Lethal Unmanned Aircraft Systems: Democratizing Air Power

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Kutz, Thomas J.

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14. ABSTRACT

The United States has dominated the skies in every conflict since World War Two but with the exploding proliferation of low-cost lethal UAS, operational commanders will no longer be able to assume the air domain is secure - they will have to deliberately contest it. What makes this new trend so disruptive in terms of operational planning and employment is that UAS are (comparatively) inexpensive to acquire and simple to operate. A modest military power can field dozens or even hundreds of combat UAS. Small and medium-sized lethal UAS have arisen as low-cost, combat-proven alternatives to traditional strike aircraft. UAS are proving inherently difficult to detect via sensors designed against traditional aircraft, and will require dedicated solutions to counter the. These weapons systems are redefining and democratizing airpower, fusing multiple joint functions into single tactical platforms that can be operated by a small team with limited training. In any future conflict, the U.S. should expect to face an increasingly-mature array of multi-mission UAS of all sizes and varieties. The JFACC will share airspace with the enemy once again, something that hasn't happened in any real sense since the first night of Desert Storm.

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The United States has dominated the skies in every conflict since World War Two, and the American military has not lost a member on the ground to an enemy aircraft since 1953. Joint commanders and planning staffs have been able to assume air superiority and thus the safety of their uncommitted or rear echelon forces. This assumption dramatically simplifies their operational design. However, this monopoly on air power is diminishing, and the risk to U.S. forces in a future operation is very real. Recent conflicts have demonstrated the effectiveness and battlefield impact of small and medium-sized lethal unmanned aircraft systems (UAS), and the popularity and pervasiveness of these weapons is rapidly increasing. With the exploding proliferation of low-cost lethal UAS, operational commanders will no longer be able to assume the air domain is secure - they will have to deliberately contest it.

There are three converging UAS trends which are creating this revolution in military affairs that will drive the future of warfare. First, the technological and financial barriers associated with UAS are dramatically lower than those associated with traditional combat aircraft. Second, despite their reduced cost and complexity, UAS are remarkably efficient at killing high-tech armored vehicles and achieving pin-point accuracy against critical components of larger targets like bridges, buildings, and warships. Finally, small/medium UAS and their associated components are inherently difficult to detect and defend against without a significant investment in purpose-built counter-UAS sensors and weapons systems.

A Brief History of Unmanned Aircraft

UAS is a broad category of diverse flying vehicles which have evolved over the past two centuries. Like many technologies throughout history, UAS developments have been driven by

military applications.[1] The first use of unmanned aircraft in combat took place in 1849, when Austrian forces launched 200 balloons loaded with bombs against an enemy fortress.[2]. In 1915, Nikola Tesla conceived a fleet of unmanned aerial vehicles that could be used in combat,[3] but it was Archibald Low who made the world's first successful radio-controlled flight in 1924.[4] This invention of the radio-frequency (RF) datalink was instrumental in unlocking the combat power of UAS, and in 1944, the Germans launched the revolutionary long-range lethal unmanned V1 "buzz-bomb" at Allied forces in France and England.[5] During the Cold War, UAS shifted away from offensive action and towards unarmed reconnaissance in environments which posed too much risk for human pilots.

Writing for Air Power Journal in 1991, Capt Brian Tice, USAF, stated that "UAVs should generally perform missions characterized by the three Ds: dull, dirty, and dangerous."[6] Since then, the MQ-1 Predator emerged as the world's first long-endurance, over-the-horizon UAS. After decades of "dull" Intelligence Surveillance and Reconnaissance (ISR) employment from Bosnia to Operation Enduring Freedom and beyond, the MQ-1's success sparked an explosion in UAS technology innovation. Meanwhile, modern and deadly air defenses have also been proliferating, and the ever-increasing risk to manned platforms is driving a growing demand for UAS tailored to tackle "dangerous" missions like armed reconnaissance and battlefield interdiction behind enemy lines.

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[1] Fahlstrom, Paul, and Thomas Gleason. 2012. *Introduction to UAV Systems*. Chichester, West Sussex: John Wiley & Sons. 4.
[2] Vasile PRISACARIU. 2017. "THE HISTORY and the EVOLUTION of UAVs from the BEGINNING till the 70s." *Journal of Defense Resources Management* 8: 181–89. 183.
[3] Ibid. 184.
[4] Ibid. 4.
[5] Ibid. 186.
[6] Tice, Brian. 2014. "UNMANNED AERIAL VEHICLES." Archive.org. 2014. https://web.archive.org/web/20090724015052/http://www.airpower.maxwell.af.mil/airchronicles/apj/apj91/spr91/4spr91.htm.

UAS Classification and Terminology

Now that unmanned aircraft systems have become so prevalent, proper classification of these aircraft has become quite challenging and the terminology often ambiguous. According to Paul Fahlstrom and Thomas Gleason, there are three kinds of aircraft, excluding missiles, that fly without pilots. Unmanned aerial vehicles (UAV), remotely piloted vehicles or aircraft (RPV / RPA), and drones.[7] For the purposes of this paper, the distinction is not terribly important. The full complement of air vehicle, control station, and data links is the "unmanned aerial system", or the UAS. For the purposes of simplicity, all unmanned vehicles will be referred to as UAS. The following table describes UAS characteristics in terms of size, payload, and common missions.[8]

Unmanned Aircraft Systems				
	Very Small	Small	Medium	Large
Size (feet)	< 2	2 to 6	6 to 30	> 30
Payload (lbs)	1 to 2	2 to 25	220 to 440	400 to 2000+
Missions	ISR	ISR, Lethal, Loitering-munition, Target Designation	ISR, Lethal, Loitering-munition, Target Designation	ISR, Lethal, Target Designation
Examples	CyberQuad Mini, IAI Mosquito	Bayraktar Mini, Switchblade 300	Bayraktar TB2, Harop, Scan Eagle	Predator, Global Hawk, CH-4

Table 1: UAS Characteristics

Weapons-delivery has become the most highly watched and rapidly growing mission area, and a unique type of "kamikaze drone", the loitering munition, is taking center stage.[9] The loitering munition is a single-use UAS that integrates a lethal payload into the body of the

[7] Fahlstrom and Gleason, 8.
[8] Ibid. 8-10.
[9] Fuhrmann, Matthew, and Michael C Horowitz. 2017. "Droning On: Explaining the Proliferation of Unmanned Aerial Vehicles." *International Organization; Int Org* 71: 397–418. https://doi.org/10.1017/S0020818317000121. 31.

aircraft, which is flown directly into its target via remote control or an autonomous seeker. From a joint fires perspective, these loitering munitions blur the line between aircraft, land attack/anti-ship cruise missiles, and artillery.

This paper focuses on small and medium UAS designed for target-designation and weapons-delivery (i.e. lethal) missions, to include loitering munitions. Very small UAS lack the payload capacity to carry meaningful weapons, and large UAS are highly expensive systems that tend to be operated by large nations with correspondingly large defense budgets, like the United States, France, China, and Russia. Finally, while hostile UAS-based ISR and Electronic Warfare (EW) are of concern to the joint force, the focus of this paper is on the changing calculus of achieving and maintaining air superiority with respect to air to surface attack. While this may sound like a tactical problem, recent examples have demonstrated that these "tactical" UAS are by necessity filling operational functions for smaller militaries. Their impact on the battlefield is certainly having operational ramifications.

Recent Examples of UAS in Combat

In September 2020, Armenia and Azerbaijan's dispute over the Nagorno-Karabakh border region erupted into a 44-day armed conflict that would leave tens of thousands dead and hundreds of armored vehicles destroyed.[10] Azerbaijan employed Turkish and Israeli UAS to decimate Armenian targets, beginning with a concerted attack on air defense radars followed by deep interdiction and close air support strikes. The Azeri president, Ilham Aliyev, stated that his military was able to destroy an estimated $1B USD worth of Armenian tanks and other military

[10] Shaikh, Shaan, and Wes Rumbaugh. 2020. "The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense." Www.csis.org. December 8, 2020. https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense.

equipment through the use of Turkish UAS alone.[11] The traditional Azeri air force would never have been capable of such precision attacks at such a rapid pace, and their aircraft would have been highly vulnerable to Russian-sourced Armenian air defenses. Unmanned systems were an enormous asymmetric edge that allowed the Azeri military to integrate multiple joint functions to achieve tactical and operational effects on a highly dynamic battlefield. Ironically, Russian advisers in Armenia who witnessed the effectiveness of lethal UAS in this conflict would find their own military suffering the same fate just 18 months later.

The Russian invasion of Ukraine in the spring of 2022 is perhaps an even more shocking demonstration of the operational and strategic level effects that tactical UAS are capable of achieving. Russia appeared to have all the advantages in terms of the classic operational factors of Time, Space, and Force. Russia had a dramatic force ratio advantage and they were able to mass over a hundred battalion tactical groups (BTGs) into a narrow space along the border. The Russians enjoyed an advantage of 3:1 in terms of armored vehicles and 6:1 in tanks.[12] On paper, Russia could rapidly overwhelm the Ukrainians and use decisive operational movement and maneuver to compress the offensive timeline to their advantage, defeating Ukraine before they could really mobilize and organize their defense.

However, at the time of this writing, the Russian offensive has been a tremendous operational failure. There are many reasons for this debacle, but a crucial factor has been the out-sized impact of small/medium UAS. In 2020, Ukraine was Turkey's second-ever export customer to for the TB2 medium-sized lethal UAS, which they have put to great use in this

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[11] Kinik, Hulya and Sinem Celik. 2021. "The Role of Turkish Drones in Azerbaijan's Increasing Military Effectiveness: An Assessment of the Second Nagorno-Karabakh War." *Insight (Türkey)* 23: 169–91. https://doi.org/10.25253/99.2021234.10.

[12]" Land Power of Russia and Ukraine in Comparison 2022." 2022. Statista. March 1, 2022. https://www.statista.com/statistics/1293587/land-power-of-russia-and-ukraine-in-comparison/.

war.[13] Statistics in an ongoing conflict are to be viewed skeptically, but according to the BBC, by 11 April, Russia had lost a staggering 460 tanks and approximately 2,000 more armored vehicles. As evidenced by hundreds of high-definition videos coming from the war zone, UAS are providing timely and accurate *tactical* intelligence to Ukrainian armored and anti-armor forces, enabling ambushes and conducting their own lethal strikes. UAS are also providing crucial insight into the Russian *operational* schemes of maneuver and identifying vulnerable logistics hubs and headquarters units. Lethal UAS are the weapons of choice to strike these deep targets, since the Ukrainian manned aircraft are limited in numbers (318 UKR vs. 4173 RUS aircraft) and much less advanced than their Russian counterparts.[14] The most shocking Russian loss to date has been that of the *Slava*-class cruiser *Moskva* in the Black Sea. Details on this attack are still incomplete, but it seems clear that a Ukrainian UAS located the ship and provided over-the-horizon targeting data to a shore-launched anti-ship cruise missile battery.

Low Barriers to Entry

These recent examples do not represent capabilities that are new to the realm of airpower. Air forces have been conducting ground/maritime target designation, interdiction strikes, and close air support for decades. What makes this new trend so disruptive in terms of operational planning and employment is that UAS are (comparatively) inexpensive to acquire and simple to operate. A modest military power can field dozens or even hundreds of combat UAS. Modern fighter price tags are between $20 and $100 million and training a single fighter pilot can cost up

[13] Kinik, Hulya and Sinem Celik. 2021. "The Role of Turkish Drones in Azerbaijan's Increasing Military Effectiveness: An Assessment of the Second Nagorno-Karabakh War." *Insight (Türkey)* 23: 169–91. https://doi.org/10.25253/99.2021234.10.

[14]" Airpower of Russia and Ukraine in Comparison 2022." 2022. Statista. March 1, 2022. https://www.statista.com/statistics/1293414/airpower-of-russia-and-ukraine-in-comparison/.

to $10 million.[15] On the other hand, in 2019 Ukraine purchased 12 TB2 aircraft and 3 ground control stations (GCS) from Turkey for a reported $69 million.[16] Additional TB2 aircraft were purchased for as little as $1 million each. The TB2 is a medium-sized, long-endurance UAS capable of carrying over a120 lb payload, so it represents the upper-end of the price spectrum.[17] Small UAS like the Israeli Harop and the Turkish Bayraktar Mini are even less costly. In fact, the recently publicized American-made Switchblade 300 loitering munition is just over 2 feet long and reportedly sells for just $6,000 per aircraft.

As stated previously, fighter pilots are enormously expensive to train, and it takes years to produce a competent operator. As a result, nations with moderate defense budgets find that operating a traditional "manned" air force is so expensive that they are often only able to field a handful of squadrons. As a result, they are highly limited in mission and platform diversity. In fact, there are fewer than 9,000 total combat aircraft amongst the 10 largest air forces in the world. If one removes America, China, and Russia from the list, the next top seven nations average only 450 combat aircraft each.[18] Furthermore, most nations are unable to afford the 100+ monthly training hours per pilot to maintain mission readiness and proficiency.

Not only cheap to acquire, UAS are an attractive alternative to expensive pilot training requirements. UAS are predominantly flown via auto-pilot; operators provide minor inputs to heading, speed, and altitude through remote GCS via RF datalinks. The training curve is much more manageable as well. For example, Azerbaijan received their UAS from Turkey in June

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[15] Mattock, Michael G, James Hosek, Beth J Asch, and Rita Karam. 2016. "Retaining U.S. Air Force Pilots When the Civilian Demand for Pilots Is Growing." https://doi.org/10.7249/rr1455.
[16] Varfolomeeva, Anna. 2019. "Ukraine Signs Agreement to Procure Turkish Bayraktar TB2 Drones" 2022. https://web.archive.org/web/20190115185431/https://thedefensepost.com/2019/01/12/ukraine-turkey-bayraktar-tb2-drones/.
[17] Ibid.
[18]" Air Force - World Air Forces Equipment in Service Inventory." 2021. *Jane's World Air Forces* 54.

2020. *Less than four months later, the TB2 aircraft were devastating Armenian forces on the battlefield.*[19] There were discussions about the West furnishing Ukraine with traditional fighter aircraft, but the learning curve and maintenance "tail" associated with conventional airplanes was deemed to be not worth the potential combat utility. Instead, the US provided Switchblade 300 loitering munition systems. The first 100 systems went into theater at the beginning of April, and now less than a month later Ukrainian forces have already begun destroying Russian targets with them.[20] Now that UAS have proven themselves to be so easily employed with limited training and preparation, *operational commanders must expect all combatants of any future conflict to have a credible airstrike capability*.

Combat Effectiveness

The history of combat is rife with examples of new technologies that have changed the face of war. Often, these advancements lead to asymmetries between combatants as one side lags behind the other. In other instances, both sides suffer increased casualties while commanders grapple with a new battlefield reality. World War I saw years of stalemate and millions of casualties before the invention of armored vehicles helped shift the balance in favor of the Allies. During the interwar period, the tank and other mechanized armored forces were improved and by World War II, the German Panzer tank and combined arms warfare had become kings of the battlefield. Tanks are force multipliers that when used properly are difficult to counter. However,

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[19] Kinik, Hulya and Sinem Celik. 2021. "The Role of Turkish Drones in Azerbaijan's Increasing Military Effectiveness: An Assessment of the Second Nagorno-Karabakh War." *Insight (Türkey)* 23: 169–91. https://doi.org/10.25253/99.2021234.10.

[20] King, John, Dana Bash, Elliot Williams, Melanie Zanona, and ZolanKanno-Youngs. 2022. "Pentagon: U.S. Has Sent Ukraine 100 Switchblade Drones; Polish President: 'Hard to Deny 'That Russian Forces Are Committing Genocide in Ukraine; WAPO: Trump Says He Wanted to March to Capitol on Jan. 6. Aired 12:30-1p ET." *Inside Politics (CNN)*.

tanks' heavy armor inhibits mobility and visibility, making them vulnerable to a fast adversary that can outflank or attack them from the rear or top, where their armor is thinnest.

Naturally, fighter aircraft fit that description, but they still require specialized weapons to pierce armor of a main battle tank. Even accurate GPS-guided general purpose bombs like the well-known Joint Direct Attack Munition (JDAM) are not well suited for tackling tanks. A 500 lb blast-fragmentation JDAM may not be effective against a tank unless it scores a near direct hit, which requires the vehicle to be stationary.[21] Instead, purpose-built anti-armor warheads use small explosively-shaped charges to fire a copper slug at hypersonic speed to penetrate inches of steel and cause catastrophic damage inside the vehicle. The only catch is that these weapons be precise enough to directly strike the armored surface.

Loitering munitions like the Switchblade are essentially small airplanes built around a shaped-charge warhead and a camera.[22] The operator watches the camera feed and simply dives the weapon into the target. Simple, effective, and precise. Medium UAS like the Bayraktar TB2 carry separate armor-piercing bombs that are laser guided by the designator on board the aircraft or via a third-party. This process is also highly accurate: if the laser spot is on target, the munition will likely hit it. At the extreme end of this miniaturization trend, troops in Ukraine have taken Soviet-era RKG-3 anti-tank grenades, fitted them with 3-d printed tail fins, and modified small UAS to carry them over the battlefield.[23] For about a thousand dollars worth of equipment, Ukrainian soldiers are killing million-dollar tanks. This is changing the face of warfare as surely as the emergence of the tank itself in WWI.

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[21] Osborn, Kris. 2021. "F-35s to Launch Stormbreaker Weapons That Kill 'on the Move 'Enemy Tanks¡Br¿" 2022. https://warriormaven.com/air/f-35-stormbreaker.

[22] Hambling, David. 2015. Swarm Troopers : How Small Drones Will Conquer the World. United States? Publishing Services Provided By Archangel Ink.

[23] "Science & Technology Improvised Weapons DARPA on the Dnieper." 2022. The Economist

A maneuvering armor battalion's combat potential is significant; it causes opposing ground force commanders to anticipate a pitched battle at an unknown time and location. This uncertainty can freeze entire brigades in place, and drastically inhibit freedom of one's own maneuver. As seen in Ukraine, when coupled with anti-tank warheads, a dozen small UAS can counter maneuver warfare by interdicting entire armored columns before their potential can be realized. Like manned aircraft, UAS expand the operational reach of the joint task force commander, shaping the battlespace by slowing down time (rate of enemy advance and maneuver) and improving force ratios at decisive points.

Returning to the Nagorno-Karabakh conflict, Azerbaijan's operational design was also focused around rapid attrition of the Armenian center of gravity: armored forces.[24] By nature, armor is mobile and targeting processes often lag behind that mobility. Dynamic targeting is a real challenge that plagues even the most capable militaries.[25] The fewer platforms and steps involved in the kill chain, the more rapidly it can be executed. Today's small/medium lethal UAS are able to find their own targets and attack them directly, without waiting for an additional strike platform to arrive. Precision and small warheads also reduce the likelihood of collateral damage, which is often a critical source of delay in the dynamic targeting process.[26]

UAS Survivability & Challenges to Air Defense

Not only are UAS readily attainable, easy to use, and highly lethal, they are proving quite difficult to counter. Small/medium UAS are inherently difficult to detect via sensors designed against traditional aircraft. Their reduced physical size means that they are not only difficult to

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[24] Kinik, Hulya and Sinem Celik. 2021. "The Role of Turkish Drones in Azerbaijan's Increasing Military Effectiveness: An Assessment of the Second Nagorno-Karabakh War." *Insight (Türkey)* 23: 169–91. https://doi.org/10.25253/99.2021234.10.

[25] Laubach, Charles D. 2017. "A Game of Cat and Mouse: Intelligence and Dynamic Targeting in Operation Allied Force." 84.

[26] Cherry, Donald Lynn. 2012. Improving Joint Fire Support for 21st Century Hybrid Warfare. NWC.

see, but their radar cross section is correspondingly much smaller as well. Secondly, these UAS fly at speeds of 120 knots or below and radars often struggle to distinguish such slow-moving targets from the static background clutter. Finally, the small engines of UAS do not produce strong infrared (IR) signatures, posing a challenge for the majority of short-range air defense systems that rely on IR to target.

Another challenge in defeating the small/medium UAS is that one cannot easily target their GCS or basing locations. Not only are the aircraft themselves smaller than manned aircraft, their support infrastructure is also smaller and less-easily recognized. Small UAS are launched by hand or small catapult, and then recovered in nets or by skidding to a halt in a field or small roadway. Their control stations are typically a man-portable case with a small monitor, user interface, and an antenna. Medium UAS are portable via truck and can be launched from rails or small fields if a runway is not available. Ground control stations are usually slightly larger than the SUAS counterpart, but they are vehicle-based and rapidly mobile.

Conclusion

Small and medium-sized lethal UAS have arisen as low-cost, combat-proven alternatives to traditional strike aircraft. These weapons systems are redefining airpower, fusing multiple joint functions into single tactical platforms that can be operated by a small team with limited training. With these UAS, a nation or non-state combatant that would otherwise lack airpower capability can now overcome rugged terrain or non-contiguous theater geometry to extend their operational reach and contest air superiority by holding important targets at risk throughout the battlespace. Air defenses and airfields are subject to attack well behind friendly lines. As seen in the recent sinking of the *Moskva*, major surface combatants in littoral waters or narrow seas are

also vulnerable to UAS-based target designation and precision strikes against critical components like communications suites, weapons systems, or command and control sections.

The individual UAS platforms themselves may be limited in terms of range, sensor capabilities, and payloads. However, they are cheap and easy to operate, so they can be massed to create operational level impacts which are quite disproportionate to their cost. Furthermore, every UAS is equipped with a camera, providing dramatic imagery that can be leveraged to affect friendly and enemy morale and achieve other effects in the information domain. The recent success of the small/medium UAS is not only embarrassing Russia and bolstering support for Ukraine, it is grabbing headlines and fueling interest and investment in technologies that will only further improve the lethality and proliferation of this game changing class of aircraft.

UAS are inherently (somewhat) expendable. Loitering munitions, often referred to as suicide or kamikaze drones, are not meant to be re-used. Lethal UAS that drop munitions or designate targets are supposed to be reused, but as previously discussed, they are relatively inexpensive. An operator can afford to take risks with their unmanned systems without dedicating costly fighter escort or other protective measures. The operator and the GCS remain concealed, and any aircraft lost can be replaced and paired with the surviving GCS.

UAS have come a long way since Capt Tice's 1991 Airpower Journal article. While the "three Ds" are still a valid way of looking at the advantages of unmanned platforms, in 2022 they are not just a "force multiplier." Modern UAS represent effective airpower on the cheap. At this time, UAS are ideally a complement to manned aircraft, but for resource-constrained combatants, the ability to purchase a combat-proven "air force in a box" is a revelation. In any future conflict, the U.S. should expect to face an increasingly-mature array of multi-mission

UAS of all sizes and varieties. The JFACC will share airspace with the enemy once again, something that hasn't happened in any real sense since the first night of Desert Storm.

Recommendations

The key to defeating these small/medium UAS is a combination of passive and active measures.

Passive measures should involve enhanced mobility and camouflage, concealment, and deception (CC&D) tactics to deny the UAS operator the critical detectable signatures needed to strike targets. Smoke pots offer low-tech but effective concealment against electro-optical sensors and IR jammers can inhibit laser targeting pods. Mobility, high-fidelity decoys, and radio deception can confuse targeting and deny insight into the pattern of operational maneuver elements.

In terms of active measures, this paper previously discussed the challenges in targeting UAS. Existing technologies allow focused multi-INT collection and fusion to track SUAS back to their points of origin to enable joint fires against their suspected GCS locations. Emerging technologies should be focused on the unique characteristics of UAS, with dedicated counter-UAS systems in addition to traditional surface to air defenses geared toward the high-end threat. The US Army has identified such systems, and has a plan to incorporate mobile short-range air defense (M-SHORAD) with their maneuver elements and near fixed critical targets. But these systems are competing for funding. In the era of great-power competition, these acquisitions can not be allowed to fall below the budget cut line. Even in a high intensity conflict, small and medium UAS will certainly play a significant role.

BIBLIOGRAPHY

"Air Force - World Air Forces Equipment in Service Inventory." 2021. Jane's World Air Forces 54.

"Airpower of Russia and Ukraine in Comparison 2022." 2022. Statista. March 1, 2022. https://www.statista.com/statistics/1293414/airpower-of-russia-and-ukraine-in-comparison/.

Borsari, Federico. 2021. "The Middle East's Game of Drones: The Race to Lethal UAVs and Its Implications for the Region's Security Landscape." Italian Institute for International Political Studies. January 14, 2021. https://www.ispionline.it/en/pubblicazione/middle-easts-game-drones-race-lethal-uavs-and-its-implications-regions-security-landscape-28902.

Bronk, Justin. 2019. "AIR FORCES: APPROACHING a FORK in the SKY." Whitehall Papers 96: 52.

"Close Air Support: Actions Needed to Enhance Friendly Force Tracking Capabilities and Fully Evaluate Training. Congressional Publications." 2021.

"COMPANY NEWS; UKRAINE'S DEFENSE MINISTRY to BUY NEW BATCH of BAYRAKTAR in 2022 – REZNIKOV." 2021. Interfax : Ukraine Business Weekly.

Cooper, Julian. 2021. "The Nagorno-Karabakh War: A Spur to Moscow's UAV Efforts?" International Institute for Strategic Studies.

Cherry, Donald Lynn. 2012. Improving Joint Fire Support for 21st Century Hybrid Warfare. NWC.

Fahlstrom, Paul, and Thomas Gleason. 2012. Introduction to UAV Systems. Chichester, West Sussex: John Wiley & Sons.

Fuhrmann, Matthew, and Michael C Horowitz. 2017. "Droning On: Explaining the Proliferation of Unmanned Aerial Vehicles." International Organization; Int Org 71: 397–418. https://doi.org/10.1017/S0020818317000121.

"GLOBAL - the GLOBAL UNMANNED AERIAL VEHICLES (UAV) - UPDATED 21 MARCH 2022." 2022. Global Industry SnapShots.

Hambling, David. 2015. Swarm Troopers : How Small Drones Will Conquer the World. United States? Publishing Services Provided By Archangel Ink.

King, John, Dana Bash, Elliot Williams, Melanie Zanona, and ZolanKanno-Youngs. 2022. "Pentagon: U.S. Has Sent Ukraine 100 Switchblade Drones; Polish President: 'Hard to

Deny ’That Russian Forces Are Committing Genocide in Ukraine; WAPO: Trump Says He Wanted to March to Capitol on Jan. 6. Aired 12:30-1p ET.” Inside Politics (CNN).

Kinik, Hulya and Sinem Celik. 2021. “The Role of Turkish Drones in Azerbaijan’s Increasing Military Effectiveness: An Assessment of the Second Nagorno-Karabakh War.” Insight (Türkey) 23: 169–91. https://doi.org/10.25253/99.2021234.10.

“Land Power of Russia and Ukraine in Comparison 2022.” 2022. Statista. March 1, 2022. https://www.statista.com/statistics/1293587/land-power-of-russia-and-ukraine-in-comparison/.

Laubach, Charles D. 2017. “A Game of Cat and Mouse: Intelligence and Dynamic Targeting in Operation Allied Force.”

“LETHAL AUTONOMY.” n.d. Foreign Policy., 18–19. https://doi.org/nfo:doi/.

Mattock, Michael G, James Hosek, Beth J Asch, and Rita Karam. 2016. “Retaining U.S. Air Force Pilots When the Civilian Demand for Pilots Is Growing.” https://doi.org/10.7249/rr1455.

MAYER, MICHAEL. 2015. “The New Killer Drones: Understanding the Strategic Implications of Next-Generation Unmanned Combat Aerial Vehicles.” International Affairs (London); International Affairs 91: 765–80. https://doi.org/10.1111/1468-2346.12342.

Osborn, Kris. 2021. “F-35s to Launch Stormbreaker Weapons That Kill ‘on the Move ’Enemy Tanks¡Br¿” 2022. https://warriormaven.com/air/f-35-stormbreaker.

Otso Iho, and Christopher Hawkins. 2017. “Game of Drones: Commercial UAVs as a Growing Security Threat in the West.” Jane’s Terrorism & Insurgency Monitor 17.

Pascarelli, Claudio, Manuela Marra, Giulio Avanzini, and Angelo Corallo. 2019. “Environment for Planning Unmanned Aerial Vehicles Operations.” Aerospace 6: 51. https://doi.org/10.3390/aerospace6050051.

Ripley, Tim, and Samuel Cranny-Evans. 2021. “Unmanned Strategy: The Fight for Nagorno-Karabakh.” Jane’s Defence Weekly 58.

“Russian RKG-3 Anti-Tank Grenades.” 2019. Jane’s Ammunition Handbook.

“Science & Technology Improvised Weapons DARPA on the Dnieper.” 2022. The Economist

"Senior Defense Official Holds a Background Briefing, April 18, 2022." 2022. Federal Information & News Dispatch, LLC.

Shaikh, Shaan, and Wes Rumbaugh. 2020. "The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense." Www.csis.org. December 8, 2020. https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense.

Sly, Liz, and Catherine Belton. 2022. "A Race against Time in Ukraine as Russia Advances, West Sends Weapons." Washington Post. 2022. https://www.washingtonpost.com/world/2022/05/05/ukraine-russia-battles-donbas-weapons/.

Tice, Brian. 2014. "UNMANNED AERIAL VEHICLES." Archive.org. 2014. https://web.archive.org/web/20090724015052/http://www.airpower.maxwell.af.mil/airchronicles/apj/apj91/spr91/4spr91.htm.

U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035 Eyes of the Army. 2010. U.S. Army Unmanned Aircraft Systems Center of Excellence.

"Ukraine : Operational Information of the General Staff of Ukraine as of 06:00 on March 21, 2022 Regarding the Russian Invasion." 2022. MENA Report.

"Ukraine Conflict: Why Is Russia Losing so Many Tanks?" 2022 2022. Ukraine conflict: Why is Russia losing so many tanks?.

Varfolomeeva, Anna. 2019. "Ukraine Signs Agreement to Procure Turkish Bayraktar TB2 Drones" 2022. https://web.archive.org/web/20190115185431/https://thedefensepost.com/2019/01/12/ukraine-turkey-bayraktar-tb2-drones/.

Vasile PRISACARIU. 2017. "THE HISTORY and the EVOLUTION of UAVs from the BEGINNING till the 70s." Journal of Defense Resources Management 8: 181–89.

Wallace, Ryan J, and Jon M Loffi. 2015. "Examining Unmanned Aerial System Threats & Defenses: A Conceptual Analysis." International Journal of Aviation, Aeronautics, and Aerospace 2: 1.

Watling, Jack, and Nicholas Waters. 2019. "Achieving Lethal Effects by Small Unmanned Aerial Vehicles: Opportunities and Limitations." The RUSI Journal 164: 40–51. https://doi.org/10.1080/03071847.2019.1605017.

"World Air Forces Equipment in Service Inventory." 2019. Jane's World Air Forces 50.