The use of technological innovations in military armaments - contemporary trends and future prospects

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***Abstract*— The aim of the work is to analyze the use of technological innovations in military armaments, with particular emphasis on contemporary trends and future prospects. In the context of dynamic technological development, the work aims to identify the main innovations in the field of armaments, their impact on changes in military tactics and strategy, and to predict the further development of these technologies. Research problems include questions about the role of new technologies, such as artificial intelligence, hypersonic weapons or autonomous weapon systems, in the future of military equipment and the challenges associated with their implementation. The research hypothesis assumes that technological innovations will have a key impact on revolutionizing the military - including changes in the structure of the army, operational effectiveness and international relations. Research methods include an analysis of the subject literature and case studies. The conclusions suggest that the development of new technologies will require appropriate international regulations, as well as new challenges related to ethics and security. Understanding these processes is crucial to ensuring global security.**

Keywords— technological innovations, military weapons, artificial intelligence, autonomous weapon systems, hypersonic weapons.

I. INTRODUCTION

Technological innovations in military armaments are of great importance to modern armed forces and are one of the most important factors determining the advantage in combat. Military armaments are constantly modernized, reflecting progress in areas such as artificial intelligence, robotics, biotechnology and nanotechnology. Today, armies around the world are investing in the latest technologies that increase their combat capabilities, improve their efficiency and reduce the risk to soldiers. In this context, technological innovations not only revolutionize the process of conducting warfare itself, but also have an impact on strategies, military organization and the way of fighting at various levels of armed conflicts. In relation to technological innovations in the context of armaments, it is worth noting that this issue does not only concern the introduction of new types of weapons, but also changes in the organization of armed forces, which use modern technologies to improve their operations. Technological innovations cover a wide range, from hypersonic weapons, through autonomous combat vehicles, to advanced anti-missile defense systems. It is worth noting that each of these technologies aims to increase combat effectiveness and protection, as well as adapt the army to the challenges of the 21st century, such as cyberwarfare or changing forms of armed conflict. Ethical and legal issues in the context of technological innovation are also becoming increasingly important in the armed forces. In particular, questions arise that concern the autonomy of weapon systems, responsibility for decisions made by artificial intelligence during warfare, and international regulations that should control

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the development of new technologies in weapons. Regardless of the importance of these challenges, the fact remains unchanged - these technologies are the future of modern armies, and their development determines the direction of changes in military structures around the world. The article focuses on presenting the main contemporary trends in technological innovations in military weapons and on forecasts for the future of this field.

II. History of technological innovation in military armaments

Military weapons technology has a long history that is closely linked to the progress of civilization. In each era, new inventions and scientific discoveries have had a huge impact on the way wars are fought, on the type of weapons used and on the organization of armed forces. Modern technologies, such as hypersonic weapons and autonomous drones, have their roots in the 19th and 20th centuries, when the development of the first modern weapon systems began. The greatest changes in the history of military technology took place in the 20th century. The industrial revolution, as well as the First and Second World Wars, contributed to the intensive development of new military technologies. During World War I, the first tanks appeared, which revolutionized the way fighting was conducted on the battlefield. It is worth mentioning that with the development of combustion engine technology and metallurgy, weapons became increasingly precise, and guns, tanks and military aircraft began to play a key role in the operation of the army (J. Solarz, 2009, p. 35).

In turn, World War II accelerated the development of technology in the area of weapons. The introduction of radars, modern fighters, bombers and ballistic missiles changed the nature of war. Another breakthrough moment was the explosion of the first nuclear weapon in 1945, which introduced a new dimension of military power – weapons of mass destruction, the impact of which on military strategy is still felt today (S. Zarychta, 2016 p. 21).

After World War II, military technology entered a new era, associated with the Cold War and the arms race. It is worth noting that during this period the first intercontinental ballistic missiles (ICBM), anti-missile defense systems, as well as technologies related to satellite communication and early warning were created. It was thanks to these technologies that states could not only wage war more effectively, but also secure their borders against nuclear attacks (M. Czajkowski 2013, p. 104).

In turn, the end of the 20th and the beginning of the 21st century was a time of development of computers and the Internet, which gave rise to new forms of war – cyberwar. Modern armies are focusing on the development of drones, combat robots and artificial intelligence, which change the way military units operate. Autonomous weapon systems, both in the air and on the ground, are becoming more and more advanced, and their development is one of the most important directions of modern military innovations (A. Bogadał-.Brzezińska, M. Gawrycki 2003, p.54).

III. Contemporary trends in technological innovation in military armaments

At the outset, it is worth noting that contemporary technological innovations in armaments encompass a wide range of solutions that revolutionize the way combat operations are conducted. Increased precision, range, and autonomy of weapon systems are just some of the characteristic features of modern military technologies. One of the most important trends in contemporary military technologies is the development of artificial intelligence and autonomous weapon systems. It is worth noting that technologies based on artificial intelligence, such as combat robots, autonomous drones, or autonomously operating defense systems, are becoming increasingly common in armies around the world (K. Nastaj-Sałek 2024, p. 75).

Currently, artificial intelligence plays a major role in many areas of life, and its importance is growing at an incredible pace. Investments in AI technology are increasing in both the private and public sectors (K. Cukier, V. Mayer-Schönberger, F. de Véricourt 2022, p. 34).

In the area of cybersecurity, artificial intelligence is used to detect and counter cyber attacks. In turn, systems based on artificial intelligence are used to simulate combat situations and military training, which allows for better preparation for various scenarios. The introduction of automation using AI allows for more effective management of supplies and military logistics (K. Nastaj-Sałek 2023, p. 150). Many of these dependencies confirm that artificial intelligence plays an important role in the military sector - its use increases the defense and strategic capabilities of states. Investments in the development of AI technologies are not only important for technological progress, but also have a significant impact on shaping the global balance of power.

With the development of new technologies, cyberwar has become an integral part of modern armed conflicts. Hacker attacks, disinformation or disruption of communication systems and military management pose a serious threat. Modern armies invest in advanced IT technologies to ensure the cybersecurity of their military systems and counteract cyberattacks during warfare (A. Żebrowski 2017, p. 71).

The development of autonomous combat vehicles, such as land and air robots, may change the face of modern warfare. These systems can operate in difficult conditions, such as mountainous terrain or a devastated battlefield, providing soldiers with support in carrying out missions. Autonomous systems also have the ability to process data faster. They can make decisions based on algorithms - which in turn can increase operational efficiency. Unmanned aerial vehicles, which were initially used mainly for reconnaissance purposes, now also play a role in precision attacks on strategic targets. Thanks to the use of AI, unmanned aerial vehicles are able to perform missions without human participation, which eliminates the risk for military personnel (K. Cyrkun 2024, p. 398).

Another important trend in modern military weapons is the

development of hypersonic weapons, which allow for reaching speeds many times greater than the speed of sound. Hypersonic missiles, which can attack targets at a long distance in a short time, pose new challenges to states and their defense systems. It is worth mentioning that the advantage in possession of this technology can provide a decisive strategic advantage, because traditional defense systems are less effective in defending against such fast-moving objects (A. Kuchciński, G. Wilk-Jakubowski, R. Harabin, T. W. Konopka 2023, p. 157).

Laser-based systems can destroy enemy missiles, unmanned aerial vehicles or aircraft in real time, offering effective protection against air attacks. Laser technologies can become an element of anti-missile defense systems, offering cheap and effective solutions in the face of the growing number of threats N. Świętochowski 2018 p. 299).

IV. The Future of Technological Innovation in Military Armaments

The future of technological innovations in military armaments seems fascinating, but also full of new challenges. Technologies that are currently in the development stage will shape the way armies around the world conduct warfare in the coming years, as well as modify the concept of war. In the context of technological innovations, these changes include not only the armament technologies themselves, but also the way military operations are conducted, the organization of the army, as well as ethical and strategic issues that will have a significant impact on global security (Ł. Kamiński 2009, p. 243).

It is also worth mentioning the further prospects for the dissemination of solutions based on artificial intelligence in the sphere of military security. The continued interest in using AI for military purposes is evidenced by the actions taken by the United States – e.g. cooperation with Google on Project Maven, i.e. the use of image processing software that records combat drones owned by the US Army in order to more effectively recognize specific objects in an image recorded from a high altitude, China - the design, construction, implementation and preparation for combat use of unmanned aerial vehicles and naval vessels, or Russia - testing combat robots in various applications on the battlefield (K. Kowalczewska 2021, p. 97).

Tools using AI will also find widespread use in collecting intelligence data, building more effective autonomous weapons and creating autonomous combat robots. It is also expected that solutions that increase the combat capabilities of soldiers by improving their biological abilities (including muscle strength, vision, or hearing) will become more widespread. A report prepared in 2019 by the US Combat Capabilities Development Command shows that technological improvements consisting of, among others, on strengthening limbs, enabling vision in the infrared and ultraviolet spectrum, equipping with audio devices providing ultra- and subsonic hearing, and even with neural devices optimizing brain power and allowing control of weapons with the mind may find real application in the American army as early as 2050. (https://cyfrowa.rp.pl/technologie/art38503091-chiny-stworza-superodpornych-zolnierzy-przerazzajace-manipulacje-genami)

Innovative technological solutions will become the basis for conducting future conflicts. A potential threat in this area is the fact that the use of autonomous solutions during military operations may lead to the escalation of the conflict. On the one hand, the use of unmanned systems can play a deterrent role, causing the enemy to withdraw from the fight, on the other - if it realizes that there is no human within the area of a given object, it can carry out a planned strike in accordance with the previous assumption. It should also be borne in mind that if a given operation is conducted by artificial intelligence, it will probably be fully implemented within the intended scope, but the side effect may be to escalate the situation in another area (P. Śledź, 2020, p. 286).

In the absence of human control over AI, force may be used where humans did not plan to do so. In turn, possible negative consequences are also made more likely by the fact that AI makes immediate decisions, so an unexpected escalation of the conflict may also occur shortly after the attack. New challenges are also created by the possibility of engaging artificial intelligence in decision-making processes - one of them is the danger of misleading military commanders, which may translate into chaos and uncertainty on the battlefield (D. Barton, J. Woetzel, J. Seong, Q. Tian 2017, p. 147).

Artificial intelligence perceives and interprets certain actions in a way different from human perception - which may result in different decisions made by the system and the human. Another problem may be the misreading of the enemy's intentions by autonomous systems. In turn, as a result, the aforementioned escalation of the conflict may occur. On the other hand, the use of innovative, precise tools and solutions may increase the level of target identification in operational activities and, as a result, reduce the number of real victims of the conflict. Undoubtedly, changes in the conduct of armed conflicts resulting from the ongoing technological development and the implementation of subsequent innovative solutions to the military security sector are inevitable (D.J. Gunkel 2018, pp. 87-89).

V. CONCLUSIONS

To sum up the analysis, the use of technological innovations in military armaments is an important element of the contemporary development of armed forces around the world. Dynamic technological progress, which includes areas such as artificial intelligence, hypersonic weapons, autonomous combat systems, laser weapons or advanced cyber technologies, is causing significant changes in the nature of contemporary armed conflicts. The technologies discussed above affect not only the operational effectiveness of the army, but also the command structures, organization of the armed forces and changes in the way warfare is conducted. In the face of such dynamic changes, armies around the world must adapt to new realities by implementing modern technological solutions and developing appropriate procedures and training that will allow for the effective use of these technologies in practice. However, with the growing importance of technological innovations in

military armaments, new challenges also arise, both technical and ethical in nature. The development of autonomous combat systems, hypersonic weapons or cyberwarfare is associated with the risk of uncontrolled use of technologies that may lead to unintended consequences, such as violations of international law or an increased risk of conflict escalation. Technologies that are designed to improve the effectiveness of military operations can, in the wrong hands, pose a threat to global peace and security. For this reason, it is necessary not only to continue developing technological innovations, but also to cooperate closely internationally to establish clear and effective legal regulations and control mechanisms that will allow for the responsible and safe use of new military technologies.

A key issue that should be highlighted is the role of ethics in the context of the use of new military technologies. The introduction of autonomous systems that can make decisions in real time raises serious questions about the responsibility for decisions made by machines. In this perspective, it will be necessary to develop new ethical and legal standards that will enable the responsible use of autonomous combat systems and ensure compliance with humanitarian norms.

Analysis of the future of technological innovations in military armaments also allows us to see potential changes in international military relations. The development of advanced armament technologies creates new opportunities, but also raises concerns about an arms race and the destabilization of the global security order. States that are able to lead the way in technological innovation can gain a strategic advantage, which may lead to increased international tensions. Therefore, to minimize the risks associated with these technologies, international cooperation and the creation of common standards are key elements of ensuring stability in the coming years.

To sum up, the conclusions from the analysis of the use of technological innovations in military armaments show that it will be crucial to find a balance between the development of technologies and their responsible use. Rapid technological progress in this field requires states and international organizations to cooperate to develop appropriate regulations that will ensure that innovations in armaments are used in a manner consistent with law, ethics and the principles of international security. Otherwise, technological advantages can lead to unpredictable and uncontrolled consequences that can threaten global peace. In the face of the challenges of the 21st century, both in the field of military technology and international politics, understanding these processes and responding to them appropriately will be crucial for the future of global security.

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