feasibility and robustness of the proposed approach, while the core models and methods remain domain-independent and applicable to a wide range of collaborative decision-support scenarios.

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# INFORMATION SUPPORT FOR DECISION MAKING IN ASSIGNING IT PROJECT TEAM MEMBERS

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***Introduction***. The modern IT industry is characterized by a shift from single-project management to concurrent multi-project environments. In practice, software companies frequently manage multiple projects with shared, limited resources, leading to competition for qualified personnel. The Software Multi-Project Scheduling (SMPS) problem involves assigning employees to tasks across various projects to optimize objectives such as duration, cost, and resource utilization [1].

Effective resource management is widely recognized as a critical factor for project success, particularly in the processes of estimating and acquiring resources [2]. A key challenge in this domain is ensuring that the assignment of team members aligns with both the project schedule and the organizational constraints. Ineffective distribution leads to resource bottlenecks, where some teams are overloaded while others remain idle, ultimately causing project delays and budget overruns.

***Relevance and Problem Statement***. The problem of distributing IT projects among development teams is complicated by the need to balance competing resource demands. Traditional manual allocation based on subjective managerial experience is often time-consuming and prone to errors. Recent studies indicate that integrating AI-based optimization methods with Project Management Information Systems (PMIS) can significantly reduce planning time and operational costs [3]. However, existing Decision Support Systems (DSS) rarely provide comprehensive integration of flexible organizational structures with advanced optimization techniques, such as Genetic Algorithms or Machine Learning ensembles, for effective team formation [4]. Furthermore, decision-making in this area is often complicated by uncertainty regarding project start times and the availability of specific competencies [5]. Therefore, the development of models and methods that support decision-making in such complex multi-project environments represents a relevant and timely scientific challenge.

The aim of the research is to enhance the efficiency of IT project management by developing a DSS for the distribution of projects among development teams, considering modern organizational approaches and industry standards. To achieve this aim, an analysis of multi-project environment features and risk assessment processes was conducted, which allowed for the identification of potential bottlenecks and resource constraints.

Based on these findings, the team formation process has been formalized through the development of a mathematical model for assigning executors to development teams. The model defines team formation criteria, including platform compatibility, application domain, and technology stacks, as well as operational constraints such as project deadlines, budget limitations, and team workload balance. The objective functions are focused on optimizing team composition, skill complementarity, and overall resource utilization in IT projects [6].

In addition, standard project management principles have been systematically integrated into the team formation decision-making model. These principles cover resource availability, levels of competence, role suitability, and experience matching, ensuring that all assignments comply with established industry best practices and organizational standards, and provide a practical framework for effective team management [2].

Given the NP-hard nature of the team formation and scheduling problem in multi-project environments, meta-heuristic and data-driven optimization approaches have been investigated. In particular, the applicability of Genetic Algorithms, Random Forest models, and their hybrid combinations has been analyzed to obtain near-optimal team formation solutions under conditions of uncertainty and dynamically changing project parameters [3,4].

***Conclusion***. The proposed research addresses the critical issue of development team formation and allocation in multi-project software development environments. By integrating structured team formation approaches, standard project management methodologies, and modern optimization algorithms, the developed information support methods will enable IT companies to improve the effectiveness of team composition, ensure balanced utilization of development teams, and reduce project planning time. The further research focuses on analyzing the risks associated with development team formation and assignment, taking into account the qualification and competencies of individual developers. This includes identifying potential bottlenecks, skill mismatches, and uncertainties related to project start times, workloads, and employee availability, as well as organizational, technical, and human-related risks.

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# COMBINED METHOD OF DIAGNOSING CONFLICT IN IT PROJECT

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Projects in the field of information technology (IT), as a form of project activity, are characterized by a high level of dynamics, dependence on human resources and constant active interaction of human resource elements. In such environment, conflicts are almost inevitable. They can arise due to limited resources, differences in work styles, priorities or approaches to task performance, etc. Untimely identification of conflicts leads to missed deadlines, increased costs and even the loss of key specialists.

General approaches to conflict management involve the following stages [1, 2]:

diagnosing conflicts; assessing the functional orientation of conflicts; preventing or stimulating conflict; regulating conflict; resolving conflict.

The process of diagnosing a conflict is a type of activity of a management entity aimed at identifying the causes of a given conflict [1, 2]. Diagnosing a conflict consists in identifying the specifics of the contradiction and the intentions of its participants, in determining the criteria for resolving the conflict with the maximum possible satisfaction of the interests of the conflicting parties [3]. It can be preventive, that is, it involves analyzing the situation in the project and identifying the possibilities of conflict situations, as well as clarifying the nature and main consequences of potential conflicts. Then, at the stage of diagnosing conflicts, the occurrence of conflicts is predicted and their possible consequences are assessed. In this case, diagnosis is a component of conflict prevention, which is most appropriate in the case of dysfunctional conflicts, when the energy and resources of the parties are spent on achieving goals that are incompatible with the goals of the project.

The developed combined method of diagnosing conflicts in IT projects allows obtaining a systemic and process understanding of conflict situations in an IT project and consists of the following stages:

– «Collection and analysis of data on the interaction of human resource elements» (stage 1);

– «Description of conflict subjects» (stage 2);

– «Determination of the structural components of the conflict in the IT project and modeling of the general conflict model» (stage 3);

– «Determination of the type of conflict and the level of the manager for diagnosis» (stage 4);

– «Investigation of the causes of the conflict in the IT project» (stage 5);

– «Assessment of the depth of the conflict2 (stage 6);

– «Determination of the conflict stage» (stage 7);

– «Modeling of the dynamic conflict model» (stage 8).

At stage 1, signs of conflict are monitored in order to predict possible conflicts. As part of the monitoring, it is proposed to combine expert interviews with methods of questioning IT project participants to identify emotional conflicts.

The main goal of stage 2 is to systematize information about the conflict participants in the IT project, which was obtained at the previous stage. At this stage, the SWOT analysis technique is used, which allows you to describe the strengths and weaknesses of the conflict subjects, as well as identify opportunities and threats that affect the development of the conflict situation. The description of the conflict subjects is formed on the data collected during the previous stage. This description of the subjects will allow you to clearly outline the object and subject of the conflict, understand the motives and positions of each party, the level in the hierarchy of the organization's structure. The description also allows you to form an idea of the subjective image of the conflict in the eyes of its participants in order to model the general structure of the conflict in the IT project.

At stage 3, the components of the general structural scheme of the conflict in the IT project are described, which is a necessary condition for its further diagnosis. The main elements of the model are the subjects (parties of the conflict), the object, the subject, the image, the motives, the positions of the conflict, the stage of the IT project life cycle, as well as the escalation time.

At stage 4, the type of conflict is determined by different managers based on the classification results, taking into account the peculiarities of the hierarchy of these managers in the IT project.

Stage 5 consists in determining the causes of the conflict, which is formed after modeling the general scheme of the conflict, according to the criterion of the peculiarities of the IT project participant.

Stage 6 consists in assessing the depth of the conflict according to the selected parameters and calculating the value of the quantitative assessment of the depth level (unit of measurement – points).

At stage 7, the stage at which the diagnosed conflict is located is determined based on the results of measuring the depth level.

At stage 8, a conflict depth model and a conflict development model are developed. Based on these models, the type of conflict is determined.

The combined method of diagnosing conflicts provides a comprehensive approach to the analysis of conflict situations, as it allows you to form both a structural model of the conflict (with the definition of the parties to the conflict, the object, the subject of the conflict, the stage of the IT project life cycle, positions, image, motives and time), and a model of its dynamics, which reflects the sequence of stages of conflict development. This approach allows not only to accurately identify the type of conflict, but also to predict its course, which significantly increases the effectiveness of conflict management in IT teams.

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# HYBRID MODELING METHODOLOGY FOR PREDICTING RISKS IN EMERGENCY MANAGEMENT

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In the contemporary era, global climate change and rapid urbanization have complicated the dynamics of emergency situations. Reports from the UNDRR and IPCC indicate a rise in hydrometeorological events and large-scale fires. Traditional research utilizes deterministic methods based on physical laws (Drysdale, 2011) or stochastic methods based on historical data. However, deterministic models often treat variable parameters (wind, humidity) as constants, failing to reflect real-world randomness. Conversely, statistical methods struggle to predict unique events. This necessitates the development of hybrid models that integrate physical laws with probabilistic calculations for real-time risk assessment.

The proposed methodology integrates the deterministic heat conduction equation with stochastic modeling of environmental uncertainties. *Deterministic Component:* The fundamental process of heat transfer in a combustible object is described by the parabolic partial differential equation:

$$\rho C_o \frac{\partial T(x,t)}{\partial t} = \frac{\partial}{\partial x}\left(k \frac{\partial T(x,t)}{\partial x}\right) + Q_{general} \qquad (1)$$

The boundary condition at the external surface (x=0) accounts for radiative $q''_{rad}$ and convective $q''_{conv}$ heat fluxes. Convective heat transfer is defined as $q''_{conv} = h_c(T_{env} - T_{surf})$, where $h_c$ is the heat transfer coefficient.

*Stochastic Component:* To model uncertainties, environmental parameters are treated as random variables. Wind speed v is modeled using the Weibull distribution (Carta et al., 2009), while ambient temperature $T_{env}$ follows a Gaussian distribution.

*Monte Carlo Simulation:* A computational experiment was conducted using Python (NumPy, SciPy). The algorithm involves:

1. Input: Defining material properties, geometric dimensions, and fire scenarios.
2. Sampling: Generating 10,000 random samples for wind speed and temperature based on their respective probability distributions.
3. Iterative Calculation: Solving the heat conduction equation for each iteration using the Finite Difference Method (FDM) to determine the time to failure $t_{fail}$.
4. Analysis: Constructing the Cumulative Distribution Function (CDF) and analyzing «Tail Risk.»

The experiment simulated a fire incident in an industrial zone. *Static vs. Probabilistic Approach:* Under average deterministic conditions $v_{mean} \approx 7.5$ m/s, $T_{mean}$

= 30°C, the calculated failure time was 1470 seconds (24.5 minutes). This static value is typically used for evacuation planning. However, the hybrid model revealed that failure time is a stochastic quantity ranging from 15 to 45 minutes.

- Mean time: 25.1 minutes.
- 95% Confidence Interval: 18.5 – 32.3 minutes.
- Tail Risk: In approximately 5% of simulations, the object failed in less than 18 minutes.

The discrepancy between the static prediction (24.5 min) and the worst-case scenario (<18 min) highlights the danger of relying solely on deterministic models. The hybrid model identifies critical risks that traditional methods miss.

*Physical Interpretation:* A counter-intuitive correlation was observed: higher wind speeds were associated with delayed failure times. Physically, while wind increases flame spread, in this specific tank heating scenario, strong wind enhanced convective cooling ($h_c$), mitigating the radiative heat load.

The research confirms that hybrid modeling successfully combines the accuracy of physical equations with the comprehensiveness of stochastic methods. While the static model predicts a 24.5-minute safety window, the hybrid model reveals a 5% probability of failure within 18 minutes. Identifying this «Tail Risk» is crucial for saving lives. The methodology offers a more realistic tool for dynamic risk assessment in emergency management.

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# INTEGRATING AI INTO JIRA USING JIRA API

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Agile project management relies heavily on accurate task estimation to support effective sprint planning. By embedding AI-driven insights into the planning process, teams can improve estimation consistency, reduce planning overhead, and enhance overall project transparency.

Jira was chosen as a platform of choice for major companies. Current Jira API doesn't provide sufficient possibilities to implement complex logic. The only solution is to use a dedicated server. Jira will communicate with it using HTTPS (Fig. 1).

Tikhonov regularization was chosen because of it's advantages in highly correlated data. Confusion matrix shows good performance (Fig. 2).

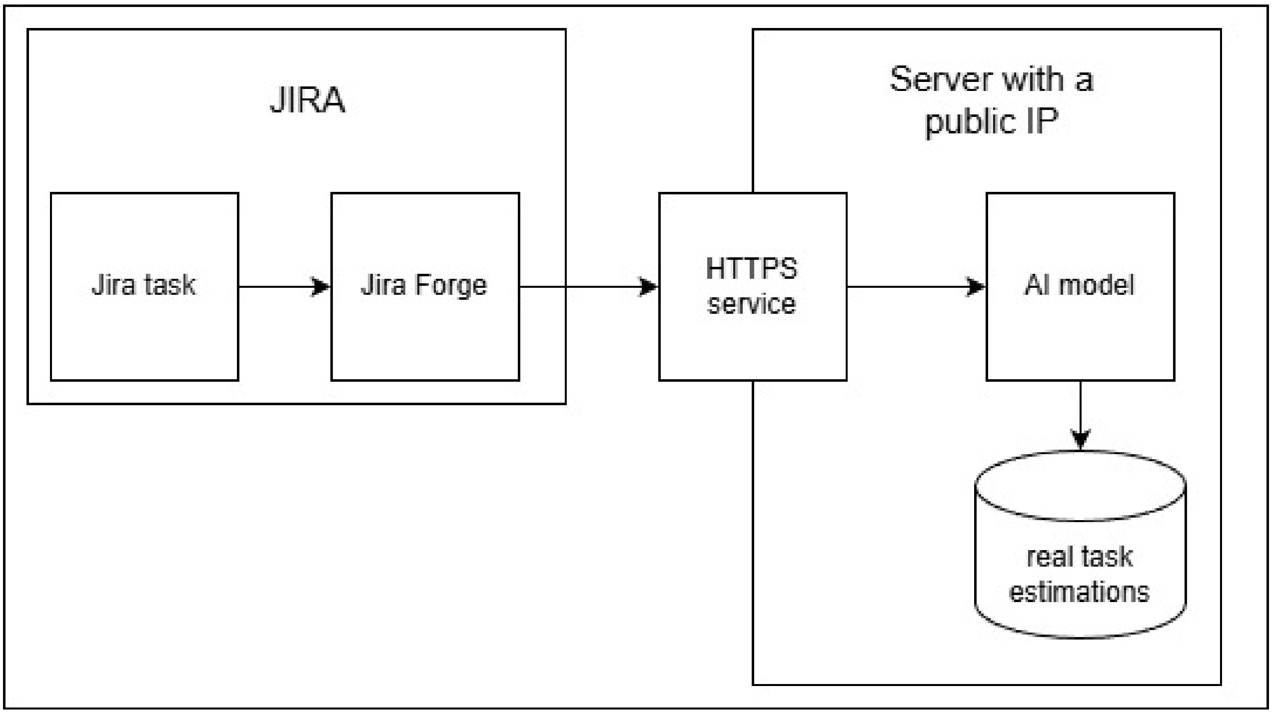


Fig. 1. System architecture

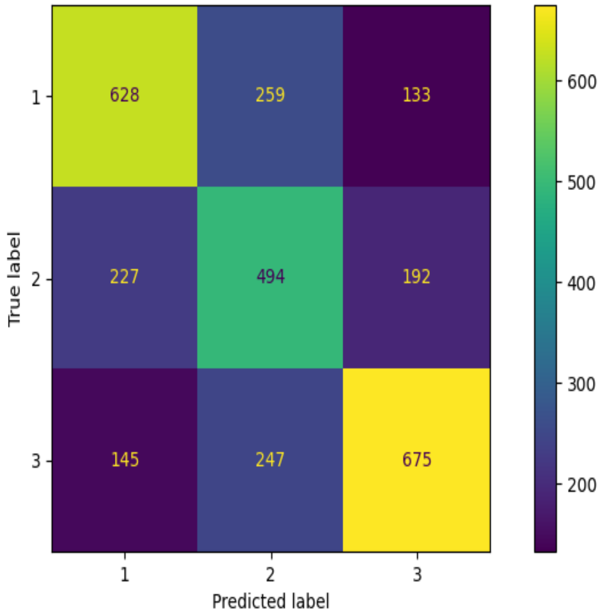


Fig. 2. Confusion matrix

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# TOWARDS THE DEVELOPMENT OF A METHOD FOR MANAGING TIME LOSS RISKS IN IT PROJECTS BASED ON MODELING THE TEAM'S COGNITIVE PROFILE

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The current state of the software development industry is characterized by a rapid shift toward Agile methodologies which, despite their flexibility, introduce specific challenges to professionals' intellectual productivity. One of the most acute contradictions lies in the conflict between the high intensity of team communications and the need for developers to remain in a state of deep, sustained concentration for extended periods of time. Traditional project management approaches often overlook the fact that each interruption of the workflow triggers complex cognitive recovery mechanisms that require substantial time resources. This paper is devoted to substantiating a method that enables these losses to be quantitatively assessed through the lens of the team's cognitive profile as a dynamic project resource.

The central idea of the study is the introduction and formalization of the concept of cognitive viscosity, which was examined in detail in [1] in the context of optimizing Agile team management. Cognitive viscosity is defined as a characteristic that describes the difficulty of returning a specialist to the execution of a complex intellectual task after an external distraction. This metric serves as the foundation for calculating the so-called cognitive debt – the accumulated risk of time losses arising from the continuous fragmentation of the working day. This debt is not a static quantity; it grows dynamically depending on the frequency of interruptions and the depth of task immersion, creating a hidden time deficit that cannot be detected by standard task-tracking tools.

The method is grounded in the understanding that every interruption – whether a message in a messenger or an unplanned meeting – disrupts the current mental model of the task. Restoring this model requires a «warm-up» period of approximately 10 to 15 minutes; however, this duration is not fixed. It depends directly on individual cognitive viscosity and the current complexity of the context. The mathematical core of the proposed approach makes it possible to transform these delays into concrete metrics that can be integrated into the overall graph of project dependencies. This enables a shift from subjective observations of team fatigue to precise forecasting of the risk of missed deadlines, while accounting for the probabilistic nature of intellectual labor.

The distinctive scientific contribution of this work lies in the analysis of cascade effects arising from cognitive losses. When a developer involved in implementing a mission-critical module is subject to frequent external interruptions, their individual cognitive debt increases, leading to shifts in the completion timeline of the associated task. Due to the presence of structural dependencies within the project graph, such delays propagate to related tasks, causing enforced idle time for other team members awaiting the results of that work. As a consequence, the cost of a single interruption becomes multiplicative, creating a systemic threat to the successful execution of the sprint. The application of the concept of cognitive viscosity enables the early identification of such «bottlenecks» at the moment they emerge, thereby shifting risk management from a reactive to a preventive mode.

An important aspect of the modeling process is the consideration of secondary or derivative risks that arise as a response to accumulated cognitive debt. When a team attempts to compensate for time lost due to distractions, it typically resorts to intensifying work or ignoring certain quality standards, which leads to an increase in technical debt. This creates a vicious cycle: cognitive fatigue degrades the quality of decisions, and correcting errors requires new cycles of concentration that are once again interrupted. The method allows this destructive dynamic to be detected at an early stage, providing management with objective data on when additional pressure on the team will lead only to product degradation rather than to faster delivery.

The practical significance of the proposed method lies in establishing a scientific foundation for the implementation of adaptive management decisions. Unlike classical monitoring approaches, this method relies on leading risk indicators. Based on a probabilistic model, the management system can automatically recommend measures of «cognitive quarantine», involving the temporary restriction of non-priority communications for key specialists at moments of highest risk. This not only helps stabilize project schedules but also prevents professional burnout, which is often the result of prolonged work under conditions of high cognitive viscosity and constant context switching.

In conclusion, integrating cognitive characteristics into IT project management systems makes it possible to transform the development process into a more predictable and resilient mechanism. An understanding of the nature of cognitive losses and the use of formalized metrics—such as cognitive debt and the cost of interruption – provide managers with an objective tool for protecting the team's intellectual resources. This ensures high quality of the final product and adherence to schedules in the dynamic environment of Agile development, grounded in a deep analysis of the relationship between communication noise and individual professional productivity.

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# КОНЦЕПЦІЯ КОМП'ЮТЕРНОЇ МОДЕЛІ ПІДТРИМКИ УПРАВЛІННЯ ТРАНСКОРДОННИМИ ПРОЄКТАМИ У СФЕРІ БЕЗПЕКИ

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Реалізація транскордонних проєктів у сфері безпеки ґрунтується на багаторічному досвіді міжнародного співробітництва, що охоплює програми прикордонної взаємодії, спільні інфраструктурні ініціативи, гуманітарні та безпекові проєкти, а також проєкти з підвищення стійкості регіонів. Практика транскордонного співробітництва свідчить, що ефективність таких проєктів значною мірою залежить від здатності учасників координувати дії між різними інституціями, оперативно обмінюватися інформацією та адаптувати управлінські рішення до змін зовнішнього середовища [1].

В умовах воєнного стану зазначені проблеми набувають ще більшої актуальності, оскільки до традиційних викликів додаються фактори безпекової нестабільності, логістичних обмежень, кадрових втрат та підвищених ризиків для інфраструктури [2].

Авторами у роботах [3, 4] виявлено системні проблеми у сфері транскордонного співробітництва, що пов'язані із недостатньою формалізацією параметрів проєктної діяльності та обмеженими можливостями адаптації управлінських рішень до динамічних змін зовнішнього середовища.

Саме тому метою цього дослідження є формування концепції комп'ютерної моделі підтримки управління транскордонними проєктами у сфері безпеки.

Авторами пропонується комп'ютерна модель підтримки управління транскордонними проєктами у сфері безпеки, яка ґрунтується не на простому переліку вхідних змінних, а на формуванні логічно узгодженої структури параметрів, яка відображає як внутрішні процеси управління, так і вплив зовнішніх загроз та ризиків [1]. Сама модель повинна забезпечити автоматизацію аналітичних розрахунків, сценарне моделювання та підтримку прийняття рішень у складному безпековому середовищі у режимі реального часу. Архітектура комп'ютерної моделі побудована за багаторівневим підходом і включає вхідний, обчислювальний та вихідний функціональні рівні (табл. 1).

Таблиця 1 – Архітектура комп'ютерної моделі підтримки управління транскордонним проєктом

| **Рівень моделі** | **Функціональне призначення** | **Основні елементи** |
|---|---|---|
| I. Вхідний (Input level) | Формування початкових даних і параметрів моделі | Базові параметри проєкту ($F_0$, $T_0$, $L_0$, $H_0$, $N_0$, $Tech_0$), ризики ($R_i$), коефіцієнти чутливості, вагові коефіцієнти |
| II. Обчислювальний (Processing level) | Реалізація математичної та аналітичної обробки | Аналітичні функції параметрів, цільова функція O, модуль чутливості $S_i$, сценарний модуль |
| III. Вихідний (Output level) | Формування результатів і управлінських рекомендацій | Інтегральний показник ефективності, рейтинг ризиків, рекомендації з оптимізації, сценарні результати |

Наведена структура (табл. 1) забезпечує логічний поділ процесів введення даних, аналітичної обробки інформації та формування результатів для підтримки управління.

Функціональна реалізація моделі здійснюється через систему взаємопов'язаних блоків (рис. 1), що формують замкнений цикл процесу підтримки управління транскордонними проєктами.

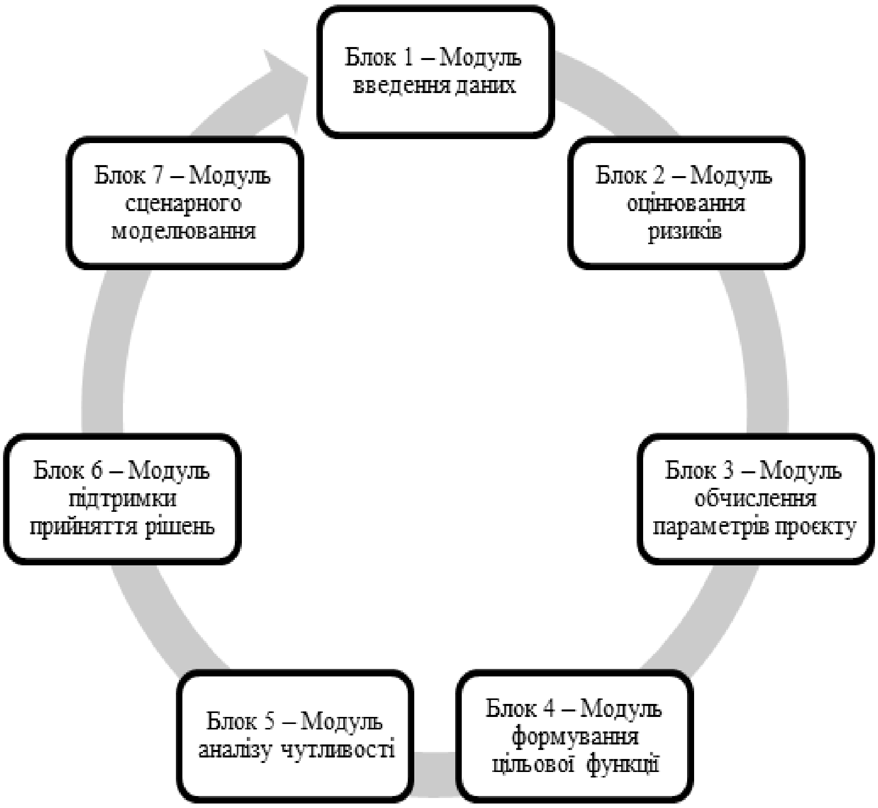


Рис. 1. Процес підтримки управління транскордонними проєктами

Таким чином, запропонована концепція комп'ютерної моделі створює основу для побудови цифрової системи підтримки управління транскордонними проєктами у сфері безпеки, та дозволить підвищити адаптивність управлінських рішень та забезпечити ефективну реакцію на динамічні загрози безпекового середовища.

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# ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ОСВОЮВАННЯ СВЕРДЛОВИН ВИСНАЖЕНИХ ГАЗОКОНДЕНСАТНИХ РОДОВИЩ

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Для отримання вуглеводнів із газоконденсатних свердловин їх освоюють після закінчення буріння, після завершення капітального ремонту або після самоглушіння через накопичення рідини. Від ефективності освоювання залежить продуктивність свердловин. Так, за умови неякісного освоювання спостерігають дебіт газу, менший від очікуваного. Значний перепад тиску між трубним та затрубним простором може свідчити про наявність рідини на вибої, тому виникає потреба повторно освоювати такі свердловини. Отже, щоб якісно освоїти свердловини, потрібно проаналізувати багато чинників, що дасть змогу забезпечити очікуваний видобуток вуглеводнів.

Сьогодні широкого вжитку набуло освоювання газоконденсатних свердловин за допомогою колтюбінгової установки. Під час освоювання свердловин по безмуфтових довгомірних трубах, які опускають у внутрішню порожнину колони ліфтових труб можуть подавати різні хімічні реагенти, в тому числі розчин поверхнево-активної речовини (ПАР) із азотом. Також, залежно від різних чинників, на свердловинах для отримання позитивного результату з освоювання, окрім колтюбінгової установки додатково застосовують й іншу техніку.

З літературних джерел [1, 2] відомо, різні технології освоювання свердловини. Проте, не завжди під час застосовування будь-якої технології можна отримати позитивний результат.

Одним із важливих чинників отримання позитивного результату освоювання свердловин є значення пластового тиску, оскільки під час розробляння газоконденсатних родовищ на виснаження пластовий тиск природно знижується. Через це на свердловинах знижуються експлуатаційні параметри (робочий тиск, дебіт газу).

У роботі [3] розглянуто практичний досвід освоювання свердловин Юліївського нафтогазоконденсатного родовища (НГКР), яке розробляють на виснаження.

Свердловину 77 Юліївського НГКР освоювали, послідовно замінюючи рідину глушіння в свердловині на рідину меншої густини, тобто закачуючи воду і періодично подаючи вибухобезпечну газову суміш від пересувної азотної компресорної станції. За цих умов знижувався гідростатичний тиск завдяки заміщенню стовпа рідини водно-газовою сумішшю. Для видалення рідини із свердловини в затрубний простір закачували 10 % розчин ПАР за допомогою насосного агрегату та продували трубний простір.

Відомо, що приплив вуглеводнів з пласта починається за умови, коли тиск стовпа рідини у свердловині буде менший від пластового тиску. З наведеного вище видно, що для освоювання свердловини 77 Юліївського НГКР використовували розчин ПАР, що дало змогу покращити винесення стовпа рідини із свердловини.

Досліджено ефективність освоювання свердловин виснажених газоконденсатних родовищ пінами. Фахівці проаналізували наявні технології освоювання свердловин. Розробили пристрій для освоювання свердловин піною. Від ефективності роботи пристрою для освоювання свердловин залежить якість піни та, відповідно, отримання флюїду з продуктивного горизонту.

Ефективним інструментом дослідження характеристик багатофазних потоків у різних елементах газопровідних систем є CFD моделювання. CFD моделювання дає розуміння складної динаміки руху багатофазних потоків елементами газопровідних систем, різним технологічним обладнанням. Щоб вирішити задачу дослідження ефективності роботи пристрою для освоювання свердловин піною було вибрано програмний комплекс скінчено-елементного аналізу ANSYS Academic 2021 R2.

Виконано CFD моделювання роботи пристрою для освоювання свердловин піною. Досліджено вплив масової витрати водного розчину на вході в пристрій на розподіл об'ємних часток газової і рідинної фази, якість піни. За результатами досліджень характеристики потоку в пристрої (розподілу швидкості, тиску) встановлено закономірності процесів формування піни. На основі двох розроблених методик проведено експериментальні дослідження та отримано збільшення видобутку.

Оскільки, багато газоконденсатних родовищ в Україні виснажені, тому для отримання позитивного ефекту із освоювання свердловин потрібно застосовувати оптимальні методи, які ґрунтуються на моделюванні та експериментальних дослідженнях.

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# ПОТЕНЦІАЛ ПРОЄКТНОГО МЕНЕДЖЕРА ЯК ЧИННИК СТРАТЕГІЧНОЇ СПРОМОЖНОСТІ ПРОЄКТНО-ОРІЄНТОВАНИХ ОРГАНІЗАЦІЙ

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У сучасних умовах зростання невизначеності, технологічних змін та турбулентності зовнішнього середовища проєктно-орієнтовані організації дедалі частіше розглядаються як ключовий механізм реалізації стратегічних цілей. Управління портфелями, програмами та проєктами в таких організаціях виходить за межі технічного планування і дедалі більше залежить від людського чинника, зокрема від ролі та можливостей проєктного менеджера.

Традиційно ефективність діяльності проєктного менеджера оцінюється через призму компетенцій – знань, навичок та досвіду, необхідних для виконання професійних функцій. Водночас у контексті проєктної діяльності, що здійснюється в умовах тимчасових організаційних структур, високої динамічності та невизначеності, такий підхід має певні обмеження і не дозволяє повною мірою оцінити здатність менеджера до розвитку, адаптації та виконання складніших стратегічних ролей у майбутньому.

У наукових дослідженнях відсутнє єдине концептуальне бачення поняття «потенціал менеджера проєкту». Низка авторів трактують потенціал як можливість майбутнього розвитку, або здатність до виконання складніших управлінських ролей. Так, Silzer та Church (Silzer & Church, 2009) визначають потенціал, як здатність до успішного виконання більш складних ролей у майбутньому, акцентуючи увагу на когнітивних здібностях, мотивації та адаптивності. Водночас цей підхід орієнтований переважно на прогноз кар'єрного зростання і недостатньо враховує контекст проєктної діяльності. Філософські та лексикографічні підходи Ж. Рей-Дебов та А. Рея (Rey-Debove & Rey, 2009), розглядають потенціал як «віртуальну можливість», що може бути реалізована за відповідних умов, однак не пропонують інструментів практичної операціоналізації цього поняття. Інші дослідники звужують потенціал до поведінкових, або «м'яких» характеристик, що перебувають у латентному стані, ігноруючи когнітивні та структурні компоненти.

Окремі дослідження вказують на зв'язок між креативним потенціалом проєктів та внутрішньою мотивацією менеджерів проєктів (Войтушенко, 2019), однак такі підходи, як правило, не формують цілісного бачення потенціалу менеджера як багатовимірної конструкції. (Войтушенко А. А., 2019). Окрему групу становлять компетентнісні підходи Р. Бояциса, PMI (Boyatzis, 1982), PMI, 2024). у межах яких потенціал фактично ототожнюється з уже сформованими управлінськими компетенціями та результативністю діяльності. Такий підхід є цінним для оцінки поточної готовності менеджера, проте не дозволяє виявити його приховані можливості та здатність діяти в нових або ускладнених проєктних умовах.

Узагальнення наукових підходів свідчить, що більшість із них зосереджуються, або на окремих складових потенціалу, або на його результативних проявах, що обмежує можливості цілісного розуміння потенціалу проєктного менеджера.

На відміну від операційного менеджменту, де діяльність відбувається в межах стабільних процесів і повторюваних структур, управління проєктами здійснюється в умовах тимчасовості, міждисциплінарності та високого рівня невизначеності. У таких умовах ключового значення набувають не лише наявні компетенції, а й внутрішня готовність менеджера до навчання, прийняття рішень в умовах неповної інформації, лідерського впливу та адаптації до змін.

Сучасні дослідження підтверджують трансформацію професійного профілю проєктного менеджера. Так, за результатами бібліометричного аналізу Rastovski та ін. (Rastovski et al., 2024) наголошують на зростаючій ролі поведінкових компетенцій, емоційного інтелекту та технологічної адаптивності. У межах даного дослідження ці елементи розглядаються не як статичні навички, а як вектори реалізації потенціалу менеджера проєкту.

Практичне підтвердження цих тенденцій знаходимо у звітах Project Management Institute «Pulse of the Profession 2025», де, поряд із традиційними компетенціями, акцентується увага на стратегічному мисленні, лідерстві, бізнес-орієнтованості та цифровій гнучкості. Аналіз змісту таких вимог дозволяє інтерпретувати їх як структурні складники професійного потенціалу, що забезпечують здатність менеджера створювати цінність у складному та мінливому проєктному середовищі.

Потенціал не функціонує як ізольована характеристика, а проявляється через сформовані компетенції, поведінкові патерни та результати професійної діяльності. У межах наукового аналізу компетенції доцільно розглядати як операційний рівень прояву потенціалу проєктного менеджера. Водночас потенціал є ширшою, інтегральною та динамічною категорією, що відображає здатність менеджера до розвитку, адаптації та виконання стратегічних ролей у майбутньому. Таке розмежування дозволяє поєднати компетентнісний підхід із дослідженням потенціалу в системі управління портфелями, програмами та проєктами проєктно-орієнтованих організацій.

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# ЦИФРОВА ВТОМА ТА КОГНІТИВНЕ ПЕРЕВАНТАЖЕННЯ МЕНЕДЖЕРІВ ПРОЄКТІВ

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Незаперечним є той факт, що управління проєктами в компанії сьогодні вже не є просто процесом планування та чіткого виконання послідовності дій, а стратегічною функцією, змушеною адаптуватися до постійних змін [Raja, M. V., 2025)]. Прискорення цифрової трансформації, розширюючи управлінські можливості, зробила роботу керівників проєктів надзвичайно динамічною, але й одночасно вразливою до явищ цифрової втоми та когнітивного перевантаження.

Постійна присутність в онлайні, безперервні повідомлення, багатозадачність і зростання темпу інформаційних потоків призвели до того, що проєктні менеджери опинилися в ситуації, коли технологічна ефективність почала знижувати психічну стійкість.

Сьогодні керівники проєктів орієнтуються в численних каналах зв'язку, цифрових інструментах та проєктах, що дублюються, часто без належного часу на відновлення. Це середовище сприяло цифровій втомі, яка характеризується емоційним та фізичним виснаження, що виникає внаслідок тривалої взаємодії з цифровими інструментами, тоді як когнітивне перевантаження виникає, коли вимоги до обробки інформації перевищують обсяг робочої пам'яті [Pasha, M. A et al., 2025].

Основні причини цифрової втоми та когнітивного перевантаження можна підсумувати наступним чином:

1) інформаційна гіперпродуктивність – надлишок даних без часу на осмислення та на рефлексію;
2) перемикання контексту – часті переходи між паралельними проєктами або інструментами комунікації;
3) постійна онлайн-доступність і мультизадачність формують стан «always-on» та розмиті межі між професійним та особистим часом;
4) технологічна надмірність – одночасне використання кількох інформаційних платформ;
5) культура терміновості – очікування миттєвої реакції від керівників.

Психологічні наслідки:

– втрата фокусування, змінює сприйняття користувацького досвіду – цифрові інтерфейси здаються складнішими, увага розсіюється, а продуктивність знижується;

– зниження здатності до прийняття рішень і підсилення відчуття фрагментованості мислення.

Для вирішення зазначених проблем у фокусі керівників має бути сучасна трансформація: від техностресу до цифрової гігієни.

Менеджер майбутнього це не той, хто реагує на кожне повідомлення, а той, хто здатен усвідомлено керувати власною увагою, встановлюючи чіткі межі між цифровою взаємодією і мисленнєвим відновленням. На рисунку представлено концептуальну схему добробуту проєктного менеджера, що відображає ключові напрями підтримки психологічного, когнітивного та організаційного добробуту менеджерів проєктів у цифрову епоху.


Рис. Схема добробуту проєктного менеджера

Добробут керівника проєкту сьогодні – це не лише відсутність стресу, а системна здатність керувати власною увагою, командною енергією та технологічним середовищем.

Цифрова втома та когнітивне перевантаження, які є побічними ефектами цифровізації, стають дзеркалом нової парадигми управління: проєктний менеджмент стає наукою про увагу, енергію та межі. Керівники, які оволодіють практиками когнітивної гігієни, зможуть перетворити технологічне перевантаження на конкурентну перевагу – створюючи команди, що мислять глибше, а не працюють швидше.

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# ВИКОРИСТАННЯ НЕСТРУКТУРОВАНИХ ДАНИХ ДЛЯ АНАЛІЗУ ТЕНДЕНЦІЙ ПРОЕКТНОГО СЕРЕДОВИЩА

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Використання великих даних (Big Data) у процесі аналізу тенденцій проєктного середовища є важливим чинником підвищення ефективності управління проєктами в сучасних умовах зростаючої складності та мінливості ринку. Обґрунтовані управлінські рішення потребують своєчасного доступу до достовірної, повної та структурованої інформації щодо ресурсів, ризиків, термінів виконання і результативності проєктів тощо. Аналіз великих масивів даних дає змогу виявляти приховані закономірності, прогнозувати розвиток проєктного середовища та адаптувати стратегії управління відповідно до актуальних тенденцій, що в підсумку сприяє підвищенню прозорості, керованості та результативності проєктної діяльності загалом.

Великі дані (Big Data) – це масив структурованої або неструктурованої інформації, що має великі обсяги, оновлюється і накопичується з різних джерел одночасно. Ця інформація занадто швидко зростає і є різнотипною, тому її досить важко обробляти за допомогою традиційних методів. Під терміном «великі дані» також розуміють сукупність методів, інструментів і програмних рішень, які забезпечують збір, зберігання, обробку та аналіз великих обсягів різнотипних даних в реальному часі. За походженням, це дані які находять з різних джерел (соціальних мереж, мобільних пристроїв, сенсорів, вебсайтів, електронних банківських транзакцій, медичних записів, GPS тощо). Основна складність опрацювання цих даних полягає у потребі коректного виявлення достовірних закономірностей, які використовуватимуться для прийняття управлінських рішень.

Традиційно Big Data описують моделлю «5V»: 1) Volume (*обсяг*) – великий обсяг інформації, який накопичується в реальному часі; 2) Velocity (*швидкість*) – постійний і високий темп надходження даних; 3) Variety (*різноманітність*) – структуровані, напівструктуровані та неструктуровані формати даних (тексти, відео, зображення, сенсорні сигнали тощо); 4) Veracity (*достовірність*) – потреба перевірки і фільтрації даних, щоб усунути хибні висновки; 5) Value (*цінність*) – корисність та аналітична цінність даних.

Окрім того, складність опрацювання таких обсягів інформації також зумовлена ступенем їх структурованості (Structured Data). Структуровані дані мають чітку впорядкованість, зберігаються у таблицях, рядках і стовпцях (SQL), де кожен елемент має певний тип – число, дата, текст тощо. Напівструктуровані дані (Semi-Structured Data) – мають певну організацію, але без чіткості упорядкування: структура є, але вона відрізняється для різних записів. Напівструктуровані дані використовують теги, або ключі для опису відповідних значень (JSON, XML, логи серверів, конфігураційні файли, API-відповіді тощо). Неструктуровані дані (Unstructured Data) – не мають фіксованого формату, або моделі (це все разом – текст, зображення, відео, аудіо, контент соціальних мереж тощо).

Оскільки саме неструктуровані дані сьогодні складають 80-90% усієї генерованої інформації то і методика її коректного опрацювання носить практичну цінність для формування рекомендацій виробникам та сервісним підприємствам (рис.).

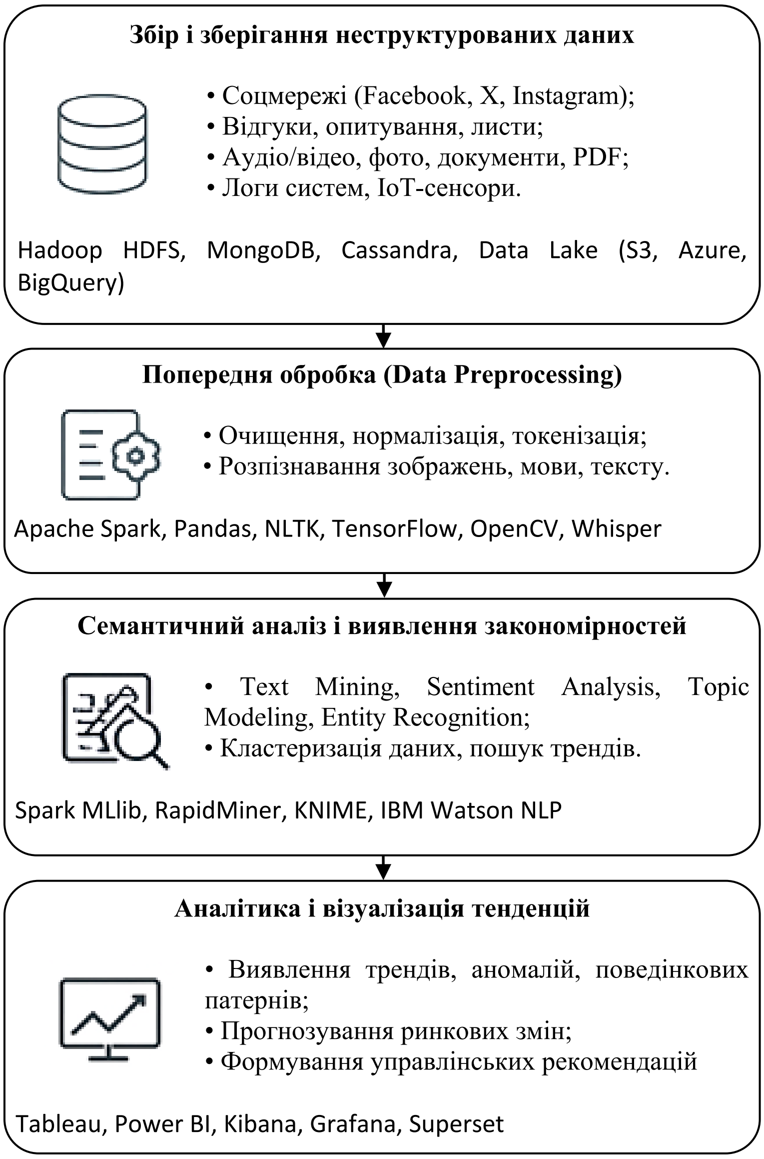


Рис. Методика опрацювання неструктурованих даних в управлінські рішення

Отже, технологія Big Data формує вагомий вплив у сучасному бізнес-управлінні, оскільки дає змогу перетворювати переважно неструктуровані дані на практичні знання для ухвалення рішень. Особливе значення мають інструменти, орієнтовані на опрацювання цих даних. Завдяки сучасним IT-рішенням, таким як Hadoop, Spark, Python-бібліотеки, Power BI, Tableau чи Grafana, можна швидко перетворювати «сирі» дані на структуровану аналітику, відстежувати зміни та прогнозувати ризики, а відтак підвищувати ефективність рішень

# УПРАВЛІННЯ ЗМІНАМИ ВИМОГ БЕЗ «SCOPE-CREEP» У ІТ-ПРОЄКТАХ

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Обґрунтовано підхід до керування змінами вимог, який поєднує політику приймання змін, дисципліну Request for Comments (RFC) для обговорення та Architecture Decision Record (ADR) для фіксації рішень, інтеграцію зі «воротами» Definition of Ready (DoR) / Definition of Done (DoD) у керованому workflow та опору на централізовану базу знань Single Source of Truth (SSoT). Показано, як такий контур зменшує невизначеність, стримує «scope creep» без зайвої бюрократії й дозволяє вимірювати ефект через процесні індикатори та метрики DevOps Research and Assessment (DORA).

У підході до ризиків «scope creep» виникає як наслідок невизначеності щодо цілей: вимоги розширюються без синхронної корекції ресурсів, строків та критеріїв приймання, що призводить до відхилень за часом і якістю. Тому першим принципом стає інтеграція управління ризиками в повсякденні процеси: зміни повинні мати передбачуваний вхід, зрозумілі ролі й прозорий моніторинг рішень – від моменту ініціації до оновлення плану та специфікацій. Такий підхід узгоджується з логікою стандарту ризик-менеджменту, де організація інформаційних потоків і комунікацій розглядається як спосіб зменшення невизначеності [1].

Сучасний погляд на проєктний менеджмент підкреслює, що «менше – краще», якщо правила зрозумілі: політика змін описує, хто ініціює, хто оцінює вплив і хто затверджує, але уникає надлишкових пунктів і перехресних погоджень. Зміщення PMBOK Guide (сьома редакція) від жорстких процесів до принципів і доменів ефективності підсилює акцент на залученні стейкхолдерів, системному мисленні, якості та адаптивності – це і є підставою для «легковагової» гавернанс-оболонки над змінами [2].

Дисципліна RFC/ADR забезпечує трасованість рішень без «паперової» інертності. RFC (Request for Comments) – короткий документ-пропозиція: контекст, варіанти, вплив, ризики, план змін і вікно для зворотного зв'язку. Після обговорення ухвалене рішення фіксується у стислому ADR (Architecture Decision Record): одна картка – одне рішення з наслідками та критеріями перегляду. Розділення «де ми обговорюємо» (RFC) і «що саме вирішено» (ADR) знімає плутанину, дає історію вибору альтернатив і дозволяє швидко повертатися до аргументації, коли контекст змінюється.

Щоб рішення не «зависали» в абстракції, вони повинні матеріалізуватися в беклозі й у керованому workflow. Погоджена зміна вимог перетворюється на епік або історії з оновленими Acceptance Criteria, а переходи в трекері зв'язуються з «воротами» DoR/DoD: елемент не стартує без посилання на відповідний RFC/ADR та заповненого контексту (DoR), а завершення інкремента можливе лише за умов виконаних перевірок, тестів, безпекових контрольних пунктів і супровідної документації (DoD). Мінімалістичні, але однозначні стани та «ворота» знижують варіативність ручних кроків і створюють відтворюваність дій команди [3].

Комунікаційна архітектура має прибирати «сірі зони» відповідальності. На практиці зручно застосовувати розкладку ролей на основі підходу DACI: Driver готує RFC, Approver ухвалює рішення, Contributors надають експертизу, Informed отримують підсумок; це спрощує ескалацію, забезпечує одну «крапку затвердження» і зменшує ризик «другого прихованого апрувера». Для зовнішніх і внутрішніх аудиторій варто стандартизувати повідомлення про зміни (короткий опис, вплив, план, терміни, посилання на артефакти), що різко зменшує кількість уточнюючих запитів [4].

Баланс між гнучкістю та передбачуваністю підтримується ритмом і кордонами. «Вікна приймання змін» – фіксовані проміжки, коли команда розглядає й затверджує RFC – дисциплінують ініціаторів і захищають час зосередженої роботи. «Заморозка змін» на критичних відтинках (фініш ітерації, підготовка до релізу) дозволяє приймати лише безпекові/регуляторні винятки з чіткими критеріями; решта переноситься у найближче «вікно». У сумі це знижує переривання та допомагає тримати фокус спринту.

Ефект варто робити видимим через поєднання процесних і результатних показників. До процесних належать частка змін, що пройшли повний цикл RFC→ADR; медіанний час до рішення; частка задач, що стартували з виконаним DoR; частка інкрементів, що виконали DoD без доопрацювань. До результатних належать метрики DORA: Lead Time for Changes (час від коміту до продакшну), Deployment Frequency (частота постачань), Change Failure Rate (частка постачань із регресією/відкатом), Time to Restore (час відновлення). Відстеження бази до впровадження, а потім динаміки протягом кількох ітерацій дозволяє побачити, як процес змін впливає на стабільність постачання.

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# АЛГОРИТМІЧНИЙ СИНТЕЗ ІГРОВИХ РІВНІВ ІЗ КОНТРОЛЕМ ЯКОСТІ: ПІДХІД CHUNK-BASED PCG ДЛЯ ENDLESS RUNNER

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Процедурна генерація контенту (Procedural Content Generation, PCG) у мобільних іграх жанру endless runner є актуальною науково-прикладною тематикою, оскільки поєднує питання алгоритмічного синтезу ігрових середовищ, проєктування інтерактивних систем і забезпечення якості користувацького досвіду. Специфіка жанру полягає в тому, що ігровий процес ґрунтується на сталому базовому ігровому циклі (безперервний біг із перешкодами), водночас потребуючи постійного відчуття новизни; за його відсутності реіграбельність і показники утримання користувача знижуються. Суто ручне створення значного обсягу ігрового контенту для підтримання різноманітності вимагає істотних ресурсів розробки та не гарантує сталого результату: зростає ризик повторюваності, «вичерпання» контенту й погіршення показників утримання користувачів. У контексті мобільного ринку, де продукт часто розвивається через регулярні оновлення, PCG виступає раціональним підходом до масштабування контенту без лінійного зростання витрат.

Ключова проблематика процедурної генерації в endless runner полягає у суперечності між варіативністю та керованістю. З одного боку, генератор має забезпечувати достатню різноманітність ситуацій, мінімізуючи передбачуваність і одноманітність. З іншого боку, генерація не може бути довільною, оскільки гра висуває строгі вимоги до прохідності, сприйманої справедливості та прогнозованого темпу зростання складності. Некоректне налаштування генератора може призводити до непрохідних комбінацій перешкод, неприйнятних «піків» складності, різких змін темпу, а також сценаріїв, що сприймаються гравцем як несправедливі (зокрема, через недостатній час на реакцію або практично неминучі зіткнення). Отже, актуальність теми визначається не лише економічною доцільністю PCG, а насамперед потребою в методах, що дають змогу формалізувати обмеження та забезпечити відтворювану якість генерованого контенту.

Практично придатним і поширеним підходом для мобільних endless runner ігор є chunk-based генерація, за якої ігровий рівень формується з наперед підготовлених модульних фрагментів – «чанків». Кожен модуль має стандартизовані точки входу/виходу та визначені структурні характеристики (тип перешкод, щільність об’єктів, очікуваний темп, допустимі параметри стрибка/прискорення тощо). Такий підхід є компромісом між повністю процедурною генерацією та ручним дизайном: він зберігає художній і геймдизайнерський контроль на рівні модулів і водночас забезпечує комбінаторне зростання кількості можливих трас. Водночас у межах chunk-based PCG залишається центральне науково-інженерне завдання:

сформулювати правила сумісності модулів і ймовірнісні ваги вибору так, щоб статистично стабільно керувати складністю, мінімізувати повторюваність і не порушувати прохідність.

Перспективним напрямом дослідження є розроблення процедур верифікації та балансування генератора. Це включає формалізацію обмежень (зокрема, прохідності як сукупності геометричних і часових умов), побудову правил стикування чанків, а також застосування метрик якості генерації: частоти повторів, розподілу перешкод за типами, середньої тривалості забігу, імовірності «смерті персонажа» на окремих ділянках, часу на реакцію, показників плавності зростання складності. Практично доцільним є поєднання перевірки інваріантів (constraint checking) для відсікання непрохідних конфігурацій із багатократними автоматизованими прогонами генератора та статистичним аналізом результатів для виявлення систематично «проблемних» переходів між модулями. Принципово важливим є перехід від суто ручного тестування до системного контролю якості на основі симуляцій і автоматизованих тестів, що дає змогу виявляти дефектні або несправедливі комбінації на етапі налаштування правил і ваг.

Окремої уваги потребує керування складністю як функцією часу або дистанції. Пропонується задавати «криву складності» (difficulty curve), яка параметризує цільові значення щільності перешкод, частоти пасток і середнього часу на реакцію на різних етапах забігу. Відповідно, вибір чанків може підпорядковуватися не лише правилам сумісності, а й цільовому профілю: на початку домінують навчальні та перехідні сегменти, у середині – більш насичені, а в пізній фазі – сегменти з комбінованими перешкодами. Для зменшення повторюваності доцільно застосовувати механізми анти-повтору: коротку пам'ять останніх N модулів із забороною повторів у вікні або динамічне зниження ваги для щойно використаних чанків. Додатковим засобом підвищення різноманітності можуть бути контекстні модифікатори — зміна візуального оформлення та дрібних параметрів (наприклад, розташування бонусів) без модифікації базової геометрії, що зменшує суб'єктивне відчуття повторюваності при повторному використанні модуля.

Отже, процедурна генерація контенту в endless runner є актуальною тематикою не лише через підвищення реіграбельності, а й через наявність чітко формалізованих проблем: забезпечення керованої варіативності, запобігання непрохідним і несправедливим конфігураціям, вимірювання якості генерованого контенту та організація процесу його балансування. Реалізація chunk-based PCG у середовищі Unity дає змогу продемонструвати повний цикл розробки – від моделювання структури модулів і правил поєднання до побудови інструментів тестування й оцінювання якості, що робить тему релевантною як для наукових публікацій з інтерактивних систем, так і для інженерних робіт, орієнтованих на відтворюваність і стабільність результату

# МОДЕЛЮВАННЯ ПРОЦЕСІВ ПОШУКОВОЇ ОПТИМІЗАЦІЇ ВЕБРЕСУРСІВ НА ОСНОВІ ІНТЕЛЕКТУАЛЬНИХ МЕТОДІВ

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Сучасні алгоритми пошукових систем базуються на багатофакторних моделях ранжування, які поєднують не лише технічні характеристики вебресурсів, якість і структуру контенту, поведінкові сигнали користувачів, а також семантичну релевантність пошукових запитів. За таких умов ефективність пошукової оптимізації визначається не окремими параметрами, а сукупністю взаємопов'язаних факторів та характером їх впливу на результати ранжування. Традиційні SEO-підходи, що ґрунтуються на евристичних правилах і ручному аналізі окремих показників, не забезпечують формалізованого врахування цих взаємозалежностей, що ускладнює об'єктивне оцінювання ефективності оптимізації та знижує точність прогнозування результатів у динамічному та швидкому пошуковому середовищі. У межах дослідження запропоновано підхід до моделювання процесів пошукової оптимізації вебресурсів як багатокритеріальної системи з взаємопов'язаними факторами, у якій інтелектуальні методи аналізу поєднуються з формалізованими процедурами прийняття рішень. Основний акцент зроблено на інтеграції результатів машинного навчання та обробки природної мови в єдину систему кількісного оцінювання ефективності SEO-стратегій.

Застосування інтелектуальних методів, зокрема машинного навчання та обробки природної мови, дозволяє автоматизувати аналіз великих масивів різнорідних даних і підвищити достовірність оцінювання SEO-факторів. Методи машинного навчання використовуються для аналізу поведінкових показників, моделювання динаміки органічного трафіку, виявлення прихованих закономірностей у взаємодії користувачів із вебресурсами та прогнозування змін ефективності оптимізації. Методи обробки природної мови забезпечують семантичний аналіз текстового контенту, кластеризацію пошукових запитів, визначення пошукових намірів користувачів і оцінювання відповідності контенту інформаційним потребам аудиторії. Поєднання цих підходів формує основу для побудови гібридних інтелектуальних моделей пошукової оптимізації, орієнтованих на контекст і поведінкові характеристики.

Для формалізованого оцінювання ефективності SEO-стратегій у роботі застосовано методи мультикритеріального прийняття рішень DEMATEL, DANP і VIKOR. Метод DEMATEL використовується для виявлення причинно-наслідкових зв'язків між технічними, контентними, поведінковими та семантичними факторами пошукової оптимізації, що дозволяє визначити структуру їх взаємного впливу та ідентифікувати домінуючі чинники. На основі отриманих зв'язків методом DANP обчислюється відносна вагомість критеріїв з урахуванням їх мережевої взаємозалежності. Подальше застосування методу VIKOR забезпечує формування інтегрального показника ефективності та компромісне ранжування альтернативних стратегій оптимізації з урахуванням загальних і часткових відхилень критеріїв.

Результати аналізу свідчать про домінуючу роль зовнішніх чинників оптимізації, зокрема якості зворотних посилань і соціальних сигналів, у формуванні ефективності пошукового просування. Технічні та контентні параметри виявляють переважно результуючий характер і значною мірою залежать від змін у зовнішньому інформаційному середовищі та поведінкових характеристиках користувачів. Отримані результати підтверджують доцільність використання гібридного інтелектуального підходу для моделювання процесів пошукової оптимізації вебресурсів. Поєднання методів машинного навчання, обробки природної мови та мультикритеріального аналізу забезпечує більш об’єктивне оцінювання ефективності оптимізаційних стратегій порівняно з традиційними евристичними підходами та створює основу для підвищення адаптивності SEO-процесів, зменшення впливу суб’єктивних рішень і формування обґрунтованих рекомендацій в умовах динамічних змін алгоритмів пошукових систем.

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# ЗАСТОСУВАННЯ МЕТОДУ АНАЛІЗУ ІЄРАРХІЙ ДЛЯ ВИБОРУ ІНСТРУМЕНТІВ ПІДВИЩЕННЯ КОНВЕРСІЇ

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E-commerce працює в умовах високої конкуренції, тому навіть невелике підвищення конверсії на етапі оплати дає відчутний ефект у доході. Однією з найпоширеніших причин втрат є «покинутий кошик», коли користувач додає товари й переходить до оформлення замовлення, але не завершує оплату. На цю поведінку впливають як технічні фактори (помилки, швидкодія, платіжні методи), так і поведінкові (довіра, сприйняття ціни, відсутність терміновості) [1]. На практиці застосовуються різні інструменти повернення користувача до покупки (нагадування, тригерні листи, push, знижки тощо), однак їх ефективність відрізняється залежно від сегмента, а надмірна інтенсивність комунікацій підвищує ризик негативної реакції та відписок. Це робить задачу вибору інструмента багатокритеріальною і потребує формалізованого підходу.

***Метою дослідження*** **є** обґрунтування підходу до вибору інструментів підвищення конверсії в e-commerce із використанням методу аналізу ієрархій.

***Постановка задачі.*** У роботі розглянуто можливість застосування методу аналізу ієрархій для формалізації вибору інструментів підвищення конверсії в e-commerce. Описано загальну методику багатокритеріального ранжування альтернатив і концепцію IT-інструмента підтримки прийняття рішень із вбудованим модулем AHP. Запропонований підхід може слугувати теоретичною основою для подальших прикладних досліджень у сфері управління конверсією.

***Методика AHP для ранжування інструментів***

− Для критеріїв та альтернатив будуються матриці парних порівнянь за шкалою Сааті (1–9) [2, 3].

− Обчислюються локальні пріоритети (ваги) критеріїв і альтернатив (наприклад, через нормування або через геометричні середні рядків).

− Перевіряється узгодженість експертних оцінок шляхом обчислення показника узгодженості CR. Судження приймаються, якщо CR < 0,1.

− Отримується глобальний рейтинг альтернатив шляхом синтезу локальних пріоритетів з урахуванням ваг критеріїв.

Модель ранжування передбачає можливість різного застосування результатів для окремих сегментів користувачів (наприклад, для нових і повернених клієнтів, високого або низького чеку, різних каналів трафіку).

***IT-інструмент підтримки прийняття рішень із модулем AHP***

Відповідно до вимог автоматизації пропонується концепція програмного IT-інструмента підтримки прийняття рішень для управління конверсією [4]. За логікою організації даних і роботи з клієнтами інструмент подібний до сучасних CRM-рішень, однак принципова відмінність полягає у вбудованому математичному модулі AHP, який формує обґрунтовані пріоритети інструментів впливу.

Функціональні модулі запропонованого інструмента:

– Модуль збору подій: трекінг дій користувача (event streaming), запис у сховище даних.

– Модуль профілю клієнта: сегментація, історія контактів, ознаки ризику відтоку/незадоволення.

– Модуль експертних правил: обмеження частоти, стоп-листи, бізнес-політики (наприклад, не надавати знижку повторно протягом 14 днів).

– Модуль AHP: формування матриць парних порівнянь, розрахунок ваг, перевірка CR < 0,1, синтез глобальних пріоритетів.

– Модуль автоматичних дій: запуск каналів (email, push, месенджери), планування та контроль виконання.

– Модуль звітності: дашборди KPI, оцінка інкрементального ефекту, аудит рішень.

З точки зору реалізації модуль AHP доцільно виконувати як окремий сервіс (мікросервіс) з API: на вхід подаються критерії, альтернативи та оцінки (експертні або з даних), а на вихід повертаються вектор ваг, значення CR і ранжований список інструментів. Такий підхід підвищує гнучкість архітектури та спрощує подальше розширення функціональності системи.

***Висновки і перспективи подальших досліджень.***

У роботі розглянуто можливість застосування методу аналізу ієрархій для вибору інструментів підвищення конверсії в електронній комерції. Показано, що AHP дозволяє формалізувати багатокритеріальну задачу ранжування альтернатив і враховувати різні фактори впливу на поведінку користувачів на етапі завершення покупки. Запропоновано концепцію IT-інструмента з вбудованим модулем AHP для підтримки прийняття рішень щодо пріоритезації маркетингових впливів. Подальші дослідження можуть бути спрямовані на практичну реалізацію запропонованого підходу та його перевірку на реальних даних e-commerce. Доцільним є поєднання експертних оцінок із поведінковими даними користувачів, а також інтеграція AHP з методами машинного навчання для адаптивного налаштування пріоритетів інструментів.

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# МОДЕЛЮВАННЯ ЗАХОДІВ ЩОДО ВІДНОВЛЕННЯ СТАНУ ДЕГРАДОВАНОЇ ІНФОРМАЦІЙНО-МЕРЕЖЕВОЇ СИСТЕМИ

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На погіршення стану інформаційно-мережевої системи (ІМС) впливають, в першу чергу, зовнішні негативні фактори. Розпізнавання існуючого стану, в якому знаходиться ІМС, дозволяє виявити рівень деградації системи та запланувати дії щодо її відновлення та підвищення стійкості через вплив негативних (агресивних) факторів. Насамперед необхідно проводити відновлення для тих компонент, які є критичними та впливають на загальний стан системи і розподілене управління особливо важливими об'єктами. Вибір необхідної підмножини компонент ІМС, які знаходяться у деградованому стані і потребують відновлення – завдання, яке зв'язане з аналізом великої кількості можливих варіантів, тому для вирішення цієї задачі будемо використовувати метод цілочисельного (булевого) програмування, який показав свою ефективність при розв'язанні задач для різних галузей (Плєхова, 2025).

Ведемо булеву змінну $x_{lk}$, яка може приймати такі значення:

$$x_{lk}=\begin{cases}1, \text{ якщо, для } l\text{-ї деградованої компоненти ІМС, щодо її відновлення, треба} \\ \text{провести заходи, які залежать від } k\text{-го стану в якій вона знаходиться;} \\ 0, \text{ в іншому випадку.}\end{cases}$$

Введемо показники, які зв'язані з оцінкою дій по відновленню стану деградованої ІМС щодо забезпечення стійкості її функціонування через вплив негативних (агресивних) факторів зовнішнього середовища: рівень покращення стану ІМС після проведення дій що до її відновлення – $P$; час необхідний для проведення заходів щодо відновлення стану деградованої ІМС – $T$; витрати, які необхідні на проведення заходів щодо відновлення стану ІМС – $V$; ризик виконання проєкту щодо відновлення стану деградованої ІМС – $R$. Представимо показники ($P$, $T$, $V$, $R$) у формальному вигляді, з використанням булевої змінної у вигляді $x_{lk}$.

Можливі такі постановки оптимізаційної задачі щодо відновлення ІМС для підвищення її стійкості, з урахуванням стану в якому вона знаходилась:

1. Покращення стану деградованої ІМС, шляхом проведення відновлювальних дій: $\max P$, $P=\sum_{l=1}^{L}\sum_{k=1}^{m_l} p_{lk}\cdot x_{lk}$, з урахуванням обмежень: $T \le T'$, $T=\sum_{l=1}^{L}\sum_{k=1}^{m_l} t_{lk}\cdot x_{lk}$, $V \le V'$, $V=\sum_{l=1}^{L}\sum_{k=1}^{m_l} v_{lk}\cdot x_{lk}$, $R \le R'$, $R=\sum_{l=1}^{L}\sum_{k=1}^{m_l} r_{lk}\cdot x_{lk}$, де $T'$, $V'$, $R'$ – допустимі значення показників ($T$, $V$, $R$).

2. Мінімізувати час щодо проведення відновлювальних дій для покращення стану деградованої ІМС: $\min T$, $T=\sum_{l=1}^{L}\sum_{k=1}^{m_l} t_{lk}\cdot x_{lk}$, з урахуванням обмежень: $P \ge P'$, $P=\sum_{l=1}^{L}\sum_{k=1}^{m_l} p_{lk}\cdot x_{lk}$, $V \le V'$, $V=\sum_{l=1}^{L}\sum_{k=1}^{m_l} v_{lk}\cdot x_{lk}$, $R \le R'$, $R=\sum_{l=1}^{L}\sum_{k=1}^{m_l} r_{lk}\cdot x_{lk}$,

де $P'$ – допустиме значення щодо покращення стану деградованої ІМС.

3. Мінімізувати витрати, щодо проведення відновлювальних дій для покращення стану деградованої ІМС: $\min V$, $V=\sum_{l=1}^{L}\sum_{k=1}^{m_l} v_{lk}\cdot x_{lk}$, з урахуванням обмежень: $P\geq P'$, $P=\sum_{l=1}^{L}\sum_{k=1}^{m_l} p_{lk}\cdot x_{lk}$, $T\leq T'$, $T=\sum_{l=1}^{L}\sum_{k=1}^{m_l} t_{lk}\cdot x_{lk}$, $R\leq R'$, $R=\sum_{l=1}^{L}\sum_{k=1}^{m_l} r_{lk}\cdot x_{lk}$.

4. Мінімізувати ризики виконання проєкту щодо відновлення стану деградованої ІМС: $\min R$, $R=\sum_{l=1}^{L}\sum_{k=1}^{m_l} r_{lk}\cdot x_{lk}$, з урахуванням обмежень: $P\geq P'$, $P=\sum_{l=1}^{L}\sum_{k=1}^{m_l} p_{lk}\cdot x_{lk}$, $T\leq T'$, $T=\sum_{l=1}^{L}\sum_{k=1}^{m_l} t_{lk}\cdot x_{lk}$, $V\leq V'$,$V=\sum_{l=1}^{L}\sum_{k=1}^{m_l} v_{lk}\cdot x_{lk}$.

У всіх постановках оптимізаційних задач необхідно, щоб: $\sum_{k=1}^{m_l} x_{lk}=1$, для всіх $l=\overline{1,\ L}$.

5. Можлива багатокритеріальна постановка завдання щодо пошуку компромісу серед значень показників ($P$, $T$, $V$, $R$).

Ведемо комплексний показник ($Q$): $Q=\alpha_P\cdot\hat{P}+\alpha_T\cdot\hat{T}+\alpha_V\cdot\hat{V}+\alpha_R\cdot\hat{R}$, де $\alpha_P$, $\alpha_T$, $\alpha_V$, $\alpha_R$ – важливість показників ($P$, $T$, $V$, $R$), для відновлення стану деградованої ІМС ($\alpha_P+\alpha_T+\alpha_V+\alpha_R=1$); $\hat{P}$, $\hat{T}$, $\hat{V}$, $\hat{R}$ – пронормовані значення показників ($P$, $T$, $V$, $R$).

Необхідно знайти: $\min Q$, $Q=\alpha_P\cdot\hat{P}+\alpha_T\cdot\hat{T}+\alpha_V\cdot\hat{V}+\alpha_R\cdot\hat{R}$.

Таким чином, поставлено та вирішено актуальне завдання щодо покращенню стану ІМС, яка деградована через вплив негативних (агресивних) факторів зовнішнього середовища. Проаналізовано множину станів, в яких знаходиться ІМС, що впливає на можливості по проведенню дій для забезпечення стійкості функціонування системи в мінливих умовах. Обмеженні можливості щодо проведення відновлювальних дій не дозволяють, у повній мірі, забезпечити покращення стану всіх деградованих компонент ІМС. Тому, виникає множина альтернативних варіантів проведення відновлювальних дій, з яких необхідно вибрати потрібний. Введено показники для оцінки стану ІМС для проведення її відновлення (рівень покращення стану час, витрати та ризики виконання проєкту). Для рішення оптимізаційної задачі було використано метод цілочисельного (булевого) програмування. Сформована багатокритеріальна задача для пошуку компромісного рішення серед показників покращення стану, часу, витрат та ризиків. Запропонований підхід дозволяє, шляхом моделювання можливих дій щодо відновлення деградованої ІМС, планувати проєкт по покращенню стану системи для забезпечення її стійкості, в умовах загроз, які існують в особливому стані країни.

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# ПСИХОЛОГІЧНІ АСПЕКТИ МАРКЕТИНГУ В УПРАВЛІННІ B2B ПРОЕКТАМИ: ІНТЕГРАЦІЯ СТРАТЕГІЧНОГО ПІДХОДУ

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Сучасне B2B середовище характеризується зростаючою складністю процесів прийняття рішень, де раціональні економічні чинники переплітаються з психологічними факторами. За даними дослідження Gartner (2023), типова B2B покупка залучає 6-10 осіб, кожна з яких керується власними мотивами та критеріями оцінки. Це створює необхідність розуміння психологічних механізмів, що впливають на формування купівельної поведінки в корпоративному секторі.

Традиційний підхід до B2B маркетингу фокусується переважно на функціональних характеристиках продукту та ROI, проте сучасні дослідження підтверджують критичну роль емоційного компоненту навіть у корпоративних закупівлях. Інтеграція психологічних принципів у стратегічне управління маркетинговими проектами дозволяє підвищити ефективність комунікації та конверсію на всіх етапах sales funnel.

Психологічні фактори прийняття рішень у B2B. Дослідження демонструють, що навіть у високотехнологічних галузях рішення про закупівлю приймаються під впливом кількох ключових психологічних механізмів:

1. Соціальне підтвердження – компанії схильні обирати рішення, що використовуються лідерами галузі або рекомендовані експертами. У технічних секторах цей ефект посилюється через потребу мінімізації ризиків.
2. Авторитет і експертність – довіра до постачальника формується через демонстрацію глибоких знань у предметній області. Для міжнародних проектів важлива адаптація експертизи під локальний контекст.
3. Когнітивна простота – складні технічні рішення потребують спрощеного викладу, що враховує рівень технічної підготовки різних стейкхолдерів у процесі закупівлі.
4. Емоційна цінність – дослідження CEB показують, що B2B покупці, які відчувають емоційний зв'язок з брендом, мають у 2 рази вищу цінність для бізнесу порівняно з високо задоволеними клієнтами.

Стратегічна інтеграція психологічних insights. Практичне впровадження психологічних принципів у управління B2B маркетинговими проектами вимагає структурованого підходу на кількох рівнях:

1. Стратегічний рівень. Розробка buyer personas з урахуванням не лише демографічних характеристик, а й психографічних профілів, мотивацій та страхів ключових осіб, що приймають рішення. Для міжнародних проектів критичне значення має культурна адаптація психологічних тригерів.

2. Тактичний рівень. Формування контент-стратегії, що поєднує раціональні аргументи з емоційними месседжами. У технічних галузях

особливо ефективним є використання case studies, що демонструють не лише технічні переваги, а й трансформаційний вплив на бізнес клієнта.

3. Операційний рівень. Застосування психологічних принципів у дизайні customer journey, персоналізація комунікації та використання behavioral triggers для оптимізації конверсії на кожному етапі воронки продажів.

***Практичний кейс***. Розглянемо застосування психологічного підходу в маркетинговому проекті для виробника бджільницького обладнання, що експортує продукцію на міжнародні ринки. Цільова аудиторія – професійні бджолярі та агропідприємства Eastern Europe та Middle East.

Аналіз психологічного профілю аудиторії виявив ключові мотиватори: потреба в надійності обладнання (мінімізація ризиків втрати бджолосімей), прагнення до технологічної модернізації (підвищення продуктивності), та важливість експертної підтримки (компенсація недостатніх технічних знань).

Стратегія передбачала створення освітнього контенту, що поєднував технічну інформацію з емоційними наративами про успіх клієнтів. Використання принципу соціального підтвердження через testimonials та case studies збільшило довіру до бренду. Адаптація комунікації під культурні особливості різних регіонів (акцент на традиційних цінностях в одних регіонах та інноваційності в інших) підвищила релевантність меседжів.

***Результати***. Зростання engagement в соціальних медіа на 180%, збільшення кількості якісних лідів на 45% протягом 6 місяців, підвищення конверсії з ліда в клієнта на 28%. Ключовим фактором успіху стала інтеграція психологічного розуміння аудиторії в усі елементи маркетингового міксу.

***Висновки***. Інтеграція психологічних insights у стратегічне управління B2B маркетинговими проектами є критичним фактором підвищення ефективності. Розуміння психологічних механізмів прийняття рішень дозволяє формувати більш релевантні меседжі, оптимізувати customer journey та будувати довгострокові відносини з клієнтами.

Для міжнародних B2B проектів особливе значення має культурна адаптація психологічних тригерів та врахування специфіки прийняття рішень у різних регіонах. Подальші дослідження доцільно спрямувати на вивчення впливу цифрової трансформації на психологію B2B покупців та розробку frameworks для систематичної інтеграції психологічних принципів у маркетингові стратегії. Практична цінність дослідження полягає в можливості застосування запропонованого підходу компаніями різних секторів для підвищення ефективності B2B маркетингових проектів через глибше розуміння психології корпоративних покупців.

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# ІНТЕГРАЦІЯ ШТУЧНОГО ІНТЕЛЕКТУ У СТРАТЕГІЧНЕ УПРАВЛІННЯ ПРОГРАМАМИ ПІДГОТОВКИ ФАХІВЦІВ ЦИВІЛЬНОГО ЗАХИСТУ В УМОВАХ НЕВИЗНАЧЕНОСТІ

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Сучасне безпекове середовище характеризується високим рівнем невизначеності (VUCA + hybrid warfare), динамічністю загроз та зростаючою складністю надзвичайних ситуацій природного, техногенного і воєнного характеру, швидкою еволюцією ризиків та нестабільністю ресурсного забезпечення. У таких умовах система підготовки фахівців цивільного захисту має не лише забезпечувати належний рівень професійних компетентностей, але й бути здатною до оперативної адаптації відповідно до змін стратегічних пріоритетів держави та еволюції ризиків. Це зумовлює необхідність переосмислення підходів до стратегічного управління освітніми програмами, зокрема у контексті управління програмами та проєктами підготовки кадрів.

Метою даного дослідження є обґрунтування підходів до інтеграції штучного інтелекту (ШІ) у систему стратегічного управління портфелем програм підготовки фахівців цивільного захисту в умовах невизначеності.

У контексті дослідження ШІ розглядається не як окремий освітній інструмент або технологічна інновація, а як складова інтегрованої системи стратегічного управління. Йдеться про використання ШІ як елемента систем підтримки прийняття управлінських рішень (Decision Support Systems), здатного обробляти великі обсяги різнорідних даних, виявляти приховані закономірності та формувати аналітичні рекомендації для управлінців [1].

Доцільно розмежовувати застосування ШІ за рівнями управління:

- стратегічний рівень, на якому визначаються довгострокові цілі, пріоритети та сценарії розвитку системи підготовки;
- рівень програм, що передбачає управління сукупністю освітніх програм, їх узгодженість із стратегічними цілями та ефективний розподіл ресурсів;
- рівень проєктів, пов’язаний із реалізацією конкретних освітніх курсів, модулів та навчальних ініціатив.

Одним із пріоритетних напрямів інтеграції ШІ є адаптивне стратегічне планування освітніх програм підготовки фахівців цивільного захисту [2]. Застосування методів машинного навчання та аналітики великих даних дає змогу аналізувати широкий спектр інформації, зокрема: статистику надзвичайних ситуацій; зміни у нормативно-правовій базі; потреби регіональних підрозділів цивільного захисту та їх переспективу; результати навчання та професійної діяльності випускників. На основі такого аналізу можливий перехід від статичних навчальних планів до динамічних освітніх програм, які можуть коригуватися відповідно до актуальних стратегічних викликів. У контексті управління портфелем програм це сприяє підвищенню гнучкості та обґрунтованості рішень щодо оновлення, масштабування або згортання окремих освітніх ініціатив.

Важливим завданням стратегічного управління є випереджальне прогнозування потреб у професійних компетентностях фахівців цивільного захисту. ШІ дозволяє застосовувати прогнозні моделі для аналізу тенденцій розвитку загроз, трансформації функцій служб реагування та змін у технологічному середовищі. Інтелектуальні моделі можуть виявляти компетентнісні прогалини та формувати рекомендації щодо оновлення змісту освітніх програм. Для прикладу, використання часових рядів та глибокого навчання (LSTM, Transformer) для прогнозу на 3–7 років: які нові загрози (кібератаки на критичну інфраструктуру, дрони-камікадзе, хімічні загрози тощо) потребуватимуть нових навичок; виявлення «майбутніх» компетентностей (наприклад, робота з AI в умовах НС, використання інтелектуальних БпЛА для оцінювання збитків) [3].

Попри значний потенціал, інтеграція ШІ у стратегічне управління освітніми програмами супроводжується низкою ризиків. Серед них слід виокремити проблеми якості та повноти даних, можливі алгоритмічні упередження, питання кібербезпеки та захисту інформації, а також етичні аспекти використання інтелектуальних систем [4]. У зв’язку з цим застосування ШІ має здійснюватися в межах чітко визначених управлінських процедур, із забезпеченням прозорості алгоритмів та збереженням відповідальності людини за прийняття стратегічних рішень.

***Висновки.*** Інтеграція ШІ у стратегічне управління програмами підготовки фахівців цивільного захисту створює умови для підвищення адаптивності, обґрунтованості та стійкості управлінських рішень в умовах невизначеності. Найбільша цінність ШІ полягає не в автоматизації управління, а в розширенні аналітичних можливостей управлінців та підтримці стратегічного мислення.

Подальші дослідження доцільно спрямувати на розроблення та емпіричну апробацію інтелектуальних систем підтримки стратегічного управління підготовкою фахівців цивільного захисту з урахуванням національних особливостей та безпекових пріоритетів.

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# ОСНОВНІ РИЗИКИ ПРОЕКТІВ АГРАРНОГО ВИРОБНИЦТВА У ВОЄННИЙ ПЕРІОД

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В умовах воєнного стану аграрне виробництво та розвиток сільських територій України зазнають комплексного впливу безпекових, економічних, соціальних та екологічних загроз. Їх ідентифікація є необхідною передумовою ефективного стратегічного і проєктного управління.

До безпекових ризиків відносяться воєнні дії та обстріли сільськогосподарських угідь, підприємств, елеваторів, тваринницьких комплексів тощо. У результаті відбувається руйнування виробничих об’єктів сільськогосподарських підприємств. Це один із найкритичніших ризиків проєктів агарного виробництва під час війни. Воєнні дії призводять до прямого фізичного знищення або пошкодження сільськогосподарських угідь (вирви, пожежі, мінування); тваринницьких комплексів і ферм; елеваторів, зерносховищ, складів; сільгосптехніки тощо.

Наслідками безпекових ризиків для проєктів аграрного виробництва є повна або часткова зупинка виробництва у проєктах, втрати врожаю та загибель поголів’я. Відбуваються зниження врожайності та продуктивності через обмежений доступ до ресурсів, порушення агротехнологічних циклів (посівна, збирання врожаю, догляд за тваринами) внаслідок дефіциту пально-мастильних матеріалів, добрив, насіння та засобів захисту рослин, зношеності і втрати сільськогосподарської техніки внаслідок бойових дій або неможливості її обслуговування. Це призводить порушення контрактних зобов’язань, до зростання витрат на відновлення або релокацію виробництв та зниження інвестиційної привабливості проєкту.

Воєнні дії призводять до мінної та вибухонебезпечної загрози на сільськогосподарських землях. Унаслідок бойових дій на полях залишаються міни та нерозірвані боєприпаси, касетні елементи, залишки вибухових пристроїв у ґрунті та лісосмугах. Це робить землі непридатними для обробітку без попереднього обстеження й розмінування.

Виконання сільськогосподарських робіт на не обстежених та не розмінованих полях становить пряму загрозу життю та здоров’ю працівників, тому стає неможливим виконання завдань проєкту. Сільськогосподарські підприємства вимушені виводити землі із проєкту для розчищення полів від вибухонебезпечних предметів. У результаті зростають витрат і затримки реалізації проєктів, втрата врожаю та доходів. Особливо великі площі мінно забруднених земель характерні у прифронтових і деокупованих регіонах. Процес гуманітарного розмінування є тривалим і дороговартісним. В Україні є обмежена кількість сертифікованих операторів розмінування та великий дефіцит відповідної техніки та обладнання.

Безпековим ризиком для проектів також є руйнування об'єктів цивільного захисту та критичної інфраструктури у сільській місцевості під час війни. Руйнування транспортної та складської інфраструктури (доріг, мостів, зерносховищ), порушення ланцюгів постачання сировини, продукції та матеріально-технічних ресурсів, обмежений доступ до портів і залізничних шляхів, що впливає на експортний потенціал.

Ворог наносить цілеспрямовані удари по енергетичній інфраструктурі. Унаслідок бойових дій пошкоджуються або знищуються об'єкти енергопостачання (електромережі, підстанції), водопостачання та водовідведення, газопроводи й системи опалення, дороги, мости, залізничні під'їзди, об'єкти цивільного захисту (укриття, пункти оповіщення, медичні заклади). У зоні ризику повторних ударів обмежені можливості швидкого ремонту об'єктів енергопостачання. Ускладнює ситуацію низька резервність інфраструктури в сільській місцевості. Без даної інфраструктури стає неможливим безперервне виконання виробничого циклу проектів, відбуваються втрати продукції через перебої з електро- та водопостачанням, порушується логістика та постачання ресурсів, підвищується небезпека для працівників і населення, зростають витрати на автономні джерела енергії та води, відбувається відтік населення й робочої сили з сільських територій. Руйнування критичної інфраструктури знижує життєздатність аграрних проєктів, навіть якщо самі виробничі об'єкти формально збережені. У результаті є неможливим виконання проектів агарного виробництва.

Для мінімізації втрат у проєктах зумовлених безпековими ризиками аграрні підприємства мають широко використовувати автономні джерела енергії (генератори, сонячні установки), створювати мобільні або модульні виробничі потужності, створювати резерви води та пального, робити пошук та планувати альтернативні логістичні маршрути, здійснювати інтеграцію заходів цивільного захисту в управління проєктами, розвивати співпрацю з міжнародними програмами розмінування та співпрацю з місцевими громадами та органами влади, тощо. Проводити гуманітарне розмінування території за допомогою сертифікованих операторів із використанням карт мінної небезпеки та супутникових даних. Поетапно повертати землі до використання у проектах.

У воєнний період проєкти аграрного виробництва функціонують в умовах підвищеної багаторівневої ризикованості, що потребує впровадження систем управління ризиками, розвиток проєктного та програмного підходів, посилення ролі та засобів сил цивільного захисту ДСНС, розмінування та відновлення інфраструктури, активної державної та міжнародної підтримки.

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# ОПТИМІЗАЦІЯ ІНФОРМАЦІЙНИХ ПОТОКІВ У СИСТЕМАХ ЦИФРОВОЇ ОСВІТИ: МОДЕЛІ ТА ПРАКТИКИ РЕАЛІЗАЦІЇ

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У роботі розглянуто проблему оптимізації інформаційних потоків у системах цифрової освіти в умовах цифрової трансформації. Інформаційні потоки трактуються як сукупність процесів збору, передачі, зберігання та обробки даних, що забезпечують координацію між учасниками освітнього середовища та підтримку управлінських рішень. Визначено основні проблеми функціонування цифрових освітніх систем, зокрема дублювання даних, перевантаження каналів комунікації, затримки в передачі інформації та недостатній рівень інтеграції цифрових ресурсів.

Обґрунтовано доцільність застосування процесних, мережевих та адаптивних моделей оптимізації інформаційних потоків. Процесні моделі спрямовані на формалізацію та автоматизацію освітніх і проєктних процесів; мережеві – на оптимізацію маршрутів передачі даних і балансування навантаження між цифровими сервісами; адаптивні – на динамічне управління потоками з використанням методів штучного інтелекту та машинного навчання. Показано, що комплексне застосування зазначених моделей підвищує гнучкість, стійкість та ефективність цифрових освітніх проєктів.

Цифрова трансформація освіти супроводжується зростанням обсягів даних, багатоканальністю комунікацій та підвищеними вимогами до оперативності управлінських рішень. У таких умовах ефективність функціонування освітніх систем значною мірою залежить від рівня організації та оптимізації інформаційних потоків. Вони забезпечують взаємодію між студентами, викладачами, адміністрацією та зовнішніми стейкхолдерами, формуючи основу управління навчальними процесами та цифровими ресурсами.

Незважаючи на активне впровадження інформаційно-комунікаційних технологій, у закладах освіти зберігаються проблеми дублювання даних, перевантаження каналів зв’язку, відсутності єдиних стандартів інтеграції та затримок у поширенні критично важливої інформації. Це зумовлює актуальність дослідження моделей та практик оптимізації інформаційних потоків у цифровій освіті.

Теоретичний аналіз дозволяє виокремити три основні групи моделей оптимізації інформаційних потоків у системах цифрової освіти: процесні, мережеві та адаптивні.

Процесні моделі базуються на описі та вдосконаленні бізнес-процесів руху інформації за допомогою нотацій BPMN та workflow-діаграм. Вони забезпечують усунення надлишкових операцій, автоматизацію рутинних процедур та підвищення прозорості управління освітніми процесами.

Мережеві моделі орієнтовані на оптимізацію маршрутів передачі даних і балансування навантаження між каналами комунікації. Застосування механізмів буферизації, пакетної обробки та динамічного розподілу трафіку дозволяє зменшити затримки та уникнути перевантажень у пікові періоди.

Адаптивні моделі ґрунтуються на використанні методів штучного інтелекту та машинного навчання. Вони забезпечують прогнозування навантажень, пріоритезацію повідомлень та автоматичне налаштування параметрів інформаційних потоків відповідно до змін освітнього середовища [1].

Аналіз практичного досвіду закладів освіти показує ефективність впровадження централізованого доступу до даних, інтеграції аналітичних BI-панелей, застосування буферизації повідомлень та використання адаптивних AI-сервісів. Такі рішення сприяють скороченню кількості інформаційних маршрутів, зменшенню навантаження на канали комунікації, підвищенню швидкості обробки даних та покращенню зручності користування цифровими освітніми платформами.

***Висновки.*** Оптимізація інформаційних потоків є ключовим чинником підвищення ефективності систем цифрової освіти. Дослідження підтверджує, що поєднання процесних, мережевих та адаптивних моделей дозволяє забезпечити цілісність, гнучкість і стійкість цифрового освітнього середовища. Практичні кейси демонструють доцільність впровадження комплексного проєктно-орієнтованого підходу до управління інформаційними потоками з метою підвищення якості освітніх процесів і управлінських рішень.

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# КОНЦЕПЦІЯ КОМП'ЮТЕРНОЇ МОДЕЛІ ПІДТРИМКИ УПРАВЛІННЯ ТРАНСКОРДОННИМИ ПРОЄКТАМИ У СФЕРІ БЕЗПЕКИ

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Стратегічне управління органічними відходами має свої особливості, які полягають в інтеграції екологічних, економічних та соціальних цілей у єдину систему прийняття управлінських рішень. Як зазначається у роботі [1], сучасні муніципальні системи збору та утилізації відходів розглядаються як складні соціо-еколого-економічні системи. У них ефективність визначається довгостроковими екологічними ефектами та рівнем залучення населення громад. За використання інтелектуального підходу доцільно розглядати управління органічними відходами як динамічну систему зі зворотними зв'язками [2]. У ній основними змінними є обсяги утворення відходів, частка їх роздільного збирання, рівень переробки та екологічні ризики (рис. 1).

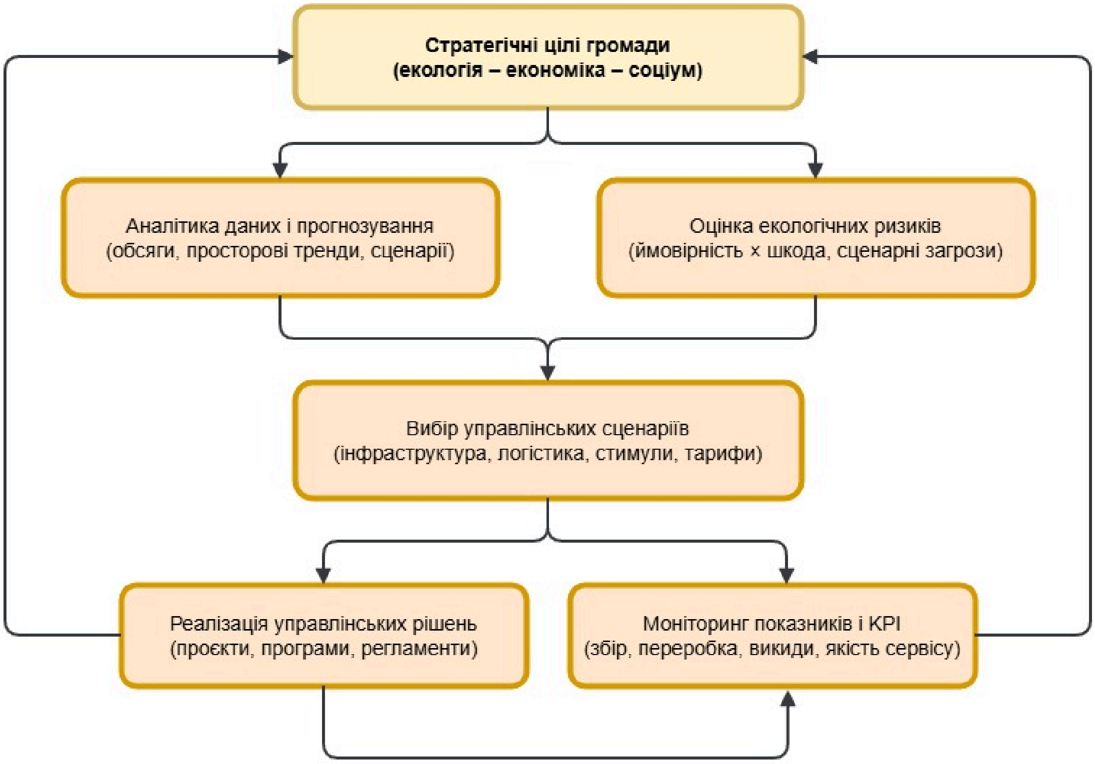


Рис. 1. Концептуальна схема стратегічного управління органічними відходами на муніципальному рівні

Узагальнений інтегральний показник ефективності стратегічного управління органічними відходами на муніципальному рівні визначається за формулою:

$$S_{OM} = w_1 R_{rec} + w_2 R_{bio} + w_3 E_{eco} + w_4 C_{soc}\ , \tag{1}$$

де $R_{rec}$ – рівень роздільного збирання органічних відходів; $R_{bio}$ – частка біологічної переробки (компостування, анаеробне зброджування); $E_{eco}$ – інтегральний екологічний ефект (зниження викидів $CO_2 - екв.$); $C_{soc}$ – соціальний ефект (залучення населення громад, рівень екологічної свідомості тощо); $w_i$ – вагові коефіцієнти стратегічних пріоритетів громади.

Рівень утворення органічних відходів суттєво різниться між житловими районами, приватною забудовою та комерційними зонами. Це зумовлює потребу у просторово-орієнтованому плануванні логістики збору та переробки відходів. Узагальнену модель прогнозування обсягів органічних відходів у громаді має вигляд:

$$W_t = \alpha P_t + \beta H_t + \gamma B_t + \delta T_t \ , \tag{2}$$

де $P_t$ – чисельність населення громади; $H_t$ – рівень домогосподарського споживання органічних продуктів; $B_t$ – активність бізнес-сектору; $T_t$ – туристичне навантаження; $\alpha, \beta, \gamma, \delta$ – відповідно параметри моделі.

Ще однією принциповою особливістю стратегічного управління є доцільність управління екологічними ризиками. Інтегральний показник екологічного ризику для громади оцінюється за формулою:

$$R_{env} = \sum_{i=1}^{n} p_i \cdot d_i \ , \tag{3}$$

де $p_i$ – імовірність настання $i$-ї негативної події (переповнення полігону, несанкціоновані звалища, витоки фільтрату); $d_i$ – обсяг потенційної шкоди.

Таким чином, особливості стратегічного управління органічними відходами на муніципальному рівні полягають у багатокритеріальності прийняття управлінських рішень, потребі прогнозування, врахування просторової орієнтації управлінських дій та інтеграції процесів управління екологічними ризиками. Використання інтелектуальних технологій створює передумови для формування стійких територіальних громад і реалізації принципів циркулярної економіки.

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# ПОЯСНЮВАЛЬНИЙ ШТУЧНИЙ ІНТЕЛЕКТ НА ОСНОВІ ВЕРБАЛЬНОГО АНАЛІЗУ У СТРАТЕГІЧНОМУ УПРАВЛІННІ

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Визначення поточного стану організації та напрямку її подальшого розвитку є одними з актуальних задач стратегічного управління. Застосування сучасних потужних методів та засобів штучного інтелекту для розв'язку цих задач стикається з проблемою довіри до логіки та результатів їх роботи: моделі, що засновані, наприклад, на глибоких нейронних мережах показують високу точність прогнозування, але є незрозумілими та непрозорими для керівників, що ухвалюють стратегічно важливі рішення. Зрозуміти процеси штучного інтелекту, підвищити довіру до результатів, отриманих за його допомогою, дозволяють методи пояснювального штучного інтелекту (eXplainable Artificial Intelligence, XAI) [1]. Перспективним напрямом XAI є створення гібридних систем, в яких, наприклад, для обробки великих даних використовуються методи машинного навчання, а для ухвалення остаточного рішення та його пояснення – методи вербального аналізу [2]. Особливість вербального аналізу полягає у застосуванні термінології користувача (особи, що ухвалює рішення) при побудові нечислових моделей порядкової класифікації, впорядкування або порівняння об'єктів дослідження [3]. Приклади вербальних критеріїв оцінки, опису класів та порядкової класифікації станів організації наведено у табл. 1-3.

Таблиця 1 – Вербальні критерії оцінки станів організації

| **Критерій** | **Шкала значень** |
|---|---|
| А. Фінансова стійкість та ресурсна база | $А_1$. Абсолютна стійкість<br>$А_2$. Нормальна стійкість<br>$А_3$. Кризовий стан |
| Б. Ринкова позиція та конкурентна сила | $Б_1$. Домінування / Лідерство<br>$Б_2$. Стабільна позиція<br>$Б_3$. Аутсайдер / Втрата ринку |
| В. Управлінська ефективність та процесна зрілість | $В_1$. Висока зрілість<br>$В_2$. Функціональна зрілість<br>$В_3$. Організаційний хаос |

Таблиця 2 – Класи станів організації

| **Клас** | **Визначення** |
|---|---|
| $К_1$. Стратегічний успіх | Стани, що характеризуються високою стійкістю та потенціалом до самостійного розвитку. |
| $К_2$. Стратегічна невизначеність | Стани «хиткої рівноваги»: мають суттєві недоліки за одним або декількох критеріях. |
| $К_3$. Стратегічна криза | Стани, несумісні з довгостроковим існуванням організації. |

Таблиця 3 – Порядкова класифікація станів організації

| Клас | Стани |
|---|---|
| $К_1$. Стратегічний успіх | (1, 1, 1), (1, 1, 2), (1, 2, 1), (2, 1, 1), (1, 2, 2), (2, 1, 2), (2, 2, 1) |
| $К_2$. Стратегічна невизначеність | (1, 1, 3), (1, 3, 1), (3, 1, 1), (1, 2, 3), (1, 3, 2), (2, 1, 3), (2, 2, 2), (2, 3, 1), (3, 1, 2), (3, 2, 1), |
| $К_3$. Стратегічна криза | (1, 3, 3), (2, 2, 3), (2, 3, 2), (3, 1, 3), (3, 2, 2), (3, 3, 1), (2, 3, 3), (3, 2, 3), (3, 3, 2), (3, 3, 3) |

Виявлення критеріїв, шкал їх значень, класів та порядкова класифікація станів організації відбувається через безпосереднє спілкування з експертами у галузі стратегічного управління або аналізу їх праць.

Порядкова класифікація будується на основі правила домінування: кращий стан не може потрапити в гірший клас. Вона однозначно ідентифікує поточний стан організації. Межі класів є основою для визначення оптимального шляху покращення поточного стану організації.

Для оцінки відстані між станами доцільно використовувати єдину шкалу змін якості (ЄШЗЯ) значень критеріїв. Ця шкала будується також через пряму комунікацію з експертами-управлінцями. Вона може мати, наприклад, такий вигляд:

$$Б2\text{-}3 < А2\text{-}3 = А1\text{-}2 < А1\text{-}3 = В2\text{-}3 < Б1\text{-}2 < Б1\text{-}3 < В1\text{-}2 < В1\text{-}3$$

Вираз «Б2-3» інтерпретується як «зміна значення критерію Б з $Б_2$ на $Б_3$». Вираз «Б2-3 < А2-3» інтерпретується як «зміна значення критерію А з $А_2$ на $А_3$ є більш суттєвою, ніж зміна значення критерію Б з $Б_2$ на $Б_3$».

ЄШЗЯ дозволяє оцінити складність переходу між станами без використання числової інформації. Наприклад, поліпшення стану (2, 2, 2) до стану (2, 1, 2) є більш складним, ніж до стану (1, 2, 2), тому що А1-2 < Б1-2.

Отже, використання XAI на основі вербального аналізу забезпечує більш глибоке розуміння причинно-наслідкових зв’язків в управлінні організацією.

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# ВПРОВАДЖЕННЯ SHIPBUILDING 4.0 ТА ІНШІ ОБОВ'ЯЗКОВІ ЕЛЕМЕНТИ ВІДНОВЛЕННЯ СУДНОБУДУВАННЯ УКРАЇНИ

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Повоєнне відновлення українського суднобудування не може обмежуватися відбудовою зруйнованого. Галузь, яка зазнала колосальних втрат, стоїть перед вибором: остаточний занепад або технологічний стрибок. Враховуючи глобальні тренди та внутрішні реалії, єдиним шляхом є інтеграція концепції Shipbuilding 4.0 – повної цифровізації та роботизації виробництва.

Поточний стан галузі.

*Неконкурентоспроможність та збитки*. Сучасне суднобудування України перебуває у глибокій кризі, спричиненій не лише війною, а й системними проблемами, що накопичувалися десятиліттями.

1. Руйнування та втрати, оскільки внаслідок російської агресії галузь зазнала прямих фізичних збитків. Лише по одному суднобудівному заводу в Миколаєві екологічні збитки від руйнувань оцінюються у понад 1 млрд грн.
2. Українські верфі програють конкуренцію через відсутність дешевого фінансування. У той час як європейські верфі залучають кредити під 1-1,5%, в Україні вартість валютних позик складає 6-7%, що «з'їдає» всю маржинальність бізнесу, рентабельність якого становить близько 7%.
3. Технологічна відсталість, оскільки виробництво залишається матеріало- та енергомістким, базуючись на технологіях минулого століття, тоді як світові лідери (Китай, Корея) вже впроваджують цифрові екосистеми.

*Пастка внутрішнього ринку*. Існує думка, що галузь може вижити за рахунок внутрішнього замовника. Потреба дійсно є: для відновлення експортного потенціалу (зерно, метал) Україні необхідно близько 160 нових суден лише у цивільному сегменті. Однак, орієнтація виключно на внутрішній попит – це глухий кут. Внутрішній ринок замалий для підтримки високотехнологічної індустрії. Без виходу на зовнішні ринки українські верфі не зможуть окупити інвестиції в модернізацію. До війни верфі Smart Maritime Group були завантажені лише на 25%, хоча мали потенціал будувати повнокомплектні судна для замовників з Нідерландів.

*Умови виходу на зовнішні ринки*. Для успішної конкуренції на глобальній арені Україні необхідно реалізувати стратегію, що базується на п'яти ключових векторах.

І*нтеграція з Європою та гармонізація стандартів*. Україна має стати частиною європейського морського кластера. Міністерство розвитку громад та територій на 2026 рік планує продовження інтеграції в європейський річковий простір та розширення міжнародного визнання українських документів. Це відкриє доступ до ринку ЄС, де попит на спеціалізовані судна залишається високим.

*Пошук ринкових ніш*. Конкурувати з азійськими гігантами у масовому сегменті (танкери, балкери) неможливо. Україна повинна фокусуватися на нішах:

1. Судна «річка-море»: Критично важливі для Дунайського кластеру, розвиток якого є пріоритетом на 2026 рік з метою забезпечення вантажопотоку не нижче 15 млн тонн.

2. «Зелений» флот: Будівництво суден, що відповідають екологічним вимогам ЄС (Fit for 55), використовуючи досвід європейських партнерів у водневих та метанолових технологіях.

*Впровадження Shipbuilding 4.0*. Цифрова трансформація – це засіб економії ресурсів та прискорення процесів.

- цифрові двійники (Digital Twins): Дозволяють моделювати процеси будівництва та експлуатації, виявляючи помилки до початку робіт;
- кіберфізичні системи: Інтеграція фізичного обладнання з цифровими мережами для управління верф'ю в реальному часі. Це дозволить українським заводам інтегруватися у глобальні ланцюги постачання.

*Радикальна роботизація та вирішення кадрової кризи*. Дефіцит кадрів є критичним: місцева влада Миколаєва констатує готовність портів до роботи, але визнає гостру нестачу людей. Відновлення галузі можливе лише за рахунок радикального скорочення залежності від ручної праці. Впровадження зварювальних роботів та автоматизованих ліній дозволить компенсувати брак персоналу та підвищити якість до світових стандартів.

*Енергоефективність*. Зниження собівартості продукції неможливе без доступу до дешевої енергії та енергоефективних технологій. Використання відновлюваних джерел енергії на виробництві та оптимізація енергоспоживання є обов'язковими умовами для конкуренції з Китаєм, який має доступ до дешевих ресурсів.

***Висновок***. Відновлення суднобудування України – це питання національної безпеки та економічного суверенітету. За оцінками експертів, потенціал галузі дозволяє збільшити її внесок у ВВП у 8–10 разів, створивши до 56 000 робочих місць. Проте це можливо лише за умови повної відмови від застарілих практик на користь моделі Shipbuilding 4.0, глибокої інтеграції з європейським ринком та державної підтримки у вигляді доступного кредитування та дерегуляції.

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# ІНТЕГРОВАНЕ СТРАТЕГІЧНЕ УПРАВЛІННЯ, УПРАВЛІННЯ ПОРТФЕЛЯМИ, ПРОГРАМАМИ, ПРОЄКТАМИ

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