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**Why Drones *Have* Revolutionized Warfare:
Drone Quasi-maneuver Attributes in the
Offense-Defense Balance (Journal Article)**

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Why Drones *Have* Revolutionized Warfare: Drone Quasi-maneuver Attributes in the Offense-Defense Balance¹

Since 2019, military forces have conducted drone operations in such diverse places as Libya, Syria, Nagorno-Karabakh, Ethiopia, and Ukraine. Countless papers have attempted to explain these operations. These papers tend to fall into two camps: some declare the revolutionary aspects of drone operations, while others claim that drones fit neatly into established patterns of warfare.² Indeed, vignettes taken from the above conflicts—and others—are used to justify either view.

In one notable paper appearing in this journal, entitled “Why Drones Have Not Revolutionized War,” Antonio Calcara et al. argue that drones as aircraft have not revolutionized warfare. Rather, the authors claim that drones are merely an extension of the “hider-finder competition between air defense and air penetration...part of the evolution of air warfare, whose fundamental principle remains to avoid exposure to enemy fire.”³ Noting the prominent modern role drones have played in air penetration of defenses,

¹ I would like to thank David A. Engel, Alec C. Wahlman, Brian Q. Rieksts, and Russell Jones, for their review of earlier versions of this paper. All reviewers provided valuable comments. Any errors and omissions are my own.

² For a revolutionary view of drone operations see Stephen Bryen, “Armed Drones Revolutionizing the Future of War,” *Asia Times*, December 9, 2020, <https://asiatimes.com/2020/12/armed-drones-revolutionizing-the-future-of-war/>; and Michael J. Boyle, *The Drone Age: How Drone Technology Will Change War and Peace* (New York, NY: Oxford University Press, 2020). For a status quo view for drone operations see Heiko Borchert, Torben Schütz, and Joseph Verbovszky, *Beware the Hype What Military Conflicts in Ukraine, Syria, Libya, and Nagorno-Karabakh (Don't) Tell Us About the Future of War*, (Hamburg, Germany: Helmut Schmidt University, 2021), <https://doi.org/10.13140/RG.2.2.10456.62723>.

³ Antonio Calcara, Andrea Gilli, Mauro Gilli, Raffaele Marchetti, and Ivan Zaccagnini, “Why Drones Have Not Revolutionized War: The Enduring Hider-Finder Competition in Air Warfare,” *International Security* 46, no. 4 (Spring 2022): 133, https://doi.org/10.1162/isec_a_00431.

the authors examine three conflicts in detail, finding that drones are vulnerable to countermeasures and do not fulfill (what the authors consider to be) the three main claims of drone enthusiasts—namely, that (1) drones provide an advantage to the offense, (2) drones will strengthen the militarily weaker side, and (3) drones make close ground combat obsolete.⁴

PREMISES AND METHOD OF INVESTIGATION

This paper has two premises. The first is drones have quasi-maneuver aspects that extend the maneuver space. Quasi-maneuver means that certain drone *effects* are similar—but lower in magnitude—to those of ground maneuver forces.⁵ We will develop the concept of quasi-maneuver more fully later in the paper. The second premise is drones have advantages when employed against an attacking opponent that—under certain conditions—could result in a stalemate, whereby neither side can conduct substantive offensive operations. We found that drones are transformational when they result in a stalemate, and this outcome can revolutionize warfare. Significantly, we qualify our claim by writing *can* because future outcomes can never be certain. Nevertheless, no matter the outcome of conflicts and despite drone warfare’s infancy, recent conflicts show definite trends in how drones are changing the dynamics of the modern battlefield.

This paper distinguishes its relevancy by using *data of drone strikes* to support its premises and analysis of recent conflicts. This data-driven approach over multiple conflicts is rare in the literature. Many papers cite data that are based on press reports concerning only one or a few conflicts, which is statistically problematic. Press reports often vary

⁴ Calcara, Gilli, Gilli, Marchetti, and Zaccagnini, “Why Drones Have Not Revolutionized War,” 147.

⁵ This paper defines the prefix “quasi” as “in some sense or degree” Merriam Webster online dictionary, <https://www.merriam-webster.com/dictionary/quasi>.

widely, as the victor is incentivized to exaggerate successes while the loser has an incentive to minimize losses. By contrast, our drone data are confirmed by photographic evidence, which places our claims on a firmer basis.

This paper's premises and conclusion diverge from those of both Calcara et al. and the drone enthusiasts. We do not dispute Calcara's well-reasoned findings except for the main one: that drone operations are not transformational.

BIDDLE'S MODERN SYSTEM AND MEASURING TRANSFORMATION

Our paper measures transformation the same way as Calcara's paper does: using Stephen Biddle's modern system of force employment (henceforth referred to as the modern-system).⁶ The modern-system, in brief, is a system of offensive and defensive principles that had their origin in the First World War (WWI). Modern-system principles emphasize small-unit, independent maneuver to avail of protection afforded by terrain and employ combined arms, in order to generate necessary capabilities. These tactics facilitate the deployment of large reserves that either exploit a breach in a defense or outright defeat an attacking force. Notably, Biddle limits modern-system principles to cases of mid-to-high-intensity ground warfare.

Using the case study method, Biddle argues that employment of modern-system principles, rather than superior technology or even numerical superiority, is the best predictor of victory in modern battle.⁷ His claim contrasts with the widespread notion

⁶ Stephen Biddle's modern-system of force employment is described and supported in Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, N.J.: Princeton University Press, 2004).

⁷ Biddle, *Military Power*, 14–27, 30–35.

during the 1990s that there was an ongoing revolution in military affairs (RMA)—the proponents of whom cited the primacy of technological innovation.

Modern-system concepts find expression in offensive tactics and operations. “Key modern-system *offensive tactics* are cover, concealment, dispersion, small-unit independent maneuver and suppression and combined arms integration.”⁸ These elements work together, allowing small units to advance using the protection of terrain and (when unprotected) indirect fires to “keep defenders’ heads down.”⁹ These attacks are concentrated on a relatively small defensive area, requiring “mutual coordination” among units and independent maneuver to identify and exploit weakly defended enemy flanks. The main objective of *offensive operations* is to break through the defense, enabling an exploitation. Large exploitation forces proceed rapidly through the breach to attack and neutralize reserves and command, control, and communications nodes, with the ultimate goal of unhinging the defense.¹⁰

Likewise, modern-system concepts find expression in defensive tactics and operations. Key *defensive tactics* are the same as those of the offense. These elements employ a mobile defense, using the same measures as the attack, but while giving up ground. The main goal of *defensive operations* is to bide time so defenders can employ large reserves to counterattack advancing forces.¹¹

⁸ Biddle, *Military Power*, 35.

⁹ Biddle, *Military Power*, 37.

¹⁰ Offensive operations explained in Biddle, *Military Power*, 42 (quote) and 39–44.

¹¹ Defensive tactics and operations explained in Biddle, *Military Power*, 44–48.

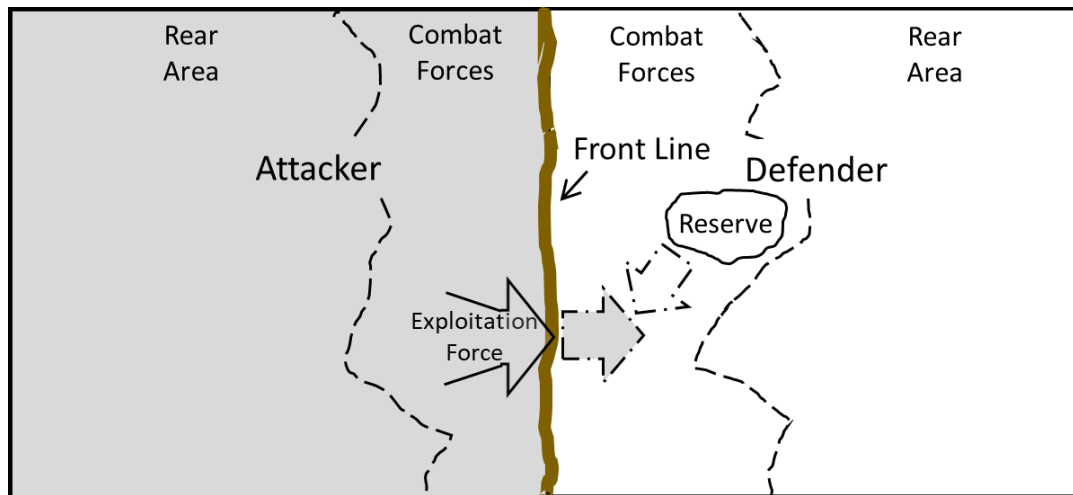


Figure 1. Modern-System Concepts for Offense and Defense (No Drones)

Figure 1 depicts Biddle's operational principles on a stylized battlefield where neither side employs drones. The attacker occupies the shaded area, while the defender occupies the white area. The majority of each side's combat forces can be found on either side of the front line. Further from the front line, a dashed line delineates the beginning of the rear area, where most forces are noncombat (e.g., logistics, communications, command and control). Using modern-system principles, the attacker concentrates forces on a narrow front to breach opposing defenses (shaded solid arrow). To unhinge the defense, the attacker intends to continue the attack into the opponent's rear area (shaded dashed arrow). The defense, also employing modern-system principles, intends to initially give up terrain and then employ reserve combat forces to stop the attack (white dashed arrow).

Modern-system elements are found in pre-WWI forms of warfare, but they have been integrated into modern warfare in ways that could not have been foreseen more than a hundred years ago. Although the modern-system's longevity sets a high standard for claiming that something is transformational, this paper will argue that drone quasi-maneuver aspects that result in stalemates do meet this standard.

Calcara et al. also rely on the modern-system to derive their “hider-finder” framework (of avoiding exposure to enemy fire). However, unlike the Calcara paper, which develops a derivative form of the modern-system, our analysis uses its main tenets as our yardstick.

DEFINITIONS

This paper claims that drones have “quasi-maneuver” aspects. We are not saying that the drone platform is similar to the ground maneuver platform: the differences between the two platforms are readily apparent. Rather, quasi-maneuver means that certain drone *effects* are similar to ground maneuver force *effects*. These effects are in the context of operations and include persistence, surveillance, target engagement, and the ability to develop the situation over time and space. These similarities operate on a different scale—one that is far smaller for drones. For this reason, we term these drone effects as *quasi-maneuver*.

In this paper, we use the term “drone” and “drone operations” interchangeably. Both terms encompass operations that could consist of one or multiple military drones. These drones display quasi-maneuver attributes. “Drone” and “drone operations” can also refer to other assets that partner closely with drones in the context of an operation. These assets include platforms external to the drone (e.g., satellites) that provide intelligence and targeting information to either drone or drone operator. It can also include kinetic (e.g., artillery) and nonkinetic (e.g., electromagnetic (EM) jamming) platforms that use drone-provided intelligence to target opposing military systems.

RELEVANT PAPERS ON DRONE WARFARE

This paper’s two premises have been stated previously in various ways. Regarding the similarity of drones’ and ground maneuver’s attributes, Jules Hurst was one of the first to recognize the potential for drones to achieve maneuver-like effects. Writing in 2017, he

asserted that multiple drones operating as swarms “will have the persistence to take and hold terrain” and that drones in combination with conventional maneuver forces can accomplish all forms of offensive maneuver.¹² Writing two years later, George Dougherty reasoned that drone persistence and other attributes can “effectively expand the ground combat battlespace at the small-unit level from two dimensions to three.” Dougherty envisioned using multiple drones, called an array, that “assumes different tactical formations depending on the task it is performing.”¹³ These drone arrays would be under the control of ground maneuver units to facilitate their operations. As one example, these ground units could use drones to conduct rapid vertical envelopments to overcome an opponent’s defenses.¹⁴ Concerning defensive advantages of drones and other sensors, T. X. Hammes, writing in *Joint Force Quarterly* in 2021, asserted that air- and space-based sensors make movement “extremely dangerous. If a [military] unit moves, it will create a signal and can be attacked at much greater ranges than in the past.”¹⁵ The result could be a period of defensive dominance.

This paper provides insights not stated in previous papers, concerning (1) the origin, nature, and limitations of the drone extended maneuver space; (2) preconditions for a drone-generated stalemate; (3) why drone operations are transformational in the context of the modern-system; and (4) the implications for future drone and counter-drone operations.

¹² Jules Hurst, “Robotic Swarms in Offensive Maneuver,” *Joint Force Quarterly* 87, no. 4 (October 2017): 107 (Quote) and 108–111, <https://ndupress.ndu.edu/JFQ/Joint-Force-Quarterly-87.aspx>.

¹³ George Dougherty, “Ground Combat Overmatch Through Control of the Atmospheric Littoral,” *Joint Force Quarterly* 94, no. 3 (July 2019): 65 and 66 (Quotes), <https://ndupress.ndu.edu/Media/News/News-Article-View/Article/1913099/ground-combat-overmatch-through-control-of-the-atmospheric-littoral/>.

¹⁴ Dougherty, “Ground Combat Overmatch Through Control of the Atmospheric Littoral,” 67–68.

¹⁵ T. X. Hammes, “The Tactical Defense Becomes Dominant Again,” *Joint Force Quarterly* 103, no. 4 (October 2021): 11 (Quote), <https://ndupress.ndu.edu/Media/News/News-Article-View/Article/2807244/the-tactical-defense-becomes-dominant-again/>.

DATA AND SOURCES

We used as our primary data source the Oryx website¹⁶ to examine drone operations in five conflicts: the Libyan Civil War, Syrian Civil War, Second Nagorno-Karabakh War, Ethiopian Civil War, and the recent Russia-Ukraine War. Oryx records military equipment losses caused by drones only where photographic or video evidence is available.¹⁷ These equipment losses include armored and unarmored ground vehicles; mortars and artillery; air defense and electric warfare assets; different types of command, control, communication, and logistics assets; aircraft; and ships. The website uses descriptors to identify type, model, and affiliation of equipment losses, the conflict where the loss occurred, and the type of drone utilized.¹⁸

This paper's use of Oryx data has several benefits, one being that Oryx data describe losses of military equipment due to drones spanning many recent conflicts (2019–23). The recency of the data is also a positive attribute mitigating the rapid evolution in drone tactics.





¹⁶ Oryx databases can be found at <https://www.oryxspioenkop.com/>.

¹⁷ Other publications have gained insights from the Oryx data. For one example, see Vikram Mittal, "Military Equipment Losses Provide Insight into Russia-Ukraine War," *Forbes*, March 10, 2022, <https://www.forbes.com/sites/vikrammittal/2022/03/10/military-equipment-losses-provide-insight-into-russia-ukraine-war/?sh=8cb52ed6f59b>.

¹⁸ There are many databases on the website. This report utilized three: (1) Bayraktar TB2 Kill List; (2) Russian loitering munition kill list; and (3) Russian military equipment destroyed by Bayraktar TB2s. As of January 3, 2024, these databases can be found at: <https://www.oryxspioenkop.com/2021/12/a-monument-of-victory-bayraktar-tb2.html>; <https://www.oryxspioenkop.com/2022/11/hit-or-miss-russian-loitering-munition.html>; <https://web.archive.org/web/20220922081832/>; and https://web.archive.org/web/20220922081832/https://www.oryxspioenkop.com/2022/02/defending-ukraine-listing-russian-army.html?fbclid=IwAR0ZDerd6JXX9hGvbV3h3HwMPXuY91PndaJRe9S1ZrHXu_UVg4h7nrQlecY. The Bayraktar TB2 (TB2) kill list contains equipment destroyed by the TB2 spanning many conflicts. The Russian loitering munition kill list contains data of Ukrainian equipment losses destroyed and damaged by Russian Lancet 3 (or 3M) drones and Russian Kub drones spanning February 2022 through April 2023. The Russian military equipment destroyed list contains data of Russian equipment destroyed by Ukrainian-operated TB2 drones spanning February 2022 through September 2022. The Russian and Ukrainian databases include the approximate date of the equipment loss. The Bayraktar TB2 kill list does not contain the date of equipment loss.

It also enables us to test our rationale using multiple examples that include the Calcara case studies.

Moreover, Oryx data always require photographic or video evidence to support their claims of loss, thereby increasing their reliability. The vast majority of the images seems to come from the drones themselves, increasing the credibility that the losses were due to a drone strike.

Drone	Photo	Type	Weight with Payload	Loiter Time	Range (Round-trip)	Speed (Maximum)	Payload
Bayraktar TB-2 (TB2)		Reusable	650 kg	27 hours	150km	220 km/h	4 munitions (150 kg payload capacity)
Lancet-3M		Loitering Munition	unknown	40-60 minutes	unknown	110 km/h	5 kg warhead
Lancet-3		Loitering Munition	12 kg	40 minutes	40 km	110 km/h	3 kg warhead
Kub (Zala Kyb)		Loitering Munition	9 kg	30 minutes	< 30 km (estimate)	130 km/h	3 kg warhead

Sources: Janes, Armed Forces.EU, and Avia.pro

A third benefit of Oryx is that the drones from our five conflicts (the Turkish-made Bayraktar TB-2 (TB2); and the Russian-made Lancet-3, Lancet-3M, and Kub) are preferred for destroying military equipment in the operational area and, therefore, relevant to our premises.¹⁹ Table 1 describes characteristics of these four high-capability drones: all are fixed-wing (versus rotary wing) and range in weight from 9 kilograms (Kub) to 650 kilograms (Bayraktar TB-2).²⁰ The TB2 is a reusable drone that carries four laser-guided

¹⁹ In contrast, drones such as the Iranian-Shahed-136 are kamikaze drones used primarily for destroying Ukrainian infrastructure and not combat forces.

²⁰ Weight includes payload.

smart munitions and a variety of optics. The Lancet-3 (and 3M) are Russian loitering munitions (also called kamikaze drones) with advanced optics. The Kub drone (also known as the Zala Kyb) is an earlier version of the Lancet-3. A search for other data revealed that Oryx had the best publicly available data to test our rationale.

Oryx data also have their drawbacks—one being that they do not include losses from other drones used to strike military equipment. These other drone types include the Chinese-made Wing Loong drones used by the UAE in Libya; the Israeli-made Harop and Orbiter 3 drones used by the Azeris in the Second Nagorno-Karabakh War; and the Russian-made Orlan-10 reconnaissance drones used against Ukraine.

Another disadvantage of Oryx data is their not containing other relevant details. For example, they provide no information on the training level of the drone operators. Further, we cannot know if other (nondrone) platforms contributed to these drone operations by providing intelligence and targeting information or kinetic and nonkinetic effects. The latter disadvantage is particularly relevant in conflicts where drones have provided targeting information to indirect fire systems, such as artillery.

Validation of the Oryx data through comparison with other sources is difficult due to a lack of publicly available corroborating data. Moreover, Oryx data have inconsistent variances, which are illustrated with two examples. During the Second Nagorno-Karabakh War, the official Azeri count of Armenian equipment losses by drone was approximately 950 items, as opposed to Oryx's count of 567.²¹ It is unclear if this discrepancy is due to Azeri exaggeration of their opponent's losses or the high standard of visual evidence

²¹ See Eado Hecht, "Drones in the Nagorno-Karabakh War: Analyzing the Data," *Military Strategy Magazine* 7, no. 4 (Winter 2022): 31–37, <https://www.militarystrategymagazine.com/article/drones-in-the-nagorno-karabakh-war-analyzing-the-data/>.

required by Oryx. The second example—of the official Ukrainian accounting of Russian equipment losses versus the Oryx data—presents a different issue. The Ukrainian Ministry of Defense claims that Russia lost approximately 60 assets from the start of the war through June 23, 2022.²² The Oryx accounting for the same time frame is 71 pieces of Russian equipment lost. The closeness of these data may indicate that Ukraine is using a similar counting methodology as Oryx. Surprisingly, the Oryx total is larger than the official Ukrainian estimate, which could be due to accounting differences.²³

We found that the advantages of using the Oryx data easily outweighed their disadvantages. In the 951 observations from the five recent conflicts we examined, the equipment losses were plentiful, allowing us to parse losses by relevant attributes: type, model, and affiliation. The drones committing the strikes were designed for use against military equipment in the operational area, and all losses were confirmed by photographic or video evidence. As a practical matter, there were no better publicly available data.

VALIDATION OF OUR TWO PREMISES

This section will validate our two premises: (1) drones have quasi-maneuver aspects that extend the maneuver space; and (2) drones have advantages when employed against an attacking opponent that—under certain conditions—could result in a stalemate. We first provide an overview of drone operations from the five chosen conflicts, and then examine how each premise played out on the battlefield.

²² Aleksandre Tsereteli, “Use of Technologies in the Russia-Ukraine War,” *Friedrich Naumann Foundation for Freedom*, August 2, 2022, <https://www.freiheit.org/south-caucasus/use-technologies-russia-ukraine-war>. Ukrainian Ministry of Defense website found at <https://www.mil.gov.ua/en/news/2023/06/23/the-total-combat-losses-of-the-enemy-from-24-02-2022-to-23-06-2023/>.

²³ For example, this paper counts command posts, communication relays, and logistics nodes as one item of lost equipment.

OVERVIEW OF RECENT DRONE OPERATIONS

We examined drone operations for five conflicts, in chronological order: Libyan Civil War (2019-20), Syrian Civil War (2020), Second Nagorno-Karabakh War (2020), Ethiopian Civil War (2021), and the recent Russia-Ukraine War (ongoing, 2022–). We studied these conflicts because they met four criteria relevant to our premises. The first two criteria were (1) the conflict was mid-to-high-intensity ground warfare, and (2) military equipment was documented on the Oryx website. The third criterion was to include the three conflicts used in the Calcara paper (to test our premises using the same case studies as Calcara).²⁴ The last criterion was to include more recent examples than Calcara to account for any changes in drone warfare.

The Oryx data allow us to examine specific phases of these conflicts. This phased approach, which the Calcara paper also uses, enables us to better establish cause and effect for longer conflicts, such as the Libyan, Syrian, and Ethiopian Civil Wars.

Libyan Civil War (July 2019–June 2020)

During the latter part of the Libyan Civil War, which began in 2014, the Libyan National Army (LNA) was conducting a successful offensive to capture Tripoli, the Government of National Accord's (GNA) capital. In July 2019, the GNA began to successfully employ Turkish-supplied TB2 drones against the LNA. By December 2019, Turkey provided the GNA additional drones, air defense systems, and electronic warfare. The air defense systems kept the LNA's Chinese-made Wing Loong drones at bay, while the GNA's electronic warfare systems and TB2's operated in tandem. Electronic warfare

²⁴ The three cases used in Calcara et al., are the Libyan Civil War, Syrian Civil War, and Second Nagorno-Karabakh War.

assets defeated LNA air defenses, enabling the TB2s to strike a variety of targets. By May 2020, the GNA was not only able to stop the offensive on the outskirts of Tripoli, but it also pushed LNA forces back over multiple axes. Surprisingly, the GNA recaptured four coastal towns and the strategic Al-Watiza airbase to the south. When GNA forces threatened to capture the strategically important city of Sirte, a hastily arranged cease fire stopped the fighting.²⁵ Up to sixteen GNA TB2 drones were lost in these operations.²⁶

Syrian Civil War (February–March 2020)

During this period in the Syrian Civil War, which began in 2011, tensions between Syria and neighboring Turkey were increasing as pro-(Syrian) government forces attempted to secure Idlib province, located along Syria’s northwestern border with Turkey. Turkey responded by deploying thousands of troops into the province to stop Syrian gains. After pro-government forces shelled Turkish positions, Turkey launched Operation Spring Shield. This operation penetrated the Syrian rear area, using a combination of drones and electronic warfare assets. Turkish electronic warfare suppressed Syrian air defenses and hacked into Syrian communications, revealing the location of Syrian units and facilitating drone access into the Syrian rear area. Once inside the Syrian rear area, Turkish drones were used for complementary tasks. Anka-S drones performed command, control, and intelligence functions, sending targeting information to TB2s for engagement. The result

²⁵ Sources for overview of Libyan Civil War are Alex Gatopoulos, “Largest drone war in the world’: How airpower saved Tripoli,” *Al Jazeera*, May 28, 2020, <https://www.aljazeera.com/news/2020/5/28/largest-drone-war-in-the-world-how-airpower-saved-tripoli>; and Dan Sabbagh, Jason Burke, and Bethan McKernan, “Libya is ground zero’: drones on frontline in bloody civil war,” *The Guardian*, November 27, 2019, <https://www.theguardian.com/news/2019/nov/27/libya-is-ground-zero-drones-on-frontline-in-bloody-civil-war>.

²⁶ Number of lost GNA TB2 drones from “Drone Crash Database,” last updated June 2023. <https://dronewars.net/drone-crash-database/>.

was the destruction of Syrian heavy weapons to the degree that some Syrians abandoned their equipment and fled. Seven days into the operation, Turkey pushed Syrian forces back without any direct participation of Turkish troops. Reportedly, ten Turkish drones were lost to air defense systems.²⁷

Second Nagorno-Karabakh War (September–November 2020)

This example spans an entire conflict. Control of Nagorno-Karabakh, a mountainous area located in the South Caucasus, has been an issue between Azerbaijan and Armenia since their achieving independence from the Soviet Union. Before the start of the Second Nagorno-Karabakh War, Armenia was firmly in control of the region, with conventional armored forces arrayed in defensive strongpoints. The Azeri offensive differed from previous border clashes in that it relied heavily on drones—in particular, the Turkish TB2 and the Israeli-made Harop and Orbiter 3. In contrast to the reusable TB2, the Israeli drones are loitering munitions.²⁸ The biggest threat to the Azeri drones were the Armenian air defense assets. The Azeris employed deception by flying remote-controlled aircraft over Armenian air defenses. In response, the Armenians turned on their radars and launched their missiles, revealing their location. This ruse enabled the Azeri kamikaze drones to easily destroy these systems. This action significantly degraded the Armenian air defense

²⁷ Sources for overview of Syrian Civil War are Scott Ritter, “Like horse-mounted cavalry against tanks: Turkey has perfected new, deadly way to wage war, using militarized ‘drone swarms,’” *Yerepouni Daily News*, November 30, 2020, <https://www.proquest.com/newspapers/like-horse-mounted-cavalry-against-tanks-turkey/docview/2465457763/se-2?accountid=11558>; and Ridvan Bari Urcosta, “The Revolution in Drone Warfare: The Lessons from the Idlib De-Escalation Zone,” *The Air Force Journal of European, Middle Eastern, and African Affairs*, August 31, 2020, <https://www.airuniversity.af.edu/JEMEAA/Display/Article/2329510/the-revolution-in-drone-warfare-the-lessons-from-the-idlib-de-escalation-zone/>.

²⁸ David Hambling, “The ‘Magic Bullet’ Drones Behind Azerbaijan’s Victory Over Armenia,” *Forbes Magazine*, November 10, 2020, available at <https://www.forbes.com/sites/davidhambling/2020/11/10/the-magic-bullet-drones-behind-azerbajjans-victory-over-armenia/?sh=64a3c8d65e57>.

system, paving the way for further drone attacks.²⁹ The Azeris employed different types of drones for different tasks. The Israeli kamikaze drones performed armed reconnaissance missions because their smaller size made them less vulnerable to countermeasures. The more efficient and reusable TB2s were used as precision weapons in areas where the air defense threat was much lower. This division of tasks was effective.³⁰ The Azeri drones successfully destroyed Armenian military forces, including fortified tank positions, hardened command posts, artillery, and a variety of armored and unarmored vehicles operating on roads in the rear area. Similar to the Syrian conflict, there were reports of Armenians abandoning their equipment as they fled. Azeri ground forces, following behind the drone strikes, were able to occupy the former Armenian positions. The Armenian forces fled to the protection of forested areas, where they resorted to guerrilla warfare. Shockingly, in a matter of 44 days, Azerbaijan gained control of Nagorno-Karabakh as well as previously lost territory.³¹

Ethiopian Civil War (November–December 2021)

This example is taken from a period in the larger Ethiopian Civil War (also called the Tigray War) that began in 2020. After a series of defeats by Tigray rebels, Ethiopian government forces were driven out of the Northern province of Tigray. By October 2021, the Tigray rebels along with other anti-government forces drove the Ethiopian ground forces 200 kilometers to the south, threatening the capital of Addis Ababa. Unbeknownst to the rebels, the Ethiopians had been purchasing drones—primarily the Turkish TB2 and

²⁹ “Drones and Maneuver Warfare,” *Marne Corps Gazette* 106, no. 5 (2022): 111, <https://www.proquest.com/trade-journals/drones-maneuver-warfare/docview/2660135875/se-2>.

³⁰ “Drones and Maneuver Warfare,” 110–111.

³¹ “Drones and Maneuver Warfare,” 113.

various Chinese armed drones.³² At the end of November 2021, Ethiopia launched a drone-led counteroffensive, called Operation National Unity. Drones—particularly the TB2—attacked vehicles and supply convoys along the major highway to the capital. Within one month, government forces had pushed the rebels 150 kilometers to the north.³³

Russia-Ukraine War (Ongoing: February 2022–)

This last example is the ongoing Russian invasion of Ukraine that began February 24, 2022. Both sides have employed drones through various phases of this conflict, during some of which Russian forces were on the offensive (e.g., advance to Kiev, advances in the east), while during others the Ukrainians were on the offensive (e.g., Kharkiv counteroffensive, Kherson counteroffensive).

In the advance to Kiev, Russian military units invaded Ukraine from the north and northeast, aiming to seize the Ukrainian capital. From the northern axis, a 60-kilometer-long column made up of armored and unarmored vehicles advanced on Kiev. Ukraine used its Turkish TB2 drones and smaller commercial drones to keep the Russian column under surveillance.³⁴ Small numbers of Ukrainian special forces reportedly conducted a number of night ambushes on the Russian column using quad bikes and night-vision goggles to traverse the forested terrain. These forces were augmented with IT specialists, who used drones with thermal-imaging capability. This combination stopped the column approximately 24 kilometers from the capital. Over the next several days, continued attacks

³² “Nobel Peace winners preside over shameful atrocities Ethiopia’s prime minister has led a brutal military campaign in Tigray,” *The Mercury*, July 16, 2021, 6.

³³ Declan Walsh, “Foreign Drones Tip the Balance in Ethiopia’s Civil War,” *The New York Times*, December 20, 2021, <https://www.nytimes.com/2021/12/20/world/africa/drones-ethiopia-war-turkey-emirates.html>.

³⁴ Andrew E. Kramer and David Guttenfelder, “From the Workshop to the War: Creative use of Drones Lifts Ukraine,” *The New York Times*, August 11, 2022, A.8.

on the Russian column destroyed armored vehicles, fuel trucks, and supporting supply depots. By 2 April 2022, all Russian forces had withdrawn from the Kiev Theater.³⁵

The conflict has since transitioned mostly to eastern and southern Ukraine, where there have been both drone and counter-drone innovations. With regard to drone employment, both sides have linked drones to artillery and other surveillance assets.³⁶ With regard to countermeasures, both sides use jamming and air defense systems to disrupt opposing drones. This refinement of countermeasures has led to the development of drone counter-countermeasures. These counter-countermeasures include Ukrainian efforts to find and exploit gaps in Russian jamming systems, and Russia's incorporating electronic warfare capabilities into its Orlan-10 drones to disrupt air defenses.³⁷ Tens of thousands of drones have been lost over the course of this conflict. Despite these losses, Ukrainian and Russian forces often have hundreds of drones in the sky due to their inexpensive cost and demonstrated utility.³⁸

³⁵ The report of the combined land and drone strikes on the Russian column has not been verified by other sources. Julian Borger, "The drone operators who halted Russian convoy headed for Kyiv," *The Guardian*, March 28, 2022, available at <https://www.theguardian.com/world/2022/mar/28/the-drone-operators-who-halted-the-russian-armoured-vehicles-heading-for-kyiv>; and Translated by Content Engine, LLC, "Video: How Ukraine Destroyed Tanks and Fuel Supplies for Russia in the War." *CE Noticias Financieras*, February 28, 2022.

³⁶ With regard to nondrone surveillance assets, Ukraine has leveraged access to Elon Musk's Starlink satellites to create a surveillance system called Delta that utilizes drones and other sensors to provide commanders a real-time digital map of Russian activities. Delta is widely distributed within the Ukrainian armed forces, facilitating decentralized command and control. See Julian Borger, "The drone operators who halted Russian convoy headed for Kyiv," *The Guardian*, March 28, 2022; and Isabelle Khurshudyan and Mary Ilyushina, Kostantyn Khudov "Russia and Ukraine are fighting the first full-scale drone war," *The Washington Post*, December 2, 2022; and "The satellites that saved Ukraine," *The Economist*, January 7, 2023, 13–15.

³⁷ Khurshudyan, Ilyushina, and Khudov, "Russia and Ukraine are fighting the first full-scale drone war;" and Andrew Kramer, "Menaced from Above, Ukraine is Pioneering Ways to Shoot Down Drones: [Foreign Desk]," *New York Times*, October 24, 2022, A.8.

³⁸ *Unmanned Aircraft Systems: Roles, Missions, and Future Concepts*, R47188, (Washington, DC: Congressional Research Service, July 18, 2022), <https://crsreports.congress.gov/product/pdf/R/R47188>, 25.

FIRST PREMISE: DRONES HAVE QUASI-MANEUVER ASPECTS THAT EXTEND THE BATTLEFIELD MANEUVER SPACE

This section describes the rationale for each part of the premise and provides evidence from the five conflict narratives. It then provides data from the Oryx database to further support the overall claim.

Drones Have Quasi-maneuver Characteristics

Drones have certain effects that resemble those of ground maneuver forces. Ground forces maneuver to gain a “positional advantage” vis-à-vis an opponent with the goal “to render opponents incapable of resisting.”³⁹ Key enablers to attaining positional advantage are the ground force’s persistence, surveillance, and engagement attributes. “Ground forces are continuously present” to surveil and immediately engage targets, as well as control terrain and populations.⁴⁰ These characteristics interact in a manner that enables ground forces to *develop the situation* over time and space.⁴¹ Persistence enables maneuver forces to take successive actions over time. Ground force surveillance enhance this chain of actions by determining the best course in an uncertain and changing environment. Options can include occupying favorable terrain, influencing populations, or engaging (or threatening to engage) an opponent. Such actions are essential to developing the situation, furthering maneuver’s aim to “render opponents incapable of resisting.”⁴²

³⁹ Joint Chief of Staff, Joint Publication 3-0, *Joint Operations* (Washington, D.C.: Government Printing Office [GPO], January 17, 2017, incorporates Change 1, October 22, 2018), III-38 (quotes) and III-37 through III-39.

⁴⁰ Biddle, *Military Power*, 37 and 57 (quote).

⁴¹ See “actions on contact” in *US Army Field Manual (FM) 3-90 Tactics* (Washington, D.C.: GPO, 2021), 4–13 and glossary-1.

⁴² Clausewitz recognizes this aspect of developing the situation when he states that “war is a series of successive acts, each of them, seen in context, will provide a gauge for those that follow. Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton: Princeton University Press, 1984), 79.

Drones can also attain positional advantage over an opponent. Drone operations afford positional advantage along the air-ground littoral—a vertical space between 10 to 8,000 meters.⁴³ This positional advantage is derived from persistence, surveillance, and engagement, albeit to a lesser extent than ground forces. Certain drones can operate for several hours, facilitating some degree of persistence. The TB2 is probably at the high end of endurance by loitering for up to 27 hours.⁴⁴ From the air-ground littoral, drones surveil the ground from high or low altitudes and at night if equipped with the proper optics. The wide variation in vertical movement allows drones to engage ground targets along a three-dimensional axis.⁴⁵ Consequently, drone operators can choose advantageous angles to engage and defeat ground targets.⁴⁶ As with ground forces, these characteristics interact in a manner that enables drone operations to *develop the situation* over time and space. Persistence enables drones to take successive actions. While drones have far less persistence than ground maneuver forces, drones can partly compensate through their speed and surveillance attributes. Drones can leverage their speed (e.g., 110-to-220 kilometers per hour for the TB2, Kub and Lancet drones) and the vantage point of the air-ground littoral to surveil (and engage targets in) a larger area per unit time⁴⁷ than ground forces.

⁴³ The air-ground littoral (also called the “air littoral”) is defined in Maximilian Bremer and Kelly Grieco, “The Air Littoral: Another Look,” *Parameters* 51, no. 4 (Winter 2021–22): 68, <https://press.armywarcollege.edu/parameters/vol51/iss4/7/>.

⁴⁴ Daily Sabah, “Turkey’s indigenous Bayraktar drone breaks endurance record,” July 19, 2019, <https://www.dailysabah.com/defense/2019/07/19/turkeys-indigenous-bayraktar-drone-breaks-endurance-record>.

⁴⁵ For example, the Turkish Bayraktar TB-2 maximum altitude is roughly 7,600 meters.

⁴⁶ Drone vertical overmatch of ground systems described in Dougherty, “Ground Combat Overmatch Through Control of the Atmospheric Littoral,” 65.

⁴⁷ “UAVs make it possible to patrol huge territories continually, highly complicating the processes of regrouping, retreating, counterattacking, or delivering reinforcements,” found in Urcosta, “The Revolution in Drone Warfare.”

Our five conflicts support the claim that drones have quasi-maneuver characteristics. Specifically, we found examples where drones gained positional advantage along the air-ground littoral to “render opponents incapable of resisting.” In both Libya and Syria, Turkish drones pushed opposing ground forces back along multiple axes.⁴⁸ In Nagorno-Karabakh, drones’ varied effects forced the Armenian army from the roads and their fortified positions. Similarly, drones drove the Tigray ground forces 150 kilometers to the north. Outside of the Kiev, Ukrainian drones likely contributed to the withdrawal of the advancing Russian column. These drone effects were not transitory but rather sustained, as seen by the inability of ground opponents to regain their lost positions. The argument that drones were a minor partner to their ground forces is weak in the cases of Syria, Nagorno-Karabakh, and Ethiopia, where ground forces were not integrated with drone operations, often trailing behind.

Drone operations developed the situation over time and space by leveraging their persistence, surveillance, and engagement to conduct complex operations. In Nagorno-Karabakh, we see drones employed in both armed reconnaissance and deception—commonly maneuver tasks. In Ukraine, drones have also been used in reconnaissance⁴⁹ and in conjunction with other arms, such as artillery. In both Libya and Syria, drones successfully operated in coordination with electronic warfare assets.

In light of these remarkable examples, it is important to note the extent that drones fall short of full ground maneuver characteristics related to persistence, surveillance, engagement, and development of the situation. Drone loiter time has both time and space

⁴⁸ Urcosta, “The Revolution in Drone Warfare.”

⁴⁹ Khurshudyan, Ilyushina, and Khudov, “Russia and Ukraine are fighting the first full-scale drone war.”

limitations. Even if this time is extended by cycling fresh drones to replace expiring ones, drone range will remain limited if there is no forward movement of the drone launch point. If these technical limitations are not enough, many drones simply cannot operate in bad weather, constraining their persistence.⁵⁰ Drone surveillance (and by extension, engagement) is also limited when compared to ground maneuver systems. Drones cannot not detect the full array of ground targets but only those with detectable signatures from the vantage point of the air-ground littoral (we will refer to these as *high signatures*). Still, even high-signature systems can evade drones through use of overhead concealment and other measures. Drones have impediments to developing the situation as opportunities arise. The previously noted limits in loiter time and range constrain the ability of drones to fully pursue sequential opportunities. In addition, drones' repertoire of actions is limited compared to ground forces. Drones cannot hold terrain or control populations; at best, drones can only deny an opponent's control of terrain.

Drones also fall short of manned aircraft in several important respects. Although drones typically cost less than manned aircraft, they are slower, have more limited payloads, and generally possess inferior optics. Some manned aircraft have radar-absorbing aspects, making detection extremely difficult and negating even that advantage of (especially smaller) drones.

But whereas manned aircraft have several advantages over drones, manned aircraft's limitations in persistence and surveillance prevent their attaining a quasi-maneuver capability. Biddle's modern-system describes manned aircraft as transient observers that

⁵⁰ The TB2 is an exception, reportedly being able to operate in 40 knot winds. Daily Sabah, "Turkey's indigenous Bayraktar drone breaks endurance record."

“patrol intermittently or respond to calls from others’ target acquisition.” The latter quality is due to a lack of situational awareness of ground operations due to their fast pace and limited loiter time. These limitations prevent manned aircraft from maintaining a “continuous presence over the entire battlefield.”⁵¹ Consequently, the sky is free of aircraft for significant periods. Persistence and surveillance are further hampered by manned aircraft’s having to *protect their human operators* while generating their desired effects. This imperative precludes manned aircraft from loitering for long periods where countermeasures exist. In contrast, drones possess an important characteristic termed by Dougherty as “attritability,” derived from their having no human passengers and lower relative costs.⁵² These qualities drastically lower the risk threshold for drones relative to manned aircraft, incentivizing their use in situations where their loss is likely. This attribute enables drones to establish presence and surveillance in hostile areas. As evidence, current reports are that the Ukrainians are losing up to 10,000 military drones a month.⁵³ Ukraine is rushing to replace these losses, testifying to the utility of these craft.

Despite drones’ inability to fully maneuver, their unique pairing of speed, overmatch, and attritability lends them remarkable quasi-maneuver characteristics. Specifically, drones can maneuver along the air-ground littoral faster than forces on the ground, and they can overmatch most ground systems by engaging targets at advantageous angles. In contrast to manned aircraft, attritability enables drones to establish a presence where manned aircraft cannot go. This presence allows drones to develop the situation in these hostile areas.

⁵¹ Quotes found in Biddle, *Military Power*, 57.

⁵² Dougherty, “Ground Combat Overmatch Through Control of the Atmospheric Littoral,” 67–68.

⁵³ “Warfare after Ukraine – Battlefield lessons,” *Economist*, Special report, July 8, 2023, 6.

Drones Extend the Maneuver Space

Drone quasi-maneuver characteristics extend the maneuver space in a new manner due to (1) the temporal lag between drone capabilities and countermeasures, and (2) the drone operational incentive.

The Calcara paper correctly asserts that drones are vulnerable to a variety of increasingly sophisticated countermeasures. These countermeasures include traditional air defense artillery, missiles, and electronic warfare assets, the last of which can down drones by jamming the operator's signal or (in some cases) taking over control of drones.⁵⁴ In addition to these countermeasures, militaries are experimenting with other drone countermeasures such as nets,⁵⁵ new forms of airburst technology,⁵⁶ directed-energy weapons, and even other drones.⁵⁷

These countermeasures have been effective in downing drones.⁵⁸ Of the 10,000 drones that Ukraine is losing a month, one-half are downed by Russian electronic warfare.⁵⁹ The average life expectancy for a Ukrainian fixed-wing drone is approximately six flights,

⁵⁴ Examples of counter-drone electronic warfare found in Vittorio Ugo Castrillo, Angelo Manco, Domenico Pascarella, and Gabriella Gigante, "A Review of Counter-UAS Technologies for Cooperative Defensive Teams of Drones," *Drones* 6, no. 3 (March 2022): 24–25, <https://www.mdpi.com/2504-446X/6/3/65>.

⁵⁵ Castrillo, "A Review of Counter-UAS Technologies for Cooperative Defensive Teams of Drones," 26; and Jason Sherman, "Drones armed with precision-fired nets protecting U.S. strategic, Ukrainian critical sites," *Inside the Army*, March 2, 2023, <https://insidedefense.com/daily-news/drones-armed-precision-fired-nets-protecting-us-strategic-ukrainian-critical-sites>.

⁵⁶ Stephen Miller, "Controlling the Forward Aerial High Ground," *Armada International*, September 2022, 13, <https://www.armadainternational.com/2022/09/issue-september-2022/>.

⁵⁷ For an example of counter-drone technology in the form of other drones, see "DroneHunter F700," Fortem Technologies, <https://fortemtech.com/products/dronehunter-f700/#:~:text=Fortem%20DroneHunter%20minimizes%20collateral%20damage,ground%20based%20electronic%20counter%20measure>.

⁵⁸ For a partial list of large (Class II and III) military drone crashes since January 1, 2007 (confirmed by at least two source) see "Drone Crash Database."

⁵⁹ "Warfare after Ukraine – Battlefield lessons, 6.

while that of quadcopter drones is much less.⁶⁰ High-end drones are not immune from these losses. Not less than 40 TB2 drones have been confirmed as lost in recent conflicts.⁶¹

While the Calcara paper correctly notes drone vulnerabilities, Ukraine and other actors persist in reconstituting and expanding their drone fleets despite catastrophic losses. The value of drones is due partly to their high quotient of effect to cost (they are relatively inexpensive)⁶² but just as importantly because a temporal lag enables drones to apply effects prior to succumbing to countermeasures or to their inherent limitations.

The rationale for this temporal lag follows. Drones can enter an opponent's area of control from a multitude of three-dimensional points. Consequently, countermeasures need to be well-distributed to cover these areas. Drones can initially overcome these countermeasures by being employed en masse or by exploiting a weakness. These actions can be bolstered by the general difficulty of detecting drones due to their small size, ability to fly low, and utilization of certain design materials. For example, the Iranian-made Shahed-136 drone's few metallic parts and ability to fly low make it difficult to detect.⁶³ Maximilian Bremer and Kelly Grieco recognize this ability of drones to overcome distributed countermeasures when they write about the drone characteristic of "quickly massing at chosen moments to strike."⁶⁴ These breakthroughs can be costly in terms of lost drones, but such losses are manageable due to the drone characteristic of "attritability." After breakthrough, surviving drones have temporal limitations. One predictable limitation

⁶⁰ "Warfare after Ukraine – Battlefield lessons, 4.

⁶¹ "Drone Crash Database."

⁶² As one measure, "hundreds of small autonomous UAVs cost less than a single tactical aircraft." David Smalley, "LOCUST: Autonomous, Swarming UAVs Fly into the Future," Office of Naval Research Communications, April 14, 2015, <https://www.onr.navy.mil/Media-Center/Press-Releases/2015/LOCUST-low-cost-UAV-swarm-ONR.aspx>.

⁶³ Khurshudyan, Ilyushina, and Khudov, "Russia and Ukraine are fighting the first full-scale drone war."

⁶⁴ Bremer "The Air Littoral: Another Look," 71.

is drone loiter time. An unpredictable limitation is that drones can be identified, tracked, and possibly destroyed by opponents after the initial breakthrough. This lag between drone penetration and their temporal expiration provides opportunities for drones to conduct activities.

After breaking through the enemy's main defenses, drones often engage in activities to destroy an opponent's rear-area infrastructure. Drones are incentivized to conduct such activities for the same reason that ground maneuver forces go to extreme efforts to break through (or bypass) an opponent's main strength: to exploit opportunities in the less well-defended rear area. This rear-area infrastructure includes command, control, and communication nodes for directing and synchronizing operations. It also includes a variety of indirect-fire assets ranging from mortars to missiles; integrated logistics, including fuel, food, maintenance, and munitions; field hospitals; and transportation assets. Modern armies rely on such infrastructure to generate effects and direct, synchronize, and sustain operations.

This rear-area infrastructure is so important that its destruction is the core objective of modern-system offensive operations. To achieve this objective, ground forces mass at certain points to "punch a hole through" an opponent's prepared positions. Reserve forces then pour through this gap into the relatively undefended rear area. These forces are able to accelerate and rapidly destroy rear-area infrastructure. If successful, this effect causes "some armies to lose composure and collapse as organized bodies. Others fight on once encircled and isolated, but do so with radically reduced per-capita effectiveness."⁶⁵

⁶⁵ Biddle, *Military Power*, 41.

As noted previously, drones can more easily penetrate the rear area than ground combat forces can. Drone quasi-maneuver characteristics enable them to identify and destroy high-signature systems and to develop the situation within their temporal limits. Like ground maneuver forces, drones have an incentive to destroy rear-area infrastructure to achieve either a collapse or degradation of opposing capabilities.⁶⁶

This operational incentive extends the maneuver space from the front line along an axis into the rear area. The limit of this axis is determined by drone range. Along this axis, drones have sufficient quasi-maneuver attributes to surveil and immediately engage ground targets at vulnerable angles.

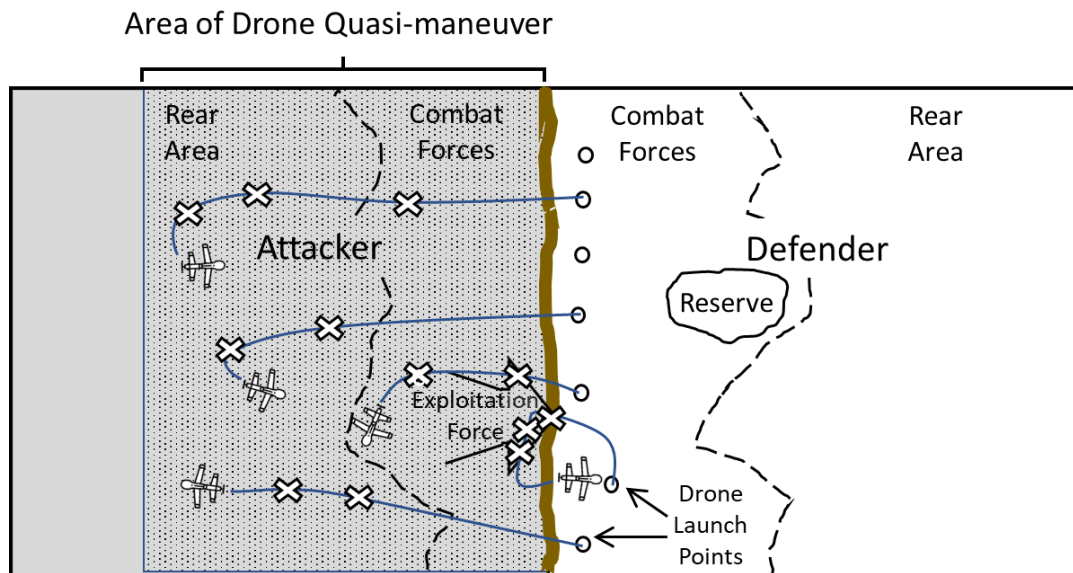


Figure 2. Defender Drones Extend the Maneuver Space

Figure 2 illustrates how drones extend the maneuver space.⁶⁷ In this example, the defender employs drones close to the front line (launch points are represented by small

⁶⁶ As one example, “[d]uring Spring Shield, Turkish UAVs were operating almost everywhere in the greater Idlib area and reached the deep rear of the Syrian Army.” Found in Urcosta, “The Revolution in Drone Warfare.”

⁶⁷ Drone icons in Figures 2 through 4 are from <https://www.freepik.com>.

circles). These launch points enable drones to employ quasi-maneuver characteristics to the limits of their range (represented by the dotted area). Many drones will be lost if the attacker has robust counter-drone capabilities; however, the temporal lag enables drones to conduct activities before their fuel or batteries are exhausted. These activities include striking targets (represented by the “X” symbol) throughout the quasi-maneuver area. These targets include the immediate threat of the attacker’s exploitation force, as well as the critical rear-area infrastructure.

Our five conflicts indicate that drones are incentivized to attack an opponent’s rear-area infrastructure, extending the maneuver space in new ways. Turkish drones effectively suppressed air defenses to penetrate the Syrian rear area. In Nagorno-Karabakh, drones targeted rear-area assets such as artillery, command posts, and logistics vehicles. In the Ethiopian Civil War, government forces targeted supply convoys. These operations destroyed rear-area infrastructure to such an extent that opposing ground forces retreated.

This idea of deep attack is not new in warfare, but drone operations add a new capability to this concept. Certainly, manned aircraft and long-range fires can strike targets deep into an opponent’s rear area with more firepower than drones can. In addition, ground maneuver forces can gain access into the rear area through infiltration, helicopter insertion, and airborne operations—means that last much longer than drone loiter time. The difference with drones is their ability to generate quasi-maneuver attributes along a continuous axis from their launch site into the opposing force’s rear area. Ground forces that break through the front line can do the same; however, the ability of drones to achieve this breakthrough along the air-ground littoral at much less cost, effort, and time provides something new in

deep operations. We do not claim that this capability is better than other alternatives, but rather different, and better suited to some situations than to others.

Support from the Oryx data for First Premise

The Oryx data provide support as well as insights to our premise that drones have quasi-maneuver aspects that extend the maneuver space. We will first examine the data and then address the two parts of the first premise.

Conflict (Operation)	Time Frame	Drone Operator	Opponent	Opponent Ground Equipment Losses from Drone Attack					
				Armor	C-drone	Indirect Fire	Node	Truck	Total
Libyan Civil War	Jul 2019-Jun 2020	Gov't Nat'l Accord	Libyan Nat'l Army	2	10	6	0	44	62
Syrian Civil War (Operation Spring Shield)	Feb-Mar 2020	Turkey	Syrian Gov't	40	9	39	0	21	109
2nd Nagorno-Karabakh War	Sep-Nov 2020	Azerbaijan	Armenia	122	30	221	0	194	567
Ethiopian Civil War (National Unity Offensive)	Nov-Dec 2021	Ethiopian Gov't	Tigray Rebels, Allies	10	8	0	0	5	23
Russia-Ukraine War	Feb 2022-Ongoing	Russia	Ukraine	21	20	53	2	14	110
Russia-Ukraine War	Feb 2022-Ongoing	Ukraine	Russia	13	20	10	9	28	80
			Total	208	97	329	11	306	951

The Oryx data in Table 2 describe ground equipment losses by drone attack for our five conflicts.⁶⁸ From left to right, the table columns describe the conflict, the time frame of the equipment losses, the side that operated the drones, and the opponent that lost the equipment. The equipment losses are organized by category. *Armor* includes tanks, armored personnel carriers, and armored engineer equipment. *C-drone* are counter-drone measures that include all types of air defense systems and jamming/electric warfare assets. *Indirect fire* includes all indirect fire systems, to include mortars, artillery, and missile

⁶⁸ The Oryx data also display aircraft and ships lost to drone attack; however, these losses only make up approximately 1 percent of the data from the Russian loitering munition kill list and from Russian military equipment destroyed by Bayraktar TB2s.

systems. *Node* spans three types of nodes: command posts, communication relay stations, and logistics nodes. *Truck* are unarmored vehicles used primarily to transport logistics. The unit of measure for equipment losses in each column follows: armored vehicle (for Armor column), self-propelled or towed counter-drone platform (C-drone), self-propelled or towed indirect fire platform (Indirect Fire), stationary or mobile command post, communications, or logistic asset (Node), and unarmored vehicle (Truck).

These categories are ordered to roughly correspond to their location on the battlefield. Armor is usually associated with frontline combat forces. C-drone are usually the first line of defense against drones. Moving rearward from the front line, one would expect to encounter various indirect-fire systems, different types of nodes, and then trucks moving supplies. This arrangement is somewhat simplistic, since armor can be held in reserve in the rear area, long-range artillery can be far behind front lines, and trucks can also support forces close to the front. Despite these caveats, this imperfect arrangement will be useful to gain analytic insights.

The total equipment losses by category suggests that drones can destroy a variety of equipment with different types of signatures. Armor, indirect fire, and trucks make up 89 percent of total losses. The first two categories have high physical signatures: tanks and armored fighting vehicles are large and have high heat signatures, while indirect-fire systems require sufficient clearance to fire at different elevations, exposing them to overhead observation and rendering them particularly noticeable when firing munitions. In comparison to armor and indirect-fire systems, trucks are typically not considered high-signature assets. However, visual evidence suggests that most of these vehicles were destroyed while transiting roads, making them vulnerable to overhead detection. The

remaining two categories that make up 11 percent of the losses are counter-drone assets and nodes of various types. Most of these assets have high EM signatures. Air defense must utilize radar, and jamming systems also emit noticeable EM signatures. Command posts and communication relays also have high EM signatures. The third type of node, logistic caches, is a large target with a lot of activity, making it detectable from above.

The data suggest that drone operations exhibit quasi-maneuver aspects. The three conflicts where drones operated forward of their ground forces were also the shortest, adding further support that drones can attain positional advantage to “render opponents incapable of resisting.” The Turkish intervention in Syria lasted a mere seven days and resulted in 109 pro-government equipment losses. The Second Nagorno-Karabakh War lasted 44 days and resulted in 567 Armenian equipment losses, and the Ethiopian counteroffensive occurred over 27 days and resulted in 23 Tigray equipment losses. The data suggest that drones can also develop the situation. The launch point of all drones occurred behind friendly lines. The dispersion of opposing equipment losses from the front line to the deep rear area implies intentionality as to how drone operations identified, assessed, and chose targets over a large area. The overall effects were remarkable. For the first four conflicts in Table 2, the introduction of drones resulted in an unexpected change in the status quo.⁶⁹ These surprising outcomes suggest that—under the right circumstances—drones can develop the situation.

The data also suggest that drone quasi-maneuver characteristics have extended the maneuver space on an axis from frontline forces to the opponent’s rear area. The wide

⁶⁹ One should note in the cases of Libyan and Syrian Civil Wars that both sides used drones extensively. The difference was that the TB2 with complementary assets (such as air defense and the Anka-S drone) overmatched opposing systems.

variety of equipment losses, from frontline to logistics, resembles that of a turning movement. U.S. Joint and Army publications describe turning movements as a form of maneuver (or envelopment) “in which the attacking force passes around or over the enemy’s principal defensive positions to secure objectives deep in the enemy’s rear to force the enemy to abandon his position or divert major forces to meet the threat.”⁷⁰ As a means of comparison, the 100-hour ground turning movement of Operation Desert Storm resulted in the following Iraqi equipment losses: 3,000 tanks, 1,400 armored personnel carriers, and 2,200 artillery pieces along with countless other vehicles.⁷¹ While the Table 2 quantities are much less than those from Desert Storm, the categories of lost equipment are similar. As further support, drone operations in Syria, Nagorno-Karabakh, and Ethiopia caused opposing ground forces to abandon their positions and retreat—a characteristic of turning movements. The evidence suggests that drone operations achieved this turning movement effect by applying their quasi-maneuver attributes on an opponent’s rear-area infrastructure.

SECOND PREMISE: DRONES HAVE ADVANTAGES WHEN EMPLOYED AGAINST AN ATTACKER THAT COULD RESULT IN A STALEMATE

Similar to the previous section, we will describe each part of the premise and provide evidence from the five conflict narratives. We will then examine the Oryx data for support.

⁷⁰ Quote taken from definition of turning movement found in the Department of Defense (DOD) Dictionary of Military and Associated Terms, as of November 2021, 221, <https://irp.fas.org/doddir/dod/dictionary.pdf>. U.S. Army definition of turning movement found in FM 3-90, 3-15 through 3-19.

⁷¹ Iraqi equipment losses found at “Operation Desert Storm,” *U.S. Army Center of Military History*, <https://history.army.mil/html/bookshelves/resmat/desert-storm/index.html>.

Drones have Advantages when Employed Against an Attacker

Drones are most effective at defeating ground systems engaged in offensive operations owing to the way drones identify targets. Previously, we noted that drones detect high-signature ground targets from the vantage point of the air-ground littoral. These high-signature systems are typically characterized by large size and weight (e.g., tanks, logistics nodes) or their emitting strong EM pulses (e.g., air defense, communications assets). These signatures are not constant but linked to system activity. The largest tank can evade drone sensors when camouflaged and the engine is cold.⁷² Radar can also be turned off until opposing aircraft are sighted. Other activities magnify a system's signature, such as vehicles' being in transit, artillery firing, air defenses using their radar, and command posts engaging in electronic communications. These activities readily draw the attention of drones if in the vicinity.

Systems engaged in offensive operations are particularly noticeable by drones due to their large concentrations and activities that magnify their signatures. In *On War*, Clausewitz notes that the “defensive is a stronger form of fighting than the attack.”⁷³ Consequently, the attacker (as a rule of thumb) requires at least three times the combat power than the corresponding defender. Generating this combat power requires high concentrations of systems, increasing the chances of discovery by drone surveillance. These systems' activities also render them vulnerable to drone detection. Attacking combat forces typically employ fires and maneuver against the defender. These activities enable drones to readily identify multiple combat systems. During offensive operations, the rear-

⁷² For a discussion of new hyperspectral camouflage advances, see “Now you see it. Now you don't,” *Economist*, April 1, 2023, 62–63.

⁷³ Clausewitz, *On War*, 84.

area infrastructure is also engaged in activities that boost their signatures. Artillery typically provides large amounts of firepower in support of maneuvering combat forces. During attacks, command and control nodes transmit orders to exploit emerging tactical opportunities. Supplies—in particular, large quantities of fuel and ammunition—are pushed forward to support attacking forces.⁷⁴ Moreover, the rear-area enterprise is continually being pulled forward to support the attack, increasing the likelihood of system detection.

By contrast, drones have more difficulty striking an opponent in a defensive posture. Defending combat forces are less concentrated in terms of high-signature systems per unit area. At least initially, these forces are often camouflaged to deceive attackers. Defenders can pre-position supplies closer to frontline forces, lessening the need for logisticians to transport supplies forward. Defenders typically require lower amounts of fuel and ammunition than an attacker, although this supply calculus is offset to some degree by a defender's higher requirements for mines and barrier equipment. Another offset is that most conventional forces employ a mobile defense, whereby frontline forces might give up ground and, at some point, a reserve may be employed. The employment of this reserve will be as noticeable as an attacking force, but reserves are typically smaller due to expected attrition of attacking forces.

The narratives of the civil wars in Libya, Syria, and Ethiopia support our assertion that drones have an advantage against an attacking opponent. In all three conflicts, one side was

⁷⁴ See U.S. Army Field Manual (FM) 101-10-1/2, Staff Officers' Field Manual: Organizational, Technical, and Logistical Data Planning Factors – Volume 2, (Washington, D.C.: GPO, 1987) for logistics planning data.

conducting a successful offensive. In Libya, the LNA had pushed GNA forces hundreds of kilometers to the West,⁷⁵ threatening the capital of Tripoli. In Syria, government forces and their allies had successfully advanced against Turkish-supported rebel forces along an 80-kilometer-wide front into Idlib province.⁷⁶ In Ethiopia, Tigray rebels had pushed government forces 200 kilometers to the south, approaching the capital of Addis Ababa. In all three conflicts, the attacker seemed on the cusp of victory. All three defenders then launched a combination of drones and (in some cases) other complementary assets. The overall effect not only stopped the attack, but the GNA, Turks, and Ethiopians were also able to launch wildly successful counteroffensives. The GNA was able to push LNA forces out of Tripoli, advance hundreds of kilometers, and threaten the LNA stronghold of Sirte. The Turks were able to push Syrian forces back, enabling pro-Turkish rebels to capture key terrain in the south of Idlib province.⁷⁷ The Ethiopian example is perhaps the most dramatic. Earlier missteps by the Ethiopian army had resulted in its retreat south from the Tigray region. As the rebels were pushing south, they were joined by other anti-government forces. The fall of the capital and the establishment of a new regime appeared imminent. The surprise introduction of drones by government forces completely reversed the situation, with the rebels being pushed back into Tigray.⁷⁸ The similarities of these three conflicts suggest that drones have an advantage when employed against forces conducting offensive operations. The results are remarkable, as a few retreating forces can suddenly

⁷⁵ Ritter, "Like horse-mounted cavalry against tanks."

⁷⁶ Jennifer Cafarella, John Dunford, Michael Land, and Blane Wallace, "Turkey Commits to Idlib," *Institute for the Study of War*, (March 18, 2020), <https://www.understandingwar.org/backgrounder/turkey-commits-idlib>.

⁷⁷ Cafarella, Dunford, Land, and Wallace, "Turkey Commits to Idlib."

⁷⁸ Joshua Dunne, "Turkish drones are destroying Ethiopia's promise of peace," *Australian Strategic Policy Institute*, The Strategist (blog), October 25, 2022, <https://www.aspistrategist.org.au/turkish-drones-are-destroying-ethiopia's-promise-of-peace/>.

execute a successful counterattack. Such a change in fortunes is reminiscent of the outcomes of successful turning movements—a form of maneuver that we noted as similar to drone operations.

If drones are so effective when employed against an attacker, then how do we explain the subsequent counteroffensive successes of Libya, Syria, and Ethiopia against their opponents? In all three cases, drone overmatch facilitated a successful counterattack. Libya's and Syria's drones and tactics were superior to those of their opponents, while Ethiopia's opponent did not have drones. Further, many of the GNA, Syrian, and Tigray forces did not go immediately from offensive operations to a defensive posture but were instead in full retreat. The rearward movement of these multiple systems boosted their signatures, facilitating drone identification and engagement.

One conflict in Table 2 seems to contradict the principle that drones are more effective when employed against forces engaged in offensive operations. During the Second Nagorno-Karabakh War, Armenian forces were in a deliberate defense. When Azeri forces used drones in their offensive, Armenian defenders were firmly defeated and driven out of Nagorno-Karabakh in 44 days. One reason for the exceptional effectiveness of offensive drones in this conflict was the limited size of the operational area relative to the range of Azeri drone aircraft. As a result, limitations on drone loiter time did not limit drone range. Once Azeri drones broke through Armenian air defenses, they could apply quasi-maneuver attributes throughout the entire operational area. Table 3 illustrates this situation by comparing drone range to the dimensions of the operational area.⁷⁹ Table 3 shows that this

⁷⁹ The operational area is defined as the central and southern parts of Nagorno-Karabakh, comprising over one half of the disputed region. By seizing control of this region, Azerbaijan effectively cut Nagorno-Karabakh off from Armenia proper.

operational area was well under the round-trip range of the main drones employed by Azerbaijan: the Turkish TB2, and the Israeli Harop and Orbiter 3. The technical fact that drone range easily spanned the operational area mitigated drone space limitations.

Dimension	Operational Dimensions (Approx.)	Azerbaijani Drone Range (Round-trip)		
		TB2	Harop	Orbiter 3
Range	30-65km	150km	100km	50km

Another reason for the exception was that the Azeris apparently had identified many Armenian targets prior to the start of the conflict.⁸⁰ As a result, the Azeris did not need the Armenians to engage in high-signature offensive activities to identify targets. Rather, Azeri drones could immediately attack the pre-identified targets.

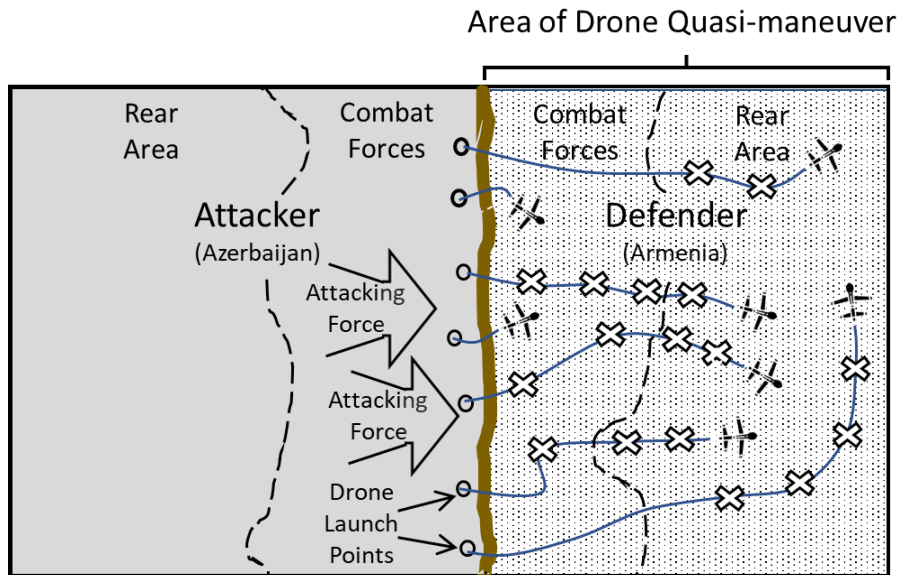


Figure 3. Conceptual Sketch of Nagorno-Karabakh

Figure 3 illustrates the Azeri advantages in employing drones. Azeri drones could apply quasi-maneuver effects throughout the operational area, while the pre-identified Armenian

⁸⁰ “Drones and Maneuver Warfare,” 111.

positions facilitated drone strikes on targets in situ. These advantages boosted drone effects, enabling Azeri ground forces to follow behind the drone strikes.

The conflict was also unforgiving to Armenian missteps, given these Azeri advantages. Armenian missteps included falling for the Azeri ruse, insufficient drone capability, and insufficient use of cover and concealment. The Azeri ruse caused the Armenians to turn on their air defense radars, facilitating their identification and destruction by Azeri drone strikes. Armenian drones were considerably fewer and lower quality than the Azeri drone fleet, constraining their ability to strike advancing Azeri ground forces.⁸¹ Armenian vehicles behind frontline forces tended to clump together in the open without any dispersion or camouflage, enabling Azeri drones to easily identify and destroy them.⁸² These missteps might not have been fatal in an operational area of greater depth, which would have allowed the Armenians to re-establish defenses beyond the range of Azeri drones. Unfortunately for the Armenians, factors of range and distance worked against them.

Drone Operations can Result in a Stalemate

Under certain conditions, drone operations can result in a stalemate. One important principle with regard to this premise is high-signature systems are often *high-value assets* and, by definition, necessary for successful operations.⁸³ This linkage between high-signature and high-value assets is due to the physics of system design. High-signature

⁸¹ Robin Forestier-Walker, "Nagorno-Karabakh: New weapons for an old conflict spell danger," *Al Jazeera*, October 13, 2020, <https://www.aljazeera.com/features/2020/10/13/nagorno-karabakh-new-weapons-for-an-old-conflict-spell-danger>.

⁸² Hambling, "The 'Magic Bullet' Drones Behind Azerbaijan's Victory Over Armenia."

⁸³ In this paper, high-value target and high-value asset/system will be used interchangeably. A high-value target is "a target the enemy commander requires for the successful completion of the mission." Found in DOD Dictionary of Military and Associated Terms, 97.

characteristics are necessary to generate critical battlefield effects such as firepower, movement, and EM activity. Since high signatures are not a desirable system attribute in operations, the benefit of these effects logically must outweigh the increased vulnerability due to a high signature. Drones have overturned this calculus by increasing the vulnerability of high-signature systems while the benefit remains unchanged. This vulnerability is magnified during an attack, when signatures are highest. Consequently, drones have become an ideal instrument to disrupt an attack by destroying multiple high-value targets.

In a general sense, a stalemate occurs when each side's defensive capabilities outweigh the opponent's offensive capabilities. If both sides have drones, a stalemate can occur, provided all three of the following conditions are met: (1) there is sufficient operational depth to withstand a massed drone attack; (2) both sides have comparable capabilities; and (3) each side can regenerate its depleted drones and high-value assets. The cycle of stalemate would proceed as follows: first, the concentrated high signatures of the attacker are readily identified by the defender's drones, which are then able to destroy sufficient high-value targets of the attacker to stop the offensive. Eventually, time and space limitations disrupt drone operations. The result is the loss of high-value ground systems (for the attacker) and drones (for the defender). If there is sufficient operational depth, the attacker can mitigate this damage by keeping some high-value assets—including drones—out of range of the drone strike. If the defender subsequently engages in a counterattack, his high-value assets will meet the same fate at the hands of opposing drones. If the opponents are near-peer, neither will likely obtain a breakthrough due to an inability to attain a technological or quantity overmatch. As drones and other forces are reconstituted

on both sides, this cycle will repeat itself. Conditions of force parity, reconstitution, and operational depth maintain the status quo.

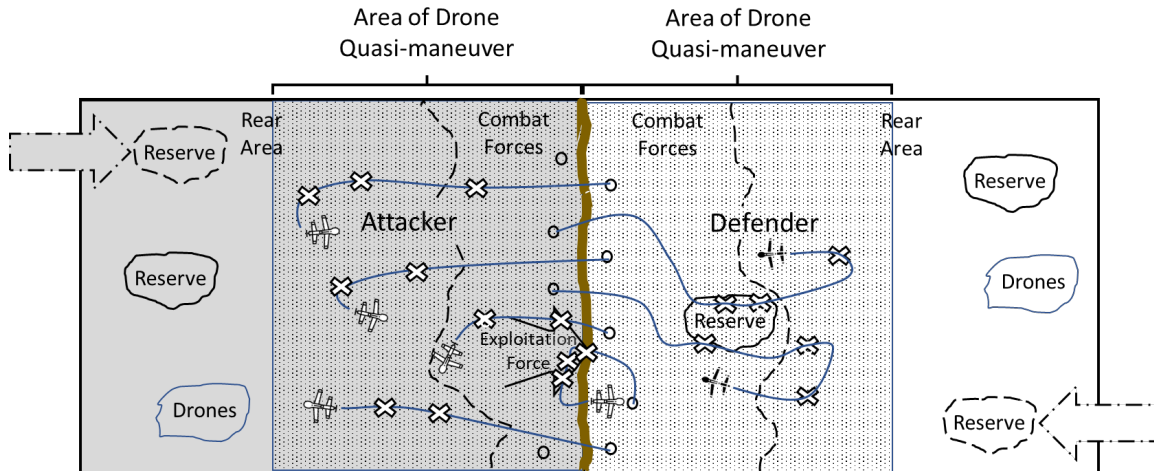


Figure 4. Conditions for Stalemate

Figure 4 illustrates this cycle. Both sides meet the conditions of parity, reconstitution, and operational depth, and both have a similar drone capability. During offensive operations, the attacker's systems will display higher signatures than the defender's. Consequently, the attacker will suffer greater losses by drone strike. This uneven loss calculus, coupled with the depth of the operational area, enables the defender to absorb an attack while losing many drones. A counterattack will likely be defeated because factors of depth and drone vulnerability will now work against the former defender. As both sides reconstitute their forces, this cycle will continue.

Russia's ongoing invasion of Ukraine (Russia-Ukraine War) exemplifies how drone operations can lead to a stalemate. Over the course of the conflict, we see our three conditions for stalemate increasingly being met. From the start, operations have been conducted over areas of great depth. The initial phases of the conflict can be characterized by great amounts of territory being gained and lost on both sides. In the Kiev operational

area, Russian forces penetrated nearly 90 kilometers from Belarus and withdrew in a little over a month. From May to July 2022, Russia consolidated its gains in the east, amounting to a huge area of roughly 100 by 460 kilometers. From September to November 2022, Ukraine was able to regain significant portions of the Kharkiv and Kherson regions. These large territorial changes did not bring the conflict to a conclusion, suggesting that the first condition of stalemate (operational depth) had been met. The frequent changes in the side that has the initiative on the surface suggests both sides have comparable capabilities with one exception. Initially, Ukraine had a clear advantage in drone operations, but over time this advantage has evaporated. Now, many publications rate Russia's and Ukraine's drone capabilities as roughly even,⁸⁴ suggesting that both sides have comparable capabilities, meeting our second condition for stalemate. Even though Ukraine and Russia have lost many high-value military systems—including drones—both countries have so far been able to replenish these systems,⁸⁵ meeting the final condition for stalemate.

Neither the Russians nor the Ukrainians have been able to conduct substantive offensive operations as our three conditions have been increasingly met.⁸⁶ Since Ukraine's Kherson offensive, which began in late August 2022, both Russia and Ukraine have launched major counteroffensives. Russian gains in the Bakhmut area were negligible,⁸⁷

⁸⁴ "Inside Ukraine's drone war against Putin," *Economist*, August 27, 2023, <https://www.economist.com/europe/2023/08/27/inside-ukraines-drone-war-against-putin>.

⁸⁵ *Unmanned Aircraft Systems: Roles, Missions, and Future Concepts*, R47188, (Congressional Research Service: Washington, D.C., July 18, 2022), 25, <https://crsreports.congress.gov/product/pdf/R/R47188>.

⁸⁶ This news has not been invisible to press. Press reports have characterized this stalemate in terms of the difficulty of conducting operations under a real-time surveillance regime combined with precision munitions. See "Warfare after Ukraine," *Economist*, 12. This linkage was observed even prior to hostilities when open source intelligence (OSINT) identified Russian military activity not only in Belarus but also within Russian territory along the Ukrainian border. OSINT and other forms of intelligence enabled Ukraine to prepare for the start of the conflict. See "An Open Book," *Economist*, January 21, 2023, 51–52.

⁸⁷ Slow Russian gains with large casualties described in *Economist*, "Hills to die on" January 7, 2023, 34–35.

whereas the Ukraine 2023 summer offensive saw only minor advances.⁸⁸ Anticipating the 2023 Ukrainian summer offensive, Russian ground forces emplaced multilayered defensive measures,⁸⁹ including obstacles and trench systems reminiscent of WWI—a conflict almost defined by stalemate. It is unclear if one of the purposes of these defensive measures is to limit the need to employ mobile reserve forces, which could possibly be detected and targeted by Ukrainian drones. The conditions of stalemate and the lack of substantive offensive operations have continued during the winter of 2023–2024.

While we argue that three conditions can result in a stalemate, it is unclear if there are other causal factors in the case of the Ukraine conflict. For example, operations during the stalemate period have occurred mainly in eastern Ukraine—a region characterized by more open terrain, enabling armored forces to disperse. Although terrain is an important factor in operations, it is unclear if the terrain in the eastern Ukraine theater is a necessary or sufficient condition for the type of stalemate argued in this paper.

Support from the Oryx Data for Second Premise

The Oryx data provide only partial support to our second premise because (1) they do not fully span the relevant phases of the Russia-Ukraine War, and (2) Russia possessed less drone capability at the beginning of the conflict.

Concerning the first part of this (second) premise—that drone operations are best utilized against an attacker: unlike Oryx data for other conflicts, the Ukrainian and Russian

⁸⁸ Slow Ukrainian advance and comparison to First World One Western Front found in *Economist*, “Warfare after Ukraine,” 3–5.

⁸⁹ A detailed description of Russian fortifications found in Seth Jones, Alexander Palmer, and Joseph Bermudez Jr, *Ukraine’s Offensive Operations: Shifting the Offense-Defense Balance* (Washington, D.C.: Perth Center for Strategic and International Studies Brief, 2023) <https://www.csis.org/analysis/ukraines-offensive-operations-shifting-offense-defense-balance>.

Oryx photos have the approximate time of the incident,⁹⁰ enabling us to sort the data by offensive/defensive phases of the war. Sufficient data are available to examine two phases of the conflict: (1) the time frame of the Russian Kiev offensive (February through April 2022) and (2) the time frame of the Kherson counteroffensive (August through November 2022).⁹¹ During the Kiev offensive, Russian forces were on the offensive, while Ukrainian forces were on the defense. During the Kherson counteroffensive, the situation was reversed, with the Ukrainians on the offensive and Russian forces were on the defense. During these phases, both Ukraine and Russia employed drones.

Given our premises, one would predict that the attacker during these phases should suffer more drone-induced equipment losses than the defender. Tables 4 and 5 display the equipment losses from drone strikes for both time frames. The units of measure for these tables are the same as for Table 2.

Losses by Country	Ground Equipment Losses from Drone Attack					
	Armor	C-drone	Indirect Fire	Node	Truck	Total
Russia (Attacker)	7	11	6	3	21	48
Ukraine (Defender)	1	0	1	0	0	2
Total	8	11	7	3	21	50

Losses by Country	Ground Equipment Losses from Drone Attack					
	Armor	C-drone	Indirect Fire	Node	Truck	Total
Russian (Defender)	6	2	2	0	2	12
Ukraine (Attacker)	6	9	14	0	4	33
Total	12	11	16	0	6	45

On the surface, the Oryx data for the Russia-Ukraine War seem to clearly show the advantage of using drones against an attacker than a defender, as our premises would

⁹⁰ Confirmed by Oryx in an email on June 20, 2023.

⁹¹ Over forty observations are available for each phase meeting the statistical threshold for random samples.

suggest. For the Kiev offensive (Table 4), the attacker (Russia) had significantly more equipment losses from drone strikes than the defender (Ukraine). When we examine the Kherson counteroffensive, we see the same trend (Table 5). The attacker (Ukraine) had more equipment losses from drone strikes than the defender (Russia). Nevertheless, one should note that the data have possible biases in two areas: drone proficiency and missing data.

The Kiev offensive occurred at the beginning of the war, when Ukraine was more proficient in drone operations than Russia. The greater Russian equipment losses in Table 4 could be wholly due to this differential proficiency, rather than to Russia's conducting offensive operations.

For the Kherson counteroffensive, the absence in the Oryx data of Ukrainian drone attacks after 4 September 2022 places the analysis into question. Since the Kherson counteroffensive lasted until November 11, 2022, we could be missing approximately two months of data on additional Russian equipment losses. As a result, Russian equipment losses in Table 5 could be greater than 12 and even exceed total Ukrainian losses of 33. We corresponded with Oryx to determine the cause of this lack of data. Oryx confirmed that there were no publicized Ukrainian TB2 drone strikes after 4 September 2022 but said that the reason was unclear.⁹² Consequently, all we can conclude for the Kherson Offensive is that the available data are consistent with our premises, but there could be missing data on Russian equipment losses that overturn these results. Additional data and analysis are required to support this part of our premise.

⁹² Email correspondence with Oryx (August 23, 2023).

Similarly, the Oryx data only partially support the second part of the premise that drone operations can result in a stalemate under conditions of depth, parity, and replenishment. This ambiguity is due to the same drone proficiency issue.

If drones were a significant contributing factor to this stalemate, we would expect more successful drone strikes during the stalemate period. We examined the Oryx data to measure cumulative drone strikes over time to check this suggested outcome. In the Russia-Ukraine War, the stalemate began after the successful Ukrainian Kherson counteroffensive (September 6 to November 11, 2022). Beginning November 12, 2022, a period called the “winter stalemate” ensued. This stalemate continued through 2023 despite attempts by each side to conduct significant offensive operations. We will test this premise with successful Russian drone strikes on Ukrainian equipment because this data spans both the non-stalemate and the stalemate periods.⁹³



Figure 5 displays cumulative Russian drone strikes that resulted in the loss of Ukrainian equipment. Two periods are depicted in the data: (1) from the beginning of the conflict to the end of the Kherson counteroffensive (February 2022 through November 11, 2022); and

⁹³ We cannot test this premise with successful Ukrainian drone strikes because the data ends prior to the stalemate period.

(2) from the beginning of the winter stalemate to when the data end (November 12, 2022 through May 4, 2023). The end of data encompasses some portion of the battle for the city of Bakhmut. The data cover roughly 15 months (February 24, 2022 through May 5, 2023). The first nine months characterized by maneuver saw 38 percent of the total successful Russian drone strikes, while the subsequent stalemate period of six months saw 62 percent of the total successful drone strikes. The higher number of successful drone strikes during the shorter stalemate period seems to support our premise's suggestion that periods of stalemate are associated with successful drone strikes.

As mentioned previously, the increase in drone strikes over time could be due to improvements in Russian drone capabilities, rather than the latter stalemate period. Consequently, additional data and analysis are required to fully substantiate our claim.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIVENESS OF DATA

Our findings should be considered an analytical *mark on the wall* for subsequent papers armed with better data to confirm or refute. Examining five conflicts and the corresponding drone data, our assessment found considerable support for our two premises: (1) drones do, indeed, have quasi-maneuver aspects that extend the maneuver space; and (2) drones have advantages when employed against an attacking opponent that (under certain conditions) could result in a stalemate. This paper used 951 incidents of equipment losses due to drone strike. While the number of losses varied by conflict, every conflict except for the Ethiopian Civil War had more than 40 data points. It is unlikely that the data were completely devoid of selection bias since they favored drones that could provide visual evidence and situations where observers on the ground were able to obtain this evidence.

Even when these conditions were met, the collector of the visual evidence had also to be willing to post the information on Oryx. This being said, we are aware of only one case where a polity could have been withholding visual evidence: Ukraine's documentation of Russian equipment losses after September 4, 2022. It should also be mentioned that some drones with lower capabilities than the four drones included in the Oryx data were excluded from our study. Given the rapid evolution of drone technology, these more advanced drones are a better proxy for future drone trends. We believe these biases were small and did not compromise our analysis, although we stress the need to reexamine this paper's conclusions when better data become available.

Our examination, however, sought to assess whether our premises—(1) drones have quasi-maneuver aspects that extend a battlefield's maneuver space and (2) drones can lead to stalemates—are transformational in modern warfare. We will examine each premise separately, recognizing that the second premise builds on the first.

EXTENDING MANEUVER SPACE: NOT TRANSFORMATIONAL

Our first premise, which involves the observation that maneuver space now extends on an axis into the opponent's rear area, is not in itself transformational. Drone quasi-maneuver aspects are remarkable; however, these effects are limited by time and space. At best, drone operations can generate a similar outcome as a turning movement, forcing an opponent to abandon its positions or divert forces, often at a great cost. This drone capability by itself does not negate the modern-system's emphasis on cover, concealment, dispersion, small-unit independent maneuver, and combined arms integration; nor does it negate the need for an attacker to concentrate forces (to achieve a breakthrough) or a defender to have reserves (to counter this possibility). From this viewpoint, drone quasi-

maneuver aspects are a variation to other well-established means of rapidly inserting ground maneuver capabilities into the rear area (e.g., airborne forces, helicopter-borne forces). The variation is that drones manifest quasi-maneuver effects along a continuous axis into the rear area, whereas airborne and helicopter-borne forces generate maneuver characteristics only when deposited on the ground (not en route). While drones represent a significant variation, as with other means of inserting ground maneuver capabilities into the opponents' rear area, they still will not overturn the modern-system.

STALEMATES FROM DRONE OPERATIONS: TRANSFORMATIONAL

The second premise—that drone operations can result in a stalemate—is transformational. Biddle notes that the concentration of exploitation forces (for the attacker) is fundamental to modern-system operations. This contention assumes that such forces can be constituted behind front lines with prudent security measures. Drone quasi-maneuver characteristics along an axis into an opponent's rear area interfere with the constitution of these forces. Even if an attacker constitutes exploitation forces beyond the range of opposing drones, attacking forces must at some point move through a breach. This large concentrated force of high-value assets will be detected by drones well before reaching the breach. The temporal lag in drone effects and countermeasures enables drone operations to disrupt the exploitation force. Without a successful exploitation, modern-system principles for offensive operations break down. Even though circumstances for the failure of the modern-system rely on several accompanying conditions—of parity, reconstitution, and operational depth, their coming together portends more frequent

stalemates, necessitating different approaches to operations that consider warfare's new character.⁹⁴

One should note that new technological advances could overturn the claim that drone operations are transformational. Drone countermeasures could evolve to a degree that there is barely any lag between drone breakthrough and expiration. If this eventuality occurs, drones will have no impact on the modern-system.

Assuming such technological advances in drone countermeasures will not occur any time soon, what can be done to improve drone capabilities—and counter-drone defenses? The sections that follow address this issue.

RECOMMENDATIONS TO IMPROVE DRONE OPERATIONS

As quasi-maneuver assets, drones will improve their operations by employing combined arms—analogue to the ground-maneuver practice of integrating with different types of forces based on the situation. Infantry, armor, combat engineers, combat aviation, and other frontline units must be prepared to operate closely together so as to complement each other's strengths and weaknesses. For example, infantry and armor can provide direct fires on a variety of targets but may need engineers to breach obstacles or the suppressive fires of artillery to maneuver near an opponent.⁹⁵

Drones have already diversified their capabilities to obtain a combined-arms capability of sorts. In Nagorno-Karabakh, the Azeris employed different types of drones for different tasks. The Russia-Ukraine War has also seen drone diversification, such as the previously mentioned incorporation of electronic warfare capabilities into the Russian Orlan-10 drone.

⁹⁴ Concerning changing character of warfare see Clausewitz, *On War*, 89.

⁹⁵ Characteristics of combined-arms integration described in Biddle, *Military Power*, 37–39.

Nevertheless, drone size, weight, and power (SWaP) considerations limit the possibilities for drone-borne effects.

Overcoming SWaP limitations requires linkages among drones and other systems. Integrating drones with indirect fire systems is one example of this principle, but another possibility might be to integrate drone operations with airborne and helicopter-borne ground forces. These forces would work together with drones, manifesting quasi-maneuver effects en route and ultimately manifesting full-maneuver effects once ground forces deployed from aircraft. One vital task of these deployed ground forces would be to provide a base for drones in order to extend their axis further into the rear area. Ground forces could thus continue to penetrate into the enemy's rear area in a leapfrog manner. Aspects of this idea are hardly new; the fundamental idea of teaming of manned aircraft and drones is at least ten years old.⁹⁶ Another idea is to use air-deployable containers to transport unmanned systems along the drone axis. These unmanned systems would generate combined-arms effects in support of drone operations and could be stationary or mobile. Moreover, the air-deployable containers could also transport drones to extend their range. A third idea would be to infiltrate light infantry forces behind enemy lines to generate ground-maneuver effects in support of drone operations. These measures and their variations can potentially increase the combined-arms possibilities for drone operations.

RECOMMENDATIONS TO IMPROVE COUNTER-DRONE OPERATIONS

One approach to counter-drone efforts is to operate like maneuver forces, given the quasi-maneuver aspects of drones. Counter-drone assets will need to more fully embrace

⁹⁶ David Vergun, "Apache-UAV teaming combines 'best capabilities of man, machine'," *U.S. Army News Service*, May 8, 2014, <https://www.google.com/search?q=U.S.+Army+News+Service>.

maneuver principles such as combined arms, terrain, depth, and reserve forces. Like conventional combined arms, different drone countermeasures can be integrated, based on the situation. Terrain will become a major consideration, as drones become better at utilizing irregular features for cover and concealment. Achieving effective drone utilization of terrain could require developing specialized countermeasures. Both vertical and horizontal depth will be required to absorb a drone attack; once such depth is achieved, however, counter-drone systems will need to find novel ways of protecting the force to bide time for employment of counter-drone reserve forces, *a la* Biddle's modern-system. These reserves will need mobility to intercept a massed drone attack. One already proposed solution is to mount countermeasures on drones to form a speedy reserve.⁹⁷

Another more radical approach is to break the link between high-signature and high-value assets; doing so will require an entirely new approach to military ground systems. How this goal can be practically accomplished is currently the stuff of imagination. One option could employ a form of stealth technology to protect high-value ground assets similar to air and sea forces.⁹⁸ Another approach is to evacuate high-signature assets rearward, out of range of opposing systems. Yet another option is to confuse drone identification of high-value assets by distributing signatures across multiple systems. A variation of this idea is to design systems with similar signatures. Perhaps the best solution lies in a combination of different approaches.

⁹⁷ J. R. Wilson, "The New World of Counter-drone Technology," *Military & Aerospace Electronics*, November 1, 2018, available at <https://www.militaryaerospace.com/unmanned/article/16707131/the-new-world-of-counterdrone-technology>.

⁹⁸ For evolving system camouflage technics see "Now you see it. Now you don't," *Economist*, 62–63.

SUMMARY

As a contrasting view to the Calcara article, this paper argues that drone operations resulting in a stalemate are transformational in the context of Biddle's modern-system. We used a data-centered analytical approach of five conflicts to support our premises that drone operations (1) have quasi-maneuver aspects that extend the maneuver space and (2) have advantages when employed against an attacking opponent that could result in a stalemate. The Calcara paper's assertion of drone vulnerability is correct but this vulnerability is mitigated by drone attritability and temporal lag (between drone effect and countermeasure). Our analysis revealed other insights, albeit supported by limited data: drone operations resemble turning movements; and drone-generated stalemates require conditions of parity, reconstitution, and operational depth.

As of this writing, this paper's claims are bolstered by current events, with a continuing stalemate in the Russia-Ukraine War even as drone attacks along the front line increased from July 2023 to January 2024.⁹⁹ Drone innovations also have advanced, not only in the air but also on land and at sea. Currently, the most popular drones on the both sides of the Russia-Ukraine War are first-person-view (FPV) drones, where operators watch a video feed through goggles, providing a literal birds-eye-view. Since August 2023, FPV drone strikes have increased every month, with 1,800 strikes in January 2024 alone. FPV pilots can strike with remarkable precision, aiming at the vulnerable points of a tank or driving infantry out of intricate trench systems. Significantly, evolving tactics indicate that FPVs

⁹⁹ "How cheap drones are transforming warfare in Ukraine" *Economist*, February 5, 2024, 13–15, <https://www.economist.com/interactive/science-and-technology/2024/02/05/cheap-racing-drones-offer-precision-warfare-at-scale>.

work best when utilized with other arms, such as indirect fires and infantry¹⁰⁰—another recommendation of this paper. These combined arms tactics are so routine that Ukrainian assault forces of up to 16 soldiers have a complement of almost as many drone operators.¹⁰¹

Meanwhile, advances in drone measures and countermeasures continue. Although electronic jamming of drones persists, substantial numbers of drones manage to get through and carry out their missions, indicating a temporal lag between drone capabilities and countermeasures. As these trends persist, the voices that drones will “revolutionize warfare” seem to grow louder.¹⁰²

¹⁰⁰ As reported on “FPV drone talk with Daniele, Andrew Perpetua and Jonathan Pearce,” *Tochnyi*, podcast, January 11, 2024, <https://www.youtube.com/watch?v=R4as5UMtjIE>.

¹⁰¹ “How cheap drones are transforming warfare in Ukraine,” *Economist*, 5 February 5, 2024.

¹⁰² “How cheap drones are transforming warfare in Ukraine.”

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