ARTICLE DOI 10.52781/cmm.a203

Case study on the use of drones in the Ukraine War and the impacts on land military doctrine

Estudo de caso sobre o emprego de drones na Guerra da Ucrânia e os impactos na doutrina militar terrestre

Resumo: O artigo busca analisar o emprego de drones na Guerra da Ucrânia e suas implicações para a doutrina militar terrestre. Objetiva compreender como os drones, especialmente veículos aéreos não tripulados (VANT), foram empregados e quais foram as suas implicações no campo tático. Foi utilizado um estudo de caso único, com abordagem qualitativa, baseado na análise de fontes abertas, como matérias de jornais especializados e relatórios de *think tanks*. Os resultados indicam que drones potencializam funções de combate (comando, inteligência, fogos, manobra, proteção, logística), mas não configuram uma Revolução em Assuntos Militares. Eles também não substituem armamentos tradicionais, mas os complementam. A análise demonstra que há espaço para a evolução da doutrina militar terrestre com esse novo vetor, tais como: adaptações na formação dos militares; estímulo à inovação, mesmo em combate; absorção de tecnologias emergentes na dotação de material; revisão de quadros organizacionais de unidades; e aprofundamento sobre questões éticas diante do uso de tecnologias emergentes.

Palavras-chave: Guerra da Ucrânia; Drones; Inovação militar; Revolução em Assuntos Militares; Estudo de caso.

Abstract: This study analyzes drone use in the Russo-Ukrainian War and its implications for land military doctrine. It aims to understand how drones, particularly Unmanned Aerial Vehicles (UAVs), were employed and their tactical impacts. A single case study with a qualitative approach was used, examining open sources like specialized news outlets and think tank reports. Results indicate drones enhance combat functions (command, intelligence, fires, maneuver, protection, logistics) but do not constitute a Revolution in Military Affairs. They complement, rather than replace, traditional weaponry. The analysis shows room for the evolution of land military doctrine, including: adapting soldier training; fostering innovation in combat; integrating emerging technologies into equipment; revising unit organizational structures; and deepening ethical considerations regarding emerging technology use.

Keywords: Russo-Ukrainian War; Drones; Military Innovation; Revolution in Military Affairs; Case Study.

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Received: Month DD, YYYY
Accepted: Month DD, YYYY

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

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1 INTRODUCTION

In November 2024, the Ukraine War saw the largest drone attack take place. While the Russians launched over 145 drones, the Ukrainians attacked Russian troops with dozens (Russia [...], 2024). Similarly, in June 2025, Operation Spider Web, launched by Ukraine against the Russians after over a year of preparation, highlighted the possibility of infiltration, within enemy territory, of drones capable of destroying highly strategic targets, revealing security vulnerabilities in Russian defense areas (Analysis [...], 2025).

This article investigates the use of drones, understood as unmanned aerial vehicles (UAVs), in the Ukraine War, from its beginning until 2025, to understand whether its use can be considered a Revolution in Military Affairs (RMA) and their impacts on the operations of the armed forces in conflict.

Our research problem is comprehending, based on these lessons learned, whether the Ukraine War was able to foster an RMA and to raise the possible implications of using drones in conflicts regarding the evolution of land warfare doctrine. Our main result indicates that using drones did not produce an RMA, but significantly impacted war operations at the tactical level.

Methodologically, we conducted a case study based on open sources from the world wide web such as newspaper articles, articles from specialized websites, and reports from think tanks.

The use of drones as weapons of war is causing stagnation on the front lines. They are being used by both parties for both target acquisition and kamikaze attacks. Any movement can be observed by the enemy, which has entrenched the combatants (Gormezano, 2025).

Commercial drones purchased on Amazon, in many cases for less than $1,000, are sent to Ukraine for performing reconnaissance, shelling, or kamikaze attack tasks (Ukraine Defense Support, [2024]). While military drones, better known in military circles as unmanned aerial vehicles or remotely piloted aircrafts (RPAs), which are mostly produced by Turkey and Iran, whereas commercial drones originate mainly from China (Mozur; Hopkins, 2023).

However, aerial vehicles are not the only ones with automation. Unmanned ground vehicles are also reshaping land operations. Russia's armed forces have used them to transport explosives directly to the enemy's position, in demining operations, to delivery ammunition and other types of supplies, to transport anti-tank mines, to evacuate the wounded, and some were equipped with cannons (Sputnik, 2025).

Unmanned maritime vehicles, like unmanned aerial vehicles, have been used by Ukraine against the Russian Black Sea fleet, at relatively low costs, spreading the urgency of obtaining this defense product (IISS, 2024, p. 7).

Intensive drone use marks a revolution in the conflict, as it has been improved in integration with electronic warfare and artillery (Aksenov; Chernysh; Howell, 2024). However, the Ukraine War was not the first conflict to use this equipment: drones have

already been used in conflicts in Libya, Syria, and Nagorno-Karabakh (Hecht, 2022), albeit incipiently.

Additionally, both contenders have used artificial intelligence to provide data analysis, improve decision-making capacity (through geospatial intelligence, analysis of unencrypted communications, cyber attacks), and build autonomous vehicles (Bendett, 2023). Drones are being enhanced with artificial intelligence and machine learning to act without GPS and even without an operator (Como [...], 2025b; Hakmeh, 2025; Stepanenko, 2025, p. 1).

These are just a few examples of how emerging Industry 4.0 technologies, more specifically equipment with technological automation, have transformed modern conflicts. Faced with these new technologies, the armed forces involved in the conflict had to adjust their employment doctrine.

Up to the 16th century, the energy source of most of the technology applied to weapons came from animals or from humans themselves. From then on, the use of chemical sources like gunpowder in weapons was a revolutionary factor in war, as it increased lethality on the battlefield and reduced dependence on the soldier's individual skills, such as physical strength (Van Creveld, 1991, p. 85).

Weaponry evolution on the battlefield kept pace with the Industrial Revolution. Certain war equipment would have been impossible without the invention of steel and steam energy (Van Creveld, 1991, p. 170).

However, it was the First World War that drove the technological evolution in war and the emergence of the "modern warfare" (Knox; Murray, 2009, p. 132). The climax was the advent of nuclear weapons (Knox; Murray, 2009, p. 6). According to Van Creveld (1991, p. 11), war "is completely permeated by technology and governed by it"; however, not all technology affects war (Van Creveld, 1991, p. 306).

Technological innovations and military doctrine interact with each other, either because new technologies that were originally non-war are absorbed into the war effort, or because the war effort demands new technological solutions for one of the warring parties to gain advantages over the other. The Ukraine War has raised discussions about military innovation in this regard (Hakmeh, 2025; The Russia-Ukraine [...], 2025). Indeed, the lessons emerging from the conflict are already influencing the thinking of many armed forces (IISS, 2024, p. 9).

Drone is the name given to the Hornet, the male bee, and its buzzing. Due to the noise it usually makes and its appearance, the term ended up being adopted to refer to UAVs or unmanned aerial vehicles (Brasil, 2015, p. 278). Another term that has been adopted in Brazilian military doctrine is remotely piloted aircraft, a class of UAV (Brasil, 2020, p. 1-2).

The set of resources required to perform a specific task using UAVs, including command and control equipment and specialized personnel, is known as a remotely piloted aircraft system (RPAS) (Brasil, 2020, p. 1-3). The fact is that, by broadening the meaning, drones have come to be used for any air, land, or sea vehicles remotely piloted or with autonomous navigation (Brasil, 2015, p. 95).

In this article, we use drone in reference to UAVs, since this is its most used meaning.

2 METHODOLOGY

Our research subject centers on the use of drones, more specifically UAVs or remotely piloted aircraft. Our overall objective is to understand how drones were used in the Ukraine War to visualize possible implications on land warfare doctrine.

For this purpose, the specific objectives contextualized the use of drones in this armed conflict, outlined theories of innovation—particularly in the military field—discussed the adequacy of these theories for interpreting the phenomenon of war, debated the consequences of introducing drones in combat and, finally, raised the consequences of using this vector in land warfare doctrine. A qualitative approach was chosen for preparing this article to explore and understand the problem (Creswell; Creswell, 2018, p. 41).

We chose a single case study as a research strategy and the use of drones in combat (Yin, 2001, p. 58) as the unit of analysis, verifying its adequacy to the standard of military innovation theories (Yin, 2001, p. 136) for an in-depth analysis of the case (Creswell; Creswell, 2018, p. 51).

A brief literature review was conducted to discuss theories of innovation, especially in the military field. This approach allows framing the problem from a theoretical framework and provides the necessary tools for a better understanding (Creswell; Creswell, 2018, p. 68).

Data were collected mainly from newspaper clippings and other media articles (Yin, 2001, p. 107), mostly retrieved from the world wide web. Intentionally, this survey perused open sources texts and videos that addressed the use of vehicles exclusively in the Ukraine War. Most recent and up-to-date publications were favored given the changes in how the war was conducted over time. Older publications ran the risk of no longer reflecting reality.

Overall, we used three types of sources: news and reports from newspapers and magazines such as *Al Jazeera*, *Sputnik*, *BBC*, and *Reuters*; articles from magazines and specialized websites, such as *War on the Rocks*, *European Secure and Defence*, *Atlantic Council*, *Modern War Institute*, and *Chatham House*; and reports produced by think tank, such as the Center for Strategic and International Studies (CSIS), the Royal United Services Institute (RUSI) and the Institut Français de Relations Internationales (IFRI).

Data analysis was structured in two stages. First, a literature review was conducted to establish a theoretical framework based on concepts of innovation, highlighting RMA. Subsequently, the case study investigated how drones have been used in the Ukraine War and the main implications for combat roles to identify patterns and infer interpretations.

3 THEORIES OF INNOVATION

In his Theory of Economic Development, Schumpeter (1997) presented a new reason for the cyclical discontinuities of the economy, proposing the concept of "creative destruction." He established the correlation between periods of prosperity and the innovation driven by entrepreneurs. As technological innovations emerge and succeed, other entrepreneurs begin

to imitate the innovative entrepreneur, producing a wave of investment and prosperity (Costa, 1997, p. 11-12).

Schumpeter (1997, p. 78) defines innovation as the introduction of a new good or a new quality of a good, or the introduction of a new production method that has not yet been tested, among other characteristics. In other words, innovation involves the emergence of something new, the improvement of something that already exists, or the creation of a new process for producing something that already exists.

Industrial revolutions are classic examples of Schumpeter's theory. The Fourth Industrial Revolution, or Industry 4.0, which is still underway, is characterized by technological advances in the Internet of Things (IoT), data science, big data, cloud computing, blockchain, and artificial intelligence—developments that result in hyperautomation and hyperconnectivity (Parashar *et al.*, 2023). "Dronization" is the result of a series of innovations stemming from Industry 4.0 (Tourret, 2025, p. 10).

Taylor (2023, p. 129) identified five pillars underpinning innovation in a country: intellectual property rights, research subsidies, education and university research, and market policy. These can account for up to 90% of the differences in national innovation indices (Taylor, 2023, p. 178), but they cannot explain all of a nation's successes and failures in innovation (Taylor, 2023, p. 181).

According to the author, there is a strong positive correlation between national protection of intellectual property rights (Taylor, 2023, p. 143), investments in science and technology (S&T) (Taylor, 2023, p. 152), university research (Taylor, 2023, p. 166), and a country's innovation index. A limited positive correlation exists between national education and the national innovation index; however, when it comes to higher education in the fields of Science, Technology, Engineering, and Mathematics (STEM), this positive correlation tends to be more significant (Taylor, 2023, p. 158). Market policy—that is, the choice between protectionism and the free market—shows the weakest correlation with a country's innovation indices (Taylor, 2023, p. 176).

Finally, Taylor (2023, p. 296, our translation) argues that the most innovative nations are "those that design institutions and policies to solve problems related to public goods that hinder progress in S&T." This means reducing transaction and information costs, mitigating risks, and providing public goods not supplied by the market, in addition to maintaining domestic and international networks of relationships and exchange.

Mazzucato (2014), on the other hand, argues that rather than merely correcting failures that limit innovation, the state should become an entrepreneur by being proactive and taking risks when funding research that carries a high probability of both failure and innovation. That is how funding from the U.S. Defense Advanced Research Projects Agency (DARPA) made it possible for Apple to invent the iPhone.

Hakmeh (2025) explains that, in Ukraine, the government has played the role of facilitator rather than regulator in the defense innovation process. Instead of relying solely on traditional defense innovation processes, the Ukrainian government has been fostering

public-private partnerships—a model that contrasts with the innovation models prevalent in many Western countries, which are generally more bureaucratic and characterized by a top-down approach.

Innovation has been a topic in forums and debates for some time now. Since 1990, the Organization for Economic Cooperation and Development (OECD) has published the Oslo Manual on this subject. Its fourth and most recent edition (OECD, 2018) defines innovation as

> [...] a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) (OECD, 2018, p. 20).

The generic term "unit" is used to describe the actor responsible for innovations (OECD, 2018, p. 20).

According to Posen (1984, p. 47), the main drivers of innovation in an organization are: failure—that is, something that has gone wrong and needs to be corrected; external pressure, such as that exerted by an authority, to modify processes or products; and the desire for expansion, either to address uncertainty in the environment or to obtain new resources.

Innovations, especially technological ones, are often classified into different categories, and not all of them have the same degree of impact. The most commonly used categories are incremental innovations and radical innovations (Shestakov; Poliarush, 2019).

Incremental innovations result from the refinement of existing technologies, products, or other innovations and tend to change the world gradually, without causing dramatic changes. Inversely, radical innovations cause a significant change in a particular area and in many areas of human life simultaneously, which can result in a meticulous restructuring of the functioning models of technical and social systems (Shestakov; Poliarush, 2019, p. 72).

4 INNOVATION IN THE MILITARY

Military innovation occurs within the context of "military change," defined by Farrell and Terriff (2002, p. 5) as "changes in the objectives, strategies, and/or structures of a military organization." Military change should not be confused with military innovation, since innovation is one of the three ways in which military change occurs, along with adaptation and emulation (Farrell; Terriff, 2002, p. 6).

For Farrell and Terriff (2002, p. 6), innovation involves the development of new military technologies, tactics, strategies, and structures. Adaptation, in turn, is simply a matter of adjusting military resources and methods, and leads to innovation only when it results in an evolution of these. Emulation, on the other hand, involves adopting tools and methods of combat by imitating other organizations.

When any of these phenomena occur only in the means and methods at the operational and tactical levels, without entailing a change in objectives, organizational strategy, or structure, they are not considered *de facto* military changes. In other words, military change occurs through

innovation, adaptation, and emulation, but not every instance of innovation, adaptation, or emulation necessarily results in military change.

Posen (1984, p. 56), in turn, asserts that new technologies, when not tested in combat, rarely serve as catalysts for doctrinal innovation. Additionally, military innovations tend to be spurred in countries by wars fought by other states to which they sell their weapons. However, the best way to foster innovation is through direct hands-on experience with a new technology.

Caldeira and Barbosa (2021) argue that innovation management should be implemented through clear, objective actions that are aligned with the life cycles of defense products and with the factors that drive capabilities. However, Diniz and Tonelli (2024) observe that organizational culture configures a barrier to innovation.

Still in the military sphere, a product or process—whether new or improved—can, in the context of warfare, be considered a military innovation or a defense innovation. Defense innovations can be both technological and non-technological. The latter include doctrinal innovations and other intangible elements, such as doctrinal, organizational, strategic, and military tactical principles (Azevedo; Mesa, 2022, p. 267).

Major conflicts are often fertile ground for defense innovations. The Vietnam War, for example, led to a fundamental shift in the doctrine of the U.S. Army. The 1973 Yom Kippur War between Israel and the Arab countries helped shape the U.S. military's analysis of what future wars would look like (Jensen, 2023, p. 45-47).

When it comes to military innovation based on technological revolution, a concept that was very prevalent in the United States—especially in the 1990s—comes to mind: the Revolution in Military Affairs (RMA), whose greatest advocate and leading figure was Andrew W. Marshall (Chapman, 2003, p. 2).

At the time, analysts believed that the use of high-tech weapons systems could be decisive in a military operation, and they had high expectations regarding the impact of information technology on combat, which could change the nature of war (Cuoco, 2010, p. 2).

Although the concept of RMA emerged in the West in the context of the First Gulf War, it was actually developed by Soviet theorists as early as World War II and revived in the 1970s under the name Military-Technological Revolution (MTR) (Cuoco, 2010, p. 12; Martyanov, 2019, p. 71).

There is no consensus on the definition of RMA. In fact, there are several schools of thought or paradigms on the subject, and the concept itself faces many critics (Chapman, 2003, p. 2). However, we identify some prevailing ideas regarding this concept. According to O'Hanlon (2000, p. 7),

> The RMA thesis maintains that further advances in precision munitions, real-time data sharing, and other modern technologies could transform the nature of future warfare and, as a result, the size and structure of the U.S. armed forces.

RMA proponents argue that precision munitions and surveillance, intelligence, and reconnaissance technologies would give the forces that possess them the power to dominate information about their enemies. Rapid mobility and precision strikes would allow these forces

to inflict greater destruction on those without such technologies. Thus, the principle of mass would no longer be the decisive factor (Robinson, 2022, p. 66).

According to Gray (2002), RMA is "a radical change in the character and conduct of war," but not in its nature, which is immutable (Gray, 2002, p. 4).

Cooper (1994, p. 12) distinguishes three types of RMA. The first is driven by purely new military technology, spurred by fundamental technological and scientific developments or inventions. It is the most commonly used term, giving the impression that this is a technology-based phenomenon, as was the case with nuclear bombs and their intercontinental delivery systems.

The second is driven by organizational and operational innovations—without emphasizing the technological aspect—to resolve a strategic problem, entailing changes in the conduct of war. One example would be the German *blitzkrieg* during World War II.

The third type is driven by social, political, and economic changes, as was the case during the Napoleonic era. Changes often occur outside the military sphere. This would be what Knox and Murray (2009, p. 7) call the Military Revolution.

RMA produces new ways to destroy opponents and

> [...] require the integration of a complex mix of tactical, organizational, doctrinal, and technological innovations in order to implement a new conceptual approach to warfare or to a specialized sub-branch of warfare (Knox; Murray, 2009, p. 12).

RMAs have four distinct characteristics. First, technology plays much more of a catalytic role than a driving one in RMAs; in other words, it is rarely the primary cause of the process. Second, RMAs arise from solutions to problems directly related to tactical and operational issues in specific theaters of operations and against specific enemies, not against hypothetical opponents. Moreover, these revolutions require a framework of coherent and realistic doctrines and concepts based on experience gained through exercises and experiments. Finally, RMAs do not replace strategy; on the contrary, they remain tied to and constrained by its parameters (Knox; Murray, 2009, p. 192-193).

In short, the RMA process usually begins with an adaptation, generating an opportunity for innovation that, ultimately, produces a Revolution in Military Affairs. The evolution of the art of war is an ongoing process that incorporates innovations and RMA. These are some of the main premises postulated by RMA theorists, especially after the First Gulf War.

5 USE OF DRONES AS A MILITARY INNOVATION IN THE UKRAINE WAR

The use of drones was not unique to the war in Ukraine. Military drones were already being used in the conflict between Azerbaijan and Armenia in Nagorno-Karabakh. But the war in Ukraine was the first major war in recent times in which opponents of nearly equal strength

faced off, unlike, for example, the Gulf War, in which clearly only one of the parties involved was capable of deploying its innovations (Lieven, 2023).

What set the war in Ukraine apart was the massive use of modified commercial drones, primarily as aerial platforms, deployed in a wide variety of combat roles. Instead of relying on highly sophisticated systems, Ukraine has prioritized low cost, adaptability, and economies of scale, which has challenged conventional thinking about technology (Hakmeh, 2025).

Commercial drones, most of which were purchased from China, were originally adapted for military use. The main model is known as first-person view (FPV), which generally resembles a quadcopter (Zoria, 2024). This led to a "democratization" of air power (Slusher, 2025).

Drones are considered revolutionary because of three direct effects they have on military conflicts and world politics: because they are small, they are harder for other aircraft's radar systems to detect; they are affordable and technologically unsophisticated; and some believe they are capable of eliminating close-quarters combat on the battlefield due to their ability to carry out long-range precision strikes (Calcara *et al.*, 2022, p. 130).

The demand created by the war, along with the low cost and ease of assembly of drone components, has enabled Ukraine to make significant progress in developing its own industrial base, to the point that it now plans to build 4.5 million units by 2025 (Tanghe, 2025). This has been further enhanced by 3D printers (Dass, 2024; Como [...], 2025a), going beyond assembly to include production on the battlefield. They are destroyed just as easily as they are produced. Ukraine is estimated to have lost around ten thousand units per month in 2023 as a result of Russian attacks (Artillery [...], [202-]).

The ability to assemble the parts "like Lego" allows drones to be configured with the size, weight, and components necessary for their intended mission, increasing the likelihood of their effectiveness (Cazalet, 2025). Since the beginning of the conflict, drones have been evolving and becoming increasingly sophisticated, stealthy, and lethal. However, tactical drones have many limitations (Jajcay, 2025).

Between 60% and 80% of them fail to hit the target (Watling; Reynolds, 2025, p. 10). Nonetheless, UAVs are estimated to already be responsible for over 70% of the casualties on both sides and for over 65% of the Russian armored vehicles destroyed (Ferguson, 2025; Slusher, 2025, p. 3).

Drones have become essential tools in warfare, being used for surveillance, long-range strikes, and tactical firepower; as a result, Ukraine has established a unified command structure for its unmanned systems to harmonize approaches, facilitate joint operations, and make the use of these vehicles more effective in combat (Hodunova, 2025). Russia, for its part, has created a new military force to oversee the production, operation, and testing of drones (Altman, 2025).

All Ukrainian combat echelons have UAVs: heavy for shelling, light, and FPV. Most brigades have a company, battalion, or other fraction of drones to support a 40- to 70-kilometer front (Watling; Reynolds, 2025, p. 10).

5.1 Drones and the Revolution in Military Affairs

The war in Ukraine has exposed the limitations of RMA (Calcara *et al.*, 2022; Lieven, 2023; Robinson, 2022). New technologies are being used to supplement and reinforce existing methods of warfare rather than change them (Robinson, 2022, p. 24).

Much more than a revolution, drones are part of the evolution of air warfare, whose fundamental principles continue to be avoiding exposure to enemy fire. Thus, they do not eliminate the imbalances between opposing forces, nor do they eliminate close combat (Calcara *et al.*, 2022, p. 131).

Drones are capable of acting as precision-guided munitions (PGM) (BAE [...], 2025). But contrary to what some people argued—that small unmanned PGMs would replace heavy munitions, such as artillery shells—what has actually been happening is the opposite: an increase in the production of heavy munitions worldwide (Fact [...], 2025).

Unlike aircraft, drones—particularly FPV drones—face few restrictions on their use, as they do not require infrastructure such as airports to operate, nor do they require large quantities of fuel, such as aviation kerosene. Moreover, they have relatively low or negligible maintenance costs, and are expendable—that is, their loss has little or no impact on those who operate them (Cazalet, 2025).

The innovation brought about by the use of UAVs has not reduced the need for large military forces. In the war in Ukraine, where the opposing sides are evenly matched, the need for compulsory conscription and the mobilization of volunteers has been confirmed, both in Ukraine and in Russia (Boechat, 2025; Kirby, 2025; Lieven, 2023).

While drones and other advanced technologies have enabled Ukraine to challenge Russia in unexpected ways, they have not yet replaced the need for traditional military power. Instead, they are more commonly used to complement it as an adaptive technological strategy (Hakmeh, 2025), in addition to drawing on the principle of mass (Tourret, 2025, p. 5).

On the other hand, some of the predictions made by RMA theorists have come true. Major technological advances resulting from the use of drones have had an impact on ammunition, communications, and intelligence, and have also provided a better view of the battlefield, enhancing situational awareness and becoming an integral part of the decision-making process.

In fact, the opponents' advantages were not achieved through the use of individual technologies, but by their ability to consistently outpace the enemy in the innovation cycle (Hakmeh, 2025). Technological advantages are usually temporary, as the adversary also adapts to the new circumstances. This leads to the concept of the principle of action and reaction, or challenge and response.

A clear example from the war was the innovative use of electronic warfare in anti-aircraft defense against drones (Zafra *et al.*, 2024), which led combatants to use drones equipped with fiber optics to remain immune to this type of defense (Walsh *et al.*, 2025). These drones are being used to destroy electronic warfare devices, thereby enabling the use of other drones for other purposes (Fiber-optic [...], 2025).

In this regard, whoever is the first to implement a technological innovation will maintain the advantage for as long as it takes for the opponent to react and regain the upper hand. Thus, the

processes involved in innovating, developing, and procuring defense products must be faster and less bureaucratic (Cazalet, 2025; Hakmeh, 2025).

The obsolescence cycle is very fast. Throughout the conflict, many weapons systems quickly become obsolete, particularly when it comes to communications, control, and electronic warfare involving drones (Cazalet, 2025).

Thus, the replacement of troops with robotic vehicles raises important questions regarding ethical, legal, and philosophical issues (Calcara *et al.*, 2022, p. 130). The use of drones has reduced the risk to human lives during operations at a very low cost in terms of equipment loss and has increased the target accuracy. This directly affects the decision-maker's ethics, as other nuances arise between the choice to preserve a high-value asset and the decision to continue operations. Decision-makers will have at their disposal a low-cost, large-scale weapon system with a high probability of effectiveness (Slusher, 2025, p. 3-4). Consequently, they may be more inclined to take an offensive stance.

Discussions are already underway at the United Nations within the context of international law—though as yet unresolved—regarding the limits of autonomous robots in making life-or-death decisions (Barini, 2025).

Finally, due to their low cost and ease of production and operation, the use of drones as a weapon of war has become so firmly established that defense products and combat tactics must be adapted.

The introduction of drones as a weapon of war—particularly those typically used for commercial purposes—did not alter the character of the conflict. Instead of replacing principles of warfare, they have enhanced a wide range of combat functions.

5.2 Use of drones in a wide variety of combat functions

Combat functions comprise six elements of combat power: command and control, movement and maneuver, intelligence, firepower, logistics, and protection. Combat functions are the set of related activities, tasks, and systems (Brasil, 2019, p. 5-6).

Drones, especially aerial drones, have become platforms that have impacted all aspects of combat. Based on studies and accounts of the war in Ukraine, we will now explain how innovations in the field of tactics arose from these factors.

5.2.1 Command, control, and intelligence

Command and control (C2) encompasses activities and tasks that enable the commander to exercise authority and direct operations (Brasil, 2019, pp. 5-6), and it is one of the functions most significantly impacted by the advent of drones.

Intelligence involves activities related to understanding the operational environment, threats, adversaries, terrain, and civilian considerations, and carries out IRVA (Intelligence, Reconnaissance, Surveillance, and Target Acquisition) activities. (Brasil, 2019, p. 5-6). Just like with C2, intelligence has evolved significantly with the widespread use of drones in combat.

The proliferation of drones has exceeded the management capacity of C2 systems (Tourret, 2025, p. 13) due to mass surveillance, particularly within three kilometers of the frontline (Watling; Reynolds, 2025, p. 14), which could lead to "data overload" (Obis, 2024). This proliferation has also compressed the OODA loop (Observe, Orient, Decide, and Act) (Baud, 2024), making it faster. UAVs have also become platforms for extending the range of communications (Slusher, 2025, p. 4).

Regarding target acquisition, electronic intelligence (ELINT) and electronic support measures (ESM) have been used to identify hostile drones (Cazalet, 2025). Drones have been used for reconnaissance in force—that is, to provoke a reaction from the enemy in order to better understand its combat capabilities and positioning—as well as to serve as "decoys" to overwhelm the enemy's defenses before the main attack (Watling; Reynolds, 2025, p. 15).

5.2.2 Movement, maneuver, and firepower

Movement and maneuver in combat relates to the deployment of forces to position them to gain an advantage over threats. For its part, firepower relates to the collective and coordinated use of kinetic (i.e., ammunition-based) and non-kinetic firepower (such as electronic warfare, cyberattacks, and psychological operations) (Brasil, 2019, p. 5-6).

A project from Ukraine led to a defense doctrine known as the "drone line" or "drone wall" (Dickinson, 2025; Kirichenko, 2025). Given that the conflict has turned into a trench war, Ukraine intends to maintain a 15- to 20-kilometer zone filled with FPV drones to establish a kill zone Anyone who is not in a trench will probably be killed. Fighters, therefore, do not leave their foxholes to shoot or throw grenades; they basically hold their ground. As a result, there isn't much movement from the trenches, due to the high risk of becoming a target (Cazalet, 2025).

The drone line has driven an evolution in the offensive actions of frontline troops. Armies are using motorcycles and buggies (Segura, 2024) because they are faster and harder to detect than armored vehicles. The tactic involves capturing a line of defense behind enemy lines to cut off their supply lines. Losing a team on a motorcycle costs less than losing a group in an armored personnel carrier. Additionally, a motorcycle is cheaper and requires a smaller crew (Cazalet, 2025).

Regarding firepower, drones have been used in several ways, especially combined with artillery. They are used to assist in target identification, fire control, and damage assessment (Zafra *et al.*, 2024). They are also used as munitions, known as kamikaze drones, either as loitering munitions—when they hover in the air awaiting a target—or as OWA (one-way attack)—when they are launched with the specific purpose of attacking. Drones enable the large-scale use of PGMs.

Using drones does not replace artillery; rather, it enhances the fire support capability. It is worth remembering that artillery is an "area weapon." Drone use depends on weather conditions, battery life, lighting, and the availability of radio frequencies, and is vulnerable to electronic

warfare. All of these factors can render them inoperable. Thus, they are no longer suitable as a suppression element (Artillery [...], [202-]; Jajcay, 2025).

Regarding non-kinetic firepower, drones have been used predominantly in two ways. First as a side effect: their sound triggers psychological effects (Pino; Pettigrew, 2024). Second, their ability to film the events unfolding during the war is being used for information operations by posting videos on social media, intended to shape public opinion (Atherton, 2022).

5.2.3 Protection and logistics

Drone protection has definitively integrated electronic warfare into air defense (Watling; Reynolds, 2025, p. 18). As such, electronic warfare equipment has become a priority target to be neutralized before other targets, either by artillery or by fiber-optic drones (Watling; Reynolds, 2025, p. 10).

Armored vehicles and other vehicles have been modified throughout the war by adding cages for anti-drone protection (Altman, 2024; Saballa, 2025a). Even drones are being equipped with cages to protect them from other drones (Axe, 2025). Concern for air defense has reached its lowest level within the military ranks, bringing the complexity of air combat down to the smallest tactical units (Salinas; Askew; Levay; 2025).

Logistics at the tactical level have become a major challenge, given the high exposure to drones. Both countries are covering their main supply routes and logistics facilities with anti-drone nets (Russia [...], 2025; Ukraine [...], 2025). Ukraine has been using fishing nets to protect its main roads (Walsh *et al.*, 2025).

On the other hand, drones have also made it possible to supply parts, ammunition (Tourret, 2025, p. 12), and even hot meals to dispersed units using UAVs, thereby reducing the risk of exposure (Walsh *et al.*, 2025). However, weight remains a limiting factor for this method, hindering the resupply of heavier materials. The Ukrainian side in this conflict usually limits the amount of supplies to ten kilograms (Walsh *et al.*, 2025). Autonomous ground vehicles are yet fully reliable for this type of task. Similarly, evacuating the wounded is also a challenge, as it must be supported by artillery fire and electronic warfare (Watling; Reynolds, 2025, p. 17). Additionally, armored personnel carriers such as the M113 have become indispensable for logistics and more intensive medical support (Watling; Reynolds, 2025, p. 21).

6 IMPLICATIONS FOR THE EVOLUTION OF LAND WARFARE DOCTRINE

Our analysis of drone use in the Ukraine War reveals some implications for the evolution of land warfare doctrine.

Automation of military equipment will not replace an "army of humans." Recruitment has remained constant in both countries throughout the conflict (Boechat, 2025; Kirby, 2025; Lieven, 2023). But the emergent "drone wall" (Cazalet, 2025) shows that drones can be used in certain areas of operations, reducing the human presence.

A new soldier profile must be able to handle this new technology. It entails not only knowing how to operate the device, but understanding how to process the products derived from its use. Drones, especially FPV ones, are accessible to any combatant. Soldiers are no longer expected to be just a sniper; they must be prepared to produce intelligence data, to conduct fire, and to have basic knowledge of anti-aircraft defense and electronic warfare (Salinas; Askew; Levay; 2025).

Additionally, combat functions will be increasingly integrated. All military specialties must encompass all combat functions, ensuring that no particular combat function is exclusive to any one specialty. As discussed, electronic warfare was fully integrated into anti-aircraft defense planning. Target acquisition has been "democratized" (Fiber-optic [...], 2025; Zafra *et al.*, 2024). Combat protection, especially against drones, is inherent to all specialties.

Importantly, every innovative weapon generates a new doctrine, just as it generates an "anti-doctrine," that is, its antithesis. In a protracted conflict where combat power is evenly matched, an army will generally gain an advantage from innovative weaponry only while the adversary adapts to the new development (Hakmeh, 2025). Thus, stimulating innovation, especially adaptation, throughout the conflict must be part of the command action.

Current armored vehicles and other defense equipment must be adapted for anti-drone protection, such as installing cages (Altman, 2024; Saballa, 2025a).

Relying solely on the use of drones in detriment of other more traditional weapons is a mistake. Drones have their limitations and are incapable of replacing mortar and artillery fire, for example (Artillery [...], [202-]; Zoria, 2024).

The ability to 3D-print parts on the battlefield is something to be considered. Producing and assembling customized drones for accomplishing a mission in the combat zone reduces logistical effort and lead time (Dass, 2024; As [...], 2025a).

The amount of information obtained by drones can lead to a "data overload" (Obis, 2024), impacting the OODA cycle (Baud, 2024). As decision-makers will need to be increasingly prepared to deal with huge amounts of data in a relatively short time, knowing how to use data science, machine learning, and artificial intelligence, among other tools, in their favor is paramount.

However, decision-makers' data overload can cause a "paradox of choice" (when there are numerous options), leading to "analysis by paralysis." Thus, commanders and staffs should be trained to have "clarity of thought" (Forester, 2023).

As for artificial intelligence, its application in drones enhances the use of this vector, making them autonomous and more effective (Como [...], 2025b; Hakmeh, 2025; Stepanenko, 2025, p. 1). Hence the importance of conducting research on the integration of artificial intelligence in drones for military use.

Regarding the purchase of commercial drones for use in the Ukraine War, this was largely due to the affordable cost and low technological sophistication of the products (Calcara *et al.*, 2022, p. 130). Thus, we must evaluate whether it is more advantageous to invest in high-tech or less sophisticated equipment (Baud, 2024).

Revising the organizational structures of all military units, including support units, is paramount to include units or subunits with training in drone operations. Likewise, the armed forces should verify the need to create specialized drone units, following the example of aviation (Hodunova, 2025; Russias's [...], 2025).

The possibility of reducing the risk to human lives during operations at a very low cost in terms of material losses, combined with an increased likelihood of successfully hitting the target, may make decision-makers more inclined to adopt an offensive stance when using drones (Slusher, 2025, p. 3-4). Which can raise ethical and moral questions (Calcara *et al.*, 2022, p. 130). Automation in warfare produces greater damage without the loss of life and the damage produced by an atomic bomb, which will probably influence the ethics of decision-makers and society when choosing war as an instrument to impose their will.

Some possible implications for land warfare doctrine regarding the use of drones in the Ukraine War were presented here. Rather than exhaustive, this was an exemplifying presentation to contribute to the debate and deepen the research.

7 CONCLUSION

We have analyzed the impact of using drones, especially UAVs, on the Ukraine War to understand its implications for the evolution of land warfare doctrine. By analyzing a unique case study centered on conflict as a "military innovation laboratory," we identified that drones represent a significant evolution in the art of war, but not an RMA.

Our analysis revealed that drones, particularly adapted commercial ones, enhanced all combat functions—command and control, intelligence, fire, movement and maneuver, protection and logistics—but did not alter the fundamental character of war. Drones complement, rather than replace, traditional weaponry such as artillery.

We employed a research methodology structured as a single case study, as defined by Yin (2001), with the use of drones in the Ukraine War as the analysis unit. Data collection explored documents, news reports and reports from think tanks to identify patterns and infer interpretations about the impact of drones.

Our study highlighted that drones have provided notable advances, such as greater situational awareness, precision strikes, and reduced risks to human lives, but have also exposed limitations in their use, including high failure rate, dependence on weather conditions and vulnerability to electronic warfare.

The Ukraine War has underscored the importance of agile innovation processes, which have allowed Ukraine to temporarily overcome asymmetries with Russia, highlighting the relevance of continuous adaptation in protracted conflicts.

Conversely, our analysis confirmed that drones did not eliminate the need for large military forces, challenging traditional RMA assumptions like replacing large armies with smaller, more lethal units.

It is still too early to analyze all the consequences of the ongoing conflict on the evolution of the art of war. However, this article can contribute to the debate on the subject, since it proposes some bases for more in-depth research.

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