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Yashar Huseynov
e-mail: yasar.huseynov@mmu.edu.az, ORCID ID: https://orcid.org/0009-0004-8855-0935

National Defense University, Nakhchivan Military College, Nakhchivan, Azerbaijan

Яшар Гусейнов
e-mail: yasar.huseynov@mmu.edu.az, ORCID ID: https://orcid.org/0009-0004-8855-0935

Національний університет оборони, Нахічеванський військовий коледж, Нахічевань, Азербайджан

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Purpose. To investigate the possibilities of modernization of artillery systems against the background of the application of innovative technologies and their impact on operational effectiveness.

Method: The research was conducted on the basis of an analytical and comparative analysis of the application of modern technological solutions in artillery systems based on a qualitative approach.

Findings. The integration of innovative technologies such as artificial intelligence, automation and real-time data processing into artillery systems significantly increases target accuracy, rapid response speed and the effectiveness of decision-making processes, thereby increasing overall combat capability.

Theoretical implications. This study presents a new conceptual approach in the context of the integration of artificial intelligence and data-based technologies into artillery systems, expands the theoretical foundations of replacing traditional military models with more adaptive, intelligent and decision-support-based systems, and contributes to the existing scientific framework in this field.

Practical implications. The study identifies specific application directions for the integration of innovative technologies into artillery systems, providing military agencies with practical solutions for the implementation of artificial intelligence-based decision support systems, strengthening real-time information processing, and optimizing operational response.

Value. This article presents a comprehensive and application-oriented approach to the modernization of artillery systems based on the integration of artificial intelligence and innovative technologies, which, unlike existing approaches, allows for the formation of more flexible, adaptive, and information-based military systems

Paper type. Theoretical.

Key words: Artillery Systems, Innovative Technologies, Artificial Intelligence, Automation, Decision Support Systems, Real-Time Data Processing, Military Technologies.

Мета дослідження. Дослідити можливості модернізації артилерійських систем на тлі впровадження інноваційних технологій та їхній вплив на оперативну ефективність.

Метод дослідження. Дослідження проведено на основі аналітичного та порівняльного аналізу застосування сучасних технологічних рішень в артилерійських системах із використанням якісного підходу.

Результати дослідження. Інтеграція інноваційних технологій, таких як штучний інтелект, автоматизація та обробка даних у реальному часі, в артилерійські системи суттєво підвищує точність ураження цілей, швидкість реагування та ефективність процесів прийняття рішень, що в цілому посилює бойові можливості.

Теоретична цінність дослідження. Дослідження пропонує новий концептуальний підхід до інтеграції штучного інтелекту та технологій, заснованих на даних, в артилерійські системи, розширює теоретичні засади переходу від традиційних військових моделей до більш адаптивних, інтелектуалізованих систем із підтримкою прийняття рішень та доповнює наявний науковий доробок у цій сфері.

Практична цінність дослідження. Визначено конкретні напрями впровадження інноваційних технологій в артилерійські системи, що надає військовим органам практичні рішення щодо інтеграції систем підтримки прийняття рішень на основі штучного інтелекту, посилення обробки інформації в реальному часі та оптимізації оперативного реагування.

Цінність дослідження. Стаття пропонує комплексний прикладно-орієнтований підхід до модернізації артилерійських систем на основі інтеграції штучного інтелекту та інноваційних технологій, що, на відміну від існуючих підходів, дозволяє формувати більш гнучкі, адаптивні та інформаційно-орієнтовані військові системи.

Тип статті. Теоретична.

Ключові слова: артилерійські системи, інноваційні технології, штучний інтелект, автоматизація, системи підтримки прийняття рішень, обробка даних у реальному часі, військові технології.

Introduction

In the modern era, the nature of military operations is changing rapidly, and these changes are mainly characterized by the development of innovative technologies. In particular, modern solutions such as artificial intelligence, automation, and digital data exchange and sensor technologies not only increase the effectiveness of military systems, but also allow them to become more flexible and adaptive. In this context, artillery systems are also moving away from traditional approaches and moving towards more technology-based, modern control and decision-making mechanisms.

Artillery systems play a crucial role in modern combat operations in the precise and rapid destruction of targets from long distances. However, traditional artillery systems face problems such as limited data processing speed, difficulty in real-time coordination, and high dependence on the human factor. These limitations make it difficult to achieve operational advantage in the modern combat environment and necessitate the application of more innovative approaches.

In recent years, the development of artificial intelligence and information-based technologies has created new opportunities for the modernization of artillery systems. Real-time data reception and processing, automated control systems and decision support mechanisms have the potential to significantly increase the operability and accuracy of artillery units. However, the integration of these technologies into military systems is accompanied by complex technical, organizational and security problems.

Although existing research is mainly focused on describing technological capabilities, the issue of complex and systematic integration of innovative technologies into artillery systems has not been sufficiently investigated. In particular, there is a scientific gap regarding the impact of artificial intelligence-based approaches on operational decision-making processes and the adaptation of these systems to real combat conditions.

In this regard, the presented study aims to explore the prospects for the modernization of artillery systems against the background of innovative technological solutions and to formulate more effective, adaptive and information-based approaches in this direction.

Theoretical background

The development of modern military systems is characterized by the integration of artificial intelligence, automation and information-based technologies. Artificial intelligence accelerates decision-making processes and increases their accuracy through the processing and forecasting capabilities of large volumes of data.

Automated control systems and sensor technologies enhance the operability and coordination of artillery systems by providing real-time data collection and processing. At the same time, digital communication and network-centric approaches increase integration between different military units, creating conditions for more synchronous and effective execution of operations.

Thus, these technologies form the theoretical basis for the transformation of artillery systems into more adaptive, flexible and highly effective structures.

Problem Statement

The effective operation of artillery systems in modern combat conditions requires high accuracy, operational response and real-time information processing. However, traditional artillery systems are characterized by problems such as late data processing, limited coordination capabilities and high dependence on the human factor, which reduces the effectiveness of operational decision-making processes.

On the other hand, although artificial intelligence, automation and digital technologies create new opportunities in this area, their integration into artillery systems is accompanied by complex technical, security and organizational difficulties. In particular, the lack of a unified and systematic approach, problems with secure data management and issues of technological compatibility hinder the effective implementation of this process.

Thus, in the current situation, the lack of sufficient development of conceptual and application-oriented approaches to the integration of innovative technologies into artillery systems constitutes the main problem of this study.

Results

The integration of innovative technologies into artillery systems is of great importance in terms of increasing operational efficiency in a modern combat environment, optimizing decision-making processes and strengthening inter-system coordination. This process is not limited to the introduction of technological innovations, but also includes their adaptation to existing military systems and effective management. As a result of the analysis, it was determined that the application of innovative technologies for the modernization of artillery systems can be carried out mainly in three directions:

Application of artificial intelligence-based decision support systems

The application of artificial intelligence-based decision support systems significantly increases the operational decision-making capabilities of artillery units. These systems analyze data from various sensor and observation sources (radar, drones, thermal cameras, sound measurement stations, etc.) in real time, presenting optimal decision options and reducing delays and errors caused by the human factor (Russell, S., & Norvig, P., 2021). In particular, the rapid processing of large volumes of data, prioritization of targets (for example, ranking enemy armored vehicles, manpower or command posts by importance), and forecasting capabilities are the main advantages of artificial intelligence technologies (Scharre, P.,2018, pp.32). The forecasting function allows, in particular, to predict possible enemy movement directions and model the results of firing in advance.

In addition, artificial intelligence-based systems allow for increased situational awareness and more accurate operational planning in the current conditions. This approach enhances human-machine collaboration, enabling more informed decision-making (Endsley, M. R., 2017). By combining the strategic thinking of human operators with the computational power of artificial intelligence, artillery units become more agile, adaptive, and responsive. Thus, these systems provide valuable support to commanders not only at the tactical level, but also at the operational and strategic levels.

Strengthening real-time information processing

The strengthening of real-time information processing technologies significantly increases the operational efficiency and coordination capabilities of artillery systems. The immediate processing of information obtained through modern sensors, unmanned aerial vehicles (UAVs) and observation systems (e.g., ground-based radars, acoustic and seismic sensors) allows for more accurate target identification and rapid response. This approach, in accordance with the concept of network-centric warfare, accelerates the exchange of information between various military units (artillery, air defense, reconnaissance, infantry) and ensures the synchronization of operations (Alberts, D. S., & Hayes, R. E., 2003). Thanks to synchronization, several units can simultaneously complete each other's actions and more effectively carry out a common combat mission.

In addition, continuous monitoring and analysis of large volumes of data allows for increased situational awareness and improved decision-making processes in the current situation. When the flow of data is processed without interruption, commanders can instantly see any changes on the battlefield (for example, a new enemy position, the deployment of reserves, or worsening weather conditions). Real-time analytics play a crucial role in achieving operational advantage by enabling immediate response to changes in the operational environment (Endsley, M. R., 2017). These technologies provide more accurate and reliable decision-making by integrating information from various sources. Thus, real-time data processing not only increases the accuracy of artillery fire, but also ensures the safety of friendly forces and allows for effective countermeasures against unexpected enemy actions.

Optimization of operational response

Optimization of operational response is of crucial importance in modern combat conditions, and this process is directly related to the integration of innovative technologies into artillery

systems. Automated control systems and artificial intelligence-based analysis tools significantly reduce reaction times by ensuring faster decision-making and execution. This allows for operational advantage, especially in dynamic and high-risk operational environments. Such systems enable real-time data processing on the battlefield, automatic target identification, and precise coordination of fire missions. As a result, the ability to respond quickly and effectively to enemy actions is formed, which is one of the main requirements of modern warfare (Scharre, P., 2018, pp.41).

At the same time, the effectiveness of operational response is determined not only by technological capabilities, but also by the level of inter-system integration and infrastructure compatibility. For the successful application of technologies in modern military systems, secure data transmission, continuous and reliable operation of systems, as well as strengthening cybersecurity measures are important. At the same time, the flexibility of command and control structures, the readiness of personnel to technological innovations, and the level of training also directly affect the speed of operational response. If the compatibility of the existing infrastructure with new technologies is not ensured, even the most advanced systems may not produce the expected effect (NATO Science and Technology Organization, 2020). In this regard, optimizing operational response requires a comprehensive approach and requires the mutual consideration of technological, organizational and security aspects. Not only the development of technical capabilities, but also the strengthening of the personnel potential to manage these capabilities, the renewal of combat charters and the introduction of agile operational procedures can reveal the full potential of operational response. Thus, when technological improvements are implemented in conjunction with organizational transformation and security guarantees, optimizing operational response becomes one of the main factors that provide advantage at the strategic level (Kott, A., & Arnold, C., 2013, pp.85).

Recommendations and future directions

Modernization of artillery systems requires targeted and systematic application of innovative technologies. Based on the analysis conducted, development and applications in the following main directions are recommended:

1. Development and application of artificial intelligence-based decision support systems: The widespread application of artificial intelligence-based decision support systems significantly increases the decision-making capabilities of artillery units at the operational, operational and strategic levels. These systems analyze data from various sources (intelligence, sensors, drones, satellites), form optimal decision options and reduce dependence on the human factor (Russell, S., & Norvig, P., 2021). In the future, improving the learning of machine algorithms and applying independent decision mechanisms should be priority directions for further development of these systems. In addition, determining the ethical and legal framework and maintaining human control are also important conditions (Scharre, P., 2018, pp.35).

2. Strengthening the real-time data processing and integration infrastructure: The development of real-time data processing systems is one of the main conditions for the effective operation of artillery systems. The integration of data obtained from various sensors, drones, satellites and other observation tools allows for more accurate and operational implementation of operations. In this direction, the establishment of high-speed data transmission networks and the creation of unified data platforms are of great importance. Such platforms also serve to ensure interoperability between different systems and share data in a standardized form (Alberts, D. S., & Hayes, R. E., 2003). At the same time, continuous monitoring and analysis of data serves to increase situational awareness in the current situation, allowing the command to respond in a timely and adequate manner to changes occurring on the battlefield (Endsley, M. R., 2017).

3. Optimization of operational response and introduction of automated control systems: Optimization of operational response is one of the key factors for increasing the effectiveness of artillery systems in the modern combat environment. Automated control systems and artificial

intelligence-based analysis tools enable faster decision-making and execution, allowing for operational advantage, especially in dynamic and high-risk operational environments (Scharre, P., 2018, pp.46).

In addition, strengthening inter-system integration and harmonization of technical infrastructure are among the key factors increasing the effectiveness of this process. Secure data exchange, continuous system uptime, and cybersecurity measures are among the essential conditions for ensuring the reliability of operational response (NATO Science and Technology Organization, 2020).

4. Ensuring cybersecurity and data protection: In parallel with the introduction of innovative technologies, cybersecurity issues are of particular importance. Protecting the data used in artillery systems and increasing the resilience of systems against cyberattacks should be one of the priorities. In the modern combat environment, data security is of strategic importance not only at the technical but also at the operational level, since data breach or capture can lead to the failure of the entire operation (Kott, A., & Arnold, C., 2013, pp.87). For this purpose, security protocols should be improved, data encryption, multi-level authentication mechanisms should be implemented, and risks should be continuously monitored.

5. Training of human resources and technological adaptation: The effective application of innovative technologies is closely related not only to the development of technical systems, but also to the training of human resources. Even the most advanced technologies will not produce the expected effect if there are no trained personnel who can use them. In this regard, it is especially important to increase the knowledge and skills of military personnel in accordance with new technologies and strengthen human-machine cooperation, and to give priority to these skills during the educational process in educational institutions. Continuous training programs, simulation exercises and practical exercises aimed at technological adaptation of personnel should form the basis of this process (Mammadzada, M., 2025).

The main goal of the above-mentioned proposals is to ensure that artillery systems operate more effectively, flexibly and reliably based on innovative technologies. These directions serve to optimize decision-making processes through the application of artificial intelligence, strengthen operational coordination through real-time data processing, and reduce reaction time with automated control systems.

At the same time, strengthening cybersecurity measures and training human resources support the long-term effectiveness of these systems by ensuring their sustainability and security. Thus, the proposals presented form a unified and systematic approach to adapting artillery systems to the modern combat environment and ensuring their technological transformation.

Conclusion

As a result of the research, it was determined that the integration of innovative technologies into artillery systems allows for increasing their effectiveness in three main areas. The application of artificial intelligence-based decision support systems accelerates decision-making processes and ensures more justified and operational decisions. Strengthening real-time information processing allows for the operational analysis of information received from various sources, leading to increased coordination and situational awareness in the current situation. Optimization of operational response ensures a reduction in reaction time and more flexible execution of operations through the application of automated systems.

At the same time, the effective application of the above-mentioned areas is closely related to the development of technological infrastructure, ensuring inter-system integration and strengthening cybersecurity measures. In this regard, the modernization of artillery systems is possible not only through the application of technological innovations, but also through the complex and systematic management of these technologies.

Consequently, the purposeful application of innovative technologies ensures the transformation of artillery systems into more adaptive, flexible and highly efficient structures and opens up broad prospects for future research in this area.

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Competing interests

The authors declare that they have no competing interests.

References

Alberts, D. S., & Hayes, R. E. (2003). *Power to the edge: Command and control in the information age*. CCRP Publication Series. https://edocs.nps.edu/dodpubs/org/CCRP/Alberts_Power.pdf

Endsley, M. R. (2017). From here to autonomy: Lessons learned from human–automation research. *Human Factors, 59*(1), 5–27. https://journals.sagepub.com/doi/abs/10.1177/0018720816681350

Kott, A., & Arnold, C. (2013). Continuous monitoring and risk scoring. *IEEE Security & Privacy, 11*(1), 90–93. https://ieeexplore.ieee.org/abstract/document/6427815

Mammadzada, M. (2025). The experience of using innovative technologies in the training process of military pedagogical personnel. *Social Development and Security, 15*(6), 112–118. https://paperssds.eu/index.php/JSPSDS/article/view/960

NATO Science and Technology Organization. (2020). *Artificial intelligence in defence*. NATO STO Report. https://zero5g.com/wp-content/uploads/2025/07/download-file.pdf

Russell, S., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson. https://d1wqtxts1xzle7.cloudfront.net

Scharre, P. (2018). *Army of none: Autonomous weapons and the future of war*. W. W. Norton & Company. https://ftp.idu.ac.id/wp20War.pdf