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Drones and conflicts: why Unmanned Combat Aerial Vehicles will not reshape the international balance of power

1. Introduction

Among the most modern inventions that the world's battlefields have witnessed in recent years, combat drones, or Unmanned Combat Aerial Vehicles (UCAVs), have been the subject of various studies and speculations.[1] Extensively employed in the last twenty-five years of conflicts, drones represent an impelling reality that perfectly fits the force packages of state-armies.[2] Their unique offensive features, combined with their supposed low requirements in terms of cost and expertise, could open a new chapter in the history of warfare.[3] At the state of the art, different literature's sources warn how almost any kind of military affair could soon fall under the influence of unmanned vehicles, unleashing a "revolution" spanning from military doctrines to international law.[4] Generally, the debates presented by drone supporters have developed into two main categories. The first one is about drones inherently possessing an offensive advantage compared to already-existing technology due to some "exclusive" features. The second, concerns their revolutionary radix, which will inevitably affect force deployment dogmas and procedures in favour of weaker and parastatal actors.[5]

According to the literature, UCAVs' superiority in terms of offensive capabilities is rooted in the following characteristics: being smaller in size, combat drones can elude radar detection better than traditional aircrafts;[6] due to their lighter weight and reduced speed, they can fly more easily to the ground-eluding radars' detection;[7] lastly, due to their simpler and less powerful engines, they can fly at lower speeds, becoming less perceived as threats by radar systems, which are usually looking for faster targets such as fighter jets.[8] On the other hand, combat drones' inherent potential to revolutionize traditional force deployment, as well as warfare in general, is based on the supposed low cost and relatively simple characteristics of such technology. This would enable weaker actors to exploit unmanned aircraft to achieve air warfare capabilities that would normally have never been able to attain, levelling the field to their favour.[9] Moreover, due to extended range, automatization and precision-strike capabilities, combat drones will eventually make close infantry fights obsolete to a point where troops' ground employment will become almost pointless.[10]

Nonetheless, there are no clear answers yet, and the warfare potential of drones is still a subject of discussion. At the state of the art, the literature exploring the topic is currently split between drone supporters and more sceptical observers. Authors such as Michael Boyle and Peter Bergen, for example, warned about the disruptive potential brought by *UCAVs* to the international environment, as well as the political and legal complications that arose when we provided autonomous machines with the ability to kill at any given input.[11] At the same time, however, researchers like Antonio Calcara, Andrea Gilli, Mauro Gilli and Ivan Zaccagnini have already been extremely critic against most of the *Drones' Revolution Theory*[12] driving principles. By simply widening the frame of analysis regarding drone technology, they were able to appoint the immense logistic, industrial, and economic requirements necessary to operate unmanned aerial vehicles, which inevitably suggests a downscaling of drone threat perception.[13] In the context of different interpretations and studies, this paper shed light on drones' capabilities to reform the distribution of armed power on a global scale, providing a series of evidence and case studies that end up complying with more sceptics researchers.

In the following pages, it will be analyzed first if drones really possess an inherent advantage towards the offensive, trying to solve the following questions: Do drones really yield an offensive advantage? Are drones really revolutionary? By examining the claims upon which such statements are built (small size, low altitude, and low speed), it is possible to describe if drones are technically excellent for attacking purposes, making suppression against defenders easier, and sudden attacks more rewarding. If this is the case, we would witness solutions and strategies that only they can achieve or perform better than existing machinery. Moreover, if this warfare evolution finds empirical feedback, critical issues are expected to arise for the international community: States would experience a huge shift in favor of traditionally less capable actors, with an overall reshaping of the global distribution of power, resulting in a high-capability, technologically-dense, multipolar system. Indeed, air warfare capabilities will become widespread and no longer an exclusive feature of nation-states, with *UCAVs*' offensive capabilities sustaining the pillars of new ad-hoc combat doctrines. Reality, however, hints at how the build-ups for such expectations may be way too exaggerated and do not consider basic air warfare principles, stealth technology's crucial role in contemporary air combat, as well as strict industrial and operational requirements. In order to provide an empirical evaluation of drones' impact on battlefields and effectively understand if they have the potential to reshape the global distribution of power, this paper will investigate their performances in the Second Libyan Civil War (2014-2020), in the Nagorno-Karabakh War (2020), and in the conflict involving Russia against Ukraine (2022) at the EU's front door. By looking at these three warfare scenarios, it is possible to address the empirical relevance of *UCAVs* for wars' outcomes, and whether they actually had the pivotal role that some literature expects from them. The research will focus only on High Altitude Long Endurance (*HALE*) and Medium Altitude Long Endurance (*MALE*) typologies of drones , as their considerable dimensions and payloads provide substantial strategic relevance . Mini- and micro-drones, due to their reduced weapon-carry, range and effectiveness against most targets, do not represent any kind of game-changing innovation. Therefore, they will not be taken into consideration.

2. Do drones really yield an offensive advantage?

2.1 Size and Stealth - Are *MALE* and *HALE* drones really so small and consequently harder to detect? Most military *UCAVs* belonging to the *MALE* category are not small. The MQ-9A Reaper and the TB2, for example, have dimensions very close to those of an F-16 and F18 fighter jets in terms of length as well as wingspan. On the other hand, he Predator C Avenger, being an *HALE* drone, has even a larger wingspan than these fighters.[14]

The assumption of expecting more or less concealment to radars depending on the aircraft's size is not necessarily wrong; in most circumstances, the *RCS*[15] of a vehicle is often directly related to its dimensions.[16] Nonetheless, we have to consider that most military aircraft, including the same F16s and F-18s, possess some degrees of stealth technology. This is a huge deal. When we provide stealth technology to a vehicle, and in particular, stealth hard-body shaping, size starts to matter less and less. The goal of a stealthy fuselage, in fact, is to bounce away incoming radar waves as much as possible, a solution which results in concealment to enemy's sensors; despite its real size, a radar will perceive a stealth aircraft as if it was exponentially smaller, possibly bypassing it until dramatically close to a radar site.[17] An aircraft's overall dimensions are, for such reason, not considered an inhibitor, or a booster, of stealth capabilities.[18] In the pursuit of stealth, what truly matters is how radar waves impact the aircraft's surface and to what degree.[19] Sources of scattering and diffraction, which can consist of cavities, ductings, and the materials on the surface itself, can still favor radar return to a certain degree.[20] Indeed, mere aircraft's dimensions, are mostly irrelevant. Moreover, they do not affect the defenders' target-acquisition radars in any way.[21] This does not mean that it is impossible to implement stealth solutions for *UCAVs*: the real question is whether it will be worth it. It is well known that anything, from ships to land vehicles, and even buildings, can incorporate solutions to become *low-observable*.[22] However, stealth technology displays a puzzling relationship with unmanned aerial vehicles and their plausible deployment. A low-observable aircraft is exponentially more expensive than a nonstealthy aircraft. Its higher pierce-tag, derived from its development and assembly costs, makes it way less expendable.[23] In fact, one of the major points in the doctrine that made stealth technology rise as the tip of the spear of the US Air Force, was the increased survivability that only *low-observable* technology could have been granted in the air domain.[24] Therefore, two possible solutions for contemporary and future drone employment in air warfare must be considered.

The first, relying on a qualitative approach, considers *UCAVs* manufactured with stealth hard-body shaping and radar-absorbing materials. As a consequence, this would make them exponentially more expensive but, despite possessing better survivability chances overall, would not grant them any immunity against incoming attacks once they happen to be under the enemy's fire. In the case of even one drone being struck down, the loss can have tremendous backsliding effects. Indeed, the enemy could grasp the possibility to collect and study taken-down drones, potentially understanding crucial know-how, components and assembling secrets: the whole industrial secrecy behind a nation's stealth technology could fall into the risk of being compromised.[25] In conclusion, it appears clear that gathering a similar unmanned fleet, and employing it in strike missions, would be so much of a bet that fighter jets would end up being a more suitable choice. Few units of last-generation fighters, better if equipped with precision-guided weapons,[26] have a greater chance of being a more effective solution. For example, fifth-generation models have endlessly more capabilities than any unmanned vehicle, going far beyond simple target acquisition, target destruction and stealth. Embodying top-of-the-notch technology, these aircrafts function as fully capable and interconnected command posts with supreme mobility: they are faster, stealthier, carry higher payloads, collect endlessly more battle data and display overall better chances of surviving a mission.[27]

However, if a quantitative solution is preferred, we would witness a swarm of cheaper, non-stealthy and expendable drones deployed as first-liner air attackers. Nevertheless, in this case, traditional defense systems would have excellent capabilities to push them back. The approaching pack, which lacks any major stealth feature, is indeed vulnerable to early detection. This translates into defenders having the time to set their *A2/AD* (Anti-Access/Area-Denial)[28] systems while ordering their own air force to take-off and approach the autonomous attackers. Effective and well-planned coordination would lead defenders to favor the tides of the clash in most cases. The plan to overwhelm, or even saturate, a foe's defense system through mere numbers seems to be the best for what will result in an expensive failure. Advanced and precision munitions are considerably less expensive and available than drones. Indeed, defensive systems of powerful actors, such as China, have improved exponentially in the last decades and have always been developed on the basis of dealing with the most advanced stealth fighters and bombers in the context of high-intensity combat and quick strike missions as well. The skilled personnel that coordinates *A2/AD* defensive systems has been trained to react at best even in the shortest of time frames and the quick execution of the *kill-chain procedure*,[29] which threatens even the last generation low-observable technology, has been designed to take-down stealthier, faster and overall deadlier fighter jets;[30] therefore, there should be no match for any swarm of *UCAVs*; moreover if there is a lack of considerable stealth capabilities.

2.2 Low Altitude and Stealth - Is drones' low-flight really so formidable at reducing the range at which they can be detected? Is this something that only drones can perform? This topic is complex. The literature addresses how such a strategy of employment could exploit the weaknesses of most air defenses, which will be less capable of intercepting approaching drones or even incapable of interception at all. However, some basic considerations have been left out, and reality states that there is no real innovation or *UCAV's* exclusivity behind stealthy low-flying. Thus, it would be wrong to consider low-flying as an offense-promoting technique, since it is neither revolutionary nor can drones perform better than other, already-existing, military platforms.

In the domain of radar concealment and stealth-related tactics, low flying is a well-established technique that aims to reduce the range of detection by radar. For example in the 1960s, during the Vietnam War, the forest-dense battlegrounds witnessed for the first time the wide employments of Soviet-manufactured radar-guided *SAMs*, which forced the US Air Force pilots to fly *ground-hugging*[31] in order to elude the deadly precision of hostile missiles batteries.32 The whole meaning behind this concealment tactic, embodied in the phrase *flying under the radar*,[33] is «to elude radar waves, which travel in a line of sight like all electromagnetic waves».[34] Radar waves, and thus radar's perception capabilities, are limited by the natural curvature of the Earth, at a range of approximately 400-600 km.[35] However, the ceiling at which the aircraft is flying, as well as the radar's location, can make a huge deal in the detection game. If the aircraft manages to stay below a certain high, it will be almost impossible to detect at certain ranges. The ratio of distance and altitude between the radar and aircraft makes it possible to pass through the *radar shadow*.[36] Researchers Antonio Calcara, Andrea Gilli, Mauro Gilli and Ivan Zaccagnini present the principles behind low-flight concealment excellently. Quoting the scholars' example «a ground-based radar will detect an aircraft flying at a 10 km altitude at more than 400 km in distance, but it will detect an aircraft flying at a 200m altitude at only 80 km in distance».[37] Flying at low altitudes, however, is considered at best as a short-term tactic, since it is effective only against ground-based radars. In fact, airborne radars like *AWACS*[38] given the high ceiling at which they are found to operate, can completely deny the concealment of low-altitude targets as a matter of fact. Because of this, the limits derived from the Earth's curvature that ground-based radars face vanish completely. Thus, it is quite clear how drones do not introduce any particular innovation that could pose new degrees of threat to existing air defense systems. As a consequence, they once again fall under the competition of fighter jets, from fourth-generation and forth, which face no particular challenges in flying close to the ground.[39] What could be identified as the most attractive and innovative element regarding drones, low-flight and airborne radars, is a possible solution to make *AWACS* systems autonomous in order to enhance general awareness. Critical or threatened areas can see the employment of *MALE* and *HALE UAVs* as a cheap and reliable solution for extended monitoring, surveillance and control purposes.[40] However, this would not make attacking any easier and could possibly result in the exact opposite effect, improving defensive awareness and capabilities rather than offensive ones. In conclusion, it is clear how low-flight radar concealment is not a drones' exclusive feature and because of that, the threat that this tactic brings to air defense systems is far from revolutionary. There is no evidence to categorize drones' low-flying as innovative, improved compared to other technologies, or capable of forcing foes into new defensive approaches. Indeed, air defenders are trained to locate and take-down targets way faster, deadlier and elusive than *MALE* or *HALE* drones such as, once again, fighter jets.

2.3 Slow Speed and Stealth - Are *HALE* and *MALE* drones' low speed capable of eluding, or at least shrinking, the range in which they can be detected? The statements presented by the literature tend to exaggerate the advantages of such tactics and, once again, do not consider how slow speed is not a drones' unique feature or a revolutionary solution. Moreover, slow speed carry some considerable vulnerabilities that significantly affect the degree of success and repetitiveness of such solution.

Most *MALE* and *HALE* drones lack turbofan engines and afterburners such as fighter jets.[41] Consequently, the speed at which they can travel is not comparable to those of most fighters and bombers.[42] In fact, adopting a lower cruising speed is a long-established solution for aircraft willing to lower their chances of being detected.[43] Radars, indeed, tend to filter out objects or vehicles that are unlikely to pose a threat, like stationary and slow-approaching targets. Stationary objects are not, by definition, perceived as threats because of their absent mobility. Low-speed targets are not significantly different and are regularly considered a minor threat.[44] In most cases, the radar return of such objects tends to be overlooked in order to avoid missing out on more impelling dangers, avoiding operator's and trackers' saturation by some targets of questionable priority. A swarm of attacking, low-flying drones can exploit this filtering to be perceived as a false alarm by radar operators, possibly lowering their chances of detection or postponing them. However, this technique has not been introduced by drones. Combat aircraft and even supersonic fighters have a *stalling speed*[45] of approximately 300 km/h,[46] which is pretty much identical to most *MALE* drone cruising speeds. If necessary, *MALE UCAVs*, can fly slightly below this speed but they still require a significant amount of thrust to avoid a crash down. Furthermore, slow speed is a simple strategy to overcome once the filtering processes are adjusted to search for slow-moving targets. Most of the rhetoric regarding the effectiveness of slow-pace flying against radar detection is based on standard filtering setups, which can be adjusted and improved with relative ease through enhanced data processing.[47] Overall, the idea of saturating radar perception with "false targets" is pretty far from actually happening, since the level of data processing and computational capabilities of modern systems allow for the detection and tracking of hundreds of targets independently from their speed.[48] Lastly, slow-pace flight shows great weaknesses against less-sophisticated air countermeasures such as artillery fire, *MANPADs*[49] and high-caliber ammunition. In fact, a swarm of low-flying attacking *UCAVs* is always under the threat of interception and could be wasted by an array of different anti-aircraft artilleries at any time while performing the attack mission. In conclusion, drones relying on slow flight are not likely to make this strategy more threatening for air defenders, given the absence of innovation behind it or the addition of some innovative technology in its execution.

3 Are drones really so revolutionary?

3.1 Drones level the field in favor of weaker actors - Because they are apparently cheap, easy to produce and effortless to employ, drones would grant to weaker actors the achievement of air warfare capabilities, allowing them to better face off against the air fleets of stronger and more industrialized countries. This would permit weaker militaries to gain access to the air domain, executing air strikes and air warfare missions possibly even outside their borders. The result would be a leveling effect between nation-states' and parastates' armies, promoting a global redistribution of power toward an offensive-dominant multipolar system. These statements, however, are not likely to find empirical confirmation in some of the recent conflicts that the world witnessed and, because of that, this paper provides evidences that support the skeptics' beliefs about the *Drones' Revolution Theory.*

The 2020 Azerbaijan-Armenian witnessed the employment of drones in both factions. However, going completely against the *Drones' Revolution Theory*, unmanned aircrafts systematically supported and favored the stronger faction, which in this case was Azerbaijan. In fact, Baku invested a growing amount of resources in its defense spending in the two years preceding the conflict, outspending by three times around the whole defense budget of Armenia.[50] Moreover, during the conflict, Azerbaijan received support from a powerful actor such as Turkey, which almost forced themselves into the conflict to run the drone campaign against the Armenians[51] causing different reactions by the international community. Not only was Armenia the weaker part of the conflict, but it did not receive any kind of support from external actors, worsening its under-dog status to a point where victory seemed practically impossible. Finding itself in the conditions that allegedly would have most favored the most a huge deployment of drones, «Armenia did not turn to drones to redress its numerical and qualitative inferiority».[52] The Nagorno-Karabakh conflict disproves as well another pillar of the drones' revolution literature: *UCAVs* are not cheap or effective in absolute terms. Indeed, Azerbaijan, with its immense defense spending compared to its opponent, was able to acquire a huge foreign-manufactured drones fleet, including some Turkish Bayraktar TB-2s and Israeli Hermes-900s,[53] while Armenia only had at its disposal some loitering munitions with a few Russian-made *UAVs* Orlan-100. Baku finances permitted the acquisition of better technologies and Armenians found themselves to operate on both numerically and technologically inferior platforms. Given the asymmetry of capabilities between the two factions, Armenia turned to ballistic missiles against Azerbaijan as a weapon of last resort, and not to drones, as the revolution-related thesis would have instead suggested.[54] This decision was made because it was no longer possible to sustain all the complex requirements demanded by drones for Armenians.

Another interesting insight is provided by the conflict between Russia and Ukraine, which began in 2022. Once again, different empirical circumstances seem to prove that the drone revolution hypothesis is incorrect for most aspects. Nonetheless, it is necessary to underline how unmanned aerial vehicles showed considerable results in dealing with Russian armored vehicles during the early stages of the war. Despite this these positive feedbacks, however, some crucial elements need to be addressed. The effectiveness of drones was more relevant at the beginning of the operation, when they were mostly limited to sabotage and convoy-hitting strikes.[55] Moreover, Kiev had to rely on foreign support because its own native unmanned air fleet would have been inadequate against the overwhelming forces of the Russian Federation.[56] TB2s lent from Turkish Bayraktar proved to be precious in slowing down the assault but, as military operations continued, Russian personnel shrunk their threat substantially, shooting down Istanbul's *UCAVs* with traditional anti-air systems[57] which proved to be perfectly capable of dealing with threats brought by unmanned vehicles. Moreover, the remarkable lacks of the Russian military's supply chain and an imprecise mission planning may have considerably fueled drones' lethality, especially in the short run.[58] Six months after the beginning of the war, it became clear how Russian mission planners had very different expectations than the ones they actually found themselves to face on the battlefield. With the appropriate adjustment being made, some quicker than others, the resistance's drones are currently no longer the menace they used to be during the first months of the military operation.[59] In conclusion, I argue that it would be wrong to consider drones as the key element in keeping Ukrainian resistance safe from defeat. Unmanned aircraft have not favored the weaker side enough to consider them the trump card of Kiev's armed forces: without the consistent and diversified Western support granted by some of the most powerful statal actors on the planet, Kiev would have stood poor chances of containing the aggression.

3.2 Drones make close combat obsolete - As stated in the introduction, some studies claim that *UCAVs* will make close infantry combat obsolete, changing forever strategies and protocols of traditional force employment. The world has witnessed conflicts where drones were employed extensively, but they did not even hint at taking over ground combat in terms of saliency and cruciality for war's outcomes. The assumption that an army composed of unmanned aerial vehicles would be preferable to a traditional one, at the state of the art, does not find any empirical confirmation.

Despite the employment of unmanned aerial vehicles by both the Libyan National Army (LNA) and the Government of National Accord (GNA), the Libyan Civil War did not witnessed the disappearance of close infantry combat. In fact, both fighting parts relied on foot solider units, in addition to traditional artillery and air power, to take control of crucial infrastructures such as airports, highways, and crossroads. To further prove the importance of ground-based soldiers, both the LNA and GNA hired mercenaries to defend strategic positions and execute mopping-up operations.[60] Once again, Turkey's establishment as the main supporter of the GNA was a crucial variable that further proved how combat skills and traditional force employment have not lost relevance in modern combat. Turkish specialists were in fact able to cut out LNA's air capabilities while allowing GNA's forces to counterattack and put an end to the bloody siege of Tripoli. Istanbul's crucial intervention was not granted by drones only, but instead by a mix of numerous assets such as artillery and radar systems merged with a general organizational as well as infrastructural support. Drones alone would not have been able to turn the tide of Tripoli's siege.[61]

Similarly, the long-lasting Syrian Civil War provides some prominent considerations that contribute to disproving any assumption about drones taking over the traditional infantry. During the conflict, *UCAVs* were deployed extensively by the fighting factions, with researchers describing the event as «the most drone-dense conflict to date».[62] In fact, the drones' models employed in conflict were not only strictly related to the military dimension, but also included commercial, hobbyist and even homemade units. Despite of their supposed low costs, high effectiveness, and numerical plenty, it is then to wonder why the Syrian armed forces, along with their Iranian and Russian supporters, opted to rely heavily on standoff fires through artillery, attack helicopters, and air-to-ground bombers, which are consistently more expensive alternatives than *UCAVs*.[63] Nonetheless, it is fundamental to underline how the limited experience, and relatively poor skills, of Syrian military personnel in operating air-defense systems may have played a crucial role in favoring the strikes effectiveness rates of drones. Owing to different operative shortfalls and training leaks, Syrians committed on different occasions the deadly mistake of exposing their position to enemy fire, which seems to be the most rational cause to explain the initial success of drones in destroying Russian-manufactured long-range anti-air systems.[64] However, the Syrian Government's adversaries proved to be remarkably more proficient in suppressing air-defenses. As a matter of fact, combat experience and on-ground operators can still make a significant difference in what will be the conflict's final outcome. At the same time, *UCAVs* do not provide a comparable decisive impacts on battlefields. Moreover, personnel capabilities and a skilled workforce are not likely to become less relevant in the upcoming years, and are even less likely to be replaced by drone employment whatsoever.

4. Conclusions

The analysis proposed in this study has proven to go against some of the literature's sources about drones and their role in conflicts. Indeed, there are three conclusions that need to be pointed out, which eventually lead to the rational expectation of drones not being able to modify in any relevant manner the global distribution of power among statal and parastatal actors. This study complies with the more skeptical views of unmanned aircraft's literature, sustaining that unmanned aircrafts are just not revolutionary enough themselves to twist decades-long air warfare protocols, doctrines and principles.

The first one concerns *UCAVs* and their impact on the offense-defense balance (*ODB*). The predisposition of the *ODB* towards offense or defense is a coherent value to understand the possible effects of the distribution of power on a world-scale dimension. In brief, considering the previously quoted cases, there are no reasons to fear unmanned technologies impacting the current worldwide *ODB*, creating new conditions favoring attack rather than defense.[65] The technology-saturated environment of the current military domain, merged with the deterrence provided by the Great Powers through nuclear warheads,[66] is far from being twisted to the core by the mere employment of unmanned aircrafts. However, some of the traditional literature related to *ODB*,[67] as well as some of the principles belonging to the offense and defense tradition,[68] are starting to feel dated and no longer suitable for the contemporary distribution of power. In fact, most sources present their observations without paying enough attention to the capabilities of emerging technologies and how older ones actually work in the current environment. Most of the considerations regarding the relationship between *OBD* and new technologies, for example, seem to be better supported by land warfare doctrines and principles,[69] while the challenges and requirements typical of different environments, such as the sea or the third dimension, seem to have been mostly left out.[70] Radar, for instance, is a much older technology compared to *UCAVs*, so the literature would expect its role to be undermined by the uprising of newer ones. However, when we look at its benefits in terms of cost and monitored area, it is possible to understand why it is still an indispensable protagonist of states' defensive capabilities. Perhaps, a more diversified perspective, which considers engineering and empirical case studies, should be preferred to overcome some sources' limits. The growing complexity of contemporary battle scenarios, as well as the military technologies employed in them, calls for an interdisciplinary and ramified approach, which should enable researchers to better understand the numerous key facets typical of contemporary battlefields. This vision goes in accordance with other researchers that have already explored the topic of *UCAVs*, like Antonio Calcara, Andrea Gilli, Mauro Gilli and Ivan Zaccagnini.

Second, dealing with the definition of "revolutionary" is quite a puzzling challenge. Indeed, as this paper shows, combat drones are not agents of revolution. In fact, the basic principle of air warfare has remained the same: «adopting a set of technologies, techniques, and strategies to avoid exposure to enemy fire as much as possible, while strongly punishing those who cannot do so».[71] *UCAVs*' capability of not exposing the aircrew to direct danger, despite being a potential step ahead towards a possible new typology of warfare, cannot be considered a revolutionary feature *in-se* for air combat, force employment or ODB principles. As the previous study cases demonstrated, *UCAVs* role is conflicts' final outcomes is minimal, appearing less incisive in the long run than more traditional military assets.

Nonetheless, their impact in the early stages of the conflict can be quite remarkable in battlefields that reward at best surveillance and remote-strikes features.

Third, the supposed leveling effect in favor of weaker actors is something that has probably been misunderstood. The idea of non-statal or parastatal actors acquiring new degrees of military power through drone air fleets is very far from factually occurring and should not be considered an impelling menace for the international community. First, drones are not cheap. A single *UCAV* unit costs millions of US dollars, depending on the model and manufacturer.[72] As the high price tag was not enough, it is crucial to consider the overall indispensable assets that a drone needs to operate, which is not only economically demanding, but extremely difficult to acquire in a pragmatic sense. The capillary distribution of command centers, radio communication stations and maintenance facilities requires a series of industrial resources that, while being unachievable by parastatal actors like rebel groups, are still challenging to acquire even for statal, less powerful, ones as well. The aircrew that operates drones must go through years of training, something that only formidable and well-structured militaries, with skilled personnel and huge budgets, can provide with consistency.[73] Moreover, *MALE* and *HALE* drones difficult to build. The absorptive capabilities, knowledge, know-how and distinct components necessary for assembling a *UCAV* are so specific that the whole process has proven to be challenging for almost any kind of user, as the various development projects shattered all around the globe demonstrate. Reverse engineering is extremely challenging to execute even for industrialized actors, given the specific requirements and interdisciplinary organizational knowledge indispensable for the construction of unmanned aircraft.[74] Moreover, direct experience, as in every technology-related field,[75] is only going to increasingly essential as development progresses,[76] augmenting the gap between already-using and non-users actors. Therefore, just as it is happening nowadays, it would be wise to expect only already powerful actors to be able to assemble, deploy and maintain operative fleets of unmanned aircrafts in the future.[77]

These complex entry barriers are very likely to exclude less powerful and industrialized actors from the competition for unmanned aircrafts in the long run. Consequently, the global distribution of power is unlikely to be shaken up to the core, with powerful actors maintaining their capabilities (if not even improving them) and less powerful ones trying to keep up the pace to fill the gap. International stability will hold excellent chances to maintain the *status quo* despite of drones' process of implementation in militaries. It is crucial to understand that technology alone is not enough to explain victories and losses on the battlefield. A newly developed technology is nothing, if not properly matched with adequate personnel, strategies, and intelligence gathering;[78] drones do not bring any exception to such already-established procedures.

In conclusion, the international community should not be too afraid of drones' implementation into national armed forces, and the global power scale between actors is not likely to be put into discussion by mere *UCAVs* employment, if the principles behind warfare manage to remain the same. However, drones present some interesting characteristics that are will give them even more saliency in the upcoming years. Probably, the most considerable inner potential for unmanned aircraft is related to surveillance purposes, given the fact that this kind of mission seems to grasp the most benefits from drones' intrinsic nature, consisting of an overall upstanding fuel efficiency, extended autonomy and range.

NOTE

[1] The literature is wide and basically divided between drones' revolution theory supporters and more skeptical researchers. For a wider picture, see: Bergen P., Rothenberg D., *Drone Wars: Transforming Conflict, Law, and Policy*, Cambridge University Press, Cambridge, 2014; Boyle M, *The Drone Age: How Drone Technology Will Change War and Peace*, Oxford University Press, Oxford, 2020; Calcara A., Gilli A., Gilli M., Zaccagnini I., *The Drone Revolution in Military Affairs? Understanding the Hider-Finder Competition in Air Warfare*, International Security Vol. XLVI, Issue 4, [s.l.], 2022.

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[8] Cavallaro J., *Living Under Drones: Death, Injury and Trauma to Civilians from US Drone Practices in Pakistan*, International Human Rights and Conflict Resolution Clinic, Stanford Law School, New York University School of Law, Global Justice Clinic, New York, 2012, pp. 140–41, https://law.stanford.edu/publications/living-under-drones-death-injury-and-trauma-to-civilians-from-us-drone-practices-in-pakistan/; Boyle M., *The Drone Age: How Drone Technology Will Change War and Peace*, Oxford University Press, Oxford, 2020, pp. 152-167; Parachini J. and Wilson P., *Drone-Era Warfare Shows the Operational Limits of Air Defense Systems*, Real Clear Defense, [s.l.] 2020, https://www.rand.org/blog/2020/07/drone-era-warfare-shows-the-operational-limits-of-air.html.

[9] Hayward K., *Unmanned Aerial Vehicles: A New Industrial System*, Royal Aeronautical Society, London, 2013, pp. 10-35.

[10] Mumford A., Proxy Warfare and the Future of Conflict, RUSI Journal, Vol. CLVIII, No. 2, [s.l.], 2013, p. 43, https://doi.org/10.1080/03071847.2013.787733; Ian G.R., *Shaw, Robot Wars: US Empire and Geopolitics in the Robotic Age*, Security Dialogue, Vol. 48, No. 5, University of Glasgow, 2017, p. 458, https://doi.org/10.1177/0967010617713157.

[11] Bergen P., Rothenberg D., *Drone Wars: Transforming Conflict, Law, and Policy*, Cambridge University Press, Cambridge, 2014; Boyle M, *The Drone Age: How Drone Technology Will Change War and Peace*, Oxford University Press, Oxford, 2020.

[12] *Drones' Revolution Theory* refers to the whole side of the scientific community supporting the revolutionizing impact of drones' technology in military affairs, politics, global security and international law. Their views are set against the skeptical researchers, like Andrea Gilli and Mauro Gilli.

[13] Calcara A., Gilli A., Gilli M., Zaccagnini I., *The Drone Revolution in Military Affairs? Understanding the Hider-Finder Competition in Air Warfare*, International Security Vol. XLVI, Issue 4, [s.l.], 2022.

[14] The following measures are given by the constructors. Bayraktar TB2 measures 6.5 m in length with a wingspan of 12m; the MQ-9A Reaper has a length of 11m and a wingspan of 20m, the F-16 and F-18 fighters are respectively 15m

and 17m long with wingspans of 9.5m and 11.5m. The Predator C is 13m long with a wingspan of 20m. For full measures see the respective constructors' websites: https://www.lockheedmartin.com/en-us/products/f-16.html;https://www.boeing.com/history/products/fa-18-hornet.page;
https://www.baykartech.com/en/uav/bayraktar-tb2/;
https://www.ga-asi.com/remotely-piloted-aircraft/mq-9a.
https://www.ga-asi.com/remotely-piloted-aircraft/predator-c-avenger.

[15] *RCS* stands for *Radar Cross Section*. It is «the sum of the major reflective components of the aircraft's shape [...] (RCS) determines the amount of the sending radar's power that is reflected back for the sender to receive». It is generally measured in square meters. See: Grant R., *The Radar Game*, Mitchell Institute, [s.l.], 2010, p. 31.

[16] Maj. Gen. Barrett M. and Col. Carpenter M., *Survivability in the Digital Age: The Imperative For Stealth*, Mitchell Institute, Arlington, 2017, p.13.

[17] A stealth vehicle is not "invisible" in absolute terms, it just means that it is way harder to detect: indeed, it can achieve an extremely close proximity to its target before it even gets noticed. For stealth and tactics, see: Maj. Gen. Barrett M. and Col. Carpenter M., *Survivability in the Digital Age: The Imperative For Stealth*, Mitchell Institute, Arlington, 2017, pp. 7-10.

[18] Indeed, aircraft's size is not present in the Radar Equation. Instead, transmit power, antenna gain, wavelength and receive power are taken into account. For a deeper understanding of the equation, see:
https://www.mathworks.com/help/radar/ug/radar-equation.html.

[19] Kingsley S., Quegan S., *Understanding Radar Systems*, IET, [s.l.], 1999, p. 33.

[20] Also radar absorbing materials, which turn radar illumination energy into heat, play a relevant role. However, experts identify aircraft shape as the most important feature, with engine inlets as a close second. See: Shaeffer J., *Understanding Stealth*, Marietta Scientific, Marietta, 2018, pp. 7-9; Grant R., *The Radar Game*, Mitchell Institute, [s.l.], 2010, pp. 31-36.

[21] Kingsley S., Quegan S., *Understanding Radar Systems*, IET, [s.l.], 1999, p. 33.

[22] Shaeffer J., *Understanding Stealth*, Marietta Scientific, Marietta, 2018, p.1.

[23] Stealth aircrafts were designed to provide better survivability chances to air forces, sustaining more costs during development and assembling in order to reduce losses' costs. Stealth shows cost reduction only in the long run and for missions' package composition. Considering a stealth aircraft as expendable would be an illogical conclusion. See: Shaeffer J., *Understanding Stealth*, Marietta Scientific, Marietta, 2018, p. 12.

[24] Rich B., Janos L., *Skunk Works*, Little, Brown and Company, Los Angeles, 1994, pp. 154-156.

[25] Reverse engineering has never been so challenging given the highly specific requirements of modern military technology. However, directly laying hands on the remains of an enemy's highly advanced aircraft could provide different solutions to contain and take-down that same technology. See: Gilli A., Gilli M., *Why China has not caught up yet: military-technological superiority and the limits*

of imitation, reverse engineering, and cyber espionage, International Security Vol. XLIII, MIT Press, [s.l.], 2018; Borger J., *Race to salvage US F-35C fighter jet that crashed in hostile South Chinese Sea*, The Guardian, Washington D.C., 2022, theguardian.com/world/2022/jan/28/f-35c-crash-leaves-us-fighter-jet-sunken-in-hostile-south-china-sea.

[26] The benefits of equipping precision weapons and jamming capabilities with stealth are astonishing. See the graph of John Shaeffer for a better understanding: Shaeffer J., *Understanding Stealth*, Marietta Scientific, Marietta, 2018, p. 13, figure 19.

[27] In order to explore the general capabilities of fifth-generation stealth fighter jets, see: Lorell M. and Laveaux H., *The Cutting Edge*, Rand, Santa Monica, 1998; Baker D., *Fifth Generation Fighters*, Mortons Media Group, Horncastle, 2021.

[28] A2/AD is a strategy that aims to deny a foe's freedom of movement. With time, however, the term evolved and nowadays it identifies the overall systems and technologies utilized to achieve that same purpose in contemporary warfare. See: Lesti S., *A2/AD Bubble in Russia*, G.E.O Difesa, [s.l.], 2021, pp. 5-50 https://mondointernazionale.org/documenti_associazione/a2-ad-bubble-in-russia-a2-ad-nella-strategia-russa-kaliningrad-bubble-sistemi-missilistici-impiegati-electronic-warfare/PAPER-A2AD.pdf; Russell, Lawlor A., *Strategic anti-access/area denial in cyberspace*, 7th International Conference on Cyber Conflict: Architectures in Cyberspace, IEEE, Estonia, 2015, pp. 153-168.

[29] The *Kill-Chain Procedure* is a military concept which indicates the different phases of attrition between attackers and defenders in different environments. The procedure is divided in the following steps, strictly interdependent among each other's: detection, engagement and probability of kill. See: Grant R., *The Radar Game*, Mitchell Institute, [s.l.], 2010, pp. 10-15.

[30] Biddle S., Oelrich I., *Future warfare in the Western Pacific: Chinese antiaccess/area denial, US airsea battle, and command of the commons in East Asia*, International Security Vol. XLI, MIT Press, [s.l.], 2016, pp. 41-48.

[31] Synonym for "flying under radar"; *Electronic Warfare Fundamentals*, Nellis Air Force Base, 2000, pp.1.6-1.10.

[32] Michel M. III, *Clashes: Air Combat over North Vietnam 1965-1972*, Naval Institute Press, Annapolis, 1997, p. 100-101; Carlson M., *Operation Spring High: Thuds vs. SAMs*, Historynet, [s.l.], 2019, historynet.com/operation-spring-high-thuds-vs-sams/.

[33] Dan M., *Fundamentals of Electronic Warfare*, Microwave Journal 44.9, [s.l.], 2001.

[34] Calcara A., Gilli A., Gilli M. and Zaccagnini I., *Will the Drone Always Get Through? Offensive Myths and Defensive Realities*, Security Studies Vol. XXXI, NO.5, [s.l.], 2022, p. 808.

[35] Biddle S., Oelrich I., *Future Warfare in the Western Pacific: Chinese antiaccess/area denial, US airsea battle, and command of the commons in East Asia*, International Security Vol. XLI, MIT Press, Cambridge MA, 2016, p. 13.

[36] Radar shadow is a term that identifies a specific zone where radar waves cannot reach approaching objects. See: Congressional Budget Office, *B-1B*

Bomber and Options for Enhancements, U.S. Government Printing Office, Washington D.C., 1988, pp. 89-90.

[37] Calcara A., Gilli A., Gilli M., Zaccagnini I., *Will the Drone Always Get Through? Offensive Myths and Defensive Realities*, Security Studies Vol. XXXI, NO. 5, [s.l.], 2022, p. 808.

[38] AWACS stands for Airborne Warning And Control System. It consists of an aero-transported radar system which can exponentially improve battle awareness. See: Clark D., *Early Advances in Radar Technology for Aircraft Detection*, Lincoln Laboratory Journal 12, NO. 2, [s.l.], 2000, pp. 80-167;

https://www.nato.int/cps/en/natohq/declassified_137124.htm.

[39] *Fly-by-wire* technology, as well as other improvements in maneuverability and control, allow fighter jets to fly incredibly close to the ground. As software technology and avionics become more and more advanced, low-flying is nowadays less challenging than it has ever been.

[40] Mahnken T., Sharp T., and Kim G., *Deterrence by Detection: A Key Role for Unmanned Aircraft Systems in Great Power Competition*, Washington, DC: CSBA, Washington D.C., 2020, pp. 15-30.

[41] Many UCAVs feature engines that allow for improved autonomy through power-fuel efficiency rather than average or top speed. The MQ-9A Reaper relies on a turboprop engine and the Bayraktar TB2 mounts an injection engine. The Kizilelma, being quite of an exception, seems to be powered by a jet-like turbofan engine. However, due to its testing phase, no official information is available directly from Bayraktar. For full details about engines, see respective constructors' websites: https://www.ga-asi.com/remotely-piloted-aircraft/mq-9a;

https://www-baykartech-com.translate.goog/en/uav/bayraktar-tb2/?_x_tr_sl=en&_x_tr_tl=it&_x_tr_hl=it&_x_tr_pto=sc;

https://www-baykartech-com.translate.goog/en/uav/bayraktar-kizilelma/?_x_tr_sl=en&_x_tr_tl=it&_x_tr_hl=it&_x_tr_pto=sc.

[42] For example, the Reaper has a top speed of 450 km/h while the F-35, with a top speed of 1900 km/h, is not even one of the fastest among 5th generation fighters due to its single engine. The B-2 bomber can reach a top speed of 1000 km/h circa.

[43] Stimson G., *Introduction to Airborne Radar*, 2nd edition, Scitech Publishing Inc., Mendham, 1998, pp. 317-322.

[44] Shrader, William W., Gregers-Hansen V., "MTI radar.", *Radar Handbook*, McGraw-Hill Companies, Cambridge MA, 1970, pp. 1-22.

[45] It is the lowest speed at which an aircraft can sustain flight.

[46] Jacques, D. R., & Strouble, D. D. (2010), *A-10 Thunderbolt II (Warthog) systems engineering case study*, Air Force Center for Systems Engineering, Wright-Patterson, 2010, p.11, 18 and 32; Harris, J. J., *F-35 flight control law design, development and verification*, Aviation Technology, Integration, and Operations Conference, Fort Worth, 2018, p. 3516.

[47] Stimson G., *Introduction to Airborne Radar*, 2nd edition, Scitech Publishing Inc., Mendham, 1998, pp. 281-317.

[48] Stillion J., Orletsky D., *Airbase vulnerability to conventional cruise-missile and ballistic-missile attacks*, Rand Corporation, Santa Monica, 1999, pp. 5-15 and 30-46.

[49] *MANPAD* stands for Man-Portable-Air-Defense-Systems. With an average weight of about 18 kilos, they can be carried by infantry and, because of that, they are extremely hard to locate for air attackers. *MANPADs* are a real threat for any kind of aircraft, including the most advanced ones, manned or unmanned.

[50] SIPRI, Sipri Military Expenditure Database, sipri.org.

[51] Hayrapetyan T., *How Ilham 'Personalizes' the Results of the 2020 Artsakh War*, ENV Report, [s.l.], 2021, evnreport.com/politics/how-ilham-aliyev-personalizes-the-results-of-the-2020-artsakh-war/.

[52] Calcara A., Gilli A., Gilli, M. Marchetti R., Zaccagnini I., *The Drone Revolution in Military Affairs? Understanding the Hider-Finder Competition in Air Warfare*, International Security Volume XLVI, Issue 4, MIT Press, Cambridge MA, 2022, p. 25.

[53] Bekdil B., "Azerbaijan to Buy Armed Drones from Turkey", Defense News, Ankara, 2020, defensenews.com/unmanned/2020/06/25/azerbaijan-to-buy-armed-drones-from-turkey/.

[54] Shaikh, Rumbaugh, *The Air Missile War in Nagorno-Karabakh*, [s.l.], 2021, pp. 1-16.

[55] Milinua, *Magyla UAV helped Ukrainian Armed Forces to destroy Russian Convoy*, [s.l.], 2022, https://mil.in.ua/en/news/magyla-uav-helped-ukranian-armed-forces-to-destroy-russians-convoy/; Borgrer J., *The drone operators who halted Russian convoy headed for Kiev*, The Guardian, [s.l.], 2022 https://www.theguardian.com/world/2022/mar/28/the-drone-operators-who-halted-the-russian-armoured-vehicles-heading-for-kyiv.

[56] Ukraine started to develop its own domestic drones fleet in 2014 as a part of the modernization process that its national army went under due to Crimea annexation by Russia. See: Lowther A., Mahbube K. Siddiki, *Combat Drones in Ukraine*, Air & Space Operation Review, Air University, [s.l.], 2022, p.5; John Wendle, *The Fighting Drones of Ukraine*, Air & Space Magazine, [s.l.], 2018, https://www.smithsonianmag.com/air-space-magazine/ukraines-drones-180967708/.

[57] Ukrainians have struck some military bases and even the Moskva warship. Nonetheless, such attacks cannot be considered enough to alter the balance of the parts involved in the conflict. Moreover, Western intelligence may have been essential for the outcomes. See: Dilanian K., Kube C., Lee C., *U.S. intel helped Ukraine sink Russian flagship Moskva, official says*, NBC News, [s.l.], 2022, https://www.nbcnews.com/politics/national-security/us-intel-helped-ukraine-sink-russian-flagship-moskva-officials-say-rcna27559.

[58] Witt S., *The Turkish Drone That Changed The Nature of Warfare*, The New Yorker, New York, 2022, newyorker.com/magazine/2022/05/16/the-turkish-drone-that-changed-the-nature-of-warfare/.

[59] Yousif E., *Drone Warfare in Ukraine: Understanding the Landscape*, Conventional Arms, Stimnson, [s.l.], 2022, stimson.org/2022/drone-warfare-in-ukraine-understanding-the-landscape/.

[60] Pack L., Pusztai W., *Turning the Tide: How Turkey Won the War in Tripoli*, Middle East Institute, Washington D.C., 2020, pp. 8-15.

[61] Itamildar, *Turkish 'Hawk' Deployed in Tripoli*, [s.l.], 2020, itamilradar.com/2020/01/18/turkish-hawk- deployed-in-tripoli/.

[62] Gettinger D., *Drones Operating in Syria and Iraq*, Center for the study of the Drone, Bard College, Annandale-On-Hudson, 2016, pp. 14-15.

[63] Schield R., *Russian AirPower's Success in Syria: Assessing Evolution in Kinetic Counterinsurgencies*, Journal of Slavic and Military Studies, Vol. XXXI, No. 2, [s.l.], 2018, pp. 214-239; Thomas T., *Russian Lessons Learned in Syria: An Assessment*, MITRE, [s.l.], 2020, pp. 7-25.

[64] Parachini J., Wilson P., *Drone-Era Warfare Shows the Operational Limits of Air Defense Systems*, RAND Corporation, [s.l.], 2020 rand.org/blog/2020/07/drone-era-warfare-shows-the-operational-limits-of-air.html.

[65] Calcara A., Gilli A., Gilli M., Marchetti R., Zaccagnini I., *The Drone Revolution in Military Affairs? Understanding the Hider-Finder Competition in Air Warfare*, International Security Volume XLVI, Issue 4, MIT Press, Cambridge MA, 2022, p. 28.

[66] Van Evera describes modern balance to be strictly related to the dominant status of Great Powers (USA, China, Russia, France, UK). Indeed, given the deterrence provided by nuclear warheads, conquering a Great Power would in fact be almost impossible; this limit is actually what shapes the world's distribution of power. See: Van Evera S., *Offense, Defense, and the Causes of War*, International Security, Vol. XXII NO. 4, Cambridge MA, 1998, pp. 17, 24 and 33.

[67] For the core literature about offense-defense theory, see: Jervis R., *Cooperation under the Security Dilemma*, World Politics, Vol. XXX, NO. 2, [s.l.], 1978, pp. 167-214; George H. Quester, *Offense and Defense in the International System*, John Wiley and Sons, Hoboken, 1977, pp. 301-302; Van Evera S., *Causes of War: Power and the Roots of Conflict*, N.Y.: Cornell University Press, Ithaca NY, 1999, chap. 6.

[68] Biddle S., *Military Power*, Princeton University Press, Princeton NJ, 2006, pp. 3-28, 150-180.

[69] *Ibis*., pp. 72-73.

[70] Jervis R., *Cooperation under the Security Dilemma*, World Politics, Vol. XXX, NO. 2, [s.l.], 1978, pp. 167-214; George H. Quester, *Offense and Defense in the International System*, John Wiley and Sons, Hoboken, 1977.

[71] Brungess J., *Setting the Context: Suppression of Enemy Air Defenses and Joint War Fighting in an Uncertain World*, Maxwell AFB: Air University Press, Maxwell Air Force Base, 1994, pp. 207-219; John A. Tirpak, *Dealing with Air Defense*, Air Force Magazine, Alrington, 1999, pp. 25-29, https://www.airforcemag.com/PDF/MagazineArchive/Documents/1999/November%201999/1199airdefense.pdf; Kopp C., *Evolving Technological Strategy in Advanced Air Defense Systems*, Joint Force Quarterly NO. 57, Washington D.C., 2010, pp. 86-93.

[72] Bayraktar TB2's supposed cost is around 5 million US dollars per unit; the MQ-9 Reaper allegedly costs between 14 and 35 million dollars per unit. Such

costs are indeed sustainable only for the wealthiest nations. See: https://engineerine.com/mq-9-reaper-vs-bayraktar-tb-2/.

[73] Roberts, Eric, and Beck A., *Management and training programs of military drone small unmanned aircraft systems*, Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Vol. LXI, NO. 1, SAGE Publications, Thousand Oaks, 2017, pp. 1131-1135.

[74] Gilli A., Gilli M., *Why China has not caught up yet: military-technological superiority and the limits of imitation, reverse engineering, and cyber espionage*, International Security Vol. XLIII, NO. 3, [s.l.], 2019, pp. 141-189.

[75] *Ibis*.

[76] Rich B., Janos L., *Skunk Works*, Little, Brown and Company, Los Angeles, 1994, pp. 167-168.

[77] Joshi S., Stein A., *Emerging Drone Nations*, Survival, Vol. 55, NO. 5, [s.l.], 2013, pp. 53-78, https://doi.org/10.1080/00396338.2013.841805; Austin Long, *Dueling Asymmetries: International Terrorism, Insurgency and Drone Warfare in the 21st Century*, The Future of War, Emirates Center for Strategic Studies and Research, Abu Dhabi, 2015, pp.13-36; Gilli A., Gilli M., *The Diffusion of Drone Warfare? Industrial, Organizational and Infrastructural Constraints*, Security Studies Vol. XXV NO. 1, [s.l.l], 2016, pp. 50-84.

[78] Biddle S., *Victory Misunderstood: What the Gulf War Tells Us about the Future of Conflicts*, International Security, Vol. XXI NO. 2, MIT Press, Cambridge MA, 1996, pp. 157-172.

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