Jurnal Keamanan Nasional , Vol. 11 Nomor 2 (2025), pp 129-146
ISSN 2442-7985 (print) | ISSN 2579-7727 (online)
Available online at: https://ejurnal.ubharajaya.ac.id/index.php/kamnas/index

Unmanned Aerial Vehicle Development, Concerns, and Future In Modern Warfare

Perkembangan Unmanned Aerial Vehicle (UAV), Tantangan, dan Prospeknya dalam Peperangan Modern

Stanislaus Riyanta[1], Lin Yola[2]
[1,2]School of Strategic and Global Studies, Universitas Indonesia
Korespondensi: stanislaus@ui.ac.id

Received:	Revised:	Accepted:	Published:
May 28, 2025	Nov. 17, 2025	Dec. 30, 2025	Dec. 31, 2025

Abstract : *The development, use, and prospects of unmanned aerial vehicles (UAVs) in contemporary warfare are to be examined in this paper. As it is, this paper collects data from the Google Scholar and Google search engine to form a comprehensive data as to provide facts and thus compile it in a literature review. From early inventions like the Kettering Bug to the present deployment of AI-powered drone swarms, it charts over the evolution of UAVs and emphasizes their increasing strategic significance in combat. The report highlights how UAVs have changed tactical operations, surveillance, and combat strategies through historical analysis, technology assessments, and a case study on the war between Russia and Ukraine. The report also discusses important issues pertaining to moral conundrums, legal frameworks, and counter-drone strategies in reaction to the widespread use of UAV technology. In the end, this study presents insight into how drones, propelled by AI breakthroughs and defense sector innovation, are changing military operations in the future while posing significant strategic and humanitarian issues.*

Keywords : *Unmanned Aerial Vehicles (UAVs), Modern Warfare, Military Drone Technology, Artificial Intelligence in Warfare, Counter-Drone Strategies*

Abstrak : *Perkembangan Unmanned Aerial Vehicles (UAV) telah menjadi elemen kunci dalam transformasi peperangan modern. Artikel ini mengkaji perkembangan, penggunaan, dan prospek UAV dalam konflik kontemporer melalui metode studi pustaka dengan sumber data yang dihimpun dari Google Scholar dan mesin pencari Google. Analisis dilakukan secara kualitatif terhadap literatur akademik, laporan strategis, dan studi kasus konflik*

Copyright (c) 2025 Stanislaus Riyanta, Lin Yola. This work is licensed under a Creative Common Attribution 4.0 International License.

Rusia–Ukraina. Hasil kajian menunjukkan bahwa UAV secara signifikan mengubah pola operasi militer, khususnya dalam pengintaian, operasi taktis, dan strategi tempur, seiring dengan kemajuan kecerdasan buatan dan sistem drone swarm. Namun demikian, proliferasi UAV juga menimbulkan tantangan serius, termasuk persoalan etika, implikasi hukum internasional, serta kebutuhan pengembangan strategi counter-drone. Artikel ini menyimpulkan bahwa UAV akan semakin menentukan karakter peperangan masa depan, sekaligus menghadirkan risiko strategis dan kemanusiaan yang memerlukan respons kebijakan yang komprehensif.

Kata kunci : *Kendaraan Udara Tanpa Awak (UAV), Peperangan Modern, Teknologi Drone Militer, Kecerdasan Buatan dalam Peperangan, Strategi Penanggulangan Drone*

INTRODUCTION

Armaments in the modern era have remained a fundamental instrument of warfare. Although many states prioritize diplomatic channels to navigate geopolitical competition, the integration of traditional military capabilities remains a critical necessity. While contemporary global trends emphasize bilateral and multilateral diplomacy, these frameworks are often secondary to the reality that—despite advancements in Artificial Intelligence (AI) and unconventional defense mechanisms—a state's power is still primarily quantified by its arsenal[1]. This aligns with the fundamental nature of combat, wherein military personnel provide the tangible force required to secure strategic objectives. Consequently, many states prioritize the importation of military-grade hardware over infrastructural development; this reflects a core operational logic in statecraft. Smaller or less developed nations often compensate for their vulnerabilities through rapid militarization. Without such capabilities, these nations would be forced to rely solely on political influence—a strategy that, within the discipline of International Relations, is often regarded as theoretical at best or merely wishfulthinking [2].

UAV's (Unmanned Aerial Vehicles) are a staple of modern technology, its utilization in warfare is considered to be above traditional aircrafts, since the strength of an aircraft is still present, however, the speciality comes into play where the pilot is in a safe and secure location manning the vehicle. UAVs or commonly referred to drones - and will be used interchangeably in this paper-, has been a trend in recent years, due to its practicality and widespread usage, the uninhibited ability to safely scout hostile or treacherous environments have been trivialized as long as the pilot, fuel, and connection is still present [3]. Hence, the issue of drones becoming a mainstream technology is in of itself a predetermined fate as one would say, the technology to safely man a vehicle that conquers the sky is the most fitting advantage for a nation, be it developed or developing. Despite the benefits that UAVs brought to the military, the capabilities of AI and its

[1] G. Razma, "A Modern Warfare Paradigm: Reconsideration of Combat Power Concept," *Journal of Security and Sustainability* Issues 8, no. 3 (2019): 435–452.
[2] G. K. Cunningham, "Landpower in Traditional Theory and Contemporary Application," in *US Army War College Guide to National Security* Issues, vol. 1 (Carlisle: US Army War College Press, 2008), 109–120.
[3] T. Jacobs, "Data from Above: The Advantages of Unmanned Aircraft," *Journal of Petroleum Technology* 65, no. 10 (2013): 36–43.

automation abilities pose new challenges which goes beyond the technical availability of its projected ability. The main issue tackled in this paper concerns the ethical, legal, and strategic dimensions of warfare with the increase of UAV autonomy.

This article thus aims to: (1) put in retrospect the historical and technological evolution of UAVs; (2) assess their strategic value and ethical implications in warfare; (3) evaluate the future trajectory in AI-driven aspects of drone development. Previous studies have described UAVs as a tool of surveillance and combat efficiency, this paper attempts to contribute its novelty through probable policies, legal, and ethical perspectives within the analysis of military innovation. Hence, situating UAV technology within the broader aspects of national resilience and security.

METHOD

This study uses a qualitative literature review with descriptive data. The sources come from journals, institutional reports, and defense documents. They discuss UAV development, AI use, and legal or ethical issues. Sources were chosen for three reasons: they are academically reliable, relevant to policy, and published in the last ten years. The data were grouped by theme which focuses on technological changes, combat utilization, governance, and counter-drone actions. Hence, this method attempts to merge different views which range from technical, strategic, and ethical concerns that gives a clear picture of UAV's as both a tool and moral concern.

DISCUSSIONS

UAVs moved from prototypes to core tools in modern militaries because they extend reach and reduce human risk. This paper reviews their technical development, combat roles, and ethical-legal implications[4]. It is also worth mentioning that UAVs core principle is to not only provide a safety measure for pilots, but to also retroactively provide support and aid for different circumstances. As Everaerts (2008) mentioned, the appearance of UAVs brought not only a novel combat tool, in addition it provides a tool for mapping and remote sensing which would help in scouting or terrain navigation. In other sectors, this would provide precise geographical knowledge and insight, needed for operations or simple investigations domestically. Using UAVs would also bring the benefits of saving lives without risking any of it, i.e. using drones to maneuver forest fires to either prevent the fire spreading or saving lives from immediate danger. This poses a new set of ideas that older generations of technology could not have done, the fact that in preventing cases of forest fire, pilots would have to fight the fire head on within a sea of flames, whilst now could be mediated in a distance is astronomical in technological development[5].

[4] J. R. Scalea, "Using Unmanned Aircraft to Save Lives: Learning to Fly," *JAMA Surgery* 155, no. 4 (2020): 355–356.

[5] A. Ollero and L. Merino, "Unmanned Aerial Vehicles as Tools for Forest-Fire Fighting," *Forest Ecology and Management* 234, no. 1 (2006): S263.

Early Innovations and Advancements

To further delve into the utilization of drones, we must uncover its early innovations and development within the scientific groups and military agendas. Starting with the oldest known record for UAV development. The invention of the Kettering Bug during World War I marked the beginning of the development of military drones. The U.S. (United States) Army assigned engineer and inventor Charles F. Kettering the mission of developing a flying bomb in 1917 that could deliver explosives to enemy locations without endangering pilot lives. Working with such luminaries as Orville Wright, Kettering's group created an unpiloted aerial torpedo capable of reaching a distance of 75 miles at 50 miles per hour[6].

Launched on a "four-wheeled dolly", the Kettering Bug was stabilized and guided toward its target by use of internal electrical and pneumatic controls. The motor would cut out after a set amount of time, and the wings would spread, sending the gadget plummeting to the ground and exploding. Despite its innovative design, the Kettering Bug never saw real combat, and its development ceased after the war. Nonetheless, it laid the groundwork for future UAV technologies and demonstrated the potential of autonomous weaponry in military applications[7]. The goal is to explain how UAV innovation shapes warfare and governance.

The Kettering Bug in World War I introduced the idea of a pilot-free weapon. It never saw combat, but it proved remote guidance possible. In World War II, the Radioplane OQ-2 and later Cold War drones like the Ryan AQM-34L advanced that idea from experiment to practical reconnaissance. The OQ-2, a radio-controlled target drone for anti-aircraft gunnery training, was intended to replicate hostile aircraft and give gunners a realistic training environment. Over 15,000 OQ-2s were produced as a result of its success, which was a major turning point in the real-world use of UAVs in military training. Its creation demonstrated the increasing awareness of UAVs' ability to improve operational effectiveness and battle preparedness. Thus, these systems laid the foundation for modern UAV design and doctrine[8].

Together, they showed how steady upgrades—not single breakthroughs—defined UAV evolution. The Ryan AQM-34L Buffalo Hunter, a jet-powered drone created in the 1960s, is one noteworthy example. The Buffalo Hunter, which was mainly used by the U.S. Air Force, flew surveillance missions over North Vietnam and other hostile areas. These missions demonstrated the strategic value of unmanned systems in intelligence collection by delivering vital intelligence while posing the least amount of risk to pilots. The Buffalo Hunter cleared the path for the incorporation of UAVs into larger military operations by proving their feasibility for strategic reconnaissance in hostile settings, the imparted lessons set the pattern for the 21st-century UAV boom[9].

---

[6] C. Marino, "Send in the Drones," *United States Army*, October 17, 2024, https://www.army.mil/article/280609/send_in_the_drones.

[7] C. Marino, "Send in the Drones," *United States Army*, October 17, 2024, https://www.army.mil/article/280609/send_in_the_drones.

[8] National Air and Space Museum, "*The Secret Histo ry of Drones*," 2024, https://airandspace.si.edu/air-and-space-quarterly/issue-12/secret-history-of-drones.

[9] Central Intelligence Agency. *CIA-RDP80M01048A000800320003-8*. n.d. https://www.cia.gov/readingroom/docs/CIA-RDP80M01048A000800320003-8.pdf.

Modern militaries now rely on UAVs for intelligence, surveillance, reconnaissance, and precision strikes. Before assaults, UAVs map enemy positions in real time. Armed variants deliver targeted strikes with minimal collateral damage. Hence, in order to improve battlefield awareness, the U.S. Army developed the Lockheed MQM-105 Aquila in the 1970s. The Aquila was built as a tiny, remotely piloted vehicle with the goal of acquiring targets and conducting real-time combat surveillance. The program's final demise was caused by financial and technological issues, despite its considerable potential. The creation of the Aquila proved how difficult it is to incorporate UAVs into tactical military operations and how important it is for UAV technology to continue to advance and improve, as such these combat uses drive demand for smarter, more autonomous drones[10].

AI enables UAVs to detect targets, plan routes, and sometimes engage autonomously as such it would be logical that automation cuts operator workload but raises questions about control and accountability. The 1980s saw a huge advancement in UAV technology with the introduction of the AAI RQ-2 Pioneer. The Pioneer was designed for a variety of target acquisition, surveillance, and reconnaissance missions in partnership with Israel Aircraft Industries and AAI Corporation. The Pioneer was used by the U.S. Army, Marine Corps, and Navy in a range of combat scenarios, including naval operations and amphibious assaults. Its versatility and effectiveness in providing real-time intelligence demonstrated the growing significance of UAVs in modern military operations, the fact is however still contested whether efficiency should surpass ethical oversight[11].

Hence, the accumulation of technological advancements has created a marvel of engineering which greatly aids modern warfare. Through trial and error, the technological marvel that would be a UAV has become not only an innovation, as well as a new form of strategic planning in the military world. Early testing of UAV technology through both scientific and military domains have laid the foundation of the drones we know today, thus forever changing the landscape of defense and combat.

Combat Roles and Operations for UAVs

Entering the 21st century, military drones were now repurposed for combat implementations, furthermore, the quota that drones were filling were the gaps military could not have filled [12]. In hindsight, this might be a new way of combat, since using robotics seems too far-fetched in actual combat, however, the presence of drones now could be to provide surveillance before operations and even for actual large-scale fights [13]. Considering the aforementioned benefits of UAVs, the typical usage of them seems apparent firsthand, mostly attributed to modern media and pop culture, moreover, the

[10] Lockheed Martin, "No Pilot Seat Necessary." n.d. https://www.lockheedmartin.com/en-us/news/features/history/uavs.html.
[11] U.S. Navy. "RQ-2A Pioneer Unmanned Aerial Vehicle (UAV)." *U.S. Navy*, September 9, 2020. https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2166538/rq-2a-pioneer-unmanned-aerial-vehicle-uav/.
[12] D. Parsons, "Worldwide, Drones Are in High Demand," *National Defense* 97, no. 714 (2013): 30–33.
[13] R. K. Rangel and A. C. Terra, "Development of a Surveillance Tool Using UAVs," in *2018 IEEE Aerospace Conference* (2018): 1–11.

impact of UAVs performances has paved a road for newer technology such as heat-seeking missiles, automated targeting artillery, or simple homing missiles[14].

Though immediate combat between nations is somewhat unreasonable within the context of modern geopolitics, terrorism on the other hand has proven itself to be another issue countries must tackle. The lack of effectiveness whilst combating terrorism in unknown terrain or topology has become an actual case study for military stratagem [15]. Military drones come into play in recent years due to its safety and efficiency which replaces traditional training and aircraft, military drones now provide support and valuable information in combating terrorism, be it from data or actual raids followed by land troops. Thus, UAVs help to reduce casualties in the battlefield, as pilots may take riskier maneuvers and become both the spear and shield in modern combat[16].

Technological Advancements in Drone Warfare

Due to the advancements of modern technology, drone warfare has been a trend in many countries. One of the most significant changes is the implementation of AI in drone technology, as the technology now not only attempts to reduce military workloads via AI directives, but also to add a new form of weaponry that is more automated. The use of AI is controversial, since directives in real time simulation could prove to be muddy, however, the benefits of fully harnessing this type of technology would provide an arsenal not codependent with human interactions[17].

This would also apply domestically, as drones would serve as defence mechanisms, the application of which requires AI to be at the forefront in these operations. For instance, the implemented AI would be able to autonomously detect threats that are in immediate proximity, thus providing ample defensive capabilities and security for the state [18]. Thus, for military purposes these drones could in theory operate on their own and apply basic strategy or commands to execute tasks which would commonly require human attention, as the technology develop, it should also serve both military and civilian purposes, as AI become more advanced, so does the directives and automation in task[19].

Swarm technology in military drones marks a major leap forward in modern warfare, allowing groups of UAVs to operate together with a high degree of autonomy

---

[14] M. Sharma, H. Singh, A. K. Gupta, and D. Khosla, "Target Identification and Control Model of Autopilot for Passive Homing Missiles," *Multimedia Tools and Applications* 83, no. 20 (2024): 58465–58494.
[15] W. Wang, B. Jiang, J. Yang, and C. Li, "Research on UAV Application in Mountain Anti-Terrorism Combat," *Journal of Physics: Conference Series* 1792, no. 1 (2021): 012079.
[16] Z. Xiaoning, "Analysis of Military Application of UAV Swarm Technology," *in 2020 3rd International Conference on Unmanned Systems* (ICUS) (2020): 1200–1204.
[17] Petrovski, A., M. Radovanović, and A. Behlić. "Application of Drones with Artificial Intelligence for Military Purposes." In *10th International Scientific Conference on Defensive Technologies (OTEH 2022)*, Belgrade, Serbia, October 2022, 92–100.
[18] Joshi, A., A. Spilbergs, and E. Miķelsone. "AI-Enabled Drone Autonomous Navigation and Decision Making for Defence Security." In *Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference*, Vol. 4, 138–143. June 2024.
[19] Joshi, A., A. Spilbergs, and E. Miķelsone. "AI-Enabled Drone Autonomous Navigation and Decision Making for Defence Security." In *Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference*, Vol. 4, 138–143. June 2024.

and coordination. Inspired by the collective behaviours found in nature—such as insect swarms—this approach enables drones to carry out complex missions more efficiently and resiliently than a single UAV could achieve on its own [20]. At its core, drone swarming involves multiple UAVs communicating and adjusting their actions in real-time to accomplish tasks like surveillance, target acquisition, and attack missions. These drones are designed to adapt to changing and dynamic environments, reassigning tasks among themselves as needed, and to continue the mission even if some units are lost, making operations much more robust and flexible, hence, safer than traditional aircraft missions [21].

The strategic benefits of drone swarms are significant. They offer a cost-effective way to multiply force capabilities by deploying many small, relatively inexpensive drones that can overwhelm enemy defences. In addition to their offensive capabilities, swarms can be used for electronic-based warfare, intelligence gathering, and precision strikes, giving military planners a wide range of new tactical options [22].

However, the use of drone swarms also brings new challenges and ethical concerns. Securing communications within the swarm to prevent hacking or interference is critical, and along with the need to carefully manage how these systems make targeting decisions to avoid unintended engagements that could harm non-combatants or allies. Moreover, the increasing potential for autonomous operations raises questions about accountability, decision-making, and compliance with international laws of armed conflict [23].

In lieu of current technological advancement in UAVs, it is known that the drones themselves are much further enhanced to aid in missions from a military and civilian standpoint as mentioned earlier. As discussed, by operating with AI the cost-effectiveness of the newer drones now operates with vast amounts of data injected within which are analyzed in real time, thus, providing rapid decision-making which does not need human intervention. This is correlated with how the drones are able to identify and engage hostiles that are simulated in environments and significantly reduce response time that normal pilots would have to calculate themselves [24].

To resist jamming, engineers use encrypted or fiber-optic control links and improved GPS protection. These measures keep connections stable in hostile environments. As fiber optic-controlled drones, connected via cables are able to operate within a 20 km radius, thus, rendering them immune to jamming and interference, as this form of technology is vastly more resilient in environments where electronic interference

---

[20] Z. Xiaoning, "Analysis of Military Application of UAV Swarm Technology," in *2020 3rd International Conference on Unmanned Systems* (ICUS) (2020): 1200–1204.

[21] X. N. Zhu, "Analysis of Military Application of UAV Swarm Technology," in *Proceedings of the 2020 3rd International Conference on Unmanned Systems* (Harbin, China, 2020), 1200–1204, https://www.scirp.org/reference/referencespapers?referenceid=3941251.

[22] S. Arif, "Era of Drone Swarming: Exploring Battlefield Implications," *Centre for Aerospace & Security Studies* (2024), https://casstt.com/wp-content/uploads/2024/12/Shaza-Arif-Dro-Swar-Bat-EB-Rev2-23-Dec-2024-HM1-ED-SSA-APP.pdf.

[23] U.S. Government Accountability Office, *Science & Tech Spotlight: Drone Swarm Technologies (*GAO-23-106930) (2023), https://www.gao.gov/products/gao-23-106930.

[24] Caballero-Martin, D., J. M. Lopez-Guede, J. Estevez, and M. Graña. "Artificial Intelligence Applied to Drone Control: A State of the Art." *Drones* 8, no. 7 (2024): 296.

is most prevalent [25]. Integration with network-centric warfare systems has been a fine addition to drone operations as it provides seamless communication and coordination with other military assets.

This would in turn enhance situational awareness and to synchronize with troops to ensure the utmost effectiveness during missions and operations [26]. It is also worth noting that modern UAVs have extended operational ranges and endurance, this helps long-duration missions without the need of refuelling or maintenance, the model MQ-9 Reaper, for instance could freely operate at altitudes up to 50,000 feet and last for 27 hours, which is suitable for prolonged surveillance and clandestine strike missions while also removing the risk factor of a pilot in those situations [27].

Case Study: Ukraine-Russia Conflict

As per recent concerns of warfare, Ukraine and Russia's conflict have been a precedent in modern news, with many discussions highlighting the intensity of the ongoing conflict over the years. This particular issue will be the case study for this paper, as the war waged between the two countries have given sufficient examples of drone warfare and its extended usage. While coverage itself may not be fully recorded, as some of the information may be gatekept by Russia or Ukraine to preserve secrecy, recent open resources and media have suggested that the war itself utilize many different types of drones to have an advantage in the war, which will be discussed after [28].

The ongoing conflict of Ukraine and Russia has been ongoing since 2014 and intensified with a full-scale invasion to Ukraine in 2022. Drones, however, have been deployed numerous times as technology advances, UAVs have transformed the battlefield, by the year 2025, drones have provided surveillance for the armies and have aided in combat operations. Furthermore, Ukraine has integrated drones to their military arsenal by utilizing military-grade and commercially available UAVs for defence and attacks.

The Turkish Bayraktar TB2 drones have been heavily used in conducting precision strikes against Russian armored vehicles and critical artillery positions. The drone's ability to engage in combat whilst also becoming a supplier of supplies and ammunition has proven detrimental to the war effort for Ukraine [29]. In addition, there are commercial drones repurposed for reconnaissance and combat roles, innovatively using siad drones to carry modified explosives or survey areas deemed treacherous for standard

---

[25] Sun, Yan, Derrick W. K. Ng, Dongfang Xu, Linglong Dai, and Robert Schober, "Resource Allocation for Solar-Powered UAV Communication Systems." In *2018 IEEE 19th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, 1–5. Piscataway, NJ: IEEE, 2018. https://doi.org/10.1109/SPAWC.2018.8445944

[26] T. Samad, J. S. Bay, and D. Godbole, "Network-Centric Systems for Military Operations in Urban Terrain: The Role of UAVs," *Proceedings of the IEEE 95*, no. 1 (2007): 92–107.

[27] T. Crowley, "Top 10 Military Drones – The Ultimate Power in the Sky in 2025," *National Security Innovation Network*, 2025, https://www.nsin.us/best-military-drones.

[28] K. Chávez and O. Swed, "Emulating Underdogs: Tactical Drones in the Russia-Ukraine War," *Contemporary Security Policy* 44, no. 4 (2023): 592–605.

[29] K. D. Thompson, "How the Drone War in Ukraine Is Transforming Conflict," *Council on Foreign Relations*, 2024, https://www.cfr.org/article/how-drone-war-ukraine-transforming-conflict.

scouting. This approach provides much needed assistance without sacrificing critical manpower or arsenal from the Ukrainian army [30].

While in Russia, they too apply the same tactics, using the drones for reconnaissance and offensive operations, the Orlan-10 drone for instance has been widely used for intelligence, surveillance, and reconnaissance (ISR) missions, hence, providing real-time data to support artillery strikes. In addition, Russia employs loitering munitions such as the Lancet-3 which covers the battlefield to bring it to their advantage, as it is autonomous, they engage prime targets and critical points using a predetermined directive [31].

Thus, the use of drones in war times have created new strategies to fend off and to strike enemies, the drones provide the military with eyes in the sky, attack power, and risk-free operations operated far away from harm. Moreover, the war itself has accelerated development of drone technology, as AI is being implemented to provide an edge in combat, the lasting impacts of these innovations have aided innovations for future military engagements worldwide as well.

Countermeasure and Defence Against Drones

With the trend and over-abundance of drone manufacturing, it is safe to assume that the international community has found ways to repel and disrupt drones to fend off attacks. There are a number of ways to effectively disarm drones, however, keep in mind that most methods themselves have a workaround to them, as drones are built to survive many encounters and reject interference.

Firstly, it is much more viable to detect and track UAVs to prevent further damage, advanced radar systems have been developed to identify small, low flying drones that traditional radars might have missed. These systems would function as a common radar, however more so that it analyses and signals back echoes of objects in the surrounding airspace, thus allowing the tracking of drones [32].

Secondly, there are electronic countermeasures. Once a drone is detected, these countermeasures disrupt the drone's operations. By jamming the signals and interfering with the drone's communication links, the connection between the UAV and the controller/pilot could be severed, thus, forcing the drone to land or return to the point of origin. Another method is to trick the drone's sense of direction, by spoofing a GPS, the drone may be misguided and venture to other territories which are not relegated for the operation, thus, reducing its effectiveness in missions [33].

Third, the use of energy weapons would prove quite effective, as it is one of the more direct approaches to this issue, these systems are able to disable or destroy UAVs by targeting their internal components. The Defence Research and Development

[30] Fr. J. Singarayar et al., "A Game of Drones in the Russia-Ukraine War – Analysis," *Eurasia Review*, 2023, https://www.eurasiareview.com/11082023-a-game-of-drones-in-the-russia-ukraine-war-analysis.
[31] Fr. J. Singarayar et al., "A Game of Drones in the Russia-Ukraine War – Analysis," *Eurasia Review*, 2023, https://www.eurasiareview.com/11082023-a-game-of-drones-in-the-russia-ukraine-war-analysis.
[32] Robin Radar USA. "10 Types of Counter-Drone Technology to Detect and Stop Drones Today." n.d. https://www.robinradar.com/resources/10-counter-drone-technologies-to-detect-and-stop-drones-today.
[33] Pentoz, "Anti-Drone Countermeasures (C-UAVs)," 2025, https://pentoz.com/anti-drone-countermeasures-c-uavs.

Organization (DRDO) in India has developed laser-based weapons capable of neutralizing drones, which enhances the country's defensive capabilities [34].

Fourth, the use of traditional weaponry to deter drones is still viable, rather than using matching technology to down a drone, it should be far simpler to utilize projectiles, nets, or interceptor drones to capture or destroy hostile UAVs. Systems such as the Marine Air Defence Integrated System (MADIS) could employ sensors and kinetic weapons to engage drones effectively. Said systems are common military assets in multiple regions to not only repel drones, but to also deflect aerial assaults and similar threats [35]. Though there are still more options for counter attacking drones, the four previously mentioned tactics are at the very least a baseline for reference. As most other deterrence strategies are correlated or based on the list provided above.

Ethical and Legal Concerns Using UAVs

UAV warfare raises ethical and legal problems—wrongful targeting, unclear accountability, and civilian trauma. Pilots may sometimes mistake civilians or non-combatants for hostile and accidentally harming or even killing them. For instance, a U.S. drone strike was initiated in Kabul August 2021, which mistakenly ended the lives of 10 civilians including children. The ethical concern of most of the cases is to ignore them as collateral damage, however, the lack of accountability most likely means that drone technology has yet to reach the perfect stage of identification. Incidents akin to this occur more often than they should, thus stress factors into the mix, as drone operators and civilians are left with the psychological impact.

Though a combat zone is oftentimes psychologically tied to warfare, yet, if the use of UAVs and their psychological effects still persists, means that it is far from perfect, as even neutralizing a target may leave others to reflect heavily upon their mental issues [36]. However, the most ethical question raised is the fact that machines are both figuratively and literally killing humans, as mental anguish may not only stem from traumatic incidents, deaths accumulated by machines portrays the soulless efficiency in war in the modern era. With lethal strikes against lives now decided by machines, it is difficult to differentiate whether war has become safer -for one side- rather than humane for all [37].

Due to the concerns of war ethics, it is a requirement to reconsider the International Humanitarian Law within the confines of conflicts and wars utilizing UAVs. As mentioned before, drones have proved to be as efficient if not more within military stratagem, yet the legal concerns of differentiating non-combatants, allies, and

[34] K. Kumar, "India Unveils Laser Weapon That Destroys Drones at Light Speed," Gulte News, 2025, https://www.gulte.com/trends/348848/india-unveils-laser-weapon-that-destroys-drones-at-light-speed.
[35] C. Panella, "The Marines Are Deploying These New Ship and Drone Killers to a Strategic US Ally in the Pacific," Business Insider, 2025, https://www.businessinsider.com/marines-deploying-new-ship-drone-killers-to-key-pacific-ally-2025-4.
[36] Total Military Insight, "The Ethics of Drone Warfare: Navigating Moral Complexities," 2024, https://totalmilitaryinsight.com/ethics-of-drone-warfare
[37] N. Robins, "AI's 'Oppenheimer Moment': Autonomous Weapons Enter the Battlefield," The Guardian, July 14, 2024, https://www.theguardian.com/technology/article/2024/jul/14/ais-oppenheimer-moment-autonomous-weapons-enter-the-battlefield.

surrendering enemies are still blurred since excessive collateral damage is still a part of war [38].

Furthermore, the context of international borders and sovereignty comes into play, where strikes in foreign sovereign land may be accrued as a spark for conflict. Thus, the need for consensus between states in operating drones, be it for military actions or simulation. Lastly, the idea of accountability is quite challenging when operations where several different actors are involved are mixed within an incident. As the lack of transparency in drone programs waters down the efforts to investigate and prosecute any violations of international laws [39].

Private startups and state programs now drive UAV innovation. Investment surges speed development but often outpace regulation. Oversight and shared standards must evolve as quickly as the technology itself. By enhancing and ensuring transparency, implementing enhanced international regulations, and added human oversight, keeping the line of humane actions in war and conflict should be far more manageable.

The Future of UAVs

The most transformative trend in UAV technology is the usage of drone swarms. The swarms, as discussed earlier, replicate a swarm of insects that operates cohesively and are able to execute commands without much of human intervention, making it an ideal tool for military strategy where multifaceted approaches are required. For example, the German made OWE-V drone by Stark has the ability to autonomously make real-time battlefield decisions, though would still need some level of human oversight [40]. Although still in its adolescent stages, using AI within the drone swarm strategy could prove to be viable, as The U.S. Department of Defence is exploring further in implementing AI the potential to overwhelm enemy defences would serve as a tactical advantage if utilized correctly. This technology attempts to force AI to operate within themselves and make decisions even in the heat of combat without losing momentum[41].

Coupled with the emerging fact that the defence industry has seen the rise of tech startups ready to jump into drone manufacturing, the industry has evolved far quicker than it should have. Companies like Shield AI, Anduril, and Applied Intuition are becoming the forefront of drone research. These companies are attempting to implement AI-driven technology into traditional defence, along with drone manufacturing becoming a trend, it would not be impossible if researches started to implement AI in other patents and involve other strategies[42].

---

[38] Total Military Insight, "The Ethics of Drone Warfare: Navigating Moral Complexities," 2024, https://totalmilitaryinsight.com/ethics-of-drone-warfare

[39] M. J. Boyle, Legal and Ethical Implications of Drone Warfare (Philadelphia: Foreign Policy Research Institute, 2025), https://www.fpri.org/books/legal-ethical-implications-drone-warfare.

[40] S. Pfeifer and P. Nilsson, "Fully Autonomous Strike Drones within Technological Reach, Says German Start-up," *Financial Times*, 2025, https://www.ft.com/content/e085334b-8697-4824-80fe-a558b869ec5c

[41] Patrick Tucker, "The Pentagon Is Already Testing Tomorrow's AI-Powered Swarm Drones, Ships," Defense One, January 2024, https://www.defenseone.com/technology/2024/01/pentagon-already-testing-tomorrows-ai-powered-swarm-drones-ships/393528.

[42] Jeffry Cooper, "The 10 Defense Tech Startups to Watch in 2025," Jeffrey L. Cooper Blog, January 18, 2025, https://jeffreylcooper.com/2025/01/18/the-10-defense-tech-startups-to-watch-in-2025.

Statistically capital investment in defence technology has significantly increased, with funding rising 33% in 2024 to 31$ billion. The income of capital has supported startups developing cutting-edge technology such as nano drones and more advanced AI systems, hence contributing to a booming and dynamic industry [43].

As expected, the technology which drones brought into the table has started a widespread arms proliferation. Major powers such as the U.S., China, Russia, India, etc, have bought patents, imported parts and models, and bought stocks in companies to provide them an edge in an arms race [44]. This would then translate to a significant advantage in the battlefield that could overturn the tides of war, especially in cases such as Ukraine and Russian war as discussed earlier.

This shift towards unmanned systems is prompting re-evaluation of military strategy while also raising concerns of the future. As autonomy reigns supreme in such cases, the balance of military power may shift, while standard and traditional aircrafts are still manned manually, the option of utilizing cutting-edge technology in times of war - especially for more developed countries- would be an advantage one could not neglect [45]. As such it is only natural for countries to have security dilemmas when their rivalling and even neighbouring countries buy up UAVs in droves or start manufacturing them. Thus, the future of drone technology is capitalized by AI and autonomous control, as the dynamic defence industry is driven by startup companies that provide this edge, they would surely forgo some ethical or legal concerns over strategic strength.

Previous literature has tended to address UAVs in a compartmentalized manner—whether solely from the perspective of technical engineering or conventional military history. In contrast, this article introduces novelty by integrating the evolution of Artificial Intelligence (AI) technologies and the concept of swarm drones directly into the realities of contemporary hybrid warfare. Whereas earlier studies (for example, those centered on the era of the War on Terror) positioned drones primarily as exclusive assets of superpower militaries, this research—through a case study of the Russia–Ukraine War—has captured a paradigm shift in which modified commercial technologies are capable of disrupting traditional military strategies and generating new forms of asymmetric threat that remain incompletely mapped in prior scholarship.

Furthermore, this article addresses a significant academic gap by moving beyond a mere analysis of tactical capabilities to critically juxtapose them with the ethical dilemmas and the persistent lacunae in international legal frameworks, which frequently lag behind the pace of technological innovation. By synthesizing potential future threats with the urgent need to develop Counter-UAV (C-UAV) systems, this work offers a more holistic and predictive analytical framework than purely historical description, thereby providing a more relevant foundation for defense policymakers confronting AI-driven warfare in 2025 and beyond.

---

[43] Jacob Hornstein, "VCs Are Pouring Billions into Defense Tech under Trump—but Some Worry the Hype Is Outpacing Reality," Business Insider, April 2025, https://www.businessinsider.com/trumps-executive-orders-boost-vc-interest-in-defense-tech-2025-4.

[44] Michael J. Boyle, "The Race for Drones," *Orbis* 59, no. 1 (2015): 76–94.

[45] John M. Sullivan, "Evolution or Revolution? The Rise of UAVs," *IEEE Technology and Society Magazine* 25, no. 3 (2006): 43–49.

Conclusion and Recommendations

In conclusion, the development and deployment of UAVs has revolutionized military operations by introducing new tactics that prioritize safety, efficacy, and real-time reaction. Since their debut as experimental devices during World War I and their current application in complex military operations, drones have been crucial for both direct combat and surveillance. The use of AI, swarm technology, and advanced navigation systems has significantly enhanced their capabilities, allowing forces to maintain operational superiority while reducing the risk to human life. However, before UAVs can be employed extensively, there are still several challenges to be solved. Legal concerns regarding autonomous weapon systems, the psychological effects on drone operators, and ethical concerns concerning human deaths must all be addressed immediately. As drone technology becomes increasingly autonomous, concerns regarding accountability and compliance with international law will continue to exist, necessitating a review of existing frameworks to ensure that the use of drones during wartime stays within legally and ethically acceptable parameters.

The future of UAVs will depend heavily on the advancement of AI, autonomous operations, and cooperative swarming techniques. The military industry's move toward technology startups and increased financial expenditures demonstrates a rapidly evolving arms race focused on drone capabilities. Although there is no denying the strategic advantages of these innovations, there is also a chance that they may escalate conflicts and encourage the proliferation of weapons. Therefore, managing the complex future of UAVs in international military affairs will need a well-rounded approach which prioritizes international cooperation, ethical supervision, and technical innovation.

This paper delves within the confines of military strategy utilizing UAVs and as such lacks the proper knowledge of more engineering innovations. The presence of drones has impacted both the world and the defense industry greatly, however, this should be interchangeable with the fact that everyday usage may also be possible as drone technology progresses. This article would not be possible without the free-access I -as the writer- have in today's age, with internet and many online sources present, this paper attempts to paint a clear picture of the development of UAVs. Thus, it is recommended that this paper be use alongside other papers which discusses more laws, policies, regulation, mathematics, etc.

Bibliography

Arif, Shaza. Era of Drone Swarming: Exploring Battlefield Implications. Centre for Aerospace & Security Studies, 2024. https://casstt.com/wp-content/uploads/2024/12/Shaza-Arif-Dro-Swar-Bat-EB-Rev2-23-Dec-2024-HM1-ED-SSA-APP.pdf.

Boyle, Michael J. "The Race for Drones." Orbis 59, no. 1 (2015): 76–94.

———. Legal and Ethical Implications of Drone Warfare. Philadelphia: Foreign Policy

Research Institute, 2025. https://www.fpri.org/books/legal-ethical-implications-drone-warfare.

Caballero-Martin, D., J. M. Lopez-Guede, J. Estevez, and M. Graña. "Artificial Intelligence Applied to Drone Control: A State of the Art." Drones 8, no. 7 (2024): 296.

Central Intelligence Agency. CIA-RDP80M01048A000800320003-8. n.d. https://www.cia.gov/readingroom/docs/CIA-RDP80M01048A000800320003-8.pdf.

Chávez, K., and O. Swed. "Emulating Underdogs: Tactical Drones in the Russia-Ukraine War." Contemporary Security Policy 44, no. 4 (2023): 592–605.

Cooper, Jeffrey L. "The 10 Defense Tech Startups to Watch in 2025." January 18, 2025. https://jeffreylcooper.com/2025/01/18/the-10-defense-tech-startups-to-watch-in-2025.

Crowley, Thomas. "Top 10 Military Drones: The Ultimate Power in the Sky in 2025." National Security Innovation Network (NSIN), 2025. https://www.nsin.us/best-military-drones/.

Cunningham, G. K. "Landpower in Traditional Theory and Contemporary Application." In US Army War College Guide to National Security Issues, Vol. 1, 109–120. Carlisle, PA: US Army War College, 2008.

Everaerts, J. "The Use of Unmanned Aerial Vehicles (UAVs) for Remote Sensing and Mapping." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 37 (2008): 1187–1192.

Hornstein, Jacob. "VCs Are Pouring Billions into Defense Tech under Trump—but Some Worry the Hype Is Outpacing Reality." Business Insider, 2025. https://www.businessinsider.com/trumps-executive-orders-boost-vc-interest-in-defense-tech-2025-4.

Institute, H., ISS, ECFR, Foundation O. R., and Fr. J. Singarayar. "A Game of Drones in the Russia-Ukraine War – Analysis." Eurasia Review, August 11, 2023. https://www.eurasiareview.com/11082023-a-game-of-drones-in-the-russia-ukraine-war-analysis/.

Jacobs, Tom. "Data from Above: The Advantages of Unmanned Aircraft." Journal of

Petroleum Technology 65, no. 10 (2013): 36–43.

Joshi, A., A. Spilbergs, and E. Miķelsone. "AI-Enabled Drone Autonomous Navigation and Decision Making for Defence Security." In Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference, Vol. 4, 138–143. June 2024.

Kumar. "India Unveils Laser Weapon That Destroys Drones at Light Speed." Gulte News, 2025. https://www.gulte.com/trends/348848/india-unveils-laser-weapon-that-destroys-drones-at-light-speed.

Lockheed Martin. "No Pilot Seat Necessary." n.d. https://www.lockheedmartin.com/en-us/news/features/history/uavs.html.

Marino, Chris. "Send in the Drones." United States Army, October 17, 2024. https://www.army.mil/article/280609/send_in_the_drones.

National Air and Space Museum. "The Secret History of Drones." Air and Space Quarterly 12 (2024). https://airandspace.si.edu/air-and-space-quarterly/issue-12/secret-history-of-drones.

Ollero, A., and L. Merino. "Unmanned Aerial Vehicles as Tools for Forest-Fire Fighting." Forest Ecology and Management 234, no. 1 (2006): S263.

Panella, Chris. "The Marines Are Deploying These New Ship and Drone Killers to a Strategic US Ally in the Pacific." Business Insider, 2025. https://www.businessinsider.com/marines-deploying-new-ship-drone-killers-to-key-pacific-ally-2025-4.

Parsons, Dan. "Worldwide, Drones Are in High Demand." National Defense 97, no. 714 (2013): 30–33.

Pentoz. "Anti-Drone Countermeasures (C-UAVs)." Pentoz Technologies, 2025. https://pentoz.com/anti-drone-countermeasures-c-uavs.

Petrovski, A., M. Radovanović, and A. Behlić. "Application of Drones with Artificial Intelligence for Military Purposes." In 10th International Scientific Conference on Defensive Technologies (OTEH 2022), Belgrade, Serbia, October 2022, 92–100.

Pfeifer, S., and P. Nilsson. "Fully Autonomous Strike Drones within Technological

Reach, Says German Start-up." Financial Times, 2025. https://www.ft.com/content/e085334b-8697-4824-80fe-a558b869ec5c.

Radovanovic, M., A. Petrovski, A. Behlic, M. Z. Chaari, E. G. Hashimov, R. Fellner, and A. Agbeyangi. "Unleashing Autonomous Forces: Integrating AI-Driven Drones in Modern Military Strategy." Systems of Control, Navigation and Communication 3, no. 77 (2024): 55–69.

Rangel, R. K., and A. C. Terra. "Development of a Surveillance Tool Using UAVs." In 2018 IEEE Aerospace Conference, 1–11. IEEE, March 2018.

Razma, G. "A Modern Warfare Paradigm: Reconsideration of Combat Power Concept." Journal of Security and Sustainability Issues 8, no. 3 (2019): 435–452.

Robin Radar USA. "10 Types of Counter-Drone Technology to Detect and Stop Drones Today." n.d. https://www.robinradar.com/resources/10-counter-drone-technologies-to-detect-and-stop-drones-today.

Robins, Nick. "AI's 'Oppenheimer Moment': Autonomous Weapons Enter the Battlefield." The Guardian, July 14, 2024. https://www.theguardian.com/technology/article/2024/jul/14/ais-oppenheimer-moment-autonomous-weapons-enter-the-battlefield.

Samad, T., J. S. Bay, and D. Godbole. "Network-Centric Systems for Military Operations in Urban Terrain: The Role of UAVs." Proceedings of the IEEE 95, no. 1 (2007): 92–107.

Scalea, Joseph R. "Using Unmanned Aircraft to Save Lives: Learning to Fly." JAMA Surgery 155, no. 4 (2020): 355–356.

Sharma, M., H. Singh, A. K. Gupta, and D. Khosla. "Target Identification and Control Model of Autopilot for Passive Homing Missiles." Multimedia Tools and Applications 83, no. 20 (2024): 58465–58494.

Sullivan, John M. "Evolution or Revolution? The Rise of UAVs." IEEE Technology and Society Magazine 25, no. 3 (2006): 43–49.

Sun, Yan, Derrick W. K. Ng, Dongfang Xu, Linglong Dai, and Robert Schober. "Resource Allocation for Solar-Powered UAV Communication Systems." In 2018 IEEE 19th International Workshop on Signal Processing Advances in Wireless

Communications (SPAWC), 1–5. Piscataway, NJ: IEEE, 2018. https://doi.org/10.1109/SPAWC.2018.8445944.

Thompson, K. D. "How the Drone War in Ukraine Is Transforming Conflict." Council on Foreign Relations, 2024. https://www.cfr.org/article/how-drone-war-ukraine-transforming-conflict.

Total Military Insight. "The Ethics of Drone Warfare: Navigating Moral Complexities." Total Military Insight, 2024. https://totalmilitaryinsight.com/ethics-of-drone-warfare.

———. "Understanding the Legal Framework for Drone Warfare Today." Total Military Insight, 2024. https://totalmilitaryinsight.com/legal-framework-for-drone-warfare.

Tucker, Patrick. "The Pentagon Is Already Testing Tomorrow's AI-Powered Swarm Drones, Ships." Defense One, January 2024. https://www.defenseone.com/technology/2024/01/pentagon-already-testing-tomorrows-ai-powered-swarm-drones-ships/393528.

U.S. Government Accountability Office. Science & Tech Spotlight: Drone Swarm Technologies (GAO-23-106930). Washington, DC: GAO, 2023. https://www.gao.gov/products/gao-23-106930.

U.S. Navy. "RQ-2A Pioneer Unmanned Aerial Vehicle (UAV)." U.S. Navy, September 9, 2020. https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2166538/rq-2a-pioneer-unmanned-aerial-vehicle-uav/.

Wang, W., B. Jiang, J. Yang, and C. Li. "Research on UAV Application in Mountain Anti-Terrorism Combat." Journal of Physics: Conference Series 1792, no. 1 (February 2021): 012079.

Xiaoning, Zhu. "Analysis of Military Application of UAV Swarm Technology." In 2020 3rd International Conference on Unmanned Systems (ICUS), 1200–1204. IEEE, November 2020.

Zhu, X. N. "Analysis of Military Application of UAV Swarm Technology." In Proceedings of the 2020 3rd International Conference on Unmanned Systems (ICUS), 1200–1204. Harbin, China, 2020. https://www.scirp.org/reference/referencespapers?referenceid=3941251.