

THE INFLUENCE OF TECHNOLOGY ON MILITARY ART: THE TRANSFORMATIVE ROLE OF UNMANNED AERIAL VEHICLES

Constantin GRIGORAȘ, Ștefan-Cristian PETRE

“Nicolae Bălcescu” Land Forces Academy, Sibiu, Romania

grigoras.constantin@armyacademy.ro

petre.stefan@armyacademy.ro

Abstract: *The advent of Unmanned Aerial Vehicles (UAVs) has ushered in a transformative era for military art, impacting strategic, operational, and tactical levels of warfare. This paper examines the profound influence of UAV technology, beginning with an overview of the three tiers of military science and highlighting the increasing prevalence of UAV usage. It delves into the diverse types and classifications of UAVs, illustrating their specific applications across the strategic, operational, and tactical domains. Furthermore, the analysis explores the significant impact of UAVs on military art, emphasizing the imperative for specialized units, tailored instruction programs, and modernized educational plans to fully leverage their capabilities. Through comparative case studies of recent conflicts, the paper underscores the revolutionary role of UAVs in shaping modern warfare, concluding with insights into the future of this rapidly evolving technology and its continued influence on military strategies and tactics.*

Keywords: UAV, military art, technology

1. Introduction

Military science is structured across three interconnected levels: strategic, operational, and tactical.

The strategic level focuses on the overarching direction of warfare, defining and supporting national policy, and addressing the fundamental rationale for conflict. It encompasses the formulation of strategic concepts, planning the employment of all national instruments of power, and directing armed forces to achieve strategic objectives, often integrating non-military elements such as economic and diplomatic considerations.

The operational level acts as a crucial bridge, translating broad strategic aims into specific tactical actions. At this level, campaigns and

major operations are planned and executed to achieve military objectives that support strategic goals. Operational art, a cognitive process involving skill, knowledge, creativity, and judgment, is essential for developing strategies by harmonizing ends, ways, and means, and for coordinating large military formations.

The tactical level centers on the planning and execution of battles and engagements. Commanders employ combat power in specific battles, engagements, and small-unit actions to achieve immediate combat objectives, governing the direct application of forces on the battlefield. These levels are intricately linked: tactical successes contribute to operational objectives, which in turn serve broader strategic goals.



Figure 1: Fundamental operational mandates across the spectrum of military art.

The operational level translates strategy into actionable plans by assigning missions and allocating resources to tactical operations. Technological advancements, particularly Unmanned Aerial Vehicles (UAVs), are profoundly influencing warfare. Initially conceived for reconnaissance, UAVs have rapidly transformed into versatile platforms for surveillance, intelligence gathering, precision strikes, and combat support. Their remote operation mitigates risks to human personnel and offers cost-effectiveness, while being continually enhanced by Artificial Intelligence (AI) and advanced communication systems. This burgeoning UAV technology is reshaping military art across the strategic, operational, and tactical echelons, necessitating a comprehensive analysis of its impact.

This study aims to investigate the profound influence of technological advancements on military art, specifically focusing on the transformative role of Unmanned Aerial Vehicles (UAVs). Our primary objectives are twofold: first, to comprehensively assess how the widespread integration of UAVs has critically reshaped traditional military doctrines and operational strategies across various conflict theaters; and second, to meticulously analyze the multifaceted impact of evolving UAV capabilities on the ethical and legal frameworks governing modern warfare. To achieve these objectives, this research will employ a mixed-methods approach, primarily drawing upon in-depth case studies of specific military conflicts and

operations where UAVs have played a pivotal role. Complementing this, a comprehensive document-based study will be conducted, examining relevant military manuals, technological reports, strategic analyses, and international legal documents pertinent to the deployment and implications of unmanned aerial systems.

2. Unmanned Aerial Vehicles (UAVs): Types and Classifications

The landscape of modern military operations is increasingly populated by a diverse range of Unmanned Aerial Vehicles (UAVs), each designed to fulfill specific roles on the battlefield. These aerial systems can be broadly categorized based on their primary function.

Reconnaissance and surveillance drones are engineered to gather intelligence and provide real-time information, often equipped with advanced sensors, high-resolution cameras, and radar systems to monitor extensive areas and track enemy movements. A notable example is the RQ-4 Global Hawk, renowned for its high-altitude, long-endurance surveillance missions.

Combat or strike drones, also known as Unmanned Combat Aerial Vehicles (UCAVs), are armed platforms designed for offensive missions, capable of delivering precision strikes using guided missiles and bombs. Prominent examples include the MQ-9 Reaper and the MQ-1 Predator, which have been instrumental in various combat operations.

Logistics and cargo drones address the critical need for efficient supply chains in military operations by transporting equipment, ammunition, and medical supplies to frontline troops, thereby enhancing both efficiency and the safety of personnel by reducing the need for manned transport in hazardous environments. The K-MAX drone serves as an example of

communications and radar systems, and swarm operations, involving coordinated attacks by multiple drones to overwhelm enemy defenses. Finally, **target drones** are primarily used for training exercises, simulating enemy aircraft or missiles to provide realistic scenarios for military personnel. This variety in UAV types underscores their multifaceted applications in contemporary warfare, with each type contributing uniquely to different aspects of military operations.

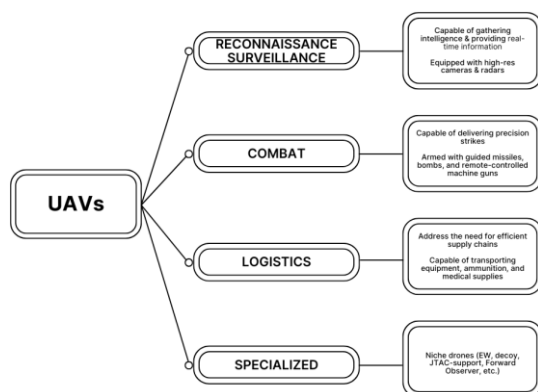
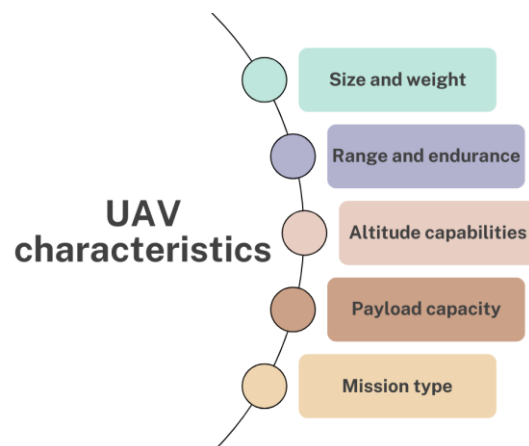


Figure 2: Task-based classification of UAVs

Beyond their functional roles, UAVs can also be classified based on several operational factors that dictate their capabilities and suitability for different missions. **Size and weight** are significant determinants, with UAVs ranging from nano UAVs, weighing less than 250 grams and used for very close-range situational awareness, to large UAVs, exceeding 150 kilograms and including Medium Altitude Long Endurance (MALE) and High-Altitude Long Endurance (HALE) systems designed for long-range Intelligence, Surveillance, and Reconnaissance (ISR) missions. The United States Department of Defense employs a five-group classification system based on a UAV's weight, operating altitude, and speed. The physical dimensions of a UAV often correlate with its payload capacity, range, and endurance, influencing its role in military operations. **Range and endurance** provide another crucial classification, with categories ranging from very close-range UAVs, having a range of

less than 5 kilometers and an endurance of under one hour, to long-range UAVs capable of traveling over 650 kilometers and staying airborne for more than 36 hours. Endurance UAVs are particularly valuable for providing persistent surveillance over extended periods, a capability highly sought after at strategic and operational levels. **Altitude capabilities** also serve as a key classification factor, spanning from low-altitude tactical UAVs, operating below 1,200 feet, to high-altitude strategic UAVs, such as HALE systems that can fly above 30,000 feet. The ability to operate at high altitudes can significantly reduce the likelihood of detection by enemy forces. **Payload capacity** varies considerably among UAVs, from lightweight drones capable of carrying only small payloads (less than 1 kilogram) to heavy-lift drones that can transport over 160 kilograms. The capacity to carry different payloads directly determines the types of sensors, weapons, or cargo a UAV can accommodate, thus defining its mission capabilities. Finally, **mission type** provides a classification based on the primary role of the UAV, including ISR, combat operations, logistics, electronic warfare, or target designation. Some UAVs, like the MQ-9 Reaper, are multi-role platforms capable of performing both ISR and strike missions, highlighting the increasing versatility of these systems.



strategic level, large, high-altitude, long-endurance (HALE) UAVs, such as the RQ-4 Global Hawk, are typically employed for wide-area surveillance, gathering intelligence over extended durations, and monitoring strategically important targets. These systems possess the long ranges and high endurance necessary to support national-level objectives and provide critical intelligence that informs high-level decision-making and national security strategies. Their capabilities align with the broad scope and long-term focus inherent to the strategic level of war. The **operational level** often utilizes medium-altitude, long-endurance (MALE) UAVs, such as the MQ-9 Reaper and MQ-1 Predator, alongside medium-range tactical UAVs like the RQ-7 Shadow, for campaign planning, reconnaissance of operational areas, and conducting precision strikes against key targets that support campaign objectives. These UAVs provide commanders with essential situational awareness and strike capabilities within the theater of operations, bridging the gap between strategic goals and tactical execution. Their characteristics offer a balance of range, endurance, and payload capacity suitable for the scale and objectives of operational warfare. At the **tactical level**, small, short-range UAVs, such as the RQ-11 Raven, and other hand-launched systems are primarily employed for close-range reconnaissance, surveillance of immediate battle areas, and target acquisition for ground units. These UAVs provide real-time situational awareness directly to soldiers on the ground, significantly enhancing their safety and effectiveness during engagements. Micro and mini-UAVs also fall under this category, offering localized intelligence and support to tactical operations. Their portability and ease of deployment are key advantages at this level, making them integral to the success of battles and engagements.

Vehicles (UAVs) has exerted a profound influence on military art, reshaping strategies, operations, and tactics across all levels of warfare. At the **strategic level**, UAVs offer persistent surveillance and reconnaissance capabilities, enabling continuous monitoring of potential threats and strategically significant areas, which directly informs national security assessments. Their capacity to conduct covert operations with reduced diplomatic repercussions, compared to manned aircraft, provides a notable strategic advantage. Furthermore, armed UAVs facilitate precision strikes against high-value targets without exposing human pilots to risk, thereby shaping counter-terrorism strategies and force projection capabilities. The relative affordability and versatility of drones have the potential to alter the balance of power in conflicts, allowing forces with fewer financial resources to compete more effectively against larger, wealthier militaries, which in turn impacts overall military strategy and defense investment priorities. Consequently, the development and proliferation of military drones have become a central element of national defense strategies for nations worldwide. This evolution signifies that UAVs are not merely supplementary tools but have become essential assets in achieving strategic objectives, offering unique advantages in intelligence gathering, targeted operations, and power projection, thus necessitating a fundamental re-evaluation of traditional military strategies and national security policies. The lower cost associated with UAVs, compared to manned aircraft, also contributes to a democratization of military power, enabling a broader range of actors to project force.

3. Analyzing the Impact of UAVs on Military Art

The integration of Unmanned Aerial

Military art level	Assigned task	UAV model	Reason of choice
Strategic	Long-range ISR over hostile territory	RQ-4 Global Hawk [1]	High altitude, long endurance, wide coverage
	Strategic strike on high-value targets	MQ-9 Reaper [2]	Long range, precision strike capable
	Intelligence for national security	Sentinel RQ-170 [3]	Stealth, strategic-level sensors
Operational	Persistent surveillance over enemy lines	Heron TP [4] Predator B [5]	Medium altitude, long endurance (MALE)
	Disruption of C2 or logistics	Bayraktar Akıncı [6] MQ-1C [7]	Multi-role, precision munitions
	Electronic warfare	Shahed-136	Swarm capability, EW attacks
Tactical	Target acquisition & close support	Switch blade [8] Warmate	Loitering munition, man-portable
	Recon & patrol of frontline areas	Puma [9] Raven [10]	Hand-launched, short range, real-time video
	Force protection & perimeter security	Skydio X2D [11] DJI Matrice [12]	VTOL, autonomous navigation, real-time feed

Table 1 UAV usage on particular tasks at different military art levels

At the **operational level**, UAVs have transformed campaign planning and execution by providing military commanders with enhanced situational awareness through real-time intelligence and detailed imagery of operational areas. They significantly improve the precision and effectiveness of reconnaissance missions, enabling the detection and tracking of enemy movements even in challenging terrains or adverse weather conditions. Long-endurance drones can maintain persistent surveillance over conflict zones, effectively reducing the element of surprise in adversarial attacks. Additionally, UAVs can be employed for target designation, directing precision-guided munitions delivered by other platforms, thereby enhancing the effectiveness of both air and ground strikes. They also play a crucial role in supporting logistical operations by delivering essential supplies to remote or dangerous locations, improving the reach and sustainability of forces. The increasing integration of AI into UAVs further bolsters their operational capabilities through features like autonomous navigation and targeting, allowing for more efficient and effective mission execution. This signifies that UAVs have revolutionized the way campaigns are planned and executed by offering unprecedented levels of intelligence, surveillance, and reconnaissance, coupled with the ability to conduct precision strikes and logistical support, leading to more informed decision-making and potentially more effective campaign outcomes [13]. The continuous flow of real-time intelligence from UAVs allows for dynamic adjustments to operational plans as situations evolve.

The impact of UAVs at the **tactical level** is equally significant, as they enhance battlefield awareness and engagement for frontline units. Tactical UAVs provide soldiers with immediate, over-the-horizon views of the battlefield, significantly improving their situational awareness and enabling more effective planning of maneuvers [14]. Small drones can be rapidly deployed for reconnaissance and target

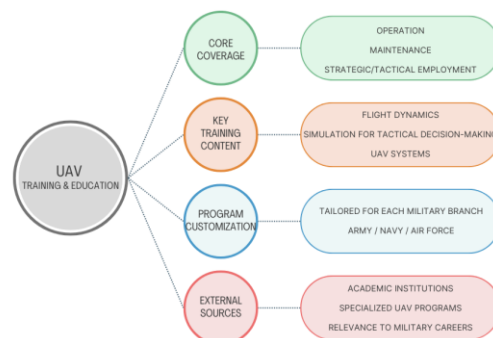
acquisition at the platoon and company levels, offering immediate intelligence where and when it is needed most. UAVs play a critical role in shortening the kill chain by providing real-time targeting data for artillery and close air support, thereby increasing the speed and precision of fires and reducing response times to threats. They can also be used for battle damage assessment, providing immediate feedback on the effectiveness of tactical engagements and informing subsequent actions. The increasing prevalence of First-Person View (FPV) drones has further amplified the tactical impact of UAVs, offering enhanced maneuverability for precise attacks and reconnaissance in complex and confined environments. This demonstrates that at the tactical level, UAVs serve as a significant force multiplier by providing soldiers with enhanced vision, faster and more accurate targeting capabilities, and the ability to engage the enemy more effectively, ultimately leading to increased survivability and mission success. The direct and immediate support provided to ground troops by tactical UAVs is a key advantage in modern battlefield scenarios.



Figure 4: Missions and effects of UAVs at all military art levels

The effective integration and utilization of UAVs across these levels necessitates the development of **specialized military units and organizational structures** tailored to their unique operational requirements. Some experts have proposed the creation of a

dedicated "Drone Corps" to centralize expertise, streamline training, and foster innovation in UAV technology and tactics [15] [16]. Others advocate for a more integrated approach, incorporating UAV capabilities within existing military formations while also establishing specialized drone warfare units focused on experimentation and the development of advanced tactical applications. The U.S. Army's "transforming-in-contact" initiative exemplifies the recognition of the need for rapid adaptation and integration of UAV technology within current unit structures to meet evolving battlefield challenges [17]. The increasing sophistication of UAV operations, including the management of advanced sensor systems and the optimization of diverse payloads, demands dedicated personnel with specialized skills and the establishment of units specifically designed to support these complex systems. This evolution highlights that the transformative impact of UAVs requires a fundamental re-evaluation of traditional military organizational structures to ensure their seamless integration and to fully capitalize on their potential to reshape warfare. This may involve the creation of entirely new specialized units or the significant adaptation of existing ones to accommodate the unique demands of UAV operations.



instruction programs for military personnel is paramount. These programs must cover the full spectrum of knowledge and skills required for the operation, maintenance, and strategic/tactical employment of UAVs. Initial training should provide a solid foundation in military protocols, the principles of flight dynamics, and the specifics of various UAV systems. The use of simulation training is crucial for allowing operators to practice tactical decision-making and to develop proficiency in handling challenging scenarios in a safe and controlled environment. Recognizing the distinct operational focuses of different military branches, training programs need to be tailored to the specific requirements of the Army, Navy, and Air Force, ensuring that personnel are prepared for the unique demands of their respective environments [18].

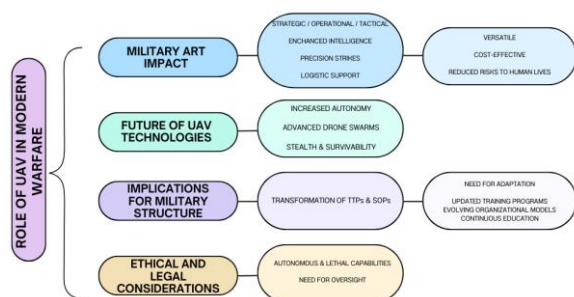


Figure 6: Role of UAVs in modern warfare

Furthermore, continuous refresher courses and opportunities for advanced training are essential to keep UAV operators abreast of the latest technological advancements and evolving operational protocols. In addition to military-led programs, some academic institutions are now offering specialized programs and certifications in UAV operations that are directly relevant to military careers, providing both theoretical knowledge and hands-on experience. This underscores that the effective utilization of UAVs is heavily reliant on well-structured and continuously updated training programs that encompass both the technical intricacies of operation and the

broader strategic and tactical implications of their deployment. Such training must remain agile and adaptive to keep pace with the rapid advancements in UAV technology.

The growing significance of UAVs in modern warfare also necessitates the evolution of military educational plans to fully incorporate their strategic, operational, and tactical implications. This includes the integration of UAV-related topics into the curricula of military academies and staff colleges, ensuring that future military leaders and strategists have a thorough understanding of these technologies. Educational plans should provide a comprehensive overview of the history and development of UAVs, their diverse range of applications across different military domains, and the critical ethical and legal considerations associated with their use. Training should also emphasize the development of strategic and critical thinking skills specifically related to the employment of UAVs at all levels of warfare, from informing national policy to shaping battlefield tactics. The creation of new military occupational specialties (MOS) specifically for UAV operators within the armed forces reflects the increasing need for specialized expertise and the corresponding adaptation of the military education system to cultivate these skills. This evolution signifies that military education must adapt to the increasing prominence of UAVs by integrating their study across all levels of professional military development, ensuring that future leaders and operators possess a comprehensive understanding of their capabilities and the profound implications for the future of warfare. Several comparative case studies of UAV impact in modern conflicts vividly illustrate the transformative role of these technologies. The Ukraine-Russia War serves as a particularly compelling case study, demonstrating the widespread and multifaceted use of UAVs for intelligence, surveillance, reconnaissance, precision

and the ingenuity employed in their deployment. Furthermore, the conflict has underscored the significant psychological impact of the persistent presence of drones on soldiers, introducing new forms of stress and anxiety on the battlefield. The Nagorno-Karabakh Conflict of 2020 provides another critical case study, where the decisive role of UAVs in Azerbaijan's victory clearly demonstrated their strategic impact by effectively neutralizing Armenian defenses and shaping the outcome of the war [19]. This conflict served as an early and stark indicator of the potential for UAVs to significantly alter the course of wars, particularly in overcoming traditional defense systems [20]. Finally, the US operations in Afghanistan, Iraq, and Pakistan offer insights into the effectiveness of armed UAVs, such as the MQ-1 Predator, in conducting targeted strikes against high-value targets, playing a crucial role in counter-terrorism efforts and highlighting the advantages of UAVs in asymmetric warfare scenarios where minimizing risks to friendly forces is paramount.

4. Conclusions

UAVs have fundamentally reshaped military art across the strategic, operational, and

tactical levels of warfare by providing enhanced intelligence, surveillance, reconnaissance, precision strike capabilities, and logistical support. Their versatility, cost-effectiveness, and ability to operate without risking human lives have made them indispensable tools in modern conflicts.

The future trajectory of UAV technology indicates a move towards increased autonomy through the integration of artificial intelligence, the development of more sophisticated drone swarms capable of coordinated actions, advancements in stealth capabilities to evade detection, and improvements in endurance and range allowing for longer and more distant operations. These future developments will further transform military strategies and tactics, requiring continuous adaptation in military organization, training, and education to effectively harness the evolving potential of UAVs in future warfare scenarios. The ethical and legal considerations related to the use of autonomous and potentially lethal UAVs will demand ongoing attention and international dialogue to ensure responsible and lawful implementation of these powerful technologies.

References list

- [1] ***<https://www.airandspaceforces.com/weapons-platforms/rq-4/>. Accessed April, 28, 2025.
- [2] ***<https://www.ga-asi.com/remotely-piloted-aircraft/mq-9a>. Accessed April, 28, 2025.
- [3] ***<http://www.designation-systems.net/dusrm/app2/q-170.html>. Accessed April, 28, 2025.
- [4] ***<https://defence-industry.eu/heron-tp-drone-bundeswehr-enhances-intelligence-and-surveillance-capabilities/>. Accessed April, 29, 2025.
- [5] ***<https://www.team-bhp.com/news/remotely-piloted-mq-9b-aircraft-design-features-specs-operation>. Accessed April, 29, 2025.
- [6] ***<https://www.baykartech.com/en/press/bayraktar-akinci-surpasses-100000-flight-hours/>. Accessed April, 29, 2025.
- [7] ***<https://www.ga-asi.com/remotely-piloted-aircraft/gray-eagle>. Accessed April, 28, 2025.
- [8] ***[https://automatedresearch.org/weapon/aerovironment-switchblade-300-block-2](https://automatedresearch.org/weapon/aerovironment-switchblade-300-block-20-loitering-munition/)

- [10] ***<https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104533/rq-11b-raven/>. Accessed April, 30, 2025.
- [11] ***<https://aeromind.pl/product-eng-13297-Skydio-X2D-Starter-Kit-Multi-band-Radio-Color-Thermal-3-years-term.html>. Accessed April, 30, 2025.
- [12] ***<https://enterprise.dji.com/matrice-30/specs>. Accessed April, 30, 2025.
- [13] Monte, E. C2 and AI Integration In Drone Warfare - Impacts On TTPs & Military Strategy [Internet]. Place: Strategy Central; 02.17.2025. <https://www.strategycentral.io/post/c2-and-ai-integration-in-drone-warfare-impacts-on-ttps-military-strategy>. Accessed April, 15, 2025.
- [14] Eric, R. Drones Over the Caspian: How UAVs are Shaping Regional Power in the Caucasus and Central Asia [Internet]. Place: Caspian Policy Center, 01.22.2025. <https://www.caspianpolicy.org/research/category/drones-over-the-caspian-how-uavs-are-shaping-regional-power-in-the-caucasus-and-central-asia>. Accessed April, 12, 2025.
- [15] Joshua, S. Imagining a US Army Drone Corps [Internet]. Place: Modern War Institute; 12.19.2024. <https://mwi.westpoint.edu/imagining-a-us-army-drone-corps/>. Accessed April, 24, 2025.
- [16] Taylor, M. How Drones Are Changing Warfare [Internet]. Place: TuftsNow, 01.21.2025. <https://now.tufts.edu/2025/01/21/how-drones-are-changing-warfare>. Accessed April, 28, 2025.
- [17] Gertler, J. and Detko, T.W. U.S. Military Unmanned Aerial Systems: Background and Issues for Congress [Internet]. Washington, D.C.: Congressional Research Service, 11.14.2022. <https://crsreports.congress.gov/product/pdf/R/R47258>. Accessed May, 1, 2025.
- [18] Joint Chiefs of Staff. Joint Education [Internet]. Place: Joint Staff, Joint Doctrine Division, 07.01.2020. Available from: https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp1_ch4.pdf. Accessed May, 10, 2025.
- [19] Lewis, J. The Drone Wars: A Debate on the Ethics, Legality, and Future of Unmanned Warfare [Internet]. Place: Center for Strategic and International Studies (CSIS), 09.01.2013. Available from: <https://www.csis.org/analysis/drone-wars-debate-ethics-legality-and-future-unmanned-warfare>. Accessed May, 2, 2025.
- [20] Johnson, S. The Drone Age: How Unmanned Aerial Vehicles Are Transforming Warfare [Internet]. Place: Council on Foreign Relations, 07.15.2024. Available from: [https://www.cfr.org/article/drone-age-how-unmanned-aerial-vehicles-are-transforming](https://www.cfr.org/article/drone-age-how-unmanned-aerial-vehicles-are-transforming-warfare)