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PREDICTING THE DEVELOPMENT OF THE TECHNOLOGICAL BASIS FOR THE WARS OF THE FUTURE

Technological progress in the field of military technology is developing rapidly, requiring constant work on the development of new systems and strategies. The article demonstrates that the growing role of artificial intelligence and autonomous systems is defining a new level of efficiency and complexity in military operations. The article assesses the use of biotechnology in the defence sector, which defines a new level of strategic importance for the development and maintenance of military power. Space, hypersonic and quantum technologies will be considered, as well as aspects related to the use of 3D printing in a military context. The possibility of using new materials that can be produced using methods from nanotechnology or synthetic biology will be assessed. The benefits of using "green" hydrogen in the military industry and the challenges of implementing this technology are presented. The concept of digital contact tracking technology is explained, and strategic and tactical applications of hyper-precision positioning technology are presented. The results of the study show that the level of protection and security of future citizens is directly related to the ability to predict dominant technologies and technological trends, to assess their impact on the future and, on this basis, to develop a strategy for the transformation of new technologies.

Keywords: *biotechnology; future war; military conflict; navigation; information technology; weapons and military equipment; management and decision support systems; technology; artificial intelligence.*

Introduction

Relevance of the topic. The technological revolution that has taken place in recent years is leading to fundamental changes in society: new cultural and economic trends, new modes of production and new forms of social communication are emerging. Areas of public life such as security and defence cannot escape the influence of the latest technological developments. The development of the latest technologies and the level of understanding of the world around us always goes hand in hand with war and has a direct impact on its emergence**.** The acceleration of technological progress has brought new discoveries and inventions to the service of war. The level of protection and security of future citizens is directly related to the ability to predict dominant technologies and technological trends, to assess their impact on the future and, on this basis, to develop strategies for the transformation of new technologies. New technological capabilities.

In the military sphere, such technologies are designed to enhance the capabilities of armed forces and their ability to operate in a rapidly changing operational environment. NATO as a politico-military bloc attaches great importance to the development and application of advanced technologies in the fields of security and defence and seeks to maintain its advantages in this area through the application of advanced scientific knowledge, technological development and innovation.

Today, the introduction of the latest technologies in the military sphere is impossible without the use of computers and other telecommunications equipment, artificial intelligence technologies, military and medical robots, quantum and space technologies, 3D printing and biotechnology.

Analysis of recent research and publications. Military conflicts are intricate and ever-evolving events that rely on various factors, including the political climate, economic circumstances, religious disagreements, and technological advancements (Fig.1). As a result, it is only feasible to create a rough outline of future warfare through technological.

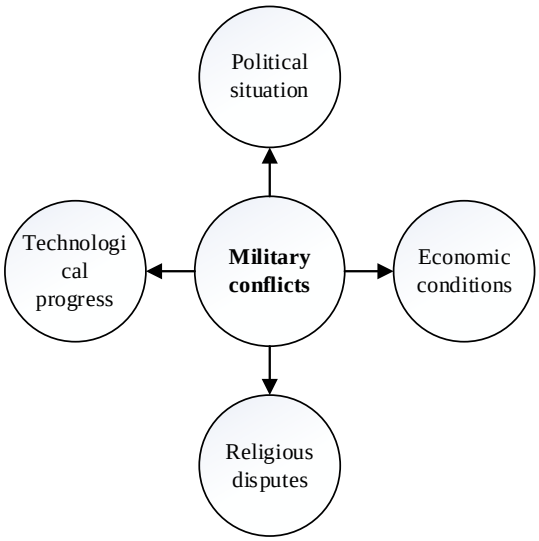

Fig.1. Main factors contributing to the emergence of military conflicts
Source: generated by the Authors.

However, it is foreseeable that upcoming conflicts will have an impact on various domains, encompassing cyberspace, space, artificial intelligence, and biological warfare.

The increasing use of technology in military matters, including drones, autonomous systems and cyber attacks, may have a substantial impact on the nature of warfare.

With the rapid advancement of technology, future wars will be markedly different from those presently observed. Here, we explore some of the crucial technological advances that could shape the basis for future military conflicts.

1) Artificial Intelligence (hereafter referred to as AI) is crucial for the military sector by enabling autonomous systems, data analysis, decision-making support, and inter-system interaction. AI is anticipated to create autonomous combat systems (hereafter known as ACS), identify and analyse adversaries, and enhance cyber military capabilities [1].

The advancement of Anti-Submarine Warfare (ASW) represents a crucial realm in military technology, characterized by swift evolution and outright influence on military engagement operations [2]. In Fig.2 autonomous combat systems' development aspects are illustrated:

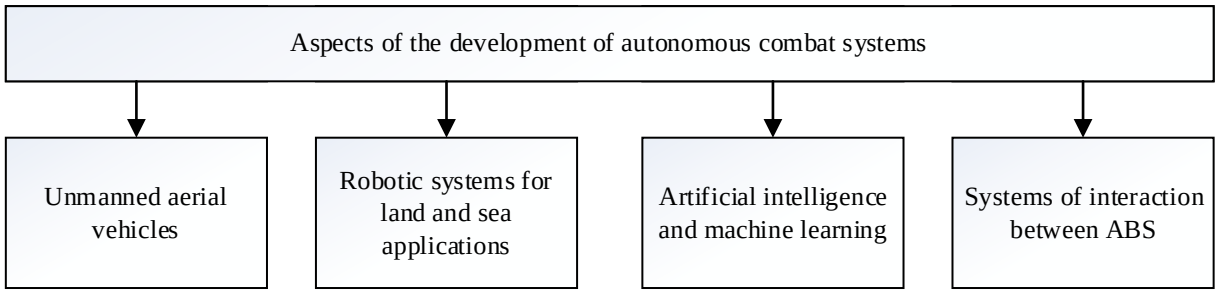

Fig.2. Aspects of autonomous combat systems development
Source: generated by the Authors.

a) Unmanned aerial vehicles (UAVs) are capable of detecting, identifying and destroying targets without direct human intervention. These systems can work in pairs or large groups, coordinating their actions to be effective in defensive or offensive operations.

b) Robotic systems for land and sea use can be used autonomously for maintaining and defending elevated objects, as well as for reconnaissance and destruction of enemy targets. They can be equipped with both light and heavy armaments, and possess the ability to detect enemy forces and complete tasks without the need for operator intervention.

c) Artificial intelligence (AI) is utilised to create algorithms that empower systems to independently determine strategies and make decisions based on collected data. These systems can learn as they operate, adapting to changes in the environment and new situations.

d) ASCs can interact with each other to achieve shared objectives, including synchronised attacks, coordinated manoeuvres and information sharing. The use of unmanned aerial systems (UAS) has sparked critical deliberations on the moral and legal implications of deploying them in military combat scenarios. Collaborative endeavours are presently ongoing to devise a coherent regulatory structure and establish universal standards.

2) Cyber defence and cyber warfare are integral to modern military operations, as information systems become increasingly vital resources in warfare. Here are some aspects of cyber defence and military technologies (Fig.3):

a) Detection and prevention. Machine learning algorithms are used to identify unusual patterns that may indicate cyber attacks. Technologies are developed to protect against known threats and expose new vulnerabilities.

b) Proactive measures. Technologies are used to conduct cyber attacks and operations against other states or ungoverned actors. Unauthorized access and control of information systems through the use of viruses, Trojan horses and other methods has become a growing concern. It is imperative to take measures to prevent these attacks.

c) Cyber Weapons: The use of cyber weapons such as computer worms to disrupt enemy systems. Also, exploiting cyber techniques for intelligence gathering and reconnaissance.

d) Protection of Critical Infrastructures: Developing technologies to safeguard vital infrastructure facilities such as power systems, transport and banks.

e) Defence Measures. Development of measures that can operate surreptitiously to evade detection and restriction.

Employing artificial intelligence for cyber defence, including analysing threat patterns and responding promptly and flexibly to novel attack methods.

These technologies have become increasingly important in today's digital era, and their efficient utilization can determine the outcome of military conflicts and impact the security of nations.

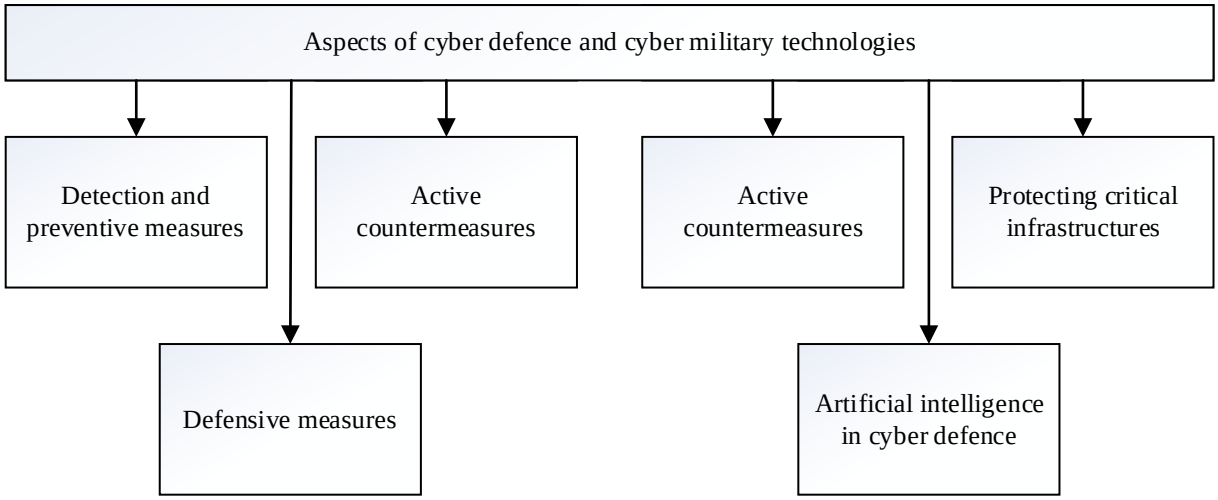

Fig.3. Aspects of cyber defense and cyber military technologies
Source: generated by the Authors.

4) Unmanned systems and robotics [4]. There has been a rise in the use of drones, autonomous and robotic systems on the battlefield. This consists of large unmanned aerial vehicles (UAVs), ground robots and maritime drones for reconnaissance, combat operations and supply.

5) Hypersonic systems that can fly at supersonic speeds have been developed which proves to be valuable for swift and efficient delivery of weapons over vast distances [5].

6) Electromagnetic and radio frequency warfare [6]. Electronic warfare will be vital in controlling the radio frequency spectrum and disrupting enemy communications.

7) Space technologies [7]. The role of space in military operations is expanding. This includes satellite reconnaissance, target designation systems, anti-satellite technologies, and space-based weapons systems.

By integrating these areas of technology, strategies can be created to determine the future nature of military conflicts.

The purpose of the article is to analyse and predict the progression of future wars, considering the innovative technological trends that will shape the character of military confrontations.

Main material

Artificial intelligence in control systems

In recent years, there has been a global competition for leadership in developing artificial intelligence. The United States and China are and will continue to be key players in this geopolitical arena. It is important to examine their strategic plans and visions for development and identify the primary targets and actors of potential future conflicts.

In 2017, China released the "Next Generation Artificial Intelligence Development Plan" [8], which details their strategy to become a global leader in AI. The plan consists of three key parts: firstly, by 2020, China aims to support the AI industry and attain the status of leading countries in the field. The second part involves achieving a significant breakthrough in the AI industry by 2025, ultimately leading to the third part – becoming a world leader in AI by 2030.

Currently, five of the world's 10 largest AI startups are represented by Chinese companies, with the other five being from the UK.

The primary areas of focus for the leading 10 firms are computer vision, cybersecurity, AI chips, finance, healthcare and speech processing.

In June 2023, two bills concerning artificial intelligence were introduced by UK MPs. One of the regulations will mandate that the US government be transparent when utilising AI to engage with individuals, while the other is focused on observing US dominance in the latest technologies. Consequently, it can be inferred that the AI sector is a priority for the forthcoming decades, and that the growth of AI could have a significant impact on the execution of future conflicts.

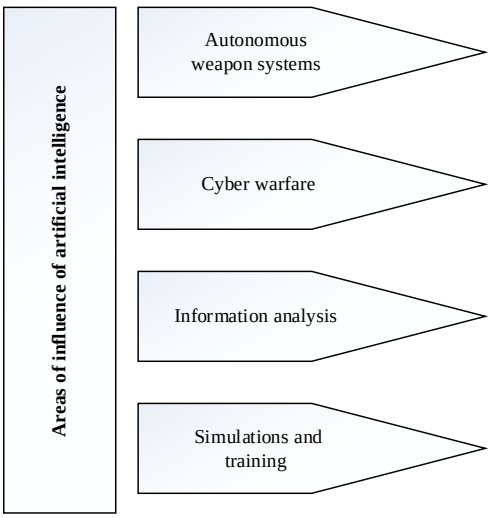

Fig.4. Spheres of influence of artificial intelligence
Source: generated by the Authors.

Given the current industry trends, we can identify various factors (Fig.4):

– autonomous Weapons Systems (AWS). AI has the potential to create autonomous weapons systems such as drones, robots, or military vehicles. These systems can have the ability to operate without direct human control and can be used for purposes of reconnaissance, attack, or defense. The application of AI in autonomous weapons systems could significantly alter the tactics and strategy of warfare;

– cyber warfare. AI can be used to conduct cyberattacks on enemy information systems, electronic networks, communications infrastructure etc. This can lead to the paralysis of enemy forces, disruption of the command and control structure, and provide an advantage on the battlefield;

– information Analysis. Artificial intelligence (AI) can assist with processing data, collecting and analysing intelligence. It processes data rapidly, identifying enemy patterns and potential threats, thereby increasing the effectiveness of intelligence and improving decision-making in military operations;

– simulations and training. Artificial intelligence (AI) can develop simulation models and train armed forces, enabling virtual military exercises to test various strategies and tactics without incurring real costs or risks.

The defence ministries of major nations are investigating the potential implementation of AI technology in the defence field, inspired by civilian sector successes from corporations like Google, Apple and Facebook [9]. They are scrutinising various applications such as detecting cyber defence threats through malicious traffic in encrypted networks and identifying people's movements to uncover abnormal behaviour in ship movement. It also encompasses the utilisation of AI capabilities in diverse fields, including provision of decision support for commanders in combat; acquisition of significant semantic information for military intelligence; efficient automation and optimisation of logistical systems; assistance for medical diagnosis and treatment; minimizing the deployment of personnel in hazardous missions and environments; facilitating unmanned autonomous vehicle operations, among others.

Over the next 15 years, significant advancements in autonomous weapons, robotics, big data analytics, and decision support systems utilizing AI and deep neural networks could transform modern warfare. An example of such an application in AI is the upkeep of military aircraft systems, such as cutting-edge invisible fighter planes [2].

In the new decade, aircraft development will rely heavily on AI technology for maintenance support software, covering aircraft design, production, and maintenance. Presently, artificial intelligence is instrumental in controlling military equipment such as drones, drone swarming technologies, and autonomous flight systems [2].

Armed forces may use autonomous weapons that can locate, identify, track, target and destroy enemy forces without human involvement in the decision-making process. By eliminating human interaction, autonomous weapons will reduce the observe-orientate-decide-act (OODA) cycle, enabling forces to act and react faster than their enemy [2].

Regulation and control the use of artificial intelligence in military conflicts

It is important to note that the progress of AI generates fresh ethical, legal, and security challenges. Proper regulation and supervision of AI usage in military operations are essential to ensure adherence to international humanitarian and moral codes [10–15].

The deployment of independent fight robots raises several ethical, legal, and security concerns. We shall examine in-depth the fields that must be governed according to societal norms and regulations:

– first, it is ethics and morality. Questions arise about the responsibility for the actions of autonomous systems, especially in the context of the use of force and the possibility of harming civilians. It is necessary to establish ethical standards and norms that will limit the actions of autonomous combat robots;

– second, legal aspects. Currently, there is no international law that would regulate the use of autonomous systems in military conflicts. Thus, international law should be developed to regulate the use and control of autonomous combat robots. The issues of safety, liability, and determining the status of autonomous systems in military conflicts require legal regulation;

– third, security and cyber threats. Autonomous combat robots can be subject to cyberattacks or hacked to change their behaviour or take control of them. Ensuring cybersecurity is an extremely important aspect when considering the use of autonomous combat robots in military conflicts.

Ultimately, humans with comprehension of the implications, ethical concerns, and international legalities should take on the duty of determining the utilisation and management of autonomous combat robots. Various organisations and countries are deliberating these matters in order to devise a legal and regulatory structure for the deployment of autonomous combat robots.

AI chips, featuring artificial intelligence, hold considerable promise (as shown in Fig.5) for defence-related applications.

The integration of artificial intelligence with customised chips can increase the effectiveness of military activities, offer a tactical edge in combat situations and guarantee the safety of soldiers. Potential

uses of AI chips within the defence industry comprise:

– Intelligence. AI chips help to perform pattern recognition, analyse images from drones and sensors to detect the enemy, identify and identify potential threats.

– Autonomous systems. The use of AI chips allows for the creation of autonomous systems, such as self-driving cars, drones, or robots, which can make decisions and perform tasks without direct human control.

– Data analysis and forecasting: Analysing vast amounts of data, including signals from multiple sensors, for real-time threat detection.

– Cybersecurity: The application of AI chips to safeguard military networks and infrastructure, detect and thwart cyberattacks, and facilitate secure data exchange.

– Decision support. By analyzing the battlefield, we generate recommendations and information for teams to make more informed and strategic decisions.

– Medical support involves the use of AI chips to analyze medical data and assist in diagnosing, treating, and rehabilitating the wounded.

The use of AI chips holds immense potential and will improve the speed, accuracy, and efficiency of military operations in the future.

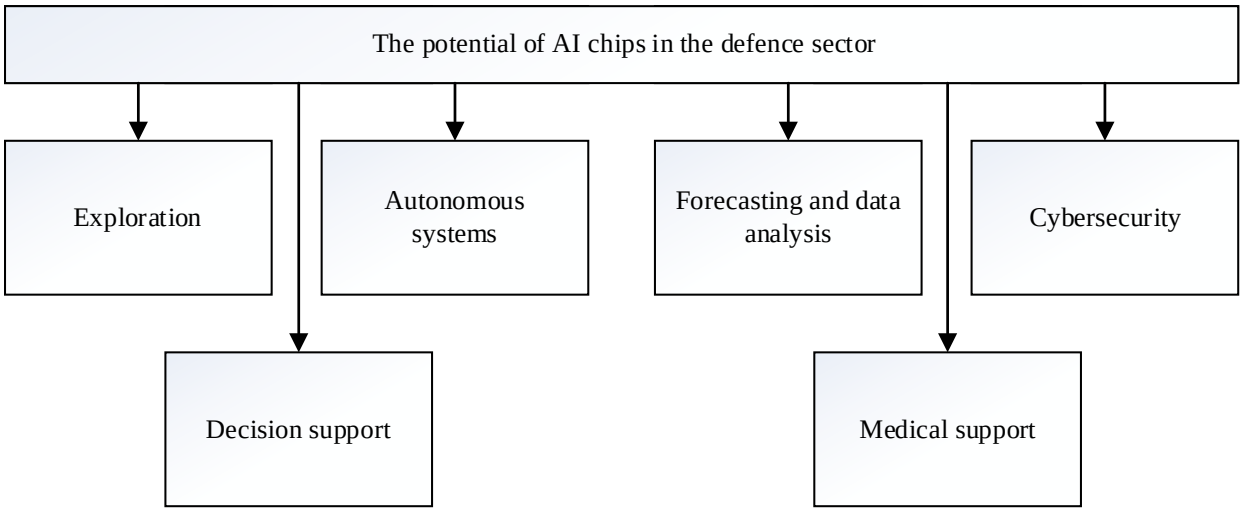

Fig.5. Potential of AI chips in the defence sector.
Source: generated by the Authors.

Bigdata technologies (Bigdata) in management and decision support systems

Bigdata [16] is a significant technological trend that has emerged in recent years and shows immense potential for future growth.

It is the outcome of the surge in digital data on the internet and the increasing number of network-connected objects. In the defence sector, various European countries and the United States are executing projects utilising big data analytics to comprehend the potential applications of these tools and capabilities for modelling the demands of the armed forces.

The areas of Bigdata application in the defence sector are shown in Fig.6.

Bigdata in defence is crucial for gathering, analysing, and utilising significant amounts of information to enhance security, intelligence, and decision-making, among other areas.

Let's explore potential Bigdata applications in the defence industry:

1. Firstly, intelligence and information analysis are critical tasks in this sector. Bigdata enables the processing of extensive data volumes from varied sources, like satellite imaging, reconnaissance drones, electronic intelligence and social media. Analytical methods like machine learning and artificial intelligence aid in recognising patterns, trends and potential risks.

2. Cybersecurity is of utmost importance in the defence industry. To protect against cyber attacks, it is crucial to utilise bigdata analysis to identify anomalous activity, potential threats, and establish preventive security measures.

3. Strategic Forecasting. Bigdata can aid forecasting and strategic decision-making by analysing extensive historical data to identify patterns, predict potential enemy actions, evaluate military operations and develop more effective response strategies.

4. Logistics and resource management. Big data aids the improvement of logistics and resource management within the defence industry. By scrutinising data on stocks, traffic, energy requisites etc., optimal planning and resource exploitation can be ensured.

5. On the battlefield, sensor technologies, drones, video surveillance and other data sources enable the acquisition of real-time information, facilitating strategic decision-making. Machine learning systems will utilize advanced data recognition to identify enemy tactics and concealed targets, enhancing accuracy and supporting management decisions.

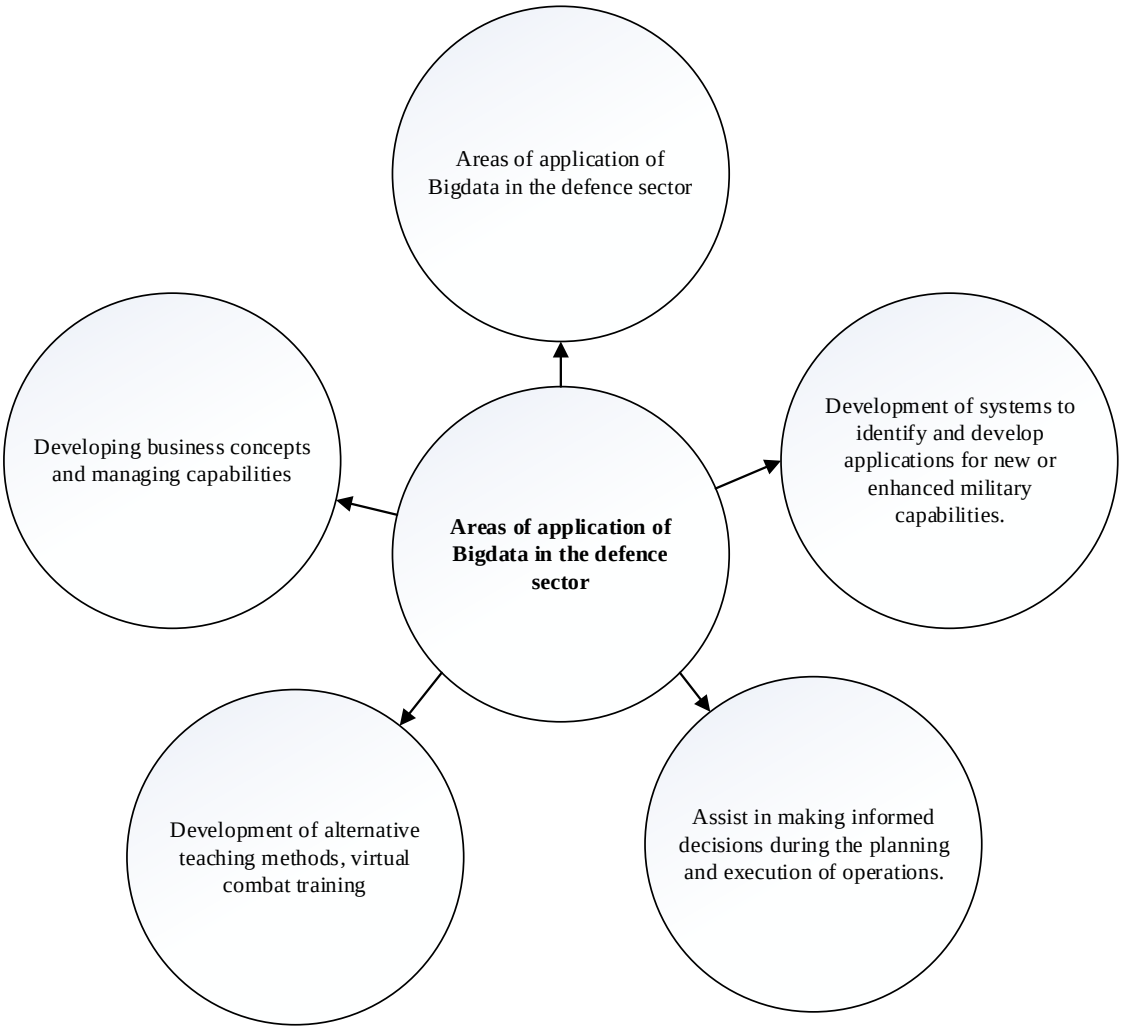

Fig.6. Areas of application of Bigdata in the defence sector
Source: generated by the Authors.

Robotic Systems

The introduction of these systems [17] will revolutionise operations and even facilitate new mission types. Currently, the assessment of defence scenarios is underway to determine the value added by heterogeneous swarms of robots across land, air, and sea domains. Drones have showcased the enormous potential of unmanned systems in all battle environments, including land, sea, air, and space [2].

For example, unmanned aerial vehicles are already used for monitoring, reconnaissance and strike operations. They can provide intelligence gathering, search missions, air attacks etc. UAVs are able to act quickly and reduce the risk to human life.

Unmanned submersibles are utilised for maritime surveillance, reconnoitring, mine and torpedo operations, and other designated tasks. They are capable of detecting and eliminating underwater targets, monitoring the ocean, and gathering intelligence.

Unmanned ground systems have applications in reconnaissance, mine clearance and security operations. These systems can be equipped with weapons and utilise artificial intelligence for effective decision-making.

In the context of space exploration, unmanned systems provide crucial support in research, communication and surveillance. They enable the safe passage of astronauts, augment scientific capabilities and help facilitate communication between space missions and the Earth.

Future unmanned systems must become more autonomous, particularly due to artificial intelligence and cognitive computing. In forthcoming conflicts, unmanned weapons like “drone swarms” will be a crucial factor, as they are integrated into a unified system. The size and velocity of drone swarms offer the opportunity of battles that are so prompt and multifaceted that humans are unable to monitor them.

Biotechnology

Biotechnology [18] in defence is used to develop new methods and technologies to protect and support military operations. Biotechnology belongs to four areas of research [2] (with significant overlap and synergy between them) (Fig.7):

1) Bioinformatics and biosensors, medical imaging and quantum biology are key areas.

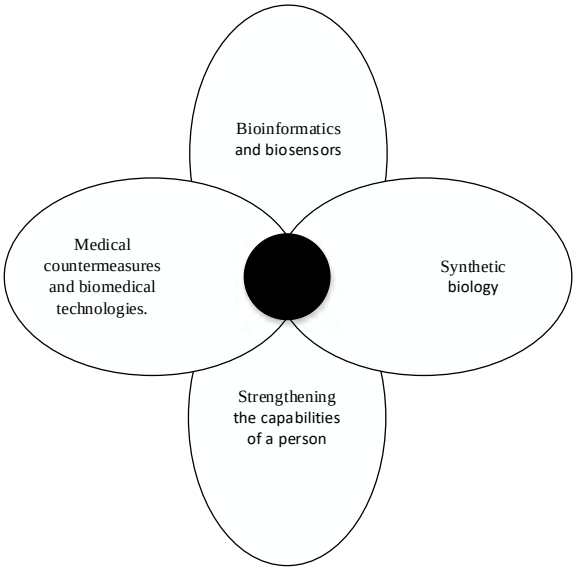

Fig.7. Areas of biotechnology research
Source: generated by the Authors.

2) Human empowerment is achieved through mixed reality, virtual reality, social networks, robotics, prosthetics, exoskeletons, neuroelectronics, rehabilitation, neuroscience, robotics, teleoperation, autonomy, cognitive performance, computing, artificial intelligence, trusted autonomy, and perception enhancement.

3) Medical countermeasures and biomedical technologies encompass chemical, biological, radiological, and nuclear countermeasures and detection, personalised medicine, biomarkers, bioengineering, supplements, nutrition, physiology, sustainability, and stress resistance.

4) Synthetic biology involves genetic engineering, DNA sequencing and use, biomanufacturing, modified microbiomes, and living sensors.

Let us examine potential uses of biotechnology in the defence industry:

– biological detection and identification. Biotechnology is employed to create and enhance detection systems for biological threats like chemical and biological weapons. This can involve crafting sensors, quick diagnostic tests, and analytical techniques for determining potentially hazardous substances or organisms;

– development of antibiotic immunity. Biotechnology is used to create new methods of fighting infectious diseases and develop antibiotic drugs. Research in genetics and immunology helps to understand the mechanisms of the immune response and develop new methods of disease prevention and treatment;

– biological sensors and biosystems. Biotechnology is used to develop biological sensors and biosystems that can sense and respond to a variety of stimuli, including radiation, chemicals or gas emissions; These technologies can be used to monitor and provide early warning of potential threats or unusual activity;

– genetic modification of organisms. Biotechnology is used to genetically modify organisms to create new properties or produce specific substances that could be useful in the military. For example, plants can be created that can be grown in contaminated areas to clean up the soil or be used in the production of fuel;

– medical research. Biotechnology is employed to advance innovations in the diagnosis, treatment, and rehabilitation of military casualties. These innovations include the growth and production of prosthetic limbs, tissue regeneration, and swift identification of potential health hazards.

Biotechnology provides a foundation for a remarkable enhancement of human abilities, expanding the limits of physiological, cognitive and social functions [2].

Space Technologies

Today, military forces' capability to carry out their missions promptly and effectively relies on space [19]. Currently, developed countries are developing programmes utilising space applications in weapon systems, which includes Ukraine.

Space technologies in the defence sector guarantee security, communication, intelligence, navigation, and other vital aspects of military operations. This article examines promising areas of space technology application in the defence sector.

Satellite Communications and Navigation: GPS and Galileo satellite systems offer precise navigation, military installation surveillance and coordination of military operations. They facilitate quick and dependable communication and data transmission, fundamental in military operations.

Satellite intelligence systems. Satellite-based intelligence systems are used to acquire high-resolution imagery, monitor military installations, detect changes on the ground, and gather intelligence. This helps to provide operational information and conduct strategic intelligence analysis.

Space reconnaissance and surveillance. Space-based surveillance provides the ability to observe territories, enemy force movements, and changes in the natural environment that are relevant to military operations. They can include optical satellites, radar systems and other sensors for data collection. Spacecraft and drones, such as spies, reconnaissance satellites and unmanned aerial vehicles, are deployed for intelligence gathering, surveillance and specialized missions, yielding information of significant value regarding hostile activities, objects and other parameters.

Space-based arms control. Space systems can be utilized to oversee the proliferation, support and monitoring of weapons of mass destruction, missile systems and other military technologies. They can also

facilitate treaty compliance, control information exchange, and promote transparency of military operations.

Space-based systems of species, radio-technical and radio reconnaissance, which comprise low-orbit and high-orbit constellations of satellites and radio interception systems in geostationary orbits, are utilised for space surveillance.

Hypersonics

Hypersonic technologies, [20] often used in defense, involve developing and using weapons that exceed the speed of sound. A country that achieves first-mover advantage in mass-producing high-precision hypersonic missiles will gain an unconditional military advantage, particularly on a strategic scale. [2].

Hypersonic cruise missiles are perfect for striking crucial targets that are safeguarded by air and missile defenses [2]. These weapons' high-speed and manoeuvrability make them hard to detect and defend against.

Fig.8 illustrates potential uses of hypersonic technologies in the defence industry in the future.

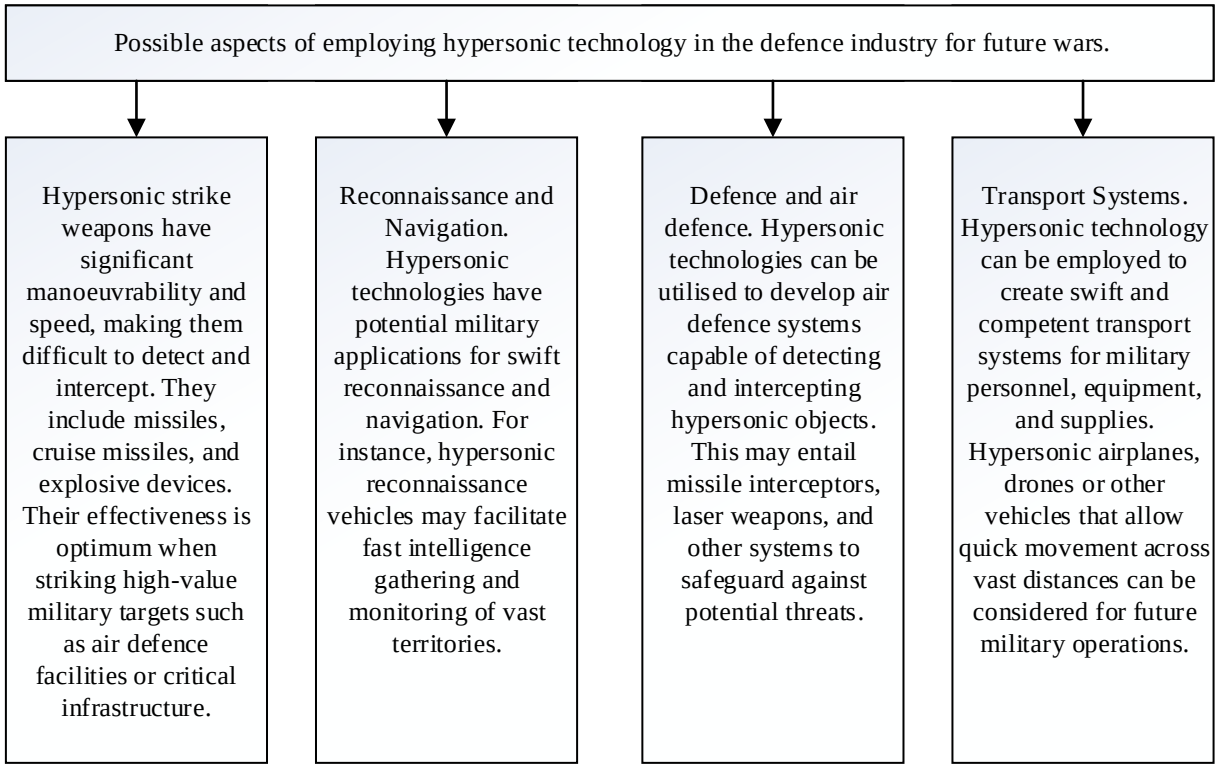

Fig.8. Potential use of hypersonic technology in the defence sector during future conflicts.
Source: generated by the Authors.

It should be noted that the development and usage of hypersonic technologies in the defence industry pose challenges, including the need for effective countermeasures, security measures and conflicts prevention. International agreements and norms may stipulate the limits for employing hypersonic weapons to retain peace and stability.

Quantum technologies (Quantum)

Quantum technologies are founded on the principles of quantum mechanics and enable the processing, transmission and storage of data on a quantum level [21]. These technologies differ from their classical counterparts as they operate using quantum bits or qubits, which can exist in states 0 and 1 concurrently (utilizing the superposition principle).

Quantum technologies, operating at the quantum level, can efficiently handle several tasks than classical computers. These include quantum computing potential, cryptography, communication, simulation, and sensing.

Quantum technologies hold immense promise for the defence sector, offering significant advantages in intelligence, communications, cryptography, and computing to armed forces. Adoption of quantum technologies may revolutionize the approach to weapon use.

Potential applications of quantum technologies in the defence industry comprise of:

– quantum cryptography offers reliable protection to the armed forces from cyberattacks. The principles of measurement in quantum cryptographic systems ensure detection of any attempt to hack or intercept the transmitted data;

– quantum communication channels offer secure information exchange within military facilities and teams. They safeguard critical data from interception and provide reliable communication in scenarios

involving electromagnetic interference;

– quantum radar. Quantum radar is capable of enhancing radar systems, enabling the detection of supersonic and stealthy aircraft, missiles and drones with greater accuracy and at an earlier stage than the conventional radar systems;

– quantum sensors will enhance the armed forces' intelligence capabilities, increasing sensitivity and accuracy while detecting enemy activity and threats more efficiently;

– quantum computing systems can solve complex computational problems that classical computers cannot.

They have a wide range of applications, such as developing cryptographic keys, optimizing military strategies, and creating new materials, among others.

The use of quantum technologies for military purposes requires attention to cybersecurity, standards and regulation, including the ethical aspects of using such technologies.

Quantum technologies are disruptive technologies. Two practical applications will be particularly important in the defence sector:

– quantum sensing (for detection and navigation systems without GPS);

– quantum computing (for cyber attacks).

3D printing

The concept of 3D printing dates back to the 1980s. 3D printing has great potential in the military and could change the way armed forces develop and use their training equipment. [22].

Fig.9 illustrates several aspects of the use of 3D printing in a military context.

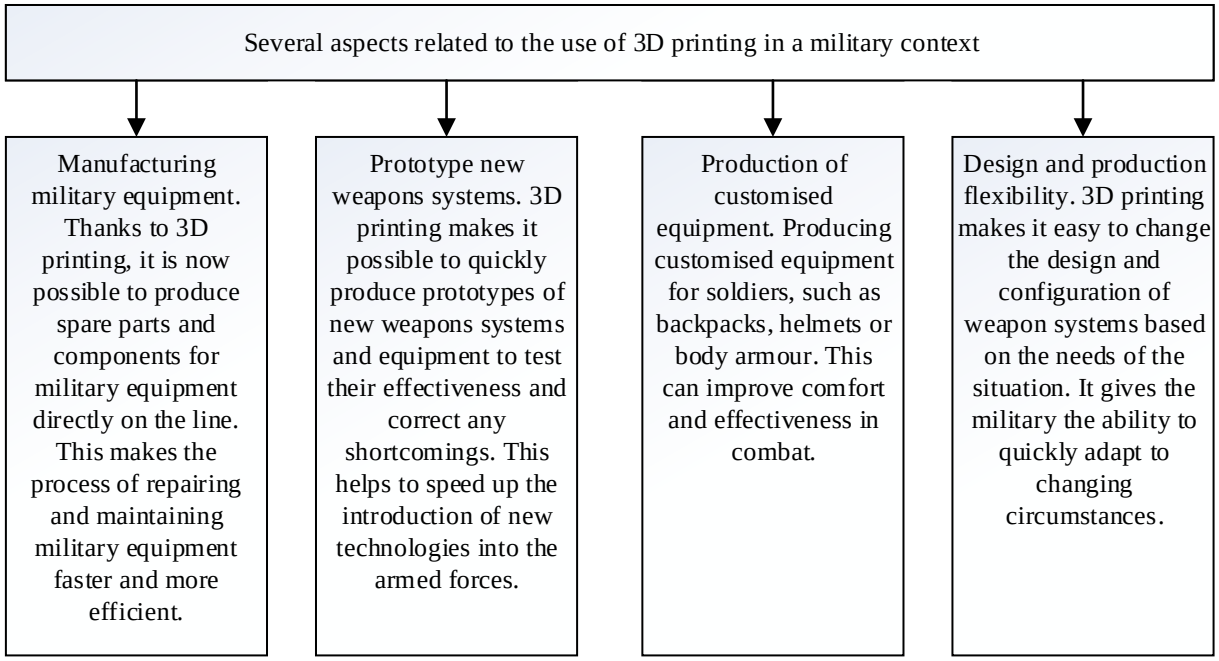

Fig.9. Some aspects of 3D printing in a military context
Source: generated by the Authors.

While 3D printing has many benefits in a military context, the use of this technology also presents challenges, such as ensuring cybersecurity, controlling the proliferation of weapons systems, and complying with international norms and regulations.

New materials

Supermaterials are next-generation materials with unique properties that are superior to conventional materials in terms of mechanical, physical, chemical and electronic properties [23]. Their unique properties result from a specific microstructural organisation or from the use of exotic materials. They can have a wide range of applications in different sectors, including industry, medicine, transport, electronics and defence.

The use of new materials with additive and hybrid manufacturing will create more efficient products with less waste, embedded electronics and sensors that will enable rapid development and production of spare parts for weapons, combat vehicles and armaments. New materials can be created using techniques from nanotechnology or synthetic biology. Developments could include coatings with extreme heat resistance, high-strength armour or platforms, invisibility, energy harvesting and storage, superconductivity, advanced sensors and decontamination.

Supermaterials have great potential for use in the defence sector, as their unique properties can provide an advantage at different stages and in different areas of military operations.

Possible military applications of supermaterials are shown in Fig.10:

– lightweight and durable bulletproof vests with enhanced protection that can be made using super materials such as graphene or nanocrystals;

– superalloys can be used to make high-strength turbine components in aircraft and helicopters, increasing engine efficiency and reducing their susceptibility to damage;

– camouflage materials, the development of camouflage materials that make military forces invisible on the battlefield. Supermaterials can make military equipment and soldiers invisible to enemy optical reconnaissance systems;

– aerodynamic parts, graphene and other supermaterials can be used to make aerodynamic parts for fighter jets, missiles and other military equipment;

– electronics: Reliable elements of weapons and military equipment, combined with innovative software products, provide an unprecedented advantage over the enemy.

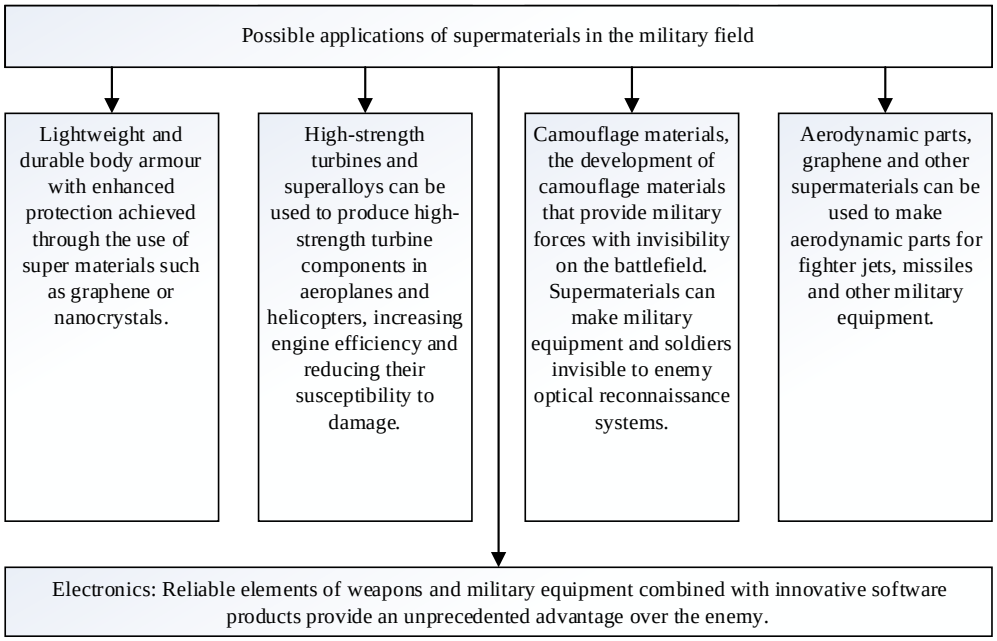

Fig.10. Possible military applications of supermaterials
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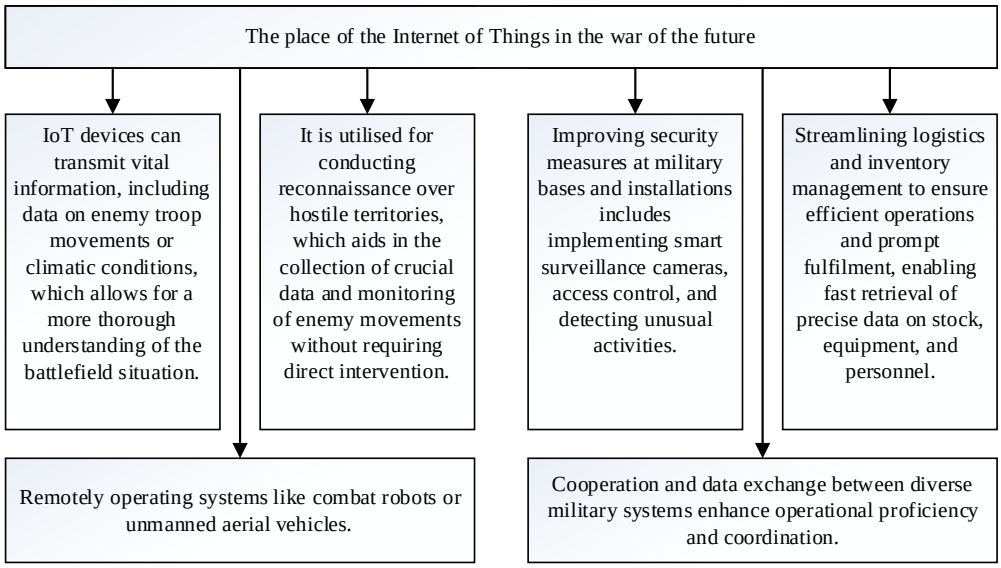

Fig.11. The place of the Internet of Things in the war of the future
Source: generated by the Authors.

Internet of Things

The term Internet of Things (IoT) was coined by Kevin Ashton in 1999. The IoT is a network of physical objects that have embedded technologies that allow them to interact with the external environment, transmit information about their state, and receive data from the outside world [24].

The Internet of Things is based on the following technologies: identification, measurement, data transmission, data processing and actuators.

The potential place of IoT in future warfare is shown in Fig.11.

However, the use of IoT requires a careful balance between the benefits and potential threats to civilians

and the military.

"Green" hydrogen

Green hydrogen refers to hydrogen generated through renewable energy including solar, wind and hydroelectric power or high-efficiency processes that emit less greenhouse gases.

The use of green hydrogen in the defence industry offers numerous benefits:

– utilise as an energy source for a range of military equipment: military vehicles, combat systems, tanks, aircraft, and missiles;

– enhanced Mobility and Flexibility. Hydrogen presents a key opportunity for boosting mobility and flexibility in military operations. For instance, military vehicles utilising hydrogen fuel cells can achieve faster speeds and longer durations in the field;

– reducing Petroleum Dependence. Employing green hydrogen as an alternate energy source may reduce reliance on traditional energy sources in the military sector, enhancing resistance to economic and political uncertainties;

– minimising the environmental impact of military operations, decreasing emissions of greenhouse gases and other pollutants.

However, it is important to note that implementing green hydrogen technologies in the defence sector may pose certain technical, economic, and strategic challenges. For instance, storing and transporting hydrogen presents numerous challenges that necessitate specialised infrastructure solutions. Furthermore, the cost and efficiency of producing green hydrogen could impede its extensive usage in military contexts. Consequently, transitioning away from hydrocarbon fuels could pose further energy difficulties, particularly with respect to maintaining and safeguarding military sites and installations.

Digital contact tracing

The technology known as digital contact tracing [27–28] can detect and track contacts, interactions, and movements of military personnel and individuals. This makes it applicable in military contexts.

The technology relies on gathering, examining, and deciphering digital data for comprehending the battlefield's circumstances and making astute tactical choices.

Some possible applications of digital contact tracing in the military:

– digital contact tracking will enable military forces to monitor the movements, weaponry, and equipment of the enemy. This will include scrutiny of social media, collection of communication signals, satellite data, radar data and other sources of information;

– the electronic information acquired from contact tracking will form the foundation for the command to make knowledgeable choices grounded on current knowledge regarding the opponent's movements and likely intentions;

– employing digital contact tracking to enhance command and coordination of their own military personnel and ensure their safety;

– anticipating enemy conduct by analysing data on enemy movements and rotations, predicting their potential actions and intentions, enabling a strategic edge in the planning of military operations;

– digital contact tracing can identify potential threats, regulate entry to important facilities, and maintain security at military installations.

Overall, digital contact tracing can prove to be a helpful tool in military operations to guarantee the efficiency and safety of the military.

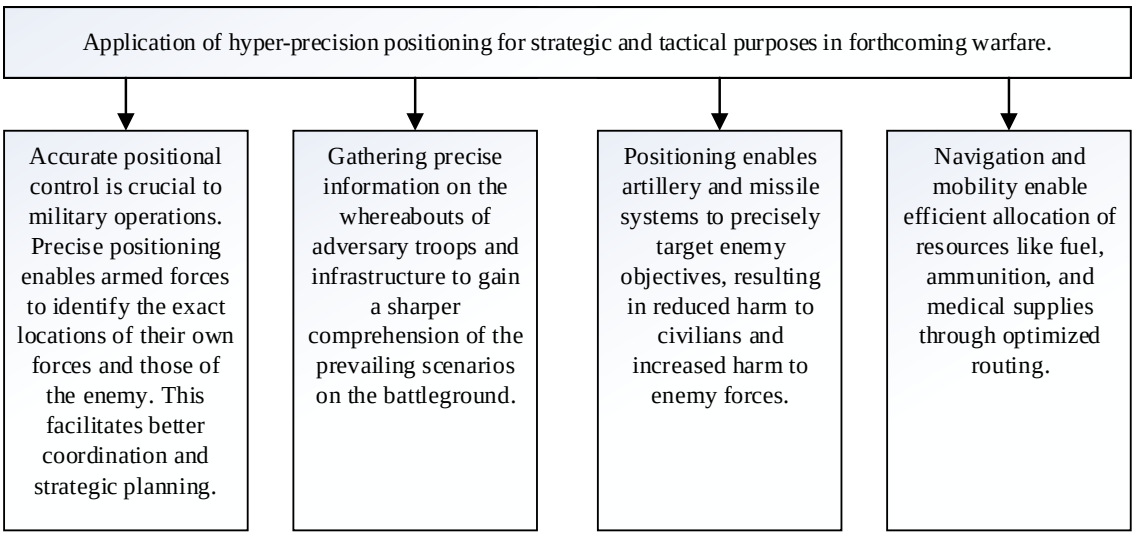

Fig.12. Application of hyper-precision positioning for strategic and tactical purposes in future warfare
Source: generated by the Authors.

Hyper-accurate Positioning

A hyper-precision geolocation technology [29] can precisely determine an object's location with high accuracy. This technology utilizes global navigation

satellite systems (e.g. GPS, GLONASS, Galileo) and other sensors to acquire precise position information.

The application of hyper-precision positioning for strategic and tactical purposes in future wars is illustrated in Fig.12.

Conclusions

Technological advancements in the field of military technology are evolving rapidly, necessitating ongoing efforts towards the creation of innovative systems and strategies.

The article highlights that the increasing influence of artificial intelligence and autonomous systems is leading to a higher degree of efficiency and complexity in military operations.

The advancement of AI presents novel ethical, legal, and security concerns. It is imperative to establish adequate measures for regulation and control of its applications. AI in military operations is a crucial responsibility to ensure compliance with international humanitarian law and ethical best practices. The prevalence of innovative technologies results in the escalation of cybersecurity risks, necessitating enhanced cyber defence measures.

The employment of big data technologies in management and decision-making systems enables significant enhancement of management efficiency and optimization of decision-making processes. It also improves the accuracy of forecasting and understanding of trends in diverse management areas, facilitates prompt response to changes and makes decisions faster. Furthermore, it allows for the processing and analysis of not only structured but also unstructured data, which broadens decision-making capabilities.

Robotic systems show great promise in achieving autonomy and enhancing efficiency in various tasks, showcasing their versatility in military applications as well as in other sectors such as industry and medicine. The range of applications for robotic systems demonstrates their versatility.

In future conflicts, autonomous weaponry, like “drone swarms”, will have a significant impact, being integrated into a unified system. The size and agility of these swarms create the potential for military confrontations that are too rapid and intricate for human monitoring.

The utilization of biotechnology within the defence sector establishes a new level of strategic significance for the advancement and upkeep of military might. Additionally, biotechnology can contribute to the formulation of tactics to counteract threats such as biological attacks and can improve the efficiency and flexibility of armed forces in diverse war scenarios.

Biotechnology provides a foundation for a substantial enhancement of human potential, surpassing limitations in physical, mental, and societal domains.

Space technology plays a vital role in contemporary surveillance, communication, and navigation systems. It provides global access to information, and is fundamental in ensuring both national and global security by facilitating early warning systems and the tracking of potentially hazardous objects.

Hypersonic technologies offer novel strategic opportunities for high-speed, unpredictable warfare. In the defence industry, notable attention focuses on hypersonic strike weapons, intelligence and navigation, and defence and air defence.

The implementation of hypersonic technologies in the defence industry presents various challenges, including the creation of efficient systems for countering these technologies, securing them, and reducing the risk of armed conflicts.

Quantum technologies hold significant potential in the defence sphere, giving armed forces an edge in intelligence, communications, cryptography and computing. They have the capability to change the paradigm of weapons use.

Multiple aspects concerning the use of 3D printing within the military are being taken into account, specifically the manufacturing of military equipment, creation of prototypes for new weapon systems, production of individual equipment, and the flexibility in design and manufacturing.

Although 3D printing offers numerous benefits within the military context, there are also several challenges that need to be addressed, including maintaining cybersecurity, managing the proliferation of weapons systems, and adhering to international norms and regulations.

The utilisation of novel materials (new-age materials with exceptional characteristics) through additive and hybrid manufacturing techniques will give rise to superior quality merchandise with minimal wastage, integrated electronic components and sensors. Consequently, enabling the expeditious design and manufacturing of replacement parts for weapons, military automobiles and arms. New materials can be created with techniques derived from nanotechnology or synthetic biology. Developments could include coatings with extreme heat resistance, high strength body armour or platforms, invisibility, energy harvesting and storage, superconductivity, advanced sensors and decontamination.

This article presents the benefits of using “green” hydrogen in the military industry, as well as the technical, economic and strategic challenges of implementing this technology. The article introduces the concept of digital contact tracking technology, which is based on the collection, analysis and interpretation of digital data to understand the battlefield situation and make informed strategic decisions. Strategic and tactical

ways of using hyper-precision positioning technology will be presented. (Hyper-accurate Positioning). This technology can be a great advantage in military operations, providing speed and unpredictability and opening up opportunities for greater tactical manoeuvrability, which can be an important factor in the effective conduct of war.

The armed forces must actively adapt to new technologie. This article presents the benefits of using "green" hydrogen in the military industry, as well as the technical, economic and strategic challenges of implementing this technology. and develop new strategies and approaches to warfare.

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ПРОГНОЗ РОЗВИТКУ ТЕХНОЛОГІЧНОЇ ОСНОВИ ВІЙН МАЙБУТНЬОГО

А.О. Бережний, А.В. Тристан

Технологічний прогрес у сфері військових технологій швидко розвивається, вимагаючи постійної роботи над розробкою нових систем та стратегій. В статті доведено, що зростання ролі штучного інтелекту та автономних систем визначає новий рівень ефективності та складності військових операцій. Проведена оцінка використання біотехнологій в оборонній сфері, яка визначає новий рівень стратегічної важливості для розвитку та збереження військової потужності. Розглянуто космічні, гіперзвукові та квантові технології, а також аспекти, які стосуються використання 3D друку в військовому контексті. Оцінено можливість використання нових матеріалів, які можуть бути виготовлені з використанням методів, взятих з нанотехнологій або синтетичної біології. Представлені переваги застосування "зеленого" водню у військовій промисловості, а також виклики впровадження цієї технології. Розкрито поняття технології цифрового відстеження контактів, а також представлені стратегічні та тактичні шляхи застосування технології гіперточного позиціонування. Результат проведеного дослідження показує, що рівень захисту та безпеки майбутніх громадян безпосередньо пов'язаний зі здатністю передбачати домінуючі технології та технологічні тренди, спроможністю оцінювати їхній вплив на майбутнє та на цій основі розробкою стратегії трансформації нових технологій.

Ключові слова: *біотехнології; війна майбутнього; військовий конфлікт; навігація; інформаційні технології; озброєння та військова техніка; система управління та підтримки прийняття рішення; технологія; штучний інтелект.*