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Original articles

Technological developments and implications of autonomous military drones: prospects in global geopolitics

Desarrollos tecnológicos e implicaciones de los drones autónomos militares: perspectivas en la geopolítica mundial

Jairo Eduardo Márquez Díaz[1] https://orcid.org/0000-0001-6118-3865

[1]*Universidad de Cundinamarca*, Chía, Colombia
jemarquez@ucundinamarca.edu.co

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Resumen

El presente artículo tiene como objetivo caracterizar los drones no tripulados empleados en las nuevas estrategias de defensa militar mundial, tomando en cuenta los desarrollos tecnológicos asociados a la inteligencia artificial y robótica. En tal sentido, se procedió a realizar un estudio de carácter documental, conducente a identificar los desarrollos más representativos existentes en el mercado de drones autónomos militares, contemplando sus implicaciones en el escenario bélico presente y futuro. El estudio estableció las implicaciones que está tomando las armas autónomas en la geopolítica mundial, suponiendo cambios en la manera de incorporar tecnologías inteligentes en busca de mejorar la autonomía de los drones para afrontar los requerimientos de defensa y ataque, que demanda los nuevos escenarios del campo de batalla. Este panorama da a entrever para los próximos años el incremento de drones como armas letales de bajo costo y alta precisión, cuyo despliegue en diversos escenarios será más efectivo en operaciones militares de diversa índole.

Palabras clave: armas autónomas, enjambres de drones, geopolítica, inteligencia artificial, tecnologías disruptivas.

Abstract

This article aims to characterize the unmanned drones used in the new global military defense strategies, considering the technological developments associated with artificial intelligence and

Summary: Introduction, Methodology, Discussion and Conclusions.

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robotics. In this sense, a documentary study was carried out to identify the most representative developments in the market of autonomous military drones, observing their implications in present and future war scenarios. The study established the implications that autonomous weapons are taking in global geopolitics, assuming changes in the way of incorporating intelligent technologies to improve the autonomy of drones to face the requirements of defense and attack demanded by the new battlefield scenarios. This scenario gives a glimpse of the coming years of the increase of drones as lethal weapons of low cost and high precision, whose deployment in various scenarios will be more effective in military operations of various kinds.

Keywords: Autonomous weapons, drone swarms, geopolitics, artificial intelligence, disruptive technologies.

Introduction

Drones, or unmanned aerial vehicles (UAVs), have been used in the military field for years. These vehicles have become increasingly popular in the military field due to their ability to carry out surveillance, reconnaissance, and attack missions without endangering the soldiers' lives. These drones can be controlled remotely, flying for long hours, which makes them ideal for surveillance and reconnaissance missions, proving to be a valuable tool for their ability to reach areas that could be dangerous or inaccessible to the soldier.

Military drones have unique features that differentiate them from civilian drones. For example, they can be equipped with high-resolution cameras and other advanced surveillance equipment to gather information about the terrain and the enemy. Some are also equipped with smart weapons that allow them to attack specific targets with a high degree of accuracy.

While drones have many advantages in the military field, they have also generated controversy due to concerns about the privacy and ethics of their use in military attacks without the assistance of a human controller (Asaro, 2020; Waxman, 2019). In addition, there are concerns about the safety of these drones, as they can be shot down or hacked by the enemy.

Research objectives

General objective

Characterize the unmanned drones used in the new global military defense strategies, considering the technological developments associated with artificial intelligence and robotics.

Specific objectives

- Identify the most representative developments existing in the market of autonomous military drones.
- Establish the implications of autonomous weapons in world geopolitics and their impact on the present and future war scenarios.
- Analyze the expected changes in incorporating intelligent technologies to improve the autonomy of drones to face the defense and attack requirements in the new battlefield scenarios.

Methodology

The research methodology was documentary in nature, which is summarized in three phases:

1. Selection: 50 relevant documents spanning ten years, from 2013 to 2023, were selected for this study. These documents included academic journals, news articles, and reports from government agencies and industry. The documents were selected based on their relevance to the topic under study.
2. Collection: An initial search was conducted using keywords related to the research objectives in databases and online search engines. Relevant documents were then examined for relevance, credibility, and date of publication.
3. Analysis and interpretation: The data was interpreted considering the research questions and the theoretical framework. The findings were used to answer the research questions and develop a deeper understanding of the object of study.

Literature review

Unmanned combat aerial vehicles (UCAVs)

Drone technology is advancing daily, as well as its applications in different areas (Márquez, 2017), with exponential growth in the military field in the last decade. In this sense, there are reconnaissance and combat drones, known as unmanned combat aerial vehicles (UCAV), with action radii in the order of 3000 km and altitude ceilings exceeding 6 km. The speed of this generation of drones can easily exceed 300 km/h, as is the case of the Kratos XQ-58A Valkyrie drone (Harper, 2023), which, apart from being difficult to detect by radar, can act as a support system for aircraft such as the F-15EX or the F-35, either to assist in an attack or defense, having sufficient payload capacity to carry air-to-ground and air-to-air missiles.

Given the particularity of the Valkyrie, it has been taken as a reference point for new technological developments that work in conjunction with fleets of manned aircraft, where joint communication allows coordinated attacks and defense without any interference, whose shared information is encrypted.

In the short term, it is expected that UCAVs will act as support on the battlefield with a greater deployment, where programming sponsored by artificial intelligence (AI) will be a determining point of success when these aircraft go into action, since apart from attacking targets, they can act as an early warning system for pilots, and even deciding to sacrifice themselves protecting their aircraft.

T tanker-type UCAVs are used to fuel fighter aircraft, resulting in reduced costs and personnel risk. For example, Boeing's MQ-25 Stingray drone (Naval Base Ventura County, 2020) has an advanced communications system for intelligence tasks, which is very useful when small, agile and difficult to detect by enemy radar is required.

Table 1 shows some types of military drones in service. Note that this is not an exhaustive list and that there may be other types of drones with different specifications. Also, capabilities and specifications are constantly evolving and improving, so the information in this table may become outdated over time.

With the notorious ease of development and the consequent production of drones, the drone industry has been boosted worldwide, facilitating missions equivalent to those of a conventional fighter plane at a fraction of the operational cost, such as patrolling, tactical reconnaissance and even individual or coordinated attacks. Drones of this type are the CH and Wing Loong series that China has begun to commercialize outside its borders, making it possible for other countries to join this new arms race of low cost and high lethality.

Table 1

Some different types of military drones, their flight range, armament, monitoring and spying technologies

Drone	Flight range (miles)	Weapons	Monitoring and Espionage Technologies
MQ-1 Gray Eagle	1,000	Hellfire missiles, laser-guided bombs	EO/IR sensors, Synthetic Aperture Radar (SAR), Communications Intelligence (COMINT)
MQ-9 Reaper	1,100	Hellfire missiles, GBU-12 Paveway II, laser guided bombs	EO/IR sensors, SAR, COMINT, Electronic Intelligence (ELINT)
RQ-4	9,000	None	EO/IR sensors, SAR, Signals Intelligence (SIGINT)
RQ-21	100	None	EO/IR sensors, laser designators
X-47B	2,000	None	EO/IR sensors, Synthetic Aperture Sonar (SAS)
Wing Loon II	2610	Laser-guided bombs, air-to-surface missiles	Synthetic aperture radar, electro-optical payloads
Beast of Kandahar	5,000	None	EO/IR sensors, SAR, Signals Intelligence (SIGINT). top secret stealth technologies
Luna	5000	Naval cruise missiles	Radar, optical, electronic intelligence sensors
Heron TP	9320	None	Ground moving target indication radar, electronic intelligence pods

Source: Author

Another line of action of drones is the of the kamikaze type (Kovačević & Vulić, 2021; Liao, 2020), which hits other drones or fixed or mobile military targets to minimize the risk of them attacking first. With this modality, the risk of neutralizing a target without using weapons that can be dangerous in an urban environment or in critical facilities is simplified (Mair, 2020; Sauer, 2020). his task is effective by providing drones with a LIDAR (Light Detection and Ranging) radar that maps information in 3D, complemented by electro-optical systems, sensors (infrared, chemical, optical and geomagnetic), artificial vision and electronic jamming systems for early detection; in addition, they have blocked an attack of one or several UCAVs, either day or night (Song, 2021).

Another feature of this type of drone is that they have a detection range that varies between 10 and 20 km, excluding human intervention in decision-making. As a particular case is the Guard drone technology, which, as Navarro (2020) points out, “has radars designed for short-range air defense and a communications intelligence module that detects, classifies and identifies a threat based on the analysis of frequencies and communication protocols used by the target drone” (n.p).

The development of this technology continues as drones on the market pursue human targets and set ambushes, as is the case of Lanius, ideal for urban warfare. This Israeli-made drone is transported in a mother ship that can fly in closed enclosures, such as buildings or tunnels, searching for its target regardless of the obstacles it encounters on its way, thanks to its AI system integrated into a specific chip. It also incorporates a SLAM algorithm (Diaz, 2022), which allows it to simultaneously locate and map its environment using image processing to identify points of interest, generating relevant identification information (friend or foe) for its operator, or acting autonomously by coordinating an ambush with other drones.

A recent DARPA ground autonomous robotics initiative called the RACER (Robotic Autonomy in Complex Environments with Resilience) program (Ackerman, 2022b) aims to develop new autonomous drone technologies (Marquez, 2021) for all-terrain combat vehicles, allowing them to maneuver out of a two-dimensional field into a three-dimensional one. The idea of this system is to emulate human's driving, taking into account speed and endurance in simulation patterns and advanced platforms, which must be superior to those used in civilian autonomous vehicles. Additionally, the vehicle is prepared for battle operations, whose displacement must be fast and, in the process, activate its defenses if necessary.

Another advanced drone project belongs to Australia, with Boeing's Loyal Wingman, equipped with AI-controlled systems to perform multiple tasks on the battlefield, such as surveillance, aerial reconnaissance, and intelligence, with a range of close to 4000 km provided by its jet engines.

One aspect to mention, based on Russia's recent invasion of Ukraine, is the role of these two nations' massive use of drones. In the case of Ukraine, it employed the Turkish-built Bayraktar TB2 drone (Rodriguez, 2022), proving to be an invaluable piece in increasing resistance against Russian troops. The drone has the capability to conduct short and medium-range missile strikes, whose advanced electronics allow it to coordinate its attack with two ground control stations. This drone has proven its worth in other latitudes, such as Libya, Karabakh and Syria, which is why several nations have purchased it due to its effectiveness on the battlefield.

Unmanned Underwater Vehicles (UUVs)

The autonomous drone developed by Northrop Grumman and Martin Defense Group, called Manta Ray, performs underwater and surface tasks. This device can operate for long periods without any maintenance or human support, performing long-duration civil or military missions without assistance even transporting payloads. Other recently operational underwater drones belonging to the U.S. Navy include functions equivalent to the Manta Ray, the Orca and the Snakehead classified as extra-large UUV (Mapson, 2022), which have advanced technologies in stealth and attack on various types of vessels (Coiras & Ridao, 2020; Brierley et al., 2018).

China has its own biomimetic UUV that has been operating for some years, demonstrating that there is competition among the great powers to create underwater drones for various purposes, considering that stealth is more significant than other currently operational vessels, making them ideal for autonomous operations and stealth, as is the case of the Chinese drone "Robo-Shark", designed to hunt submarines.

One result of the conflict between Ukraine and Russia is a military UUV called Kronos, which can operate piloted or remotely, carrying up to six torpedoes, operating underwater or at sea level with great versatility, added to the composite materials with which it is built, which gives it a manta ray shape and stealth, adsorbing the acoustic waves of any sonar.

A recent two-in-one drone development for civilian and military purposes is the Sea-Air integrated Drone and the KDDI flying drone, which carries the FIFISH Pro V6 Plus underwater drone. The flying drone can hover on the surface and land vertically, safely releasing the underwater drone. These devices can be operated by remote control or autonomously. In principle, these drones have been created for underwater inspection (Liu & Zhang, 2019).

However, their potential in military applications, especially those operating in swarms, is worth mentioning, aimed at nullifying any anti-submarine capability, either for detection or destruction.

From the above, it can be inferred that autonomous weapons can be considered as emerging cybertechnologies, with well-established purposes in the military field, where one of them is the reduction of war costs. Therefore, evaluating how AI is increasingly integrated into these cybertechnologies drives new advances in intelligent strategic systems whose dependence on humans is decreasing. In this regard, significant ethical and moral concerns surround the development and use of autonomous weapons, as they raise questions of responsibility and the possibility of unintended consequences such as the violation of international law.

Autonomous Weapons and Artificial Intelligence

Autonomous weapons are systems that can select and attack targets without human intervention. These weapons rely on artificial intelligence and machine learning algorithms to identify and engage targets, with the potential to revolutionize modern warfare by increasing the speed and accuracy of attacks. Examples of autonomous weapons include drones, armed robots and missile systems.

AI gained momentum in recent years, all thanks to increased computational power. In the case of the latest generation of UCAVs used for various targeted and coordinated attacks, it demands intelligent software to perform such actions. Such is the case of the Turkish STM Kargu-2 drones, which in 2020 carried out an autonomous attack against the Libyan national army (Sierra, 2021). A particularity of this attack lay in the fact that it was with autonomous systems, technically called Slaughter Bot. Drones operating under this modality are characterized by facial recognition algorithms and spatial algorithms that allow them to form swarms, even if the radio and GPS links were blocked, all this autonomously.

A reference of Slaughter Bot drones is the Turkish-made Aksungur, which can operate over long distances with a flight altitude of 6 km above sea level. The most important functions of this aircraft are intelligence, surveillance and reconnaissance, and day and night air attack with a diverse armament capacity of close to one ton, such as anti-tank missiles and smart missiles for destruction of static and moving targets.

Currently, no legislation regulates the development of Slaughter Bot and/or similar weapons, whose primary targets are human beings. The truth of this scenario is that this technology quickly went from science fiction to reality because its development was easier due to its low investment, demonstrating its versatility and high effectiveness in espionage, monitoring and attack operations. China leads the list of Slaughter Bot technologies exported to several countries with a wide portfolio of unmanned systems. Similarly, Israel, Iran, Russia, the United States and the United Kingdom, among other countries, have their own Slaughterbot-type technology development initiatives.

The programming of these drones is based on AI, which allows, apart from performing biometric analysis in situ, to form swarms, whose coordination makes them more assertive when carrying out selective attacks, all thanks to the scalability of intelligent algorithms that evolve permanently in each mission. Although the technology of Slaughterbots is not new, the algorithms and weaponry are where AI, robotics and advanced communication network systems facilitate new developments.

Nanodrones

Another potential applications and development of autonomous systems are nanodrones whose purpose is focused on one or a swarm of them accompanying a soldier on reconnaissance missions, literally becoming his eyes, monitoring his surroundings, detecting improvised explosive devices, or acting as a defense and attack system. For example, the U.S. Black Hornet nanodrone was the most advanced at the time of writing.

Within their nanoscale technology, these vehicles have an artificial vision system integrated with machine learning algorithms, which allows them to detect the most likely places where there would be explosives or predetermined targets. This task is complemented with drone sensors that create a 3D map emulating digital twins (Varas et al., 2020), where the encrypted data is transmitted to a cloud computing platform to be consulted by different search teams. This information is processed by an AI that communicates it back to each nanodrone to obtain more data to identify the threat more easily.

A civilian application like the nanodrone is Snapchat's Pixy mini drone, which autonomously accompanies its user to record selfies or panoramic shots, and then transfers them wirelessly to the cell phone., Apart from being lightweight, this mini drone has a flight autonomy of 5 to 8 hours with a 20-minute recharge. It also allows configuring four flight routes in which it can float, orbit around its user and follow him.

Snapchat's Pixy is not the only mini drone on the market, but it is one of the most complete, which means that in the short term, the competition and the military will develop new, improved versions of Pixy.

Security

Current global security presents a complex dynamic that promises to become even more acute based on geopolitical and economic instabilities (Deutsche Welle, 2022), leading to military conflicts involving the major powers. Likewise, the possibility of developing new unmanned weapons capabilities has opened, with the consequent integration of autonomous systems for mission-critical military applications, involving portable communication stations and scalable computing systems, expanding their applications not only to the air but also to land, submarine, surface and subsurface operations, even in space.

The adaptation and scalability of unmanned systems are defined considering that their application is focused on civil or military missions, which require a coordinated deployment of multiple technologies to achieve their objective. To this end, they make use of advanced avionics, drones, robotics, AI and the internet of things, and more recently, perimeter security and edge computing, among other disruptive technologies, which contribute their share to the continuous improvement of new intelligent weapons and communications support for unmanned systems. Such is the case of drones whose technology allows them to carry out highly accurate attacks based on the GPS movement of a target, collecting metadata from images, photos and files that are then transmitted through a computer virus, even from SIM cards, infecting the target's electronic device(s).

A high-impact military project by the United States is constructing the flying aircraft carrier, intending to launch swarms of combat drones anywhere in the world. The architect of this development was DARPA, with the X-16 Gremlins project, which consists of modifying a Lockheed C-130 Hercules aircraft into a platform for launching X-16A drones that, once their mission is over, the mother ship will receive them to refuel in the air. "The drones will be able to fly for one hour within a radius of 300 nautical miles (about 555 kilometers) with 22 kilos of cargo." (Díaz, 2021 , n.p). This system is intended to be scaled up to other larger aircraft types, such as a B-52 Stratofortress that can fly at higher altitudes and carry more drones and munitions.

The next step of this project is to send drones directly from space, working in conjunction with a fleet of permanent flying aircraft carriers, extending the range of monitoring and eventual attack to the entire planet. What is striking about these projects is that human intervention is completely excluded. In theory, with this type of technology, these platforms could be used for more altruistic purposes of a scientific nature, such as monitoring the climate or pollution levels in different areas of the world, among others.

Disruptive technologies on the battlefield

Drones can be used for various military purposes, including surveillance, reconnaissance, and attack. In addition, they offer several advantages over conventional aircraft, including the ability to fly for long periods, operate in hazardous or inaccessible areas, and be controlled remotely or autonomously on a case-by-case basis.

Polymorphic robotics is another disruptive technology characterized by the fact that it can change from one form to another depending on environmental conditions. Robots of this type demand more energy for transformation and an accompanying increase in mass in most cases leading to the invention of new elastomers such as mechanical metamaterials with reversible plasticity (Hwang et al., 2022). Those materials become an ideal option to elaborate phase change metallic skeleton systems with switchable stiffness, proposing new developments of Slaughter Bot-like drones adaptable to the operating environment.

In the case of design, development and certification of advanced unmanned systems such as the Slaughter Bot for applications focused on area, ground, maritime and space security, they are supported by the objectives of the certification authorities' software team called CAST-32A (CAST, 2016); this for the case of the United States, which ultimately is a world reference whose military industry is supported by multi-core computational hardware, with particular attention to synchronization behavior.

Slaughter Bot is an emerging example of disruptive technology, which military forces worldwide have implemented due to its low development and implementation cost and its high effectiveness in critical operations related to selectively nullifying targets, where human influence in decision -making is suppressed. In strategic and defensive terms, this type of technology proves to be an ideal weapon, even at the metropolitan level (Márquez, 2018), given that its "payload, performance and autonomous capabilities grow rapidly" (Bajema, 2021 , n.p). Likewise, these types of systems are used in other areas such as "reconnaissance, target acquisition, confined space and subway inspection, mapping, security, wireless mesh networks, perimeter security, etc." (Ackerman, 2021 , n.p).

The Slaughter Bot, in conjunction with other advanced unmanned systems (MQ-9 Reaper, Predator C Avenger, RQ-4 Global Hawk, Wing Loong 3 and 1E, CH7, FH97A, WJ-700, X-47B, among others), are not a replacement for conventional weapons, since their function is centered as a support resource for the military and government agencies. Therefore, prohibiting the use of these technologies is out of the question, for the simple fact that their design, development, and implementation are fast and do not require an extensive technical and technological infrastructure, making them an invaluable resource for secret and military operations.

Advances related to inertial navigation solutions, leading to the highest accuracy, reliability, redundancy in data handling, scalability and durability, consistency in hostile environments and rough terrain, interference-proof, and compatible with other technologies, are becoming more relevant.

The integration of disruptive technologies such as Deep Learning, Big data, IoT and Edge computing, among others, are contributing to the development and management of autonomous weapons faster than expected, driving many nations to bet on these type of weapons due to their rapid deployment and replacement on the battlefield, such is the case of the United States, with hundreds of incursions in Yemen and Kabul for several years in asymmetric conflicts (Chehtman, 2017).

Discussion

Various civilian groups have expressed concern about using Slaughter Bot and similar technologies, excluding morality in making decisions about who lives and dies in a military action, leaving everything in the hands of AI algorithms without human supervision. The problem of establishing international regulation is becoming increasingly acute due to the proliferation of the autonomous weapons market, where not only the superpowers are leading the way, but countries such as Turkey, Israel, and Iran, which have seen a lucrative business in selling this type of weaponry to politically unstable countries. The critical aspect of this issue lies in the fact that this technology can be easily copied by terrorist groups and organized crime with minimal investment.

Access to this technology by various military and illegal groups is of concern to the international community since it is difficult to control, in addition to the fact that the development of these weapons does not require a robust technological infrastructure.

The possibility of acquiring Slaughter Bots on the black market is high, and not only these devices but also anti-personnel micro-drones, which can be deployed stealthily to selectively track and fix targets, which turns them into vectors to detonate micro-explosives and even disperse biological or chemical agents.

The outlook for Slaughter Bots in the military shows that they will continue to proliferate, due to their rapid progress in critical operations, as opposed to other conventional weapons, which makes them ideal for military forces that lack advanced aerial technology and require rapid results on the battlefield when deploying their troops. For example, in Azerbaijan in 2020, Israeli 1K and Harop drones were employed in the Nagorno-Karabakh conflict (Martin, 2019). This deployment was attributed to a small group of individuals who once released, selected their targets and killed them. In general, these drones can loiter for several hours in a region until they find their target, which can be weapons, communication systems or fixed or mobile defense systems, among others.

Using intelligent weapons against human targets is a fact, and the moratorium is still on paper. Russel et al. (2021) points out that:

> Agreements are needed to facilitate verification and enforcement of the moratorium and treaties, including design restrictions on remotely piloted weapons that prevent software conversion to autonomous operation, as well as industry rules to prevent large-scale illicit weaponization of civilian drones. (n. p)

Implementing a moratorium on this type of technology is complex, in part because the development of Slaughter Bot-type systems is easy to carry out, as is the incorporation of intelligent algorithms, giving drones greater autonomy in their military tasks.

With AI, a drone or a swarm of drones can be programmed to carry out targeted attacks, turning them into scalable weapons of mass destruction (WMD), which contain weapons of mass agility (WMA) for use in targeted assaults using chemical or biological agents. This type of scenario is known as drones (Marquez, 2021c), which frames the integration of advanced emerging technologies converging to the development of multicore platforms for critical avionics and robotics applications.

It is common to find in autonomous drone's multicore processor technologies combined with state-of-the-art computing about system hardware architecture. For example, PCIe 4.0 and 5.0 data communication buses (Gomez, 2021) integrated with next-generation memories, which show new multithreaded processing architectures, thus breaking traditional computing schemes, accelerating SoC (System on Chip) processes with higher speed rates and low latency, essential for technologies that must respond to events in extremely short times.

Avionics is designed to delimit and control physical interference patterns specific to the processor cores and the external environment. Likewise, it seeks to optimize the development of applications that allow the rational use of all cores, minimizing conflicts on shared resources in the process, considering that AI-based algorithms demand them. With this type of technology, SWaP requirements (weight, size, and power) increase, becoming a priority when evaluating the performance of autonomous and semi-autonomous systems, for which miniaturization goes hand in hand with power and improved thermal dissipation.

What is perceived from these technological developments is that robotics and AI will be the articulating points of the new generations of autonomous weapons in the future. In this way, attacks by any power or terrorist group can be unpredictable, generating chaos in society in search of geopolitical imbalance, especially if we take into account that this type of device can carry and detonate dirty bombs (Biancotto et al., 2020; Rump et al., 2021) which, although they have not yet been used, is an issue to contemplate, taking into account that many politically unstable countries are developing their own nuclear initiatives. Also, there is the potential for autonomous weapons to become vectors for disseminating biological or chemical agents.

Autonomous weapons have opened a new niche for the arms race, where superpowers do not want to leave any space for advantage against their counterparts (Saeed, 2017; Jash, 2018; Haosheng, 2021), driving ever more extraordinary advances for which precision and lethality are essential, being the sentence "shoot and forget" more valid than ever.

On-air mission tactics, these have been adapting to new possible battle scenarios such as the case of Ukraine-Russia, China-Taiwan or South Korea-North Korea, all motivated by the flexibility of programming fleets of drones to attack one or several targets in situ, as is the case of the Turkish drone Bayraktar TB2 (Sanchez, 2021), as well as the American kamikaze drones Switchblade (Miller & Chadwick, 2018) put to the test in the same battle scenario. Also, Poland placed at the Ukrainian army's disposal the Fly Eye drone, which acted as a backup to the counter-offensive showing in real-time the location of the enemy, allowing to coordinate the assaults to assess the damage subsequently.

A variant of the Bayraktar Is the Akinci, specialized for possessing a range close to 8000 km and a flight autonomy of a full day, with a payload capacity of one and a half tons, allowing it to carry smart weapons such as MK-82s (Geneva International Centre for Humanitarian Demining, 2017) and fire cruise missiles from the air. This action that was only possible from fighter jets and submarines.

In the case of the Russian military, they employed drones whose similarity in some cases has been inferior to those used by Ukraine. However, the Olan-10 drone stands out because it works in conjunction with the Leer-3 electronic warfare system, consisting of a truck equipped with Krasukha-4 technology, which blocks communications several kilometers around, deactivated at the same time the drones that circulate within its radius of action by interfering with their GPS signals (Clark, 2022).

With the use of swarms of drones, the possibility of success of a mission is expanded since, from a group, the probability of dispensing with some of them is acceptable as long as the objective of attacking and/or neutralizing a target is achieved. This all comes down to operating costs, which are low compared to a single-person aircraft whose value can be 10 to 15 times higher, where stealth may not suffice. Incorporating drone swarms in support of fifth and sixth-generation fighter aircraft will become a trend in the coming years, providing more excellent safety for pilots while increasing defensive and offensive power.

Cooperating drone swarms are ideal as opposed to employing a single drone, as the workload can be divided and respond to different variables in response to environmental. Similarly, the development of three-in-one drones that fly, navigate, and hover on the ground will soon become a reality, expanding their multifunctionality on the battlefield.

The low-cost arms race is growing, driven not only by the superpowers, as countries such as Israel, Turkey, India, and Iran, among others, have their own R&D programs. Consequently, a myriad of possibilities is opening as to what will happen in the coming years on the battlefield, espionage, urban surveillance, monitoring and targeted attacks; for which the existence of lethal autonomous weapons raises a broad discussion of their impact on society.

There are concerns about the ethical implications of using autonomous drones and the possibility that they may be employed in ways that violate international law. Some critics argue (Bolaños & Bossano, 2020; Rivera, 2017; Chamayou, 2016) that drones can carry out targeted killings or extrajudicial executions without sufficient oversight or accountability. There is also uneasiness about the possibility of drones being hacked or used as weapons by terrorists or other malicious actors.

What can we expect for the future? Undoubtedly significant advances in AI combined with IoT and quantum computing, opens a myriad of development possibilities aimed at creating and improving the performance of autonomous weapons, increasing the capacity for massive data analysis, improving cyber security and defensive intelligence. With the current geopolitical dynamics, what is expected is an intensification of the quantum arms race, understood as the use of quantum computing integrated with disruptive technologies applied to the military environment, given its potential to leave current offensive and defensive systems in tatters.

Conclusions

The research successfully achieved its objectives by characterizing current and future autonomous military drones, their implications for defense strategies and the technological trends shaping their development. Regarding the specific objectives, several autonomous drone developments were identified and how they are accelerating the arms race, changing tactics and strategies, raising concerns about proliferation risks, and ethical implications.

Autonomous drones are seen as low-cost but high-impact weapons that will transform future battlefields. This leads to evaluating their role in global security, which has been undergoing substantial changes, accentuating arms competition in the face of new warfare demands.

Opponents of these technologies (Johnson, 2020; Marks, 2020; Slijper et al., 2019) argue that military drones must be programmed with some degree of ethics, raising issues such as the responsibility assumed by the programmer(s) if an autonomous system mistakenly kills civilians. Likewise, it has been brought to the forefront how these systems are increasingly lethal and, at some point, violate ethical principles and international law.

The actions intended to be implemented in limiting or prohibiting technologies such as the Slaughter Bot or any advanced unmanned system, should be directed in another direction, more towards the technological aspect than anything else, because thinking about global control of intelligent weapons is utopian. However, the effort by UNESCO (2021) to adopt the recommendation on the ethics of artificial intelligence in its 41st meeting, for which the actions in this regard are divided, is valued.

Moreover, there is a trend of integrating AI, IoT and quantum computing, among other technologies, leading to improved autonomy, lethality, and data processing capabilities of drones. Future drones are expected to have multipurpose functionality and operate in swarms. This scenario poses several dilemmas, which must be addressed diligently based on the new global geopolitical landscape. New threats are constantly emerging, so new drone technology developments are expected, even at the hypersonic level, e.g., the Turkish Kizilelma drone, taking military and espionage incursions to a higher level combined with cyber-attacks.

Suggestions for future research.

The above can be built upon by analyzing ethical, legal and governance dimensions, such as:

- a study of the ethical and legal framework for autonomous weapons and drones,
- exploring the human role in the control and oversight of autonomous weapons,
- an analysis of the impacts of emerging technologies, such as quantum computing, on future drones and weapons systems,
- a study of multinational collaborations and governance efforts around autonomous weapons, and
- monitoring proliferation risks from non-state actors acquiring autonomous weapons.

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