

THE ROLE OF HMEI^{1*} IN ENSURING INNOVATIVE DEVELOPMENT OF THE CAPABILITIES OF THE DEFENSE FORCES OF UKRAINE IN WAR CONDITIONS

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Abstract. The article provides a comprehensive analysis of the transformation of priority areas of scientific research and innovation activity in Ukraine during 2021–2025 in the context of meeting the needs of the state's security and defense sector. Based on an analysis of regulatory and legal acts defining priority thematic areas of scientific research and scientific-technical development, a clear trend has been identified: a shift from the dominance of fundamental research toward a defense-oriented applied model of scientific development under martial law conditions.

It is substantiated that the key directions of contemporary defense scientific and technical policy include the development of unmanned and robotic systems, artificial intelligence technologies, cybersecurity, automated command and control systems, logistics support, and unit energy independence. It is demonstrated that higher military educational institutions are acquiring the status of important actors within the innovation ecosystem of the security and defense sector by integrating the educational process with the implementation of applied research projects directly oriented toward the operational needs of the Armed Forces.

Using the case of the Kyiv Institute of the National Guard of Ukraine, a positive dynamic is demonstrated in terms of the growth in the number of research projects and the strengthening of the applied orientation of innovative developments during 2022–2025. Particular attention is paid to the necessity of introducing foresight approaches to the formation of defense research priorities, taking into

^{1*} HMEI - higher military educational institution

account Euro-Atlantic standards and projected trends in the development of advanced science and technology in NATO member states up to 2040.

It is concluded that the transformation of state scientific policy in the field of security and defense contributes to the formation of a new institutional model in which higher military educational institutions play a significant role in ensuring the innovative development of the capabilities of the Defense Forces of Ukraine under martial law conditions.

Keywords: national security; Defense Forces of Ukraine; higher military educational institutions; innovation activity; research and development; artificial intelligence; unmanned systems; robotic systems; defense technologies; foresight studies.

Introduction

Under the current conditions of confronting the full-scale aggression of the Russian Federation, the issue of strengthening the capabilities of the Defense Forces of Ukraine in order to deter the enemy and provide an adequate response remains highly relevant. This objective is directly linked to the development and implementation of innovative solutions within the armed forces.

In these new realities, the acceleration of technological progress, the introduction of innovations, and cooperation with the military formations of leading countries worldwide create increased demands for new discoveries and inventions in the military sphere, taking into account combat experience and evolving trends in the security environment. This fully corresponds not only to the national interests of Ukraine but also to broader trends in the development of international relations in the field of scientific and scientific-technical activity within the context of national security (KARPENKO 2024, 62).

Against this background, strengthening the role of higher military educational institutions (HMEIs) in conducting research aimed at enhancing the capabilities of Ukraine's security and defense forces becomes particularly relevant, especially

considering existing combat experience and the best practices of NATO member states.

1. Trends in Innovative Scientific Research in Ukraine under Wartime Conditions (Analysis of Regulatory Documents)

Since the beginning of the full-scale war in Ukraine (February 24, 2022), the priority areas of scientific research and innovation activity in the country have shifted. This shift has been reflected in a number of state documents, namely:

- Laws of Ukraine: On Priority Directions of Science and Technology Development (Law of Ukraine No. 2623-III), On Priority Directions of Innovation Activity in Ukraine (Law of Ukraine No. 3715-VI);
- Resolutions of the Cabinet of Ministers of Ukraine: On Approval of the List of Priority Thematic Directions of Scientific Research and Scientific-Technical Developments for the Period up to 2023 (Resolution of the Cabinet of Ministers of Ukraine No. 942), On Approval of the List of Priority Thematic Directions of Scientific Research and Scientific-Technical Developments for the Period until December 31 of the Year Following the Termination or Revocation of Martial Law in Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 476).

An analysis of the amendments to the provisions of the Law of Ukraine On Priority Directions of Science and Technology Development (Law of Ukraine No. 3715-VI) during 2021–2024 shows that, among the priority areas for the period until the termination or revocation of martial law in Ukraine, and until December 31 of the year following its termination or revocation, the research in the field of national security and defense has been placed first (from 2024 onward). This replaced fundamental scientific research addressing the most critical issues of scientific-technical, socio-economic, socio-political, and human potential development to ensure Ukraine's global competitiveness and sustainable societal and state development, which had been the number-one priority until 2024.

Gradually, these changes also affected the list of priority thematic areas of scientific research and scientific-technical developments in Ukraine for the period

2021–2023, which were approved by the Resolution of the Cabinet of Ministers of Ukraine No. 942 of September 7, 2011 (as amended). This document covered broad areas of fundamental research, including: fundamental scientific problems in physical-mathematical and technical sciences; the most important fundamental problems in materials science and chemistry; fundamental problems in life sciences and biotechnology; fundamental research in social sciences and the humanities; development of rocket and space technologies; and information and communication technologies.

During 2022–2023, this document did not undergo significant changes, although scientific research was conducted taking into account the martial law conditions and the needs of Ukraine’s defense sector.

In 2024, a significant development was the update of the list of priority thematic areas for scientific research and scientific-technical developments, taking into account the martial law conditions, through the adoption of the Resolution of the Cabinet of Ministers of Ukraine No. 476 of April 30, 2024. The changes consist of defining priority directions in the field of “*National Security and Defense*”, which include:

1. New and modernized types of weapons, military and special equipment, and combat robotics;
2. Information and communication systems and electronic warfare systems;
3. Information security and cybersecurity;
4. Technologies for diagnostics, operation, and maintenance of military equipment;
5. Robotic and automated systems;
6. Methods and tools for information-analytical and regulatory-methodological support of decision-making processes in the field of national security and defense;
7. Tactical medicine and protection against CBRN threats;
8. Environmentally balanced energy and other directions related to national defense and security.

These priority areas remain relevant as of 2026.

A similar situation was observed in changes to the priority areas of innovation activity in Ukraine. An analysis of the amendments to the provisions of the Law of Ukraine *On Priority Directions of Innovation Activity in Ukraine* (Law of Ukraine No. 3715-VI) during 2021–2024 shows that the priority directions for the period until the termination or revocation of martial law in Ukraine include:

1. Technological modernization and development of the national security and defense sectors;
2. Mastering new technologies for high-tech development in the transportation system, rocket and space industry, aviation and shipbuilding, as well as armament and military equipment;
3. Development of modern information and communication technologies and robotics.

A selective analysis of existing publications by domestic scholars and military specialists on the prospects and emerging trends in the development of military science and education under contemporary global challenges and conflicts (Central Research Institute of the Armed Forces of Ukraine 2025, KRALICH, Ye. 2024) allows for the identification of the following priority thematic areas that align with current state policy:

- Defense management and planning for the development of the Armed Forces of Ukraine and other military formations;
- Mathematical and simulation modeling (survivability, combat success, and optimal allocation of unit resources);
- Information-analytical support for scientific and scientific-technical activities;
- Development of automated and unmanned systems;
- Planning and command of troop (force) deployment and operations;
- Support, logistics, and electronic warfare (EW);
- Regulatory and legal governance of the activities of the Armed Forces of Ukraine and other military formations;

- Development of armaments and military equipment;
- Development of command and control systems;
- Military-historical research;
- Modern methods of military education;
- Training and professional development of human capital in the military sphere.

It should be noted that, recently, research topics related to the use of artificial intelligence (AI) in the military-technical sphere, as well as strike unmanned aerial vehicles (UAVs) and ground robotic complexes (GRCs), have become particularly relevant for the armed forces, as they play a significant role on the battlefield. Regarding the application of AI in the military-technical sphere, three primary areas are currently distinguished (HURZHIY, S. 2024, 145): integration of AI into automated weapon systems; application of AI in conducting cyber or information operations; active use of AI-based “decision-approval systems” in the military-technical sphere.

In this regard, it appears promising, taking into account the existing innovative potential of higher military educational institutions (HMEIs), to conduct research involving higher education students on the following topics: the use of AI in UAVs for target recognition and engagement; military intelligence using OSINT-technologies; analysis of large datasets for decision-making at the platoon, company, and battalion command levels; and detection of disinformation in the military sphere.

When studying issues related to the use of strike UAVs and ground robotic complexes (GRCs), the problem of legally establishing the principle of responsible use of autonomous systems under martial law conditions requires resolution.

As researchers and military specialists note (HOROWITZ, M., 2018), in modern warfare, a central issue is determining the limits of autonomy for single-use strike UAVs and GRCs: specifically, who – human or artificial intelligence – should make the final decision regarding engagement, and at what stage. The international community, scholars, and human rights organizations express concern that the

automation of engagement processes may lead to violations of International Humanitarian Law (IHL) and reduce the level of human accountability (UNIDIR, 2025).

It should be emphasized that, in Ukraine, the updating of priority directions in the security sector will soon be conducted according to a new mechanism—based on the results of forecast-analytical (foresight) studies – which aligns with leading international practices. Overall, the idea of defining priorities in science and innovation through foresight research, analysis of future needs, and differentiated allocation of state funds to relevant research is gradually being implemented in Ukraine. This approach aligns with the European model and was reflected in the draft Law of Ukraine *On Priority Directions of Scientific, Scientific-Technical, and Innovation Activities*, which the Verkhovna Rada of Ukraine adopted in the first reading on November 6, 2025 (Resolution of the Verkhovna Rada of Ukraine No. 4691-IX).

Thus, it can be observed that, under the current conditions in which Ukraine finds itself, there is a clear trend in the research sphere toward changing both the directions of scientific research and innovation activities, with a focus on meeting the needs of the defense forces and strengthening the country's defense capabilities. In this process, not only enterprises of the defense-industrial complex and business play an important role, but also research institutions, higher education institutions, and higher military educational institutions. The role of the latter is particularly promising and closely linked to the development of innovative potential.

2. The role of higher educational institutions in conducting innovative research for the needs of the defense forces (on the example of the Kyiv Institute of the National Guard of Ukraine)

Ukraine has more than 16 higher military educational institutions (universities, academies, and institutes) operating within the military education system of the Ministry of Defense of Ukraine, the Security Service of Ukraine, the State Border

Guard Service of Ukraine, the National Guard of Ukraine, and the Foreign Intelligence Service (Unified State Electronic Database on Education, 2026).

The primary tasks of these HMEIs include:

Conducting educational activities that provide training for military specialists for the security and defense forces at the levels of higher and military education;

Conducting scientific, scientific-technical, and innovative activities in the interests of the Armed Forces of Ukraine, the National Guard of Ukraine, and other components of the security and defense sector of Ukraine through research activities, facilitating the creative activities of participants in the educational process, training highly qualified scientific personnel, and integrating the obtained results into the educational process (Resolution of the Cabinet of Ministers of Ukraine No. 467).

The implementation of the second task became even more critical under the conditions of the full-scale invasion of Ukraine by the Russian Federation on February 24, 2022. HMEIs, like most research institutions in Ukraine engaged in the defense sector, were tasked by the leadership of ministries, agencies, and armed formations to direct their efforts in scientific research and innovation activities toward addressing the urgent needs of the armed forces and enhancing their capabilities under the legal regime of martial law.

In this area, HMEIs face several critical challenges, including:

1) bridging the gap between scientific research and the content of education, which is oriented toward practical activity. This principle is enshrined in the Strategy for the Development of Higher Education in Ukraine for 2022–2032 (Resolution of the Cabinet of Ministers of Ukraine No. 286-r);

2) studying and integrating into scientific activities the combat experience of the armed forces, based on the evolution of technical features and tactics of ground, naval, and aerial operations by the adversary during 2022–2025;

3) introducing higher education students to the fundamentals of foresight research in the educational process, to utilize these results in the formulation and implementation of managerial decisions in the military sphere;

4) training military personnel with active incorporation of innovative technologies, particularly through gamification and elements of augmented and virtual reality (AR/VR), which significantly enhances students' motivation for scientific activity and develops practical skills through interactive scenarios;

5) increasing the engagement of higher education students in research and innovation activities by implementing STEAM education (Science, Technology, Engineering, Arts, Mathematics) within HMEIs, which emphasizes the practical application of knowledge, creativity, critical thinking, and solving real-world problems, thereby preparing military specialists to meet contemporary innovative challenges in the defense sector.

Next, we consider the experience of the Kyiv Institute of the National Guard of Ukraine (KI NGU) in conducting research aimed at the innovative development of the capabilities of National Guard of Ukraine (NGU) units under martial law conditions.

The Kyiv Institute of the National Guard of Ukraine (KI NGU) is a higher military educational institution training future officers for the National Guard of Ukraine. Founded in 2021, KI NGU is currently the leading higher military educational institution of the National Guard of Ukraine, with a strong scientific component.

In matters of developing the capabilities of the NGU and implementing advanced technologies (based on the experience of NATO member states and FIEP), the scientific work of higher education students and academic staff is focused on (Priority Directions of Scientific Research of KI NGU for 2023–2027):

- Scientific and methodological justification of prospective pathways for developing the NGU's capabilities across key areas (institutional, operational [combat], readiness, and operational support);
- Training of military command bodies and NGU units (subunits);
- Improving national legislation in the field of state security and harmonizing it with European Union law and NATO documents;

- Developing (or refining) the legislative and regulatory framework for the activities of the National Guard of Ukraine, based on the experience of NATO member states and FIEP;
- Cooperation in the fields of national security and defense;
- Studying advanced practices of NATO member states regarding operational stabilization following the Stability Policing model;
- Improving the NGU training system in all areas of service and combat activities, taking into account Euro-Atlantic principles and approaches;
- Enhancing the capabilities of civil-military cooperation.

During the period 2022–2025, the institute has gradually strengthened its innovative potential (researchers and higher education students), which is reflected in the number of research projects conducted in the interests of the National Guard of Ukraine to enhance unit capabilities. Over the reporting period, the number of conducted research projects increased from 2 to 16 (+14). This is illustrated in more detail in *Fig. 1*.

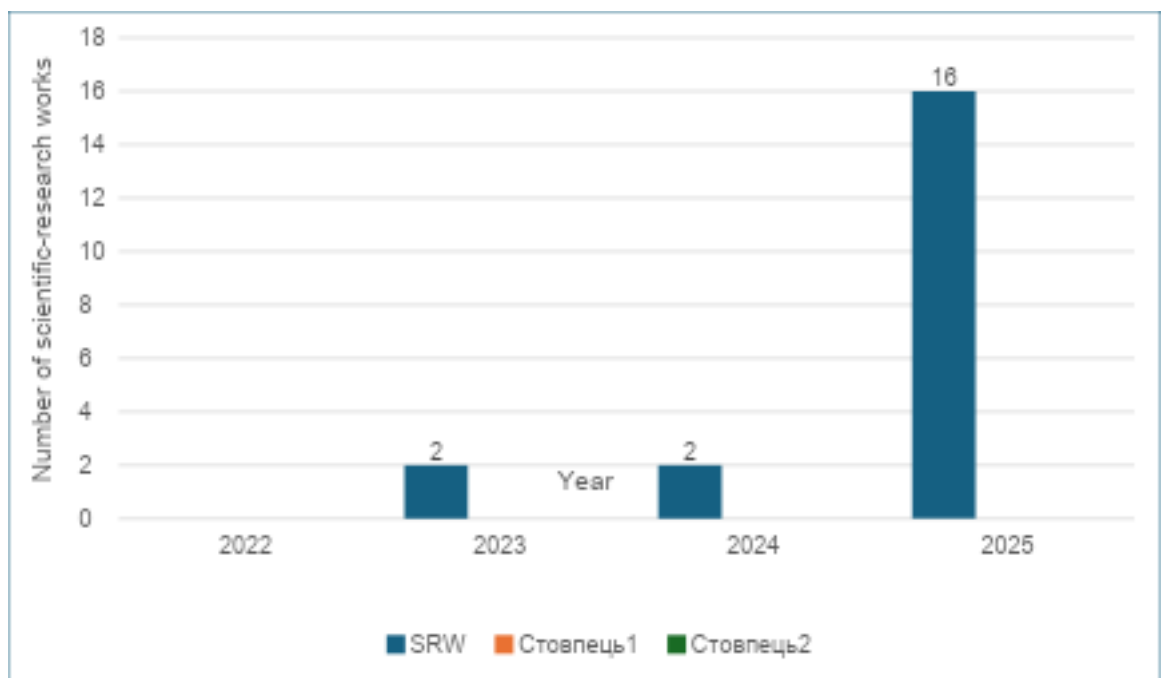


Fig. 1: Dynamics of changes in the number of scientific-research works performed by the institute in 2022-2025

For example, in 2022, two research projects were conducted. As a result of one project, proposals were developed and implemented to improve the use of the ISTAR (Intelligence, Surveillance, Target Acquisition, and Reconnaissance) system in NGU combat brigades as an integrated system for intelligence, surveillance, target designation, and reconnaissance.

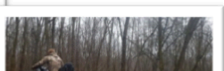
By 2025, out of 16 research projects, 8 were initiative projects and 8 were commissioned by the NGU Main Directorate, aimed at addressing applied issues for operational units. All research conducted by the institute's academic staff, with the involvement of higher education students (cadets), covered the following topics:

1. Improvement of logistics support for units and evacuation of the wounded;
2. Engineering training and demining;
3. Development and enhancement of training systems for firearms practice;
4. Development of a tactical scenario generator for military simulations using artificial intelligence algorithms;
5. Use of UAVs and electronic warfare systems by units, including countermeasures against FPV drones (TYTARENKO, O., & ABRAMOV, S., 2025);
6. Ensuring security of units in recently liberated territories;
7. Maintaining military discipline in units under martial law conditions;
8. Implementation of NATO standards in the educational process and during individual personnel training (Education & Individual Training Directive – Bi-SCD 75-7).

Recently, KI NGU researchers have intensified activities in conducting innovative research commissioned by the NGU Main Directorate, involving the development of experimental prototypes at TRL 3–TRL 4. These developments aim to enhance the capabilities of NGU units in areas such as safe evacuation of the wounded, UAV deployment, and increasing the energy independence of small units in combat zones (Fig. 2). All developments have been legally protected through intellectual property documents (utility model patents).



INNOVATION ACTIVITY KINGU - 2025



«ATV TRAILER FOR EVACUATION OF THE WOUNDED»
(utility model patent № 158663 from 2025.03.05)

Fig. 2: Result of innovation activity Kyiv Institute of the National Guard of Ukraine 2025

A distinctive feature of KI NGU in conducting research oriented toward the needs of NGU units is the involvement of higher education students (cadets) with combat experience, as well as representatives of combat brigades, in the research process.

In the future, scientific research and innovations in the military sphere should be taken into account by HMEIs when determining the content and development of educational programs. This approach ensures that the programs remain relevant and practice-oriented, in accordance with NATO standards: Bi-SCD 75-2 and Bi-SCD 75-7 (SYROTENKO, A., 2018; SHUMKOV, I., 2024).

Furthermore, within the framework of establishing international cooperation, studying and implementing the experience of NATO countries' HMEIs in conducting innovative research aimed at enhancing the capabilities of national defense and security forces, it is promising to create scientific and educational consortia for participation in grant programs such as NATO DEEP, DIANA²¹, ESDC³², Erasmus+, Horizon Europe, and others.

In this context, to ensure the relevance of priority areas of scientific research in which HMEIs may participate, it is advisable to consider not only current needs (requests) of Ukraine's security and defense forces but also predictive (foresight) trends in the development of advanced science and technology practices in NATO member states up to 2040 (Science & Technology Trends 2020–2040; Summary of the NATO–Ukraine Innovation Cooperation Roadmap, 2024).

Conclusions and summary

The article presents a comprehensive analysis of the transformation of priority directions in scientific research and innovation activities in Ukraine during

²¹ DIANA - Defence Innovation Accelerator for the North Atlantic.

³² ESDC – European Security and Defence College.

2021–2025 in the context of meeting the needs of the security and defense sector, and identifies the role of higher military educational institutions (HMEIs) in this process.

It was found that during 2021–2023, state policy in the field of scientific research formally maintained a focus on fundamental directions in the development of science and technology; however, in practice, it gradually adapted to the needs of wartime conditions. Conceptual changes occurred in 2024 with the adoption of an updated list of priority thematic areas, in which research in the field of national security and defense became a primary state priority.

It is demonstrated that the contemporary model of Ukraine's scientific-technical policy is characterized by a shift from a general scientific paradigm to an applied defense-oriented model, encompassing the development of robotics, unmanned systems, artificial intelligence, cybersecurity, automated control systems, decision-support technologies, and tools to enhance the autonomy of military units.

It is substantiated that the innovative development of defense capabilities occurs not only through enterprises of the defense-industrial complex but also through the activation of scientific activity in HMEIs, which integrate the educational process with applied research activities.

Using the example of the Kyiv Institute of the National Guard of Ukraine, a clear trend is confirmed toward increasing applied scientific activity and innovation capacity of HMEIs, reflected in the growth of research projects, the focus of developments at Technology Readiness Levels TRL 3–4, the acquisition of intellectual property protections, and the direct implementation of results in unit operations.

It was established that the distinctive features of the modern HMEI activity model include: integration of combat experience into scientific research; involvement of cadets with combat experience in research projects; combination of scientific activity with the educational process in accordance with NATO standards (Bi-SCD 75-2, Bi-SCD 75-7); and orientation toward practice-oriented training of military specialists.

Special attention is required for the development of research in artificial intelligence and autonomous weapon systems, together with the legal regulation of their operational limits in accordance with international humanitarian law, which establishes a new interdisciplinary scientific field at the intersection of military science, law, and ethics.

It is argued that the further development of innovative activities in HMEIs should be ensured through: the creation of interagency scientific-educational consortia; participation in international grant programs (NATO DEEP, DIANA, ESDC, Horizon Europe, Erasmus+); expanded cooperation with defense-industrial enterprises and technology businesses; and the development of STEAM education and digital educational technologies (AR/VR, gamification).

Thus, the transformation of state priorities in the field of science and innovation during 2021–2025 reflects the adaptation of the national scientific system to the conditions of full-scale war and establishes a new institutional model in which higher military educational institutions act not only as training entities but also as active participants in generating innovative solutions to strengthen the country's defense capabilities.

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