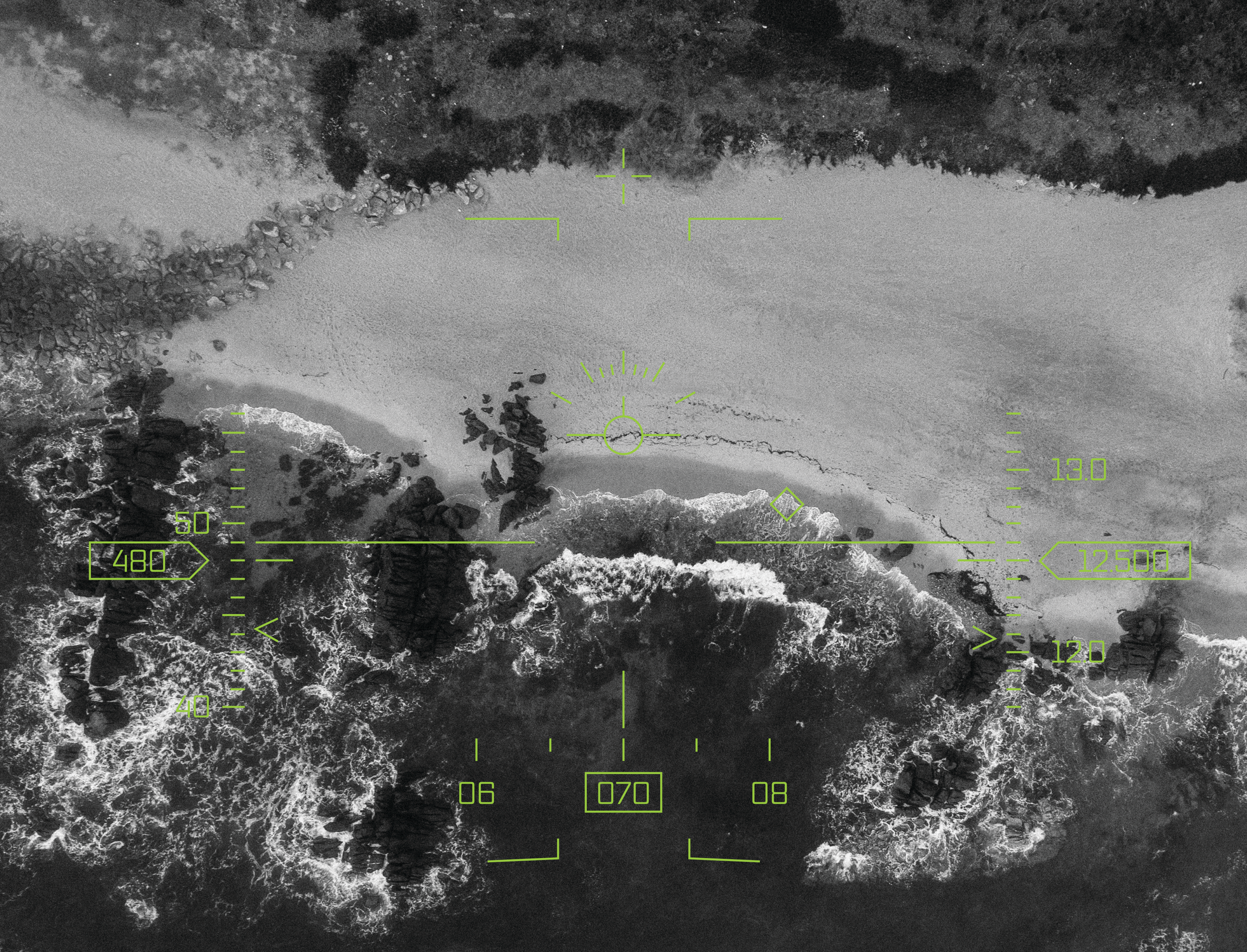

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COMBINED ARMS WARFARE AND UNMANNED AIRCRAFT SYSTEMS

A NEW ERA OF STRATEGIC COMPETITION

Seth G. Jones — Jake Harrington — Christopher K. Reid — Matthew Strohmeyer

A Report of the CSIS International Security Program

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EXECUTIVE SUMMARY

Unmanned aircraft systems (UASs) have played an important role in warfare over the past two decades, including for counterterrorism operations. But there has been a growing debate about their utility for competition and interstate war—including between major powers such as the United States and China. For some, UASs are creating a "revolution in military affairs," which will fundamentally reshape military doctrine, organization, force structure, operations, and tactics. For others, however, the effectiveness of UASs has been overstated, and UASs will likely have limited utility in highly contested environments.

To better understand the utility of UASs, this report asks two questions. First, how have UASs been utilized in modern warfare, particularly in interstate wars? Second, what are the future implications for UASs in warfare and competition? To answer these questions, this analysis adopts a comparative case study approach. It examines two cases—the Nagorno-Karabakh war in 2020 and the Ukraine war in 2022—to better understand how UASs have been used in warfare. It also examines the Northern Edge-21 exercise in 2021, which provides a useful examination of UASs in Indo-Pacific competition and war.

Based on the analysis, this report comes to several conclusions.

First, UASs have been increasingly integrated into combined arms warfare, a notable shift from their use in tracking and targeting terrorist networks over the past two decades. For example, Azerbaijan effectively utilized UASs as part of a combined arms approach—including with fixed-wing aircraft, helicopters, loitering munitions, guided missiles, and artillery—to reverse Armenia's three decades of control over large swaths of Nagorno-Karabakh. In Ukraine, both Russia and Ukraine have used UASs as part of combined arms warfare to conduct offensive and defensive operations following Russia's February 2022 invasion. Front lines have often been saturated by UASs, which have proven particularly valuable in the contested environment of Ukraine to improve battlefield awareness without risking loss of life. In Northern Edge 21, UASs—including MQ-9 Ghost Reapers—were integrated into combined arms operations in an Indo-Pacific scenario that included long-range fires, F-35A Lightning IIs, satellites, F-15C Eagles, F-15E Strike Eagles, and other platforms and systems to collect intelligence and conduct strikes.

As illustrated in Figure S.1, UASs will likely be integrated into a broader battlefield network that includes fifth-generation fighters, such as F-35s and F-22s; aerial refueling aircraft, such as KC-135s; long-range bombers, such as B-21s; cruisers and destroyers; satellites; carrier strike groups; land-based expeditionary advances bases; command-and-control centers; long-range fires; and other platforms and systems.

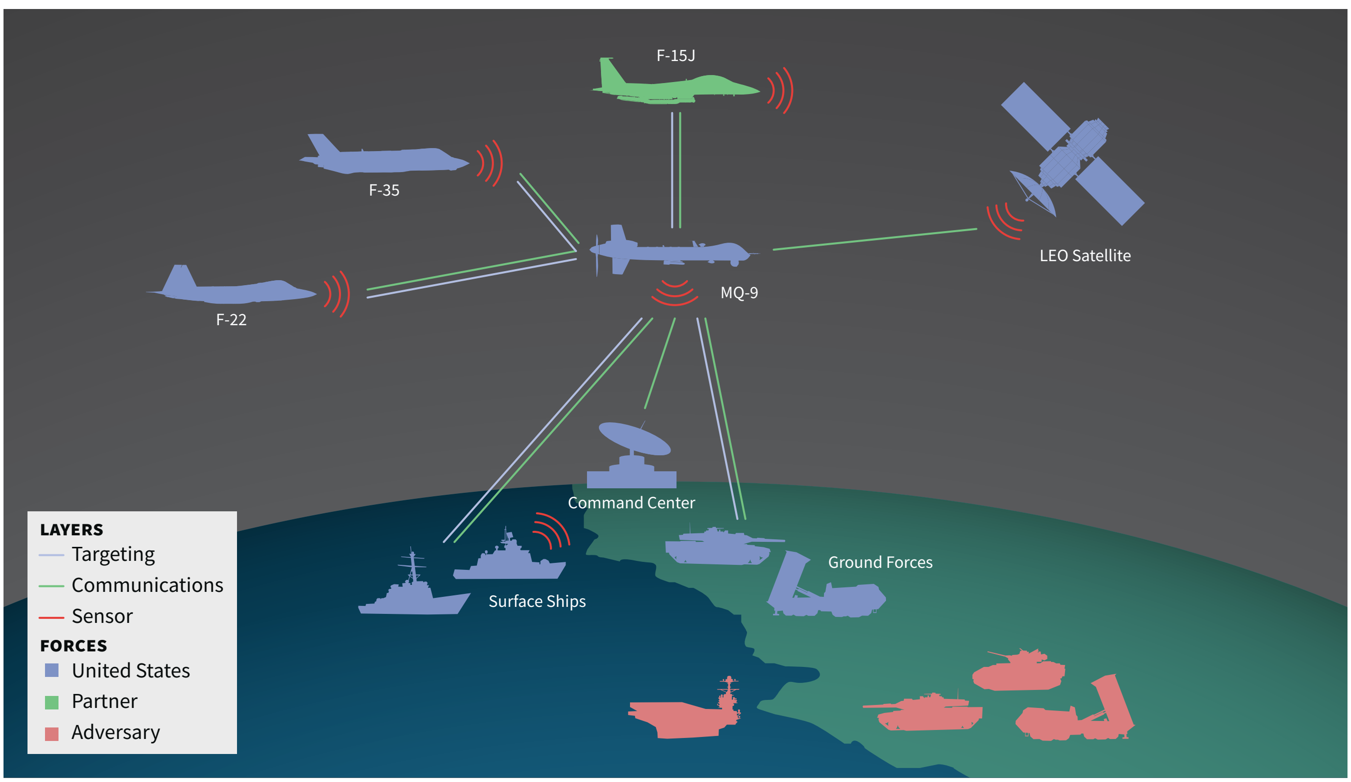
Second, UASs will likely have significant utility for both broad-based competition and warfare in the future. Security competition involving the United States, China, Russia, and other countries will likely be global in scope and cover significant expanses of the land, air, maritime, cyber, and space domains in Asia, Europe, Africa, Latin America, and across large bodies of water. In this context, it will be important to have platforms and systems capable of collecting intelligence over vast geographic areas, striking targets if necessary, and operating in a contested environment. In the future, UASs will likely play a critical role conducting several types of missions as part of combined arms warfare, including:

- Domain awareness and early warning;
- Battlefield awareness;
- Targeting for stand-off attacks;
- Strike;
- Electronic warfare; and
- Information operations.

In sum, UASs will likely play an important role in competition and warfare with such countries as China and Russia—a notable shift from their earlier use for counterterrorism operations. UASs may be particularly useful because they are capable of expeditionary operations with extended range and persistence. In addition, UASs are often viewed by governments as less escalatory than piloted aircraft. Conducting a broad array of missions will require a suite of UASs and loitering munitions that vary in range, payload, cost, and capabilities. In response to the growing use of UASs by state and non-state actors, there will also be a growing need to adopt counter-UAS tactics, techniques, procedures, and capabilities.

While the technology for UASs has evolved, the most significant change is *how* UASs are being used as part of combined arms warfare and *what* this suggests about the future. "What is past is prologue," wrote William Shakespeare in *The Tempest*. The recent past in Nagorno-Karabakh, Ukraine, and exercises in the Indo-Pacific offer a prescient prologue for the growing use of UASs in combined arms operations in the future.

Figure S.1: UASs and Battle Networks



Source: CSIS International Security Program.

CHAPTER ONE

INTRODUCTION

Unmanned aircraft systems (UASs) are playing an increased role in warfare.[1] In the decades following the September 11, 2001, terrorist attacks, the United States utilized UASs across the globe to conduct intelligence, surveillance, and reconnaissance (ISR) of terrorists and their infrastructure, as well as to strike terrorist targets. Russia, Ukraine, Israel, the United Kingdom, Iraq, Iran, Turkey, Azerbaijan, and other countries have also developed UASs and used them for ISR and strike missions. However, with the shift to strategic competition between the United States and other countries, such as China and Russia, there is an evolution in the use of UASs. As Russian defense minister Sergey Shoigu argued following the 2022 Russian invasion of Ukraine, "UASs are being widely used by the Russian army to cope with a wide range of tasks. Over the past ten years the intensity of their flights has been up 7 times, and the annual flight time, 23 times."[2]

But there is a significant debate about the utility of UASs—particularly for warfare and balance-of-power competition among major powers. For some, UASs are creating an "unmanned revolution in military affairs," which will fundamentally reshape military doctrine, organization, force structure, operations, and tactics.[3] According to proponents, UASs have several benefits: they have relatively low costs and low barriers to entry, they improve a user's long-range precision-strike capability, and they can deliver multiple mission capabilities, including strike, reconnaissance, and battlefield communications, with negligible risk to human operators.[4]

For others, however, UASs are of limited value, and their effectiveness has been overstated. As one assessment concluded, "Drones have not tilted the military balance toward the offense, they have not had an equalizing effect between strong and weak states, and they have not eliminated close combat."[5] In addition, some U.S. officials have argued that existing UASs are incapable of operating in highly contested environments and that modern electronic warfare and air defense systems would quickly destroy or ground these aircraft.[6] Vulnerabilities associated with these systems are well documented, including the June 2019 Iranian shoot-down of an RQ-4 Global Hawk over the Strait of Hormuz and Iranian-backed Houthi militants downing an MQ-9 Reaper over Yemen that same month.[7]

RESEARCH DESIGN

To better understand the utility of UASs—especially for balance-of-power competition—this analysis asks two questions. First, how have UASs been utilized in modern warfare, particularly in interstate wars? Second, what are the future implications for UASs in warfare and competition? While there has been extensive analysis of UASs to conduct counterterrorism operations, there has been less focus on their actual use in interstate wars.

To answer these questions, this report adopts a comparative case study approach. It examines two historical cases—Nagorno-Karabakh and Ukraine—to better understand how UASs were utilized in warfare and how they contributed to the outcome. It also analyzes the Northern Edge-21 (NE21) exercise, a 2021 exercise situated in the Indo-Pacific. NE21 involved F-15EX Eagle IIs, F-35A Lightning IIs, MQ-9 Reapers, F-15C Eagles, F-15E Strike Eagles, and other platforms and systems in high-end combat. These cases were chosen because there is notable variation in how UASs were used (e.g., for strike, intelligence collection, targeting for artillery, bomb damage assessment, and electronic warfare), where they were used (e.g., in the Caucasus, Eastern Europe, and the Indo-Pacific), and how effective they were in achieving operational and tactical objectives. Since there has not been a major war in the Indo-Pacific involving UASs, NE21 provides an interesting preview of future conflict in the region. Each of the case studies is organized along the same lines. It begins with an overview of the war (and the exercise for NE21) and then outlines major lessons in UAS and counter-UAS activity.

Consistent with current U.S. Department of Defense usage and guidance, this report utilizes the term "unmanned aircraft systems," or UASs, instead of other terms—such as unmanned aerial vehicles, uncrewed aircraft systems, or remotely piloted aircraft.[8] The word "systems" is important in UASs since such platforms increasingly incorporate a broad suite of sensors, command-and-control systems, and communications networks that are much broader than just aircraft. The report also examines loitering munitions.

In addition, this report examines the future implications of UASs for both warfare and balance-of-power competition. Used in this context, "warfare" involves military operations between adversaries, which usually involves the use—or threat—of violence. "Competition," on the other hand, is the constant struggle between countries, including major powers, in the international system for power and influence.[9] Security competition is a normal reality of balance-of-power politics.

ROADMAP

The rest of this report is divided into the following chapters. Chapter 2 provides an assessment of the role of UASs in competition. Chapter 3 examines UASs in the war in Nagorno-Karabakh. Chapter 4 analyzes Russian and Ukrainian use of UASs in the 2022 war in Ukraine. Chapter 5 explores lessons from NE21. Chapter 6 offers policy implications on the future role of UASs in warfare and competition. Finally, Appendices 1, 2, and 3 provide an overview of the UASs used by Azerbaijan, Ukraine, and Russia, respectively, as highlighted in the case studies—including such information as type, description, range, endurance, country of origin, and manufacturer.

CHAPTER TWO

UASs IN WARFARE AND COMPETITION

Three fundamental characteristics of the current global security environment are relevant to the use of UASs. The first is the use of UASs in combined arms operations. The second is that modern security challenges still reflect the traditional "hider-finder" dynamic—the cyclical struggle between those who try to conceal their activities from those determined to detect them.[1] The third is that states engaged in balance-of-power competition will calibrate their behavior in an effort to avoid a major war between nuclear powers.

This chapter explores the role of UASs in performing missions as part of combined arms operations and "hider-finder competition," and it will explore their effects on escalation and crisis dynamics. It argues that UASs have significant utility in military operations, attributable to their multimission functionality and reduced risk to human life. Its conclusions draw upon primary source military strategy and doctrine from China, Russia, and the United States, recent empirical research and examples, and the deployment of Chinese UASs around Taiwan in 2022.

Global military forces are rapidly adjusting strategy, policy, doctrine, and capabilities to prevail in this era of renewed security competition. This competition exists along a continuum where binary labels such as "peace" or "war" do not apply. Chinese military strategy reflects a similar assessment of the current era. As the Chinese *Science of Military Strategy 2020* argued, "The international strategic situation and the pattern of strategic competition are undergoing historic changes. China is facing both rare development opportunities and severe security threats at the same time."[2] For its part, Russia's 2022 invasion of Ukraine reflects merely the latest iteration of its decades-long shift toward "new generation" or "nonlinear" warfare, where Russia "clearly [sees] the kinetic and the non-kinetic as interchangeable and mutually supporting."[3]

The battlespace in this era of interstate security competition involves a mix of irregular and conventional war. States such as China and Russia pursue their geopolitical interests across the information, economic, diplomatic, and military domains, and they view U.S. global behavior through a similar lens. Russia accuses the United States of weaponizing "the technologies of 'color revolutions' and 'soft power.'"[4] China has described a U.S.-led West engaged in an era of "new strategic containment" that is "long-term and complex" and where the intensity of competition will inevitably follow "a phased cycle of 'ease—intensify—ease.'"[5]

In response, military planners need to develop doctrine and capabilities that can deliver strategic advantages across the spectrum of threats, including war between major powers. Based on their common assessment of the operating environment, strategists in Washington, Beijing, and Moscow concur on one key priority: the enduring importance of information across the entire spectrum of activities. Specifically, military thinking is increasingly focused on the effective collection, analysis, and operationalization of information to shape or alter a competitor's behavior. This is translating into various initiatives in the United States, such as the Joint All-Domain Command and Control (JADC2) concept. In China, it is reflected in Beijing's concept of "informatized local wars" with the People's Liberation Army's strategy prioritizing the requirement to collect "timely, high fidelity information" while simultaneously degrading the adversary's information capabilities.[6] Whether using the U.S. term "information advantage" or the Chinese equivalent "information dominance," the world's two foremost major power rivals agree that data is critical to future war.

COMBINED ARMS

This focus on translating information into kinetic and non-kinetic effects is integral to the concept of combined arms. Combined arms involves the combination of infantry, direct and indirect fire, aviation, and other joint capabilities to achieve political and military objectives. As Gerald Gilbert, a major in the British army, remarked in 1907:

> We have got into the fashion of talking of cavalry tactics, artillery tactics, and infantry tactics. This distinction is nothing but a mere abstraction. There is but the one art, and that is the tactics of the combined arms. The tactics of a body of mounted troops composed of the three arms is subject to the same established principles as is that of a mixed force in which foot soldiers bulk largely. The only difference is one of mobility.[7]

Current U.S. military strategy emphasizes the need to achieve information advantage at all levels and phases of combined arms. Defense leaders are increasingly focused on efforts to translate information advantage into kinetic outcomes by connecting sensors to shooters. This vision of translating information into outcomes extends below the threshold of conventional war.[8] Such a vision places intelligence, surveillance, reconnaissance (ISR) and global situational awareness at the center of U.S. strategy for security competition.

In the current environment, potential threats are widely dispersed, quick to manifest, and often difficult to discern from routine state behavior. This reflects the "sensing" challenge. Harder still will be efforts to make sense of disparate, seemingly unconnected activities that may correlate to a competitor's broader pattern of hostile behavior that manifests across multiple regions and multiple operating domains. For the U.S. military and the intelligence community, the all-source collection requirements for strategic competition will be exceptionally broad and multimodal. Collectors and the decisionmakers they support will need to rely on a global network of air, sea, ground, space, and cyber sensors (as well as human sources) to deliver timely and accurate indicators and warning on a planetary scale.

In this environment, collection demands will undoubtedly exceed supply, and budget constraints will require investments in systems that are both cost effective and capable of performing multiple missions. In the air domain, these are attributes that are shared by several UAS platforms that already perform multiple ISR missions. These include maritime domain awareness, sensitive reconnaissance operations, long-loiter reconnaissance activities, and tactical ISR missions. And across these operations, a single platform can often perform multiple mission types. This may include imagery intelligence, including full motion video; measurements and signals intelligence; electronic intelligence; and signals intelligence. Simultaneously, UASs can collect and act as a communications hub for an integrated space, air, sea, or ground operation while also ingesting, processing, and disseminating multiple streams of intelligence.

This level of mission flexibility is not unique to UASs. Several piloted aircraft are similarly multimission capable. But manned aircraft carry added risk to life and must respect the physical and mental limitations—specifically in terms of flight duration—of an onboard crew.[9] As such, UASs are postured to serve as a lower-risk and highly adaptable link in combined arms warfare. There is also evidence that some UASs, such as the MQ-1B Predator and MQ-9A Reaper, have significantly lower operation and maintenance costs per flying hour than manned aircraft.[10]

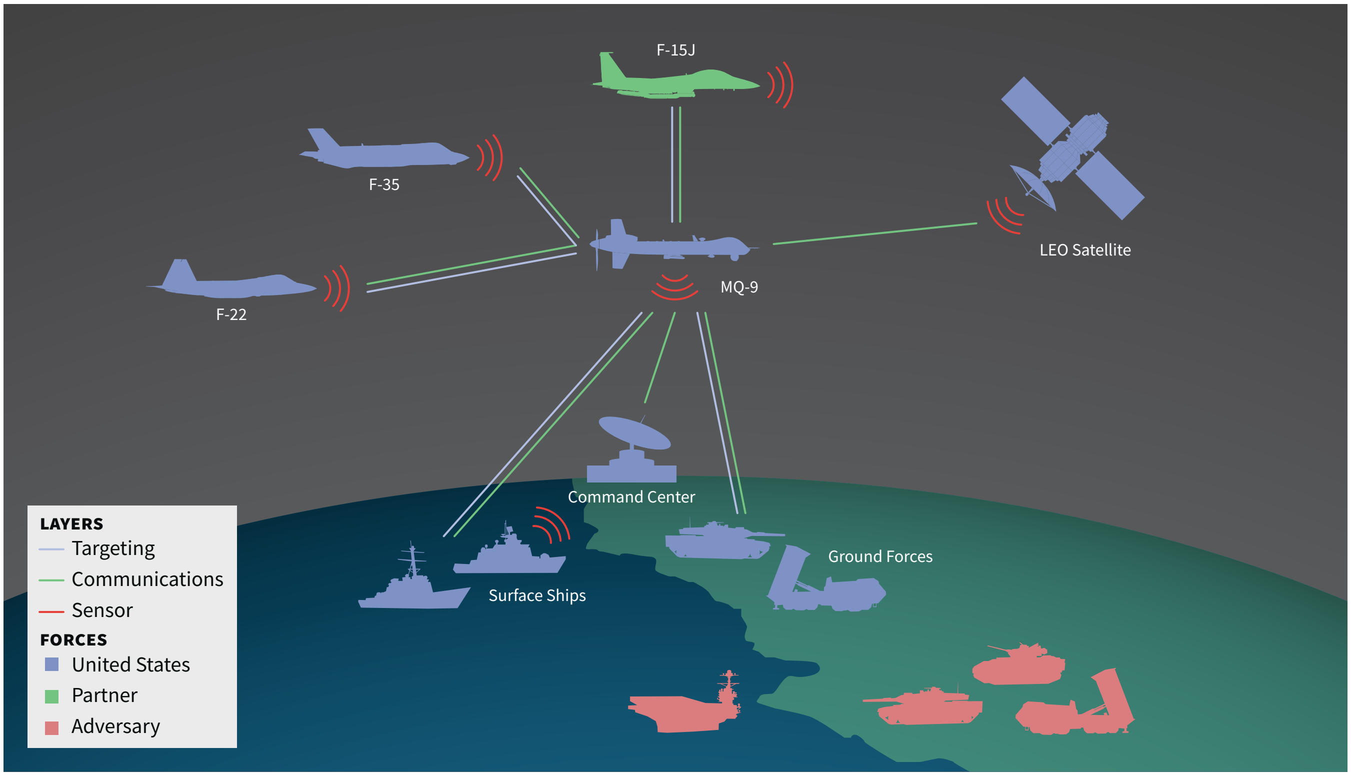
When competition intensifies, multimission UASs can adapt to support the joint force in times of crisis. Examples include conducting electronic warfare and strike operations, if necessary, while also serving as a critical hub in a multidomain, combined arms operation. Used in this context, UASs are increasingly part of a network of collaborative platforms and systems in a contested battlespace—a notable change from how they were used to conduct unilateral counterterrorism operations after 9/11.

As highlighted in Figure 2.1, for example, these platforms and systems can include fifth-generation fighters, such as F-35s and F-22s; aerial refueling aircraft, such as KC-135s; long-range bombers, such as B-21s; cruisers and destroyers; satellites; carrier strike groups; land-based expeditionary advances bases; command-and-control centers; and long-range fires. To communicate across these platforms and systems, UASs need to pass information through layered networks, such as tactical targeting network technology (TTNT), Link 16, Multifunction Advanced Data Link (MADL), multiband satellite communications (SATCOM), and mesh networks.

UASs AS TOOLS OF CRISIS AND ESCALATION MANAGEMENT

The "competition continuum" refers to a spectrum of activities—such as cooperation, armed conflict, and competition below the level of armed conflict—that describes interaction between states. The concept of a competition continuum recognizes that a military force "is never solely in cooperation (or in competition below armed conflict or in armed conflict) but instead campaigns through a mixture of cooperation, competition below armed conflict, and armed conflict calculated to achieve the desired strategic objectives."[11] Competition occurs along a spectrum of intensity. This includes steady-state "hider-finder" operations intended to detect, understand, and confront hostile activities below the threshold of war. But systemic competition hews to a phased cycle of "ease—intensify—ease." In times of intensifying competition, states use a variety of military and non-military means to signal their interest and resolve. In the military domain, this signaling may include deploying assets to demonstrate presence and commitment. Examples include naval freedom of navigation operations (FONOPS) and airborne sensitive reconnaissance operations. It is in these latter operations where the employment of UASs can substantially expand a signaler's options and ability to manage escalation in times of crisis.

Figure 2.1: UASs and Battle Networks



Source: CSIS International Security Program.

The United States has historically defined sensitive reconnaissance operations as "non-wartime reconnaissance operations by manually or remotely operated DoD platforms involving significant military risk or political sensitivity."[12] Emerging technologies offer modern nation-states several mechanisms for collecting overhead intelligence, including space-based remote sensors that are increasingly ubiquitous. Aircraft, however, offer two advantages when the circumstances warrant.

First, they can conduct collection activities at a lower altitude, and therefore much closer to the target, than space assets. They are capable of collecting full motion video should requirements necessitate such collection, and many modern platforms are capable of long-duration, sustained loitering over a target of interest. Second, aircraft are detectable. Space reconnaissance can collect a wide range of critical and observable intelligence, and these systems can deliver this information discreetly or clandestinely to the collector. However, in terms of signaling, passive space collection leaves little-to-no tangible evidence of a nation's interest or presence. Sensitive reconnaissance operations, on the other hand, signal awareness, interest, and presence—while also limiting the risk a decisionmaker incurs in terms of human life.

Thomas Schelling described much of international relations as "a competition in risk taking, characterized not so much by tests of force as by tests of nerve." The risk calculations that nations make are clouded by "the sheer unpredictability of dangerous events."[13] States attempt to manage this uncertainty by calibrating their actions and reactions along graduated degrees of risk to avoid unintended escalation. In modern crises, there is emerging evidence that UASs, when utilized for sensitive reconnaissance operations, offer opportunities for leaders to demonstrate interest, presence, and resolve while avoiding a key historic driver of escalation: loss of human life.

Some recent empirical evidence suggests that leaders view the loss of a UAS qualitatively differently than the loss of a manned aircraft. In one 2015 example, Turkey shot down a Russian UAS that had entered its airspace, an act that did not provoke a reciprocal retaliation from Russia. One month later, Turkey shot down a manned Russian Su-24 attack aircraft, which precipitated a series of airstrikes against Turkish interests in Syria.[14] In 2019, the Iranian military shot down an American RQ-4 Global Hawk while it was operating in international airspace over the Strait of Hormuz.[15] According to news reports, U.S. president Donald Trump initially approved a series of retaliatory air strikes against Iran but subsequently decided not to conduct the strikes. In the aftermath, the president indicated that the fact that the RQ-4 was a UAS influenced how the United States should respond. As President Trump said, “We had nobody in the drone. It would have made a big difference, let me tell you, it would have made a big, big difference” if the aircraft had been piloted.[16] In addition, there is some evidence that the deployment and potential loss of UASs in times of crisis alleviate some of the key drivers of escalation, including a leader’s emotional urge for retaliation as well as concerns about incurring a domestic or international price for not pursuing a proportionate response.[17]

This logic was likely reflected in the way that China utilized UASs as part of a broader escalation of tensions with Taiwan and the United States during the Taiwan Strait Crisis in 2022. On August 3, 2022, a People’s Liberation Army Air Force (PLAAF) UAS flew over the Taipei-controlled Kinmen Islands, the first time any Chinese military aircraft had flown over Kinmen since the 1950s. The incident occurred as a wide range of PLAAF manned and unmanned aircraft entered Taiwan’s air defense identification zone. The PLA also launched live-fire missiles over the island as part of military exercises following the visit of Nancy Pelosi, speaker of the U.S. House of Representatives, to Taipei. No other PLAAF aircraft other than UASs flew over Taipei-controlled land. One retired PLAAF equipment expert suggested that Beijing might not rule out flying over Taiwan itself in the future. “To reduce friction and misjudgment,” he said, “we can send unmanned vehicles [to the island].”[18]

This perception that losing a UAS offers leaders a wider range of kinetic and non-kinetic options appears to be shared by some U.S. military personnel as well. In his recent work, Erik Lin-Greenberg used a series of wargames to test how U.S. military personnel weighed responses in one scenario where an MQ-1 Predator was shot down compared to the loss of an MC-12 Liberty aircraft, which carries four crew members.[19] None of the teams that lost the MQ-1 recommended military strikes in retaliation, while all of the teams that lost the MC-12 in the same scenario recommended a kinetic response. In the words of one player, “We are not going to war over a Predator.”[20] The study also suggests that the loss of a UAS extends the range of a leader’s credible response options beyond the military domain. Wargame participants did not view the loss of an MQ-1 as costless, but the range of acceptable retaliatory options they considered were non-kinetic.

One lingering question is whether views on the qualitative difference between the loss of manned and unmanned aircraft is sustainable in the long term. If defenders understand that they are less likely to incur kinetic retaliation if they shoot down a UAS, will this lead to an overall increase in the volume of these platforms that are shot down? At some point, will states cease to view increasing losses of UASs as more acceptable than the loss of manned aircraft? At least in the near term, the use of UASs in times of escalating tensions and crisis appears to offer leaders a wide range of options. Certainly, a leader *could* credibly cite the loss of a UAS as sufficiently provocative to warrant a kinetic response. But a scenario incurring the loss of an unmanned aircraft and no human lives appears to introduce a range of credible response options beyond the military domain.

CONCLUSION

As this chapter highlights, UASs continue to be important in security competition to help states detect—and take actions against—their adversaries as part of combined arms warfare. UASs offer countries numerous options because of their multimission functionality and reduced risk to human life. In addition, UASs are often palatable because they are viewed as less escalatory than some types of manned aircraft.

To better understand the use of UASs in modern warfare—including their application for competition with major powers—the next three chapters examine the 2020 Nagorno-Karabakh war, the 2022 Ukraine war, and the 2021 NE21 exercise.

CHAPTER THREE

NAGORNO-KARABAKH WAR

Throughout 2020, longstanding tensions between Azerbaijan and Armenia erupted over the fiercely contested region of Nagorno-Karabakh. After skirmishes in July, a major air and ground war broke out on September 27, 2020. During a six-week conflict that killed more than 6,000 combatants, Azerbaijan reversed Armenia's nearly 30-year control over wide swaths of territory in and around Nagorno-Karabakh. Ultimately, Armenia lost 75 percent of the territory it had held in these areas since 1994.[1] Since the hostilities ended in November 2020, the conflict has emerged as a noteworthy lesson in how smaller states can integrate UASs into modern combined arms warfare. This case study evaluates how Azerbaijan applied its technological superiority on the battlefield, specifically focusing on the use of UASs at the tactical and operational level.

The 2020 Nagorno-Karabakh war has three key lessons for the role of UASs in modern warfare. The first is that UASs are an important—and often cost-effective—component of an integrated, combined arms battle network. The second is that UASs are being leveraged extensively to enable information and psychological operations. The third is that the proliferation of low-cost UASs allows modern militaries to innovate their tactics by accepting increased risk for systems that are considered attritable.

This chapter analyzes the role of UASs in the 2020 Nagorno-Karabakh war across two phases of the conflict. Phase one occurred during the first three weeks of the war, when fighting concentrated on the plains and foothills surrounding Nagorno-Karabakh. Azerbaijan sought to reclaim substantial buffer territory around Nagorno-Karabakh that Armenia had controlled since the 1994 ceasefire. As highlighted in Figure 3.1, this phase of fighting was concentrated in the Fuzuli and Jabrail regions, which lie to the south of Nagorno-Karabakh along the border with Iran. These flat, low-lying areas lack natural cover, and—as visible in the dozens of videos released by Azerbaijan's Ministry of Defense—Armenian forces were easily discovered by intelligence, surveillance, and reconnaissance (ISR) assets and targeted with armed UASs, loitering munitions, and artillery. It is also in this phase, and in these regions, where Azerbaijan's air dominance was most decisive.

The second phase of the conflict was underway by late October, when Azerbaijani forces began more intensively pushing into the political boundaries of Nagorno-Karabakh. The Nagorno-Karabakh enclave is mountainous, with dense forest that provides better natural cover compared to the outlying plains and foothills. In this phase, the war shifted to one of attritional ground combat, where Azerbaijani special forces, ground components, and Turkish-backed foreign mercenaries pushed into the forested, mountainous terrain against Armenian forces who benefited from more favorable defensive positions. This phase continued until Azerbaijani forces captured the strategic city of Shusha on November 8, at which point both countries agreed to a ceasefire on favorable Azerbaijani terms.

Both phases carry lessons for the role of UASs in modern combat. In the first phase, Azerbaijan quickly secured air superiority, which it then exploited to find and target poorly or insufficiently concealed Armenian armor, artillery, and personnel. Air power degraded Armenian defenses and supply lines and allowed Azerbaijani special forces and ground components to encircle Nagorno-Karabakh and threaten critical Armenian supply lines into the region.

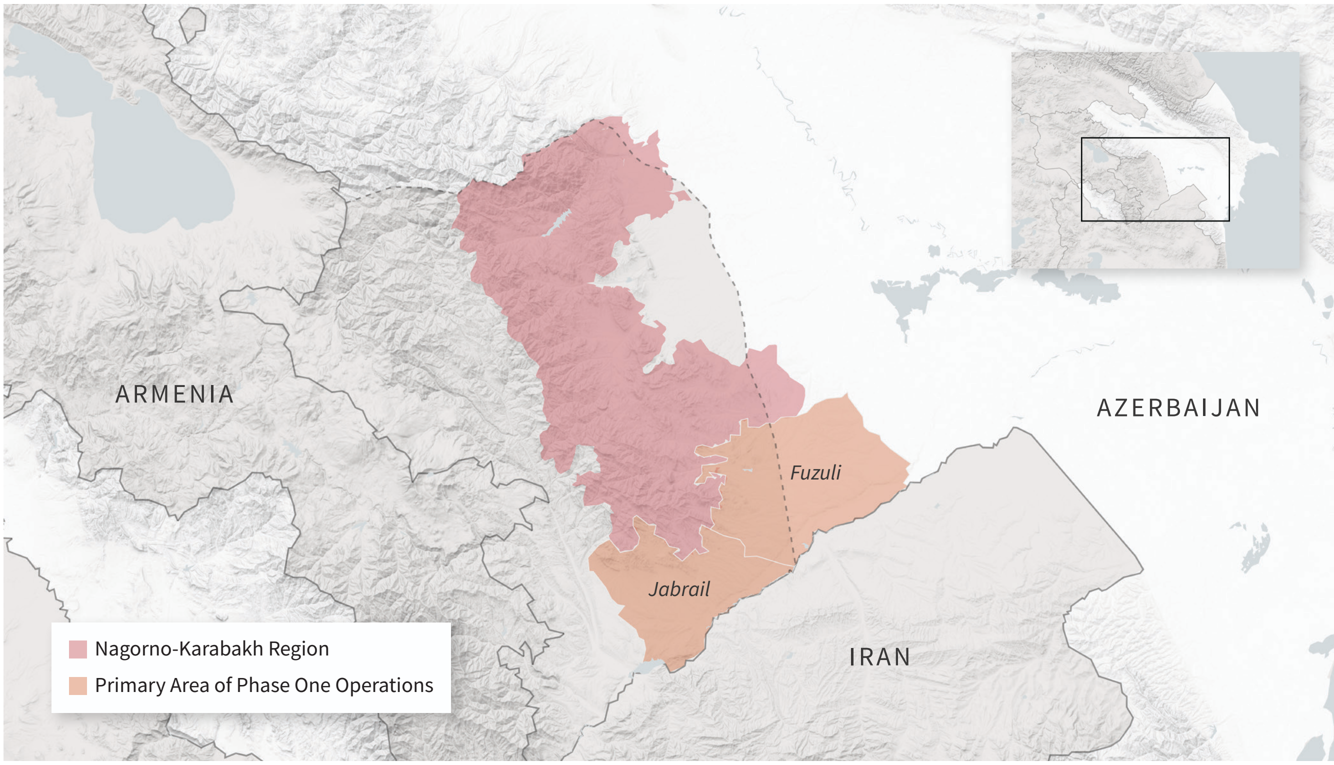
Entering the second phase of the war, the utility of UASs changed as Azerbaijani forces pushed into mountains where Armenian defensive positions were stronger and harder to find from the air. Videos and imagery of combat within the heavily forested and mountainous areas of Nagorno-Karabakh reveal a much different hider-finder dynamic, with the deeply entrenched Armenian forces benefitting from a defensive advantage. Moreover, the Armenians adapted their defensive posture toward UASs, markedly improving their ability to counter these systems with traditional air defense and electronic warfare capabilities as the conflict progressed, likely with Russian assistance. However, these gains were insufficient to alter the war's trajectory after Azerbaijan's early dominance.

The rest of this chapter is divided into two main sections. The first provides an overview of the Nagorno-Karabakh war. The second section highlights several major lessons, including the use of UASs as part of a connected battlefield and for information operations.

OVERVIEW OF THE WAR

Nagorno-Karabakh is a mountainous, majority ethnic Armenian enclave broadly recognized as a geographical component of Azerbaijan. Control over the region has been subject to fierce competition and conflict for decades, if not centuries. However, the current intensity of the conflict emerged in the wake of the dissolution of the Soviet Union. In the early 1990s, as the Soviet Union

Figure 3.1: Map of Fighting during Phase One of the Nagorno-Karabakh War



Source: Geodata for the Nagorno-Karabakh region is courtesy of the Europe and Central Asia Program at the International Crisis Group. See "The Nagorno-Karabakh Conflict: A Visual Explainer," International Crisis Group, last updated October 11, 2022, https://www.crisisgroup.org/content/nagorno-karabakh-conflict-visual-explainer.

disintegrated, the newly independent Armenian and Azerbaijani states fought a protracted war. After six years of conflict, a 1994 ceasefire agreement left Armenia in control of Nagorno-Karabakh, in addition to a sizeable portion of Azerbaijani territory surrounding the enclave.

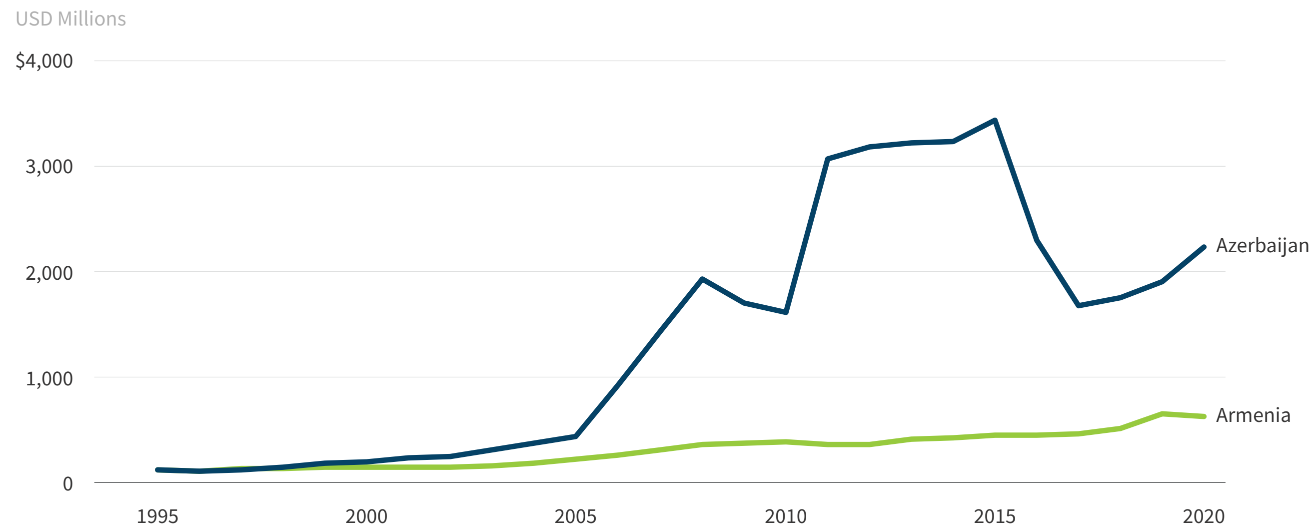
For 15 years prior to the outbreak of war in 2020, the Azerbaijani military underwent a sustained period of investment driven by oil and gas revenues (see Figures 3.2 and 3.3). Beginning in 2006, Baku seized upon rising global energy prices to increase annual military spending by several orders of magnitude. Between 2005 and 2015, Azerbaijan's annual defense budget increased by more than 700 percent in real dollars. Armenia, for its part, doubled its own defense spending over the same period, but the disparity by 2015 was clear. That year, Azerbaijan spent $7.46 for every Armenian defense dollar. Still, by great power standards, these were modest investments. Azerbaijan's total defense spending over 15 years totaled $34.1 billion, less than 5 percent of the U.S. Department of Defense's 2020 budget.[2]

Azerbaijan and Turkey also deepened their diplomatic and military alliance. Turkey—under its "one nation, two states" support for the ethnic Turkic-Azerbaijani state—delivered substantial military, intelligence, and political support to Azerbaijan before, during, and after the conflict. Turkish support, including the deployment of a variety of Turkish-backed Syrian mercenaries, contributed substantially to Azerbaijan's decisive victory.

During the period of rapidly increasing defense spending, Azerbaijan invested heavily in Israeli UASs. At the outbreak of the 2020 war, Azerbaijan's inventory included at least seven different categories of Israeli unarmed UASs and two categories of loitering munitions (see Appendix 1).[3] Azerbaijan also purchased several ballistic and guided missile systems from Israel during the same timeframe.[4]

In mid-2020, Azerbaijan also announced its plan to acquire its first armed UAS, Turkey's Bayraktar TB2. Reports suggest that Azerbaijan purchased five of these systems, which were in service at the outbreak of the September war.[5] While the TB2 emerged as perhaps the most prominent capability deployed during the war, available evidence suggests it is likely that the TB2s used in the 2020 war were owned by Azerbaijan but operated by Turkish airmen and crews.[6] One other Turkish system, a portable rotary-wing loitering

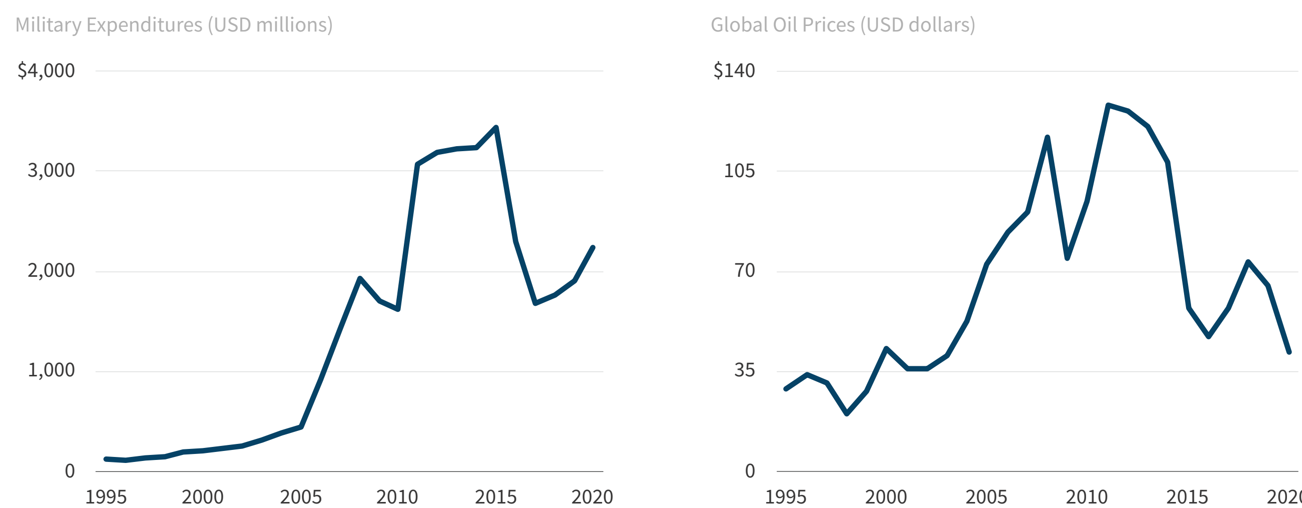
Figure 3.2: Azerbaijan and Armenian Defense Spending, 1995–2020



Note: Measured in millions of 2020 real dollars.

Source: "SIPRI Military Expenditure Database," Stockholm International Peace Research Institute, https://www.sipri.org/databases/milex.

Figure 3.3: Azerbaijani Defense Spending and Average Price of Brent Crude, 1995–2020



Note: Measured in 2020 real dollars. Military expenditures in millions.

Source: "SIPRI Military Expenditure Database," Stockholm International Peace Research Institute; and "Spot Prices (Crude Oil in Dollars per Barrel, Products in Dollar per Gallon," U.S. Energy Information Administration, https://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm.

munition known as the KARGU, was used by Azerbaijani special forces in mountain combat against Armenian forces.[7]

The inability of Armenian air defenses to combat Azerbaijani UASs is well documented. Many of Armenia's air defenses, including the OSA, Krug, and Strela-10, were of Cold War vintage. Armenia had acquired more advanced capabilities, including the Russian S-300, Buk, and Tor-M2KM, but these systems were not effective at countering small, low-altitude threats such as Azerbaijan's UAS fleet.[8] Overall, Armenia lacked an integrated air defense system, with acute deficiencies in its short-range air defense capability. Azerbaijan exploited these weaknesses early in the conflict—with Baku claiming to destroy 12 OSA air defense systems on the first day of fighting alone—and benefited from broad air superiority throughout the remainder of the war.[9]

MAJOR LESSONS

Combined Arms Warfare: From the outset of the 2020 war, it was apparent that Azerbaijan's years of military modernization equipped them with an effective combined arms capability. As one U.S. Army official noted, "What's clear in that conflict is that a less funded nation can do combined arms warfare. You don't need to be the United States or Russia. The cost of entry into combined arms warfare is lower than initially thought."[10]

The realization of this capability was most formidable during the early fighting in the Fuzuli and Jabrail regions. One of Azerbaijan's key operational objectives in the conflict was to recapture these regions to the south of Nagorno-Karabakh and then proceed to encircle the enclave's western border. This maneuver would ultimately jeopardize Armenia's access to the Lachin Corridor, which contains the sole highway directly connecting Armenian territory to Nagorno-Karabakh.

Azerbaijan's operations in these southern regions in the first two weeks of the war reflected a combined arms approach that integrated multiple armed and unarmed systems, loitering munitions, guided missiles, and artillery. Videos and imagery of Azerbaijani operations in these regions show Bayraktar TB2s being utilized for both targeting and strike, operating in tandem with lower-altitude, smaller UASs, such as the Israeli-manufactured Orbiter, as well as other ordinance delivery mechanisms.[11] The TB2 is armed with an MAM munition, which carries a significantly smaller payload than other missiles in the Azerbaijani inventory. In some circumstances, such as against undefended Armenian artillery batteries and personnel, the MAM was sufficient. Against Armenian T-72 tanks and other armored vehicles, however, the TB2s appeared to deliver targeting information to Azerbaijani multiple launch rocket systems and other fires—allowing Azerbaijan to use higher payload weapons when needed.

Benefitting from air superiority and the wide range of ISR systems at Azerbaijan's disposal, battle damage assessments could be easily conducted in connection to these operations. Overall, the integration of multiple UAS sensors with various weapons, including missiles, loitering munitions, artillery, and other fires, reinforced that the cost of entry for advanced combined arms warfare is declining.

Azerbaijan leveraged its air superiority in a region with few natural defenses to push deep into Armenian lines. Based on available evidence, Azerbaijani air operations allowed special forces to advance upon, seize, and control territory. Imagery suggests Azerbaijani special forces arrived in the city of Jabrail by the first week of October 2020, capturing wide swaths of territory controlled by Armenia.[12]

Despite these successes, one outstanding question from this phase of the conflict is how effectively air and ground forces were integrated. Imagery and video released during the conflict reflects Azerbaijan's ability to integrate a variety of UASs with fires. However, there is less available open-source insight into how these combined arms operations were synchronized with the ground forces responsible for seizing and holding territory. It is possible that the dominance of Azerbaijani combined air and fires capabilities may have masked shortcomings in the integration of ground forces into the combined arms approach. Regardless, by October 22, 2020, Azerbaijan controlled the entire territory south of Nagorno-Karabakh and was likely within 10 kilometers of reaching the Lachin Corridor.[13]

While Azerbaijan dominated the plains using its technologically advanced combined arms approach in the first phase of the conflict, fighting in the mountains during the second phase was a more primitive affair. At the tactical level, the role of unmanned systems in the mountains was less prevalent. Azerbaijan used these systems within Nagorno-Karabakh largely to shell urban areas, particularly the enclave's capital of Stepanakert. Stepanakert was heavily

A Bayraktar TB2 circles overhead during a technology festival in Baku, Azerbaijan.

Source: Aziz Karimov/GettyImages

targeted throughout the conflict by Azerbaijani drones and artillery; however, the purpose and effect of these operations was likely intended to be more psychological than tactical. The primary warfighting in the mountains was close-combat, trench-style warfare, conducted by Azerbaijani special forces and ground components and augmented by Turkish-backed Syrian mercenaries.[14] Perhaps the most notable tactical use of unmanned systems in this phase was the utilization of the Turkish KARGU loitering munition. The KARGU is a portable, rotary-wing tactical drone with intelligence, surveillance, and reconnaissance (ISR) capabilities and a small explosive payload.[15] The extent to which the KARGU enabled Azerbaijani special operations forces to advance into Armenian territory is unclear; however, these ground forces were instrumental in the larger mountain and urban combat operations that resulted in Azerbaijan's victory in the battle for the city of Shusha. It was Armenia's loss of this key city, only 15 kilometers from Stepanakert, that ended the 44-day war.

Information Operations: The second notable lesson from the 2020 Nagorno-Karabakh war is the extent to which modern states are willing to leverage drones in support of information operations. During skirmishes that occurred in July 2020, several months before the outbreak of the war, Azerbaijan's Ministry of Defense posted several videos of air, missile, and artillery strikes on YouTube. Beginning September 27, 2020, the first day of the war, Azerbaijan began posting multiple videos each day of raw drone footage of air and artillery strikes. These videos were derived from a variety of unmanned systems and loitering munitions, as well as the Spike NLOS guided missile, which is equipped with a full motion video camera. While these videos were dramatic, they were often delivered without information about where they took place or additional context about the broader strategic objectives they supported.

The primary purpose of this propaganda was likely to solidify domestic public support for the war and the ruling administration. During the war, the Azerbaijani government played combat footage on large monitors on public display in Baku.[16] There was also an international dimension to this information effort, as Azerbaijan's Ministry of Defense released English-language press releases documenting its claimed military successes.[17] Armenia countered with its own efforts to broadcast its counterattacks against Azerbaijani forces. However, these were often captured by land-based cameras and lacked much of the modern style and production value of Baku's videos.[18]

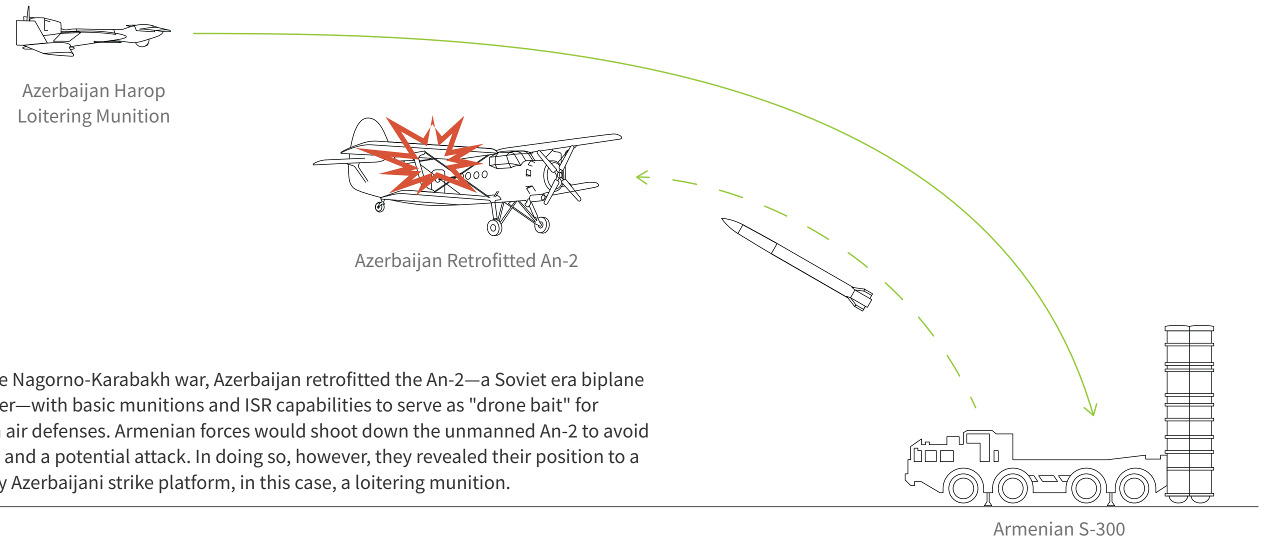
Ultimately, the 2020 Nagorno-Karabakh war was decided on the battlefield, owing to Azerbaijan's overwhelming military superiority. The utility of the information dimension of UAS propaganda, however, is likely a critical lesson for future prolonged conflicts of attrition. As has been evident in the experience of Ukraine in its war against Russia, the information environment is an important domain for building and sustaining domestic and international support. The 2020 Nagorno-Karabakh war was one of the first modern conventional wars to be tracked in near real-time on social media, with both sides widely releasing documentary information from the battlefield.

Attritable Systems and Risk: The third key lesson from the 2020 Nagorno-Karabakh war is the role of lower-cost UASs in a military's risk calculus. None of the assets in Azerbaijan's drone inventory likely cost more than $20 million per unit.[19] Most cost far less, including the TB2, which likely costs between $2 million and $5 million per unit.[20] Since lower-cost systems can be purchased in larger quantities, the broader operational impact of the loss of a single system is reduced. Add to this the reduced risk to human life that is associated with UASs and the risk aperture for certain activities widens even further.

Nowhere was this risk calculus more profound in the Nagorno-Karabakh conflict than in Azerbaijan's use of the Antonov An-2. The An-2 is a single-engine biplane originally manufactured in 1947. In advance of the 2020 war, Azerbaijan retrofitted several An-2 aircraft with remote piloting capabilities and added armaments to some. This allowed Azerbaijan to conduct effective suppression of enemy air defenses (SEAD) operations using an outdated, expendable airframe—similar to Vietnam-era "Wild Weasel" operations.[21] In Nagorno-Karabakh, An-2s were deployed as bait against Armenian air defenses. In multiple cases, the Armenian air defenses engaged the An-2 and shot it down. By doing so, however, the Armenian air defense revealed their positions, allowing other Azerbaijani assets to find and target the now-exposed air defense systems.

This tactic reflects a potentially significant role for UASs in future SEAD operations. With multiple airframes integrated with other capabilities, such as artillery or long-range fires, air defense systems can be forced into a defender's dilemma. That is, if an air defense system is in jeopardy of discovery—or simply identifies a target of opportunity—its use risks exposing itself to secondary strike. Conversely, Azerbaijan's use of the An-2 as bait demonstrates the risk-taking possibilities associated with cheaper, "attritable"

Figure 3.4: Attritable Systems and Risk



During the Nagorno-Karabakh war, Azerbaijan retrofitted the An-2—a Soviet era biplane crop duster—with basic munitions and ISR capabilities to serve as "drone bait" for Armenian air defenses. Armenian forces would shoot down the unmanned An-2 to avoid discovery and a potential attack. In doing so, however, they revealed their position to a secondary Azerbaijani strike platform, in this case, a loitering munition.

Source: CSIS International Security Program.

unmanned systems. Today, commanders can absorb more risk in deploying these platforms into contested airspace. In so doing, they force a decision on the adversary to either engage the platform or risk being discovered and targeted—a disaster outcome in either scenario. Indeed, the proliferation of highly capable but attritable UASs has broad implications for the future of SEAD operations.

CONCLUSION

As Carl von Clausewitz noted, "An engagement in the mountains is in itself and in its consequences quite different from one on the plains."[22] Reflecting on the 2020 Nagorno-Karabakh war, Clausewitz's observations hold true in the era of network warfare and UASs. The first phase of the 2020 war in the plains demonstrated the extent to which air superiority, the application of multiple, interconnected unmanned systems, and poor battlefield tactics by the adversary can be exploited to overwhelming effect. Against unprotected, uncovered, and often concentrated Armenian forces, the first phase of the war was when Azerbaijan's technological dominance was, quite literally, put on global display via social media. Although the second phase of the war in the mountains was short, it was by-and-large an intense infantry engagement of close combat. UASs were applied in this context, but their ability to hunt and target critical defenses within the forests and ravines of Nagorno-Karabakh was not decisive.

CHAPTER FOUR

UKRAINE WAR

This chapter examines the utilization of UASs by Russia and Ukraine following Russia's invasion of Ukraine in February 2022. The continuation of military operations in Ukraine means that the "fog of war"—or uncertainty of what is occurring during combat—remains a factor.[1] Despite the limitations inherent in an analysis of an ongoing and rapidly evolving war, there are still important lessons that can be identified.

This case study finds that UASs have been critical as part of combined arms warfare. Both Russia and Ukraine have used UASs for several types of missions that have relevance to future competition: collecting battlefield intelligence through surveillance and reconnaissance missions; identifying targets for medium- and long-range artillery and aircraft; conducting electronic warfare; orchestrating strike missions against land, air, and maritime targets; and participating in information operations. Because of the effectiveness of UASs, Russia and Ukraine have also developed counter-UAS tactics, techniques, and procedures.

The rest of this chapter is divided into two main sections. The first provides a brief overview of the war in Ukraine. The second section analyzes the major lessons, from target identification to strike.

OVERVIEW OF THE WAR

Russia's 2022 invasion of Ukraine began in the early hours of February 24, when the Russian military used UASs as decoys to expose Ukrainian radars and air defense systems.[2] These actions facilitated an opening salvo of missile strikes, including from Kalibr cruise missiles and Iskander systems, on Ukrainian air defenses.[3] Russia's airborne forces spearheaded the invasion, and the Russian military conducted the initial stage of the invasion along several fronts:

- **Northern Front:** Russian forces pushed toward Kyiv from Belarus, led by units from the Eastern Military District, including the 29th, 35th, and 36th Combined Arms Armies.
- **Northeastern Front:** Russian forces moved east toward Kyiv from Russian territory, led by units from the Central Military District, including the 41st Combined and 2nd Guards Combined Arms Armies.
- **Eastern Front:** Russian forces pushed toward Kharkiv and out of the Donbas, led by units from the Western Military District, including the 1st Guards Tank Army and 20th and 6th Combined Arms Armies.
- **Southern Front:** Russian forces moved from Crimea west toward Odesa and north and east toward Mariupol. They were led by units from the Southern Military District, including the 58th, 49th, and 8th Combined Arms Armies, (Russian Airborne Forces) VDV's 7th Air Assault Division, and VDV's 11th Air Assault Brigade.

In the northern front, a company-sized element of the VDV attempted an airborne seizure of Hostomel Airport, approximately 40 kilometers outside of Kyiv, in order to establish an airbridge capable of rapidly transporting Russian matériel to the outskirts of the Ukrainian capital. This assault quickly floundered as VDV forces failed to execute suppression of enemy air defense, allowing elements of Ukraine's 4th Rapid Reaction Brigade to target multiple transport aircraft carrying paratroopers and ultimately render Hostomel Airport inoperable.[4] Meanwhile, follow-on forces advancing southward from Belarus were disrupted by Ukrainian defensive efforts. Even when Russian infantry advanced southward, these advances were often unsupported by artillery, and ground forces did not attempt a series of combined arms breakthroughs and exploitations, as Russian doctrine would dictate.[5]

The Russian military faced considerable logistics and command-and-control challenges, in part because of poor training and planning. Without access to rail transport and with roads clogged with Russian vehicles, Russian ground forces failed to move fuel, munitions, spare parts, and other matériel quickly and efficiently to forward-deployed units. Supply lines could not keep up with the long combat pushes, and logistics vehicles were not properly protected. The effectiveness of Russian long-range strike—a key aspect of Russian military operations—has also been severely impacted by logistical challenges, including an insufficient supply of precision-guided munitions. In addition, the Russian ground offensive appears to have been planned and executed based on poor assumptions about how the Ukrainian military—and the population—would respond, as well as how the West might react.

Seizing and holding territory has been a major political objective of Russian policymakers. But controlling territory in a foreign country with a hostile Ukrainian population is deeply problematic for the Russian military. In addition, Russian forces have failed to effectively integrate combined arms to seize and hold Ukrainian territory, including coordination between land power, air power, and long-range fires.[6] The Russian invasion force has also been far too small to achieve its objectives and has neglected to block Ukraine's western border to prevent the supply of foreign weapons, systems, fuel, and other aid to Ukraine.[7]

Russian forces along the southern axis of advance made operational gains during the opening phase of the invasion. Elements of Russia's 42nd Motor Rifle Division, as well as some VDV elements, captured Kherson on February 25.[8] Russian forces also advanced along the coast of the Sea of Azov, beginning a siege of Mariupol on February 24 and capturing Melitopol on March 1. Ukrainian forces waged a protracted urban defense in Mariupol, which was gradually weakened by intensive Russian artillery shelling throughout April that culminated in a Ukrainian retreat to the Azovstal steel plant, where forces held out until they were overrun by a Russian advance in May 2022.[9]

The initial Russian invasion scheme was likely designed to rapidly seize Kyiv and other major urban centers, thereby forcing the capitulation of the Zelensky government and clearing the way for Russian-backed regime change. Facing the compounding difficulties of a logistics breakdown and a stalled advance to Kyiv, Russian political and military authorities reoriented the invasion efforts around the eastern and southern axes of advance. By April 6, Russian forces had withdrawn along the northern axis of advance, removing forces from the outskirts of Kyiv and the city of Chernihiv.[10]

On April 19, Russian foreign minister Sergey Lavrov announced the "next phase" of the Russian invasion would focus on the "complete liberation" of the Donetsk and Luhansk Oblasts in eastern Ukraine, collectively known as the Donbas.[11] That same day, Russian missile and artillery forces struck hundreds of targets, primarily in the Donbas, as Ukrainian military officials claimed to repel seven different Russian thrusts against the line of contact.[12] Russian offensive efforts along the southern and eastern axes were uneven. While Russian forces advancing along the coast of the Sea of Azov secured control of territory from the Russian city of Rostov-on-Don to Crimea, forces in the east initially made some operational gains against determined Ukrainian defenses. In focusing their campaign on eastern and southern Ukraine, Russian forces seized the Luhansk Oblast in July and attempted to push to western parts of Donetsk Oblast.

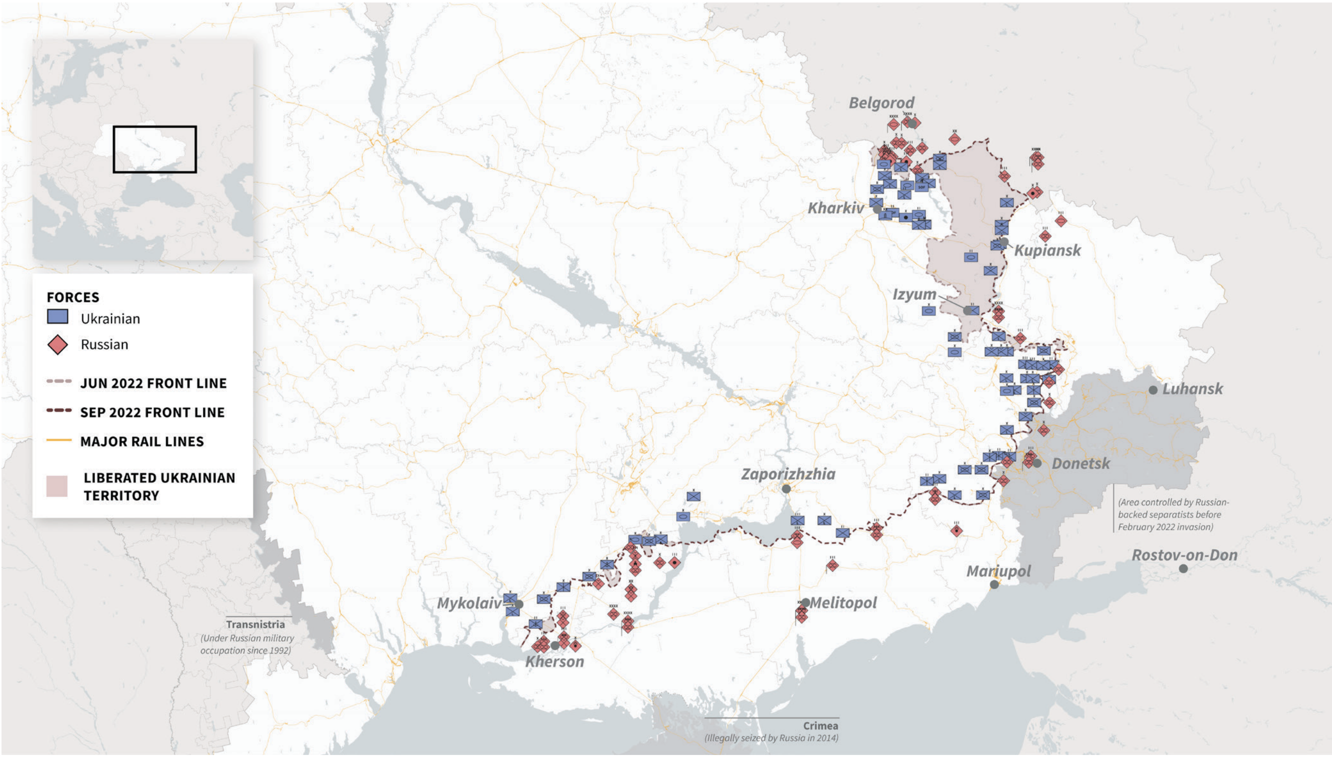
But some of these gains were wiped out following Ukraine's offensive. On August 29, the Ukrainian military announced that it had begun offensive operations in southern Ukraine centered on Kherson Oblast. Ground engagements began shortly thereafter, with Ukrainian forces reportedly breaking through defensive lines led by the 109th Donetsk People's Republic regiment and forcing their withdrawal near Kherson. Ukrainian forces fielded High Mobility Artillery Rocket Systems (HIMARS), provided by the United States, to great effect. Ukraine struck ammunition depots and bridges across the Dnipro River—as well as the Kerch Strait Bridge connecting Russia with Crimea—disrupting Russian logistics and resupply. The Ukrainian military similarly used long-range strikes to threaten Russian naval assets in the region, prompting the Russian navy to relocate Kilo-class submarines from Sevastopol, Crimea, to Novorossiysk, Russia.

On September 6, Ukraine's military launched a large counteroffensive in the northeastern Kharkiv Oblast. Ukrainian forces punched holes through Russian lines, encircling and recapturing the town of Balakliya. The Ukrainian thrust then advanced farther east, blitzing through large swaths of Russian-held territory and triggering a Russian retreat. By September 10, Ukrainian forces had seized the nearby town of Kupiansk, which served as a vital railway hub supplying Russian forces in the region. That same day, Ukrainian forces retook Izyum, a key command center and staging ground for Russia's northern front. In response, the Russian defense ministry announced the official withdrawal of troops from the collapsing frontline.

In reality, Russian troops had already begun a chaotic retreat, abandoning large stores of ammunition and combat-ready equipment. Ukraine's army captured two brigades' worth of military equipment in less than a week. Images and videos from liberated towns in Kharkiv Oblast show Ukrainian soldiers posing with abandoned Russian T-80 tanks, armored vehicles, counter-battery radars, and howitzers. Following the liberation of Izyum, Ukrainian forces continued to press north toward the Russia-Ukraine border, and east, engaging in fighting with Russian troops as they attempted to set a new defensive line on the eastern bank of the Oskil River. Ukrainian forces also regained territory in Donetsk and Luhansk Oblasts.

By late 2022, as highlighted in Figure 4.1, Russia controlled a shrinking amount of territory in southern and eastern Ukraine.

Figure 4.1: Russian and Ukrainian Force Disposition, September 2022[13]



Source: See "Chapter 4: Ukraine War" endnote 13 for full citation.

MAJOR LESSONS

Both Russia and Ukraine have integrated UASs into their war efforts—including their "kill chains." A kill chain refers to the process of gaining an understanding of the battlefield, identifying a possible target, determining the target's location and other pertinent information, deliberating what action to take, and making a decision that creates an effect to achieve an objective (such as conducting a strike).[14] The Russian military has long identified UASs as playing an important part of its "reconnaissance strike complex" (or разведивательно-ударный комплех), which is designed for the coordinated employment of high-precision, long-range weapons linked to real-time intelligence data and accurate targeting.[15] Russian forces have used a variety of UASs and loitering munitions in Ukraine, including the Orlan-10 and -30, Forpost-R, Eleron-3, Granat-1 and -2, Zastava, Takhion-4, Orion, and ZALA-421. Russia has also imported UASs from Iran, including the Shahed-131 and Shahed-136.[16]

The short-range Orlan-10, launched by folding catapult, has been the most widely used Russian UAS in the Ukraine conflict and is the most numerous in Russian military service. Each Russian land force division and brigade has had an organic UAS company equipped with Orlan-10s, and Russia possessed as many as 3,000 Orlan-10s before the war.[17] The Orlan-10 was developed for such missions as aerial reconnaissance, electronic warfare, detection of radio signals, target tracking, observation, and monitoring. It can accommodate photo and video cameras, a gyro-stabilized TV camera, and an infrared imager.[18] Russia's Forpost-R, which was developed by Israel Aerospace Industries as the Searcher Mk II, is capable of reconnaissance and strike and is equipped with indigenous software, datalinks, electro-optical sensors, an APD-85 piston engine, signals intelligence sensor packages, and a reinforced fuselage for additional survivability.[19] It includes ground control stations, antennas, and logistics support equipment. Russia also has used the Eleron-3, a small, tactical delta-wing UAS used for intelligence, surveillance, and reconnaissance (ISR).[20] There are other UASs and loitering munitions in the Russian inventory, including the short-range, flying-wing Granat-1 and -2, Israeli-manufactured Bird-Eye 400 (Zastava), "mini-UAS" Takhion-4 for reconnaissance, and the ZALA-421 loitering munition for reconnaissance and surveillance.[21]

Ukraine has operated several types of UASs. One of the most frequently used has been the Bayraktar TB2, a medium-altitude, long-endurance UAS.[22] It can perform a range of ISR and attack missions—including firing MAM-C and MAM-L guided bombs, long-range anti-tank missiles, Cirit laser-guided 70-mm rockets, and TUBITAK-SAGE laser-guided rockets. Ukraine also has operated small A1-SM Furia flying-wing UASs for day and night reconnaissance, hand-launched Leleka-100 and Spectator-M mini-UASs for artillery spotting and aerial reconnaissance, the Punisher UAS produced by UA Dynamics and used to strike military targets, and larger indigenously produced PD-1s and UJ-22s.[23] Ukrainian forces have utilized off-the-shelf commercial UASs, such as DJI Mavic 3 quadcopter, which has a retail price of roughly $3,000.[24] In some cases, Ukraine has manufactured UAS parts with 3-D printers.[25]

In addition, the United States has provided several loitering munitions to Ukraine, such as the tube-launched Switchblade 300 (with an Orbital ATK high-explosive warhead) and the long-endurance Phoenix Ghost.[26] The Phoenix Ghost, for example, is a tactical loitering munition that can fit inside a backpack, hover over a target for approximately six hours, and strike it with an explosive munition. It has infrared guidance and can operate at night.[27]

UASs have been used to conduct several types of missions in Ukraine in 2022, including: target identification for artillery and aircraft; strike; battlefield ISR; electronic warfare; and information operations. These uses have significant implications for the future of competition.

Target Identification for Combined Arms: Russia and Ukraine have used UASs to identify targets for artillery and aircraft as part of combined arms operations.[28] In one instance, Ukrainian ground forces used forward-deployed UASs to identify a Russian infantry unit near Bakhmut in Donetsk Oblast and fed the information to a command-and-control center, which passed it to Ukrainian soldiers that hit the Russian unit with a 122-mm howitzer.[29] Ukrainian forces have utilized Kropyva, an intelligence mapping and artillery software populated by information from UASs and other sources.[30] Forward-deployed tactical units have downloaded the software and continuously updated it on handheld tablets and computers. Ukraine has leveraged Starlink—a commercially owned satellite internet constellation that provides high-speed, low-latency broadband internet using advanced satellites in low earth orbit—for identification. As one Ukrainian military official noted, "We use Starlink equipment and connect the drone team with our artillery team. If we use a drone with thermal vision at night, the drone must connect through Starlink to the artillery guy and create target acquisition."[31]

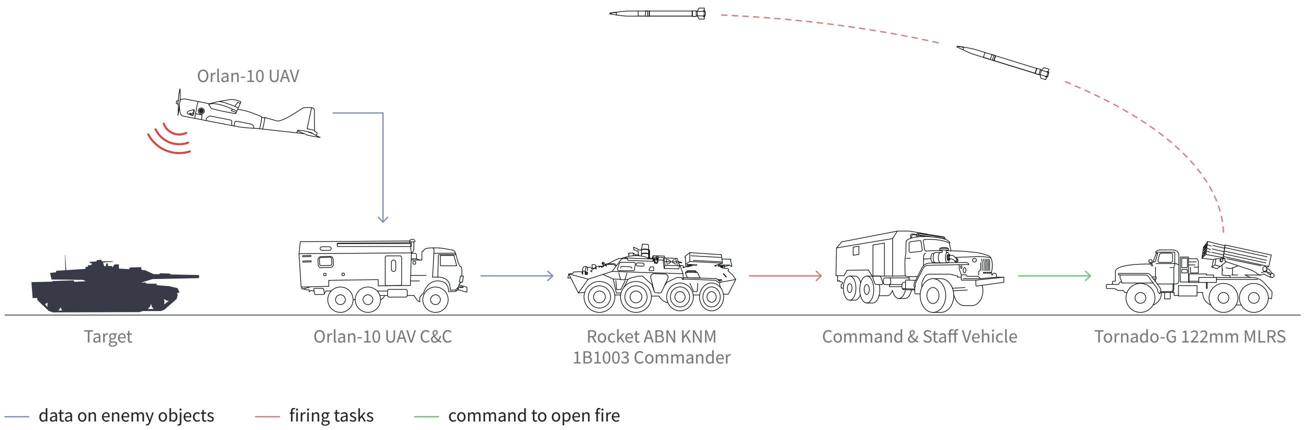
An Orlan-10 is launched via catapult as part of an exercise at the Kapustin Yar Russian training ground.

Source: Russian Ministry of Defence.

UASs have also been an important part of Russia's reconnaissance strike complex, and Russia has utilized UASs to identify targets as part of combined arms operations.[32] As highlighted in Figure 4.2, for example, Eleron-3 or Orlan-10 UASs might identify potentially targets, such as Ukrainian infantry or main battle tanks; pass the information, including the type of target and its coordinates, to command-and-control facilities; and distribute it to systems that can strike the target, such as 2S19 Msta-S 152-mm self-propelled howitzers or Tornado-S 300-mm multiple launch rocket systems.[33] In cases where UAS reconnaissance identifies a target, Russian artillery can frequently bring accurate fire down on the target three to five minutes later. In cases where a target is identified with electronic warfare direction finding, acoustic reconnaissance, or counter-battery artillery radar, it might take Russian artillery half an hour for accurate artillery fire. If Russian forces are able to keep a UAS on a target, they can adjust fire in near real-time—even if the target is moving.[34]

Strike: Russia and Ukraine have utilized UASs for strike missions, including against land, air, and maritime targets. Ukrainian Bayraktar TB2 drones have struck numerous

Figure 4.2: Example of UASs and Russia's Reconnaissance Strike Complex



Source: Jeffrey Edmonds and Samuel Bendett, *Russian Military Autonomy in a Ukraine Conflict* (Arlington, VA: Center for Naval Analyses, February 2022), 7, https://www.cna.org/reports/2022/02/russian-military-autonomy-in-a-ukraine-conflict. Concepts translated from Col. D. Mishin, "Особенности организации боевой подготовки подразделений ракетных войск и артиллерии Сухопутных войск, входящих в состав разведывательно-ударных и разведывательноогневых комплексов" [To understand the fundamentals: Organization of combat training of Ground Forces' missiles and artillery units that are part of the reconnaissance-strike and reconnaissance-fire complexes], Russian Armed Forces, July 15, 2021, accessed January 31, 2022, https://army.ric.mil.ru/Stati/item/334380.

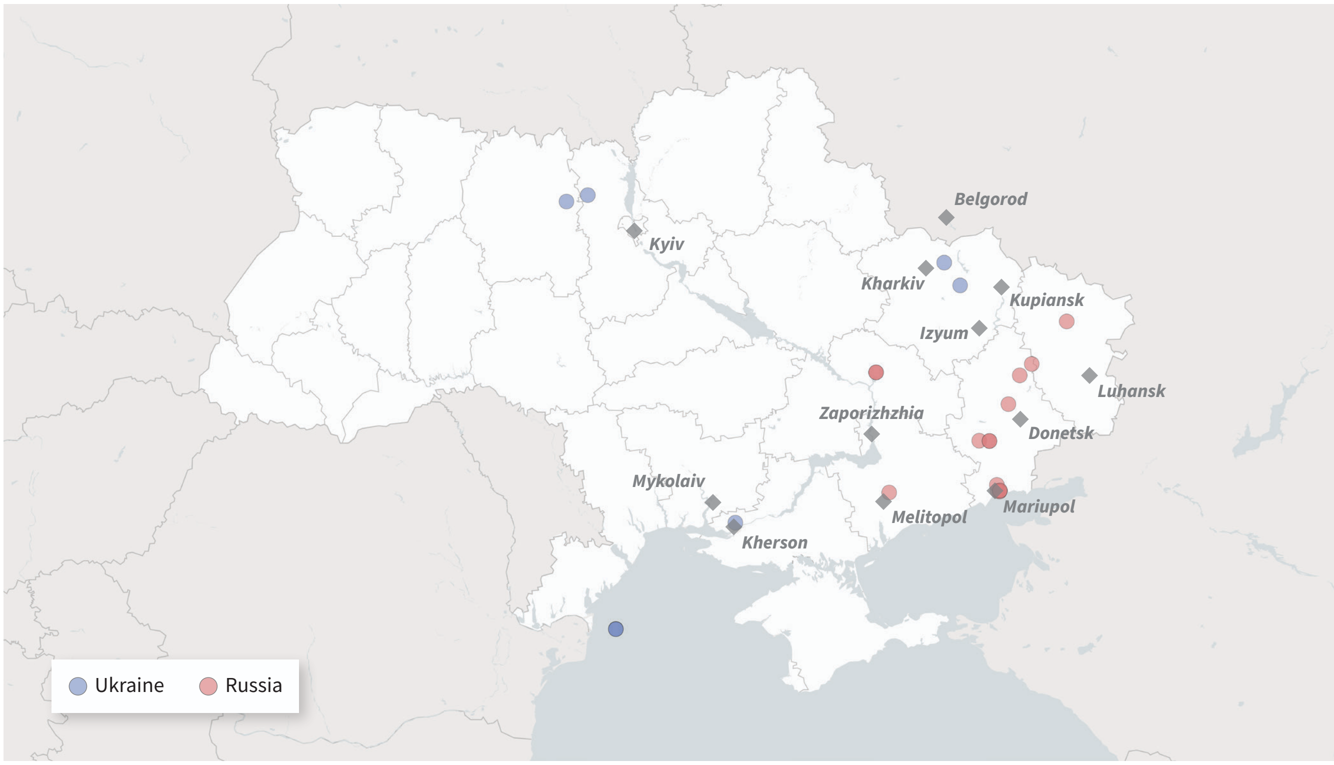
Russian targets, such as howitzers, main battle tanks, supply trucks, towed artillery, maritime vessels, command posts, logistics depots, and Buk, Tor, Strela, and ZU-23 air defense systems.[35] Between April 26 and May 8, 2022, for example, Ukrainian TB2s targeted several Raptor-class patrol boats, a Sarna-class landing craft, and helicopters in and near the Black Sea.[36] Russia has also conducted strikes with UASs, including Orlan-10s armed with freefall high-explosive fragmentation grenades.[37] Russian forces have also utilized Iranian Shahed-131 and Shahed-136 UASs to strike targets deep inside Ukrainian territory.[38] These types of UASs posed challenges for the Ukrainian military because they can fly at low altitudes that make it difficult for air defenses to detect. In October 2022, for example, a Shahed-136 struck a Ukrainian military headquarters roughly 50 miles south of Kyiv, causing significant damage to the facility and surrounding infrastructure.[39]

Battlefield Awareness: Russia and Ukraine have utilized UASs for ISR missions of enemy activity to facilitate battlefield awareness.[40] The sensors on Russian and Ukrainian UAS platforms have collected signals intelligence, videos, and other information for operational use by ground, air, and maritime forces. The Russian Orlan-10, for example, can carry photo and video cameras, a gyro-stabilized television camera, an infrared imager, and—especially with the Orlan-30—signals intelligence sensors (including direction finders).[41] These capabilities have also allowed UASs to be useful for battle damage assessment. In addition, both Russia and Ukraine have utilized UASs as decoys to provide helpful battlefield information. In the opening hours of the war, for example, Russia dispatched pulsejet-powered E95M target drones that were attacked by Ukrainian air defenses in an effort to expose Ukrainian radars and launchers to Russian suppression of enemy air defense strikes.[42] There are some indications that Ukraine has used Tu-141 UASs as decoys for similar purposes.[43]

Electronic Warfare: Russia and Ukraine have utilized UASs for electronic warfare. For example, Russia has used RB-341V Leer-3 electronic warfare payloads mounted on Orlan-10 UASs to target Ukrainian cell phone networks.[44] More broadly, Russia has utilized UASs, such as the Orlan-10, to jam GSM 900, GSM 1800, 3G, and 4G signals within a radius of roughly 6 kilometers.[45] In response, Ukraine has attempted to counter Russian electronic warfare, such as by using a radar-homing seeker payload for explosive-laden drones. Since most electronic warfare complexes take between 25 to 40 minutes to set up, forcing displacement can be an effective means of suppression that, in turn, can create windows of opportunity for Ukrainian UASs and reconnaissance teams to communicate the position of Russian systems in real-time and determine the exact coordinates of positively identified targets.[46]

Information Operations: Russia and Ukraine have utilized UASs for information operations. For example, both countries have used UAS footage to show successful strikes

Figure 4.3: Sample Locations of UAS Strikes in Ukraine



Source: CSIS analysis using data provided by Janes. Data includes information from February to June 2022.

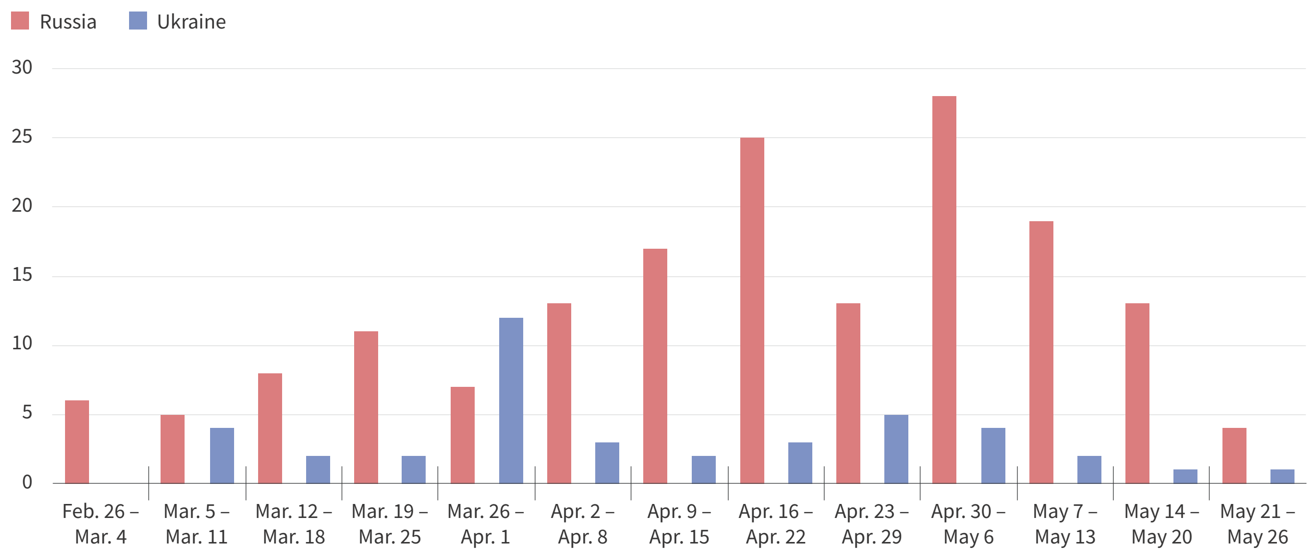
and place them—overtly or covertly—on social media platforms such as Twitter, Telegram, YouTube, and TikTok.[47] UAS surveillance has also provided high-quality imagery of ground engagements that is reminiscent of video games.

Counter-UAS Activity: In addition to these types of missions, Russia and Ukraine have developed counter-UAS tactics, techniques, procedures, and capabilities over the course of 2022. For both sides, counter-drone efforts have involved trying to break the kill chain between the operator and the UAS.[48] Russian and Ukrainian UASs have suffered high rates of attrition. Many have been shot down on the battlefield or have been subject to electronic jamming, as highlighted in Figure 4.4. For example, TB2s have been vulnerable to air defense systems, air attacks, and electronic warfare because they are slow, large, low-flying, and radio-controlled.[49] Russian UASs, such as the Orlan-10 and Forpost, have also suffered a high rate of attrition. Many have been shot down on the battlefield or subject to electronic jamming. These challenges have been exacerbated by the inability of Russia's domestic arms industry to replace these UASs quickly.[50]

According to one captured Russian document, Moscow assessed that Ukrainian "UASs, high-precision loitering, and artillery ammunition and communications equipment rely on positioning through the reception of signals from satellite radio navigation systems."[51] Russian leaders recommended that their forces continuously suppress access to satellite navigation through regular operation of the Pole-21 system and the R333Zh, both on maximum power using omni-directional jamming. The Russian guidance noted that the impact on command and control could be limited by linking command posts by ground-laid field cable. Both the Pole-21 and R330ZH systems were turned off prior to the initiation of Russian artillery strikes that might require accurate satellite-based positions.[52] Russian units have also utilized Krasukha-S4 electronic warfare systems to take down Ukrainian UASs.[53] Effective use of electronic warfare can cut off drone pilot communications, interrupt live video, or force systems to crash or retreat.[54]

To defend against electronic warfare, Russia has used the Shipovnik-Aero, a truck-mounted jamming system with a range of 15 kilometers optimized for targeting UASs. The system has detected UASs through their control frequency, analyzed and reconfirmed the information, and jammed the command frequency. The system has also been used to override the position of the UAS so that return-to-base

Figure 4.4: UASs Lost in Ukraine, February–May 2022



Source: CSIS analysis using data from open-source websites ACLED and Oryx.

Figure 4.5: Example of UASs Lost by Platform Type

UAS TYPE	NUMBER LOST
Military Forces of Russia	**169**
KBLA-IVT	1
Enix E95M	3
Enix Eleron	10
Forpost-R	3
Kalashnikov Group KUB-BLA	1
Kronstadt Orion	1
STC Orlan variants	101
Izhnash Takhion	2
ZALA 421-16E2	3
Unspecified reconaissance drone	2
Unknown	42

UAS TYPE	NUMBER LOST
Military Forces of Ukraine	**41**
Athlon-Avia A1-SM Fury	4
DeViro Leleka-100	3
Spaitech Sparrow	1
TB2	11
Tupolev variants	5
Ukrjet UJ-22	1
Unspecified loitering munition	1
Unspecified VTOL UAV	1
Unknown	14

Source: CSIS analysis using data from open-source websites ACLED and Oryx. Data collected runs from February–May 2022.

protocols lead the UAS to land in a location designated by Russian forces.[55] In addition, Russia has used Pantsir short-range air-defense systems to target Ukrainian TB2 drones.[56] Russians forces have also used early warning radars to identify UASs and electronic warfare systems and jam and disrupt their communication. To target UASs and ground control stations, Russian forces have used machine guns; air defense systems, such as the Tor missile system; 152-mm howitzers; 300-mm multiple launch rocket systems; and Tochka-U systems.[57] Russian successes over time in targeting Ukrainian UASs have led to a lifespan of roughly seven days for a Ukrainian UAS.[58]

Ukraine has conducted its own counter-UAS efforts. For example, Ukraine has maintained organic man-portable air-defense teams, sometimes equipped with visually guided systems, such as Starstreak and Martlet, to target UASs.[59] In response to Russian activity, many Ukrainian units have had to choose between having a live feed from their UASs and risking a high likelihood of losing the platform or sending UASs out on pre-set flight plans and analyzing their intelligence *after* they return. While this tactic has minimized Russian counter-UAS activity, it also has caused significant delays in using intelligence for operations.[60] As UASs become more autonomous and less dependent on GPS, jammers will be less effective.[61]

CONCLUSION

As this chapter highlights, Ukraine and Russia have utilized UASs in combined arms operations—a notable evolution from the use of UASs against terrorist targets. UASs have been used for collecting battlefield intelligence, identifying targets for strikes by artillery and other platforms, conducting electronic warfare, executing strike missions, and waging information operations.

CHAPTER FIVE

NORTHERN EDGE 21

There is a significant empirical gap in current assessments about the role of UASs in future war—especially the potential utility of these systems in a high-intensity conflict between the United States and China. This was the case in May 2021, when U.S. Indo-Pacific Command (INDOPACOM) convened the 2021 iteration of its biannual Northern Edge exercises. Northern Edge 21 (NE21)—held in various locations in and around Alaska—included approximately 15,000 U.S. service members, 6 Navy vessels, and 240 aircraft.[1] For 2021, Northern Edge was designed to test the current capacity of U.S. forces to conduct joint operations and execute on the vision of the U.S. Department of Defense's joint all domain command and control (JADC2) concept against a major competitor in the Indo-Pacific area, such as China.

The U.S. Department of Defense disclosed some information about the overarching purpose of NE21, along with a list of specific assets and capabilities involved in the exercise; however, only limited details about the specific combat scenarios themselves have been made publicly available. Individual elements of the exercise are known to have included large-scale air combat operations, some of which included the deployment of more than 100 friendly and adversary aircraft; a long range, non-line of sight simulated hypersonic strike; and a joint force seizure of an enemy airfield.[2]

The overall purpose of the Northern Edge exercises is to stress test emerging capabilities and concepts in a realistic exercise environment that simulates a conflict against a major power. As one commander involved in NE21 noted, "It is one of only a handful of exercises that combine great power competition-level threat complexities with the joint interoperability necessary to realistically inform our test data."[3] While not a historical case study, such as Nagorno-Karabakh and Ukraine, NE21 provides a useful preview of future conflict.

OVERVIEW OF THE EXERCISE

NE21 included several crewed aircraft, such as the F-35A, B-1 Lancer, U-2, multiple iterations of the F-15 (including the new F-15EX featuring an upgraded electronic warfare suite), several cargo aircraft, and a B-52H modernized to ingest targeting data from a range of all-domain sensors.[4] The primary UAS integrated into NE21 was the MQ-9 Reaper, including the so-called "Ghost Reaper," an Air National Guard MQ-9 with upgraded communications packages and machine learning capabilities. The Ghost Reaper modifications, alongside additional MQ-9 modernizations that include new sensors and anti-jamming capabilities, will result in a retrofitted multidomain operation version of the aircraft, which the U.S. Air Force claims will be better suited for strategic competition and major power threats.[5] All of these air assets were integrated with a carrier strike group and Army ground components, including an M142 High Mobility Artillery Rocket System (HIMARS) battery.

Despite the absence of available in-depth information detailing the overall NE21 scenario, some judgments about the potential role of UASs in future joint all domain operations can be formulated based on the objectives of the exercise—specifically to test new joint all-domain operations capabilities and concepts—and on available information about the various new UAS capabilities that were deployed as part of the exercise. The remainder of this chapter evaluates the specific UAS capabilities deployed during NE21 and concludes with observations about what these systems suggest about the future role of UASs in joint operations against major powers.

The MQ-9 Reapers deployed during NE21 integrated at least four new payloads that were designed to enhance the platform's utility beyond its traditional utility for intelligence, surveillance, and reconnaissance (ISR) and strike operations in uncontested airspace. The first is the Reaper Defense Electronic Support System (RDESS), which reportedly allows the MQ-9 to "collect and geo-locate signals of interest from standoff ranges."[6] The claimed significance of this platform is that it enables the MQ-9 to conduct ISR operations and precision targeting at a sufficient standoff distance from the target so as to avoid enemy countermeasures. The RDESS capability, deployed alongside additional electronic countermeasures, is intended to augment the survivability of the existing MQ-9 airframe.[7]

The second and third new payloads were designed to facilitate communications and data flows consistent with the "sense and integrate" pillars of the JADC2 strategy.[8] This includes the Rosetta Echo Advanced Payloads (REAP) Pod and the Freedom Pod, both of which enable communications interoperability across different protocols and radio networks.[9] These types of "Rosetta Stone" communications capabilities are important remedies to poor communications interoperability across weapons

PHOTO SOURCE: U.S. AIR FORCE PHOTO BY SENIOR AIRMAN BEAUX HEBERT platforms. A range of software-defined capabilities and new payloads—including devices like the Freedom Pod that bridge communications between fourth and fifth generation fighters—are unavoidable stopgap solutions that the United States needs to adopt if it has any realistic intention of achieving the level of machine-to-machine integration it envisions for the future joint force.[10] The integration of these communications capabilities into an MQ-9—or any other UAS or manned air asset—allows communications and data to flow between platforms that may use different tactical data links, such as Link 16, the F-35's Multifunction Advanced Data Link, or the F-22's Intra-Flight Data Link.

The fourth and final new payload is the MQ-9 Centerline Avionics Bay (CAB) pod, which is designed to integrate high-performance onboard computing capability for processing sensor data onboard the aircraft. Bandwidth and computing demands in modern warfare are massive. Future combined arms warfare focuses on the continuous flow of timely, actionable information across all domains. Continuous modernization across tactical sensors in the air, space, sea, and land domains will result in these battle networks collecting larger and larger quantities of data. While the joint force would prefer to push tactical data to robust, large-scale, ground-based cloud computing clusters, high-intensity conflict will require conducting these activities within the battle network itself. As demonstrated at NE21, aircraft, including UASs, are viewed as suitable assets for conducting high-powered computing data analytics within the tactical battle network itself. The United States is preparing to conduct such operations in a communications-deprived environment. Integrating onboard compute capabilities into multimission tactical platforms such as UASs can substantially reduce bandwidth challenges by conducting initial data triage and purging extraneous "noise."

One additional data point from NE21 that helps illuminate the role of UASs in future war is the exercise's disclosures about the integration of the all-domain operations capability-experiment (ADOC-E) with a B-52 Stratofortress carrying a simulated hypersonic missile. According to the U.S. Air Force, the ADOC-E is designed to enable joint operations in environments where traditional command-and-control structures are degraded or denied.[11] In the scenario, the ADOC-E fed targeting data—integrated from multiple sensors, services, and platforms—to the B-52 from a distance of 1,000 miles, enabling the B-52 to launch a simulated AGM-183A missile at a target 600 miles away. Even though this element of the exercise did not emphasize UAS, it is an important example of the types of all-domain operations that were being tested. In this case, it was the simulation of a capability that can ingest multimodal targeting data and feed it to a long-range strike platform, a mission that could be tasked to a UAS in a different scenario.

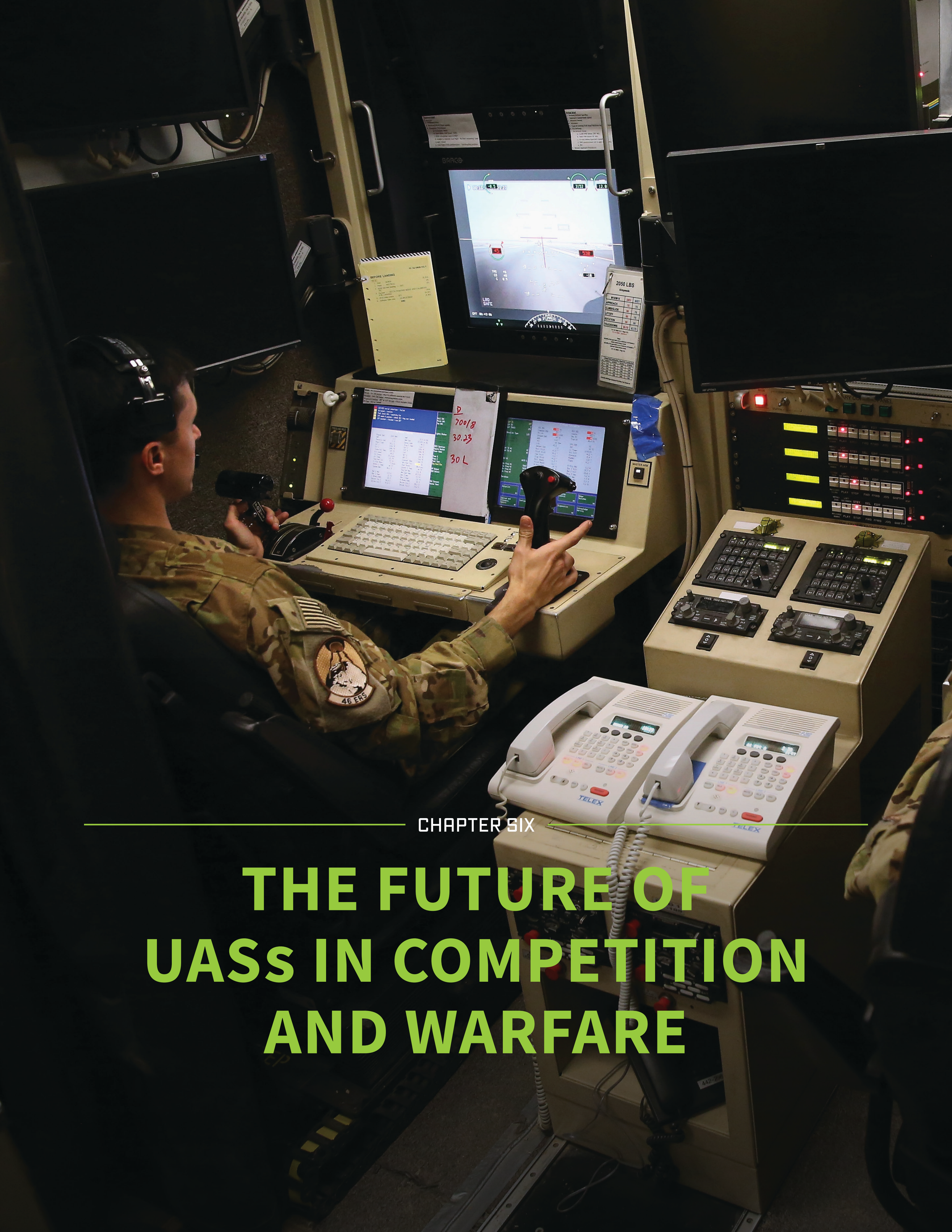
MAJOR LESSONS

The available data about the MQ-9 capabilities deployed in support of NE21, and the exercise's focus on enabling joint all domain operations, suggest three primary lessons for UASs in conflict with a major power.

Survivability in Contested Airspace: The first lesson is the importance of improving the survivability of these systems to conduct ISR operations in contested airspace. Based on NE21, efforts to field more survivable UAS platforms are not necessarily restricted to ongoing U.S. Air Force efforts to field entirely new airframes. As suggested by the utilization of the RDESS pod, ongoing developments in advanced sensors are making it possible for retrofitted platforms to conduct missions at increasing standoff distances, reducing their exposure to air defenses. Additional efforts to harden the ability of existing systems to withstand communications jamming and other electromagnetic attacks, again, reflect efforts to recapitalize existing airframes for strategic competition and great power conflict in the near term.

Nodes in an Integrated Battle Network: The second lesson is the utility of UASs as communications nodes in an integrated battle network. This includes the capacity to ingest data from air, land, sea, space, and cyberspace and relay this data back to decisionmakers and joint fires. Given the range of different assets deployed in support of NE21, future joint operations are building toward an integrated network of diverse sensors. These sensors, however, will not be effective if the data they generate cannot be ingested, fused, analyzed, and disseminated at machine speed, even in austere and denied environments. In a conventional war with a major power, all sides will likely leverage artificial intelligence to accelerate decisionmaking, seeking information and decision advantage over their adversary. Correspondingly, all sides will be under significant pressure to build sensors, battle networks, edge computing, and analytics to exploit decision windows that are getting smaller and smaller.

MultiMission ISR: The third lesson is the capacity for UASs to conduct multimission ISR in support of joint operations. This includes signals intelligence, electronic intelligence, measurement and signature intelligence, and imagery intelligence collection, the latter of which includes full motion video and hyperspectral, multispectral, and synthetic aperture radar. In future combat, intelligence generated by these systems will be fused with collection from other assets—such as satellites—to contribute to an integrated intelligence and targeting picture.



CHAPTER SIX

THE FUTURE OF UASs IN COMPETITION AND WARFARE

As this report highlights, UASs have played an increasing role in interstate warfare and have been integrated into combined arms warfare. They have been used to collect intelligence for battlefield awareness, provide real-time or near real-time information to artillery and other systems for standoff attack, perform battle damage assessment, conduct electronic warfare, strike targets, engage in information operations, and execute other missions. These uses represent a departure from the way the United States has frequently utilized UASs against terrorist networks, which often includes unilateral operations to target terrorist leaders and infrastructure.

As the cases studies highlighted, Azerbaijan effectively utilized UASs as part of a combined arms approach—including with fixed-wing aircraft, helicopters, loitering munitions, guided missiles, and artillery—to reverse a three decade-long stalemate in Nagorno-Karabakh. In Ukraine, both Russia and Ukraine have used UASs as part of combined arms warfare to conduct offensive and defensive operations—including to seize or defend physical territory in Ukraine—following Russia's February 2022 invasion. UASs have been particularly valuable in a contested environment to improve battlefield awareness without risking loss of life. In Northern Edge 21 (NE21), UASs—including MQ-9 Ghost Reapers—were involved in an integrated battle network that included long-range fires, F-35A Lightning IIs, satellites, F-15C Eagles, F-15E Strike Eagles, and other platforms and systems to collect intelligence and conduct strikes in an Indo-Pacific setting.

This chapter builds on the previous chapters by asking: what are implications for the future of warfare and strategic competition? It argues that future security competition involving the United States, China, Russia, and other countries will likely be global in scope and cover significant areas of the land, air, maritime, cyber, and space domains. It will be important to have platforms and systems capable of collecting intelligence over vast geographics areas, striking targets if necessary, and operating in a contested environment as part of combined arms warfare. UASs will be useful because they are capable of expeditionary operations with extended range and persistence. In addition, leaders often prefer UASs over piloted aircraft because they are perceived as being less escalatory.

Conducting a range of missions will require a broad suite of UASs and loitering missions that vary in range, payload, and sophisticated capabilities such as advanced sensors. In particular, UASs will likely play an important role in several types of missions as part of competition and warfare with such countries as China and Russia, including:

- Domain awareness and early warning;
- Battlefield awareness;
- Targeting for stand-off attacks;
- Strike;
- Electronic warfare; and
- Information operations.

The rest of this chapter is divided into three sections. First, it examines the evolving nature of strategic competition and warfare. Second, it assesses the primary missions of UASs as part of combined arms warfare. Third, it provides a brief conclusion, including the challenges and opportunities of innovation.

UASs IN COMPETITION AND WARFARE

Security competition is not likely to occur only in such areas as the Taiwan Strait, South China Sea, or the Baltics. Instead, it is likely to be global for at least two reasons. First, great powers need access to foreign markets for raw materials and other goods and services that they need to bolster their military and economic power.[1] Second, great powers have historically attempted to expand their influence, particularly at the expense of other powers.[2] During the Cold War, for example, competition did not primarily occur in Europe but rather in Africa, Latin America, and Asia. As the political scientist Hans Morgenthau argued, the Cold War was fought across the globe "primarily in terms of competition between two rival political philosophies, economic systems, and ways of life."[3] Indeed, future competition with China and, to a lesser extent, Russia will likely occur across a diverse geographic landscape, from densely populated cities to littoral areas, deserts, and mountains.

China, for instance, is expanding its global reach. Beijing is increasing its global power projection by building military bases, infrastructure, and access across the globe, including in Cambodia, Djibouti, Pakistan, Tanzania, Equatorial Guinea, and the United Arab Emirates. In April 2022, China signed a security pact with the Solomon Islands, raising concern in Australia, the United States, and other countries that it would help Beijing further establish a military foothold in the Western Pacific.[4]

In addition, China's Belt and Road Initiative is an ambitious global development strategy that uses infrastructure investments to expand China's political, economic, and military power.[5] But China has used economic assistance as part of the Belt and Road Initiative to pressure foreign governments to adopt favorable policies on such issues as Taiwan, Hong Kong, Tibet, control of islands in the South China Sea, and the plight of Uyghurs in western China. Chinese president Xi Jinping's goal is to create a vast network of railways, highways, energy pipelines, maritime trade routes, and ports to connect China with the rest of Asia, Europe, the Middle East, and Africa. The "belts" refer to the network of land routes that connect China to Central Asia, the Middle East, Russia, and Europe. The "roads" refer—somewhat confusingly—to the maritime routes, including ports, that connect Chinese seaports to countries in the South China Sea, Indian Ocean, South Pacific, and Mediterranean Sea.

Russia has also expanded its global footprint. Russia has military bases in Ukraine, Armenia, Azerbaijan, Belarus, Georgia (in Abkhazia and South Ossetia), Kazakhstan, Kyrgyzstan, Moldova, Sudan, Syria, Tajikistan, and Vietnam. Instead of deploying large numbers of conventional Russian soldiers, however, Moscow has leveraged special operations forces, intelligence units, private military companies, and other governmental and nongovernmental organizations to expand its influence, build the capacity of partners and allies, and increase economic opportunity. Some Russian private military companies, such as the Wagner Group, are quasi-arms of the Russian government, and they have direct or indirect links with the Russian Ministry of Defense (particularly the Main Intelligence Directorate), the Federal Security Service, the Foreign Intelligence Service, and the Kremlin.[6]

These developments have important implications for UASs for competition and warfare.

First, given the decline in the U.S. military footprint in key parts of Africa, the Middle East, and South Asia, there will likely be a growing need to develop and utilize UASs and other air- and space-based capabilities that can collect and process vast amounts of information on adversary activities as part of balance-of-power competition. Countries such as China, Russia, and Iran will likely attempt to hide their actions in the land, maritime, air domains; across a rich variety of terrain, from jungles and mountains to dense forests and sub-surface locations; and in areas with diverse demographics, including tightly packed cities. These countries may also attempt to use denial and deception tactics and techniques, as well as stealth and other technologies, to hide or mask their actions. These challenges will require the United States and its partners to overcome the tyranny of distance (operating over a significant area) and time (reacting quickly when necessary).[7]

Second, there will likely be a need to focus on UASs that can operate with extended range, higher payloads, and improved technology in contested environments during warfare. China and Russia are expanding their kill zones with improved ballistic, cruise, and hypersonic missiles; long-range fires; fifth-generation aircraft; and other systems and platforms. In addition, such countries as China, Russia, and Iran could give increasingly sophisticated capabilities to state and non-state actors, or they could forward-deploy standoff systems to foreign countries. As discussed in more detail in the next section, UASs will likely have an important role to play during warfare to conduct battlefield awareness, strike, electronic warfare, and other missions.

The United States' main strategic competitors are also continuing to develop UASs. As part of its comprehensive military modernization program, for example, China is developing longer-range and more technologically sophisticated UASs that can operate with higher payloads for intelligence, surveillance, reconnaissance (ISR), strike, and other missions—such as the WZ-7 Xianglong (Soaring Dragon), Wuzhen-8 (WZ-8), Gongji-11 (GJ-11), Feihong 95 (Flying Swan or FH-95), and Caihong-7 (CH-7).[8] The FH-95 has electronic intelligence (ELINT), electronic support measures, and electronic warfare payloads to collaborate with other manned and unmanned platforms to conduct deep strikes against enemy targets.[9] In August 2022, the People's Liberation Army deployed BZK-005E (Changying), TB-001, and other UASs near Taiwan and Japan during heightened tension between the United States and China following the visit by Nancy Pelosi, speaker of the U.S. House of Representatives, to Taiwan.[10] Chinese assessments recognize the utility of UASs and other unmanned systems in warfare.[11] As some Chinese analysts have concluded, UASs can be helpful for ISR and targeting in a contested environment—including providing timely bomb damage assessment.[12]

After examining Russian operations in Syria, one Chinese assessment concluded, "In order to be familiar with the battlefield situation and accurately determine the nature and location of the target, the Russian army used unmanned reconnaissance aircraft, reconnaissance satellites and other air and space capabilities during attacks against the Islamic State in Syria, which greatly improved the strike accuracy and the strike effect."[13] China has also conducted multiple experiments with swarming UASs in combat.[14] In addition, China has introduced other unmanned systems, such as autonomous ground vehicles, into its military. In 2021, for example, the Sharp Claw I unmanned ground vehicle, which was produced by China North Industries Corporation, entered service with the People's Liberation Army Ground Force.[15]

COMBINED ARMS

UASs will continue to play an important role in several types of missions as part of strategic competition and warfare with such countries as China and Russia, including domain awareness and early warning, battlefield awareness, targeting for standoff attacks, strike, electronic warfare, and information operations. For example, the U.S. Marine Corps is planning to utilize various types of UASs—such as MQ-9A block 5 extended-range Reapers and block 30 ground control stations—to conduct electronic warfare, airborne early warning, maritime domain awareness, and communications and data network relay in the Indo-Pacific to counter a growing threat from China.[16] UASs, such as the MQ-9B short-takeoff and landing (STOL), can be launched off ships, such as the Wasp-class landing helicopter dock (LHD) amphibious assault ship.

While it is not the focus of this report, there will also be a growing need to adopt counter-UAS tactics, techniques, procedures, and capabilities in response to the proliferation of UASs. Examples include GPS hardening; integration with systems, such as Starlink; and development of various command-and-control options, such as multiband satellite communications (SATCOM), tactical targeting network technology (TTNT), Link 16, high frequency, and cloud-based artificial intelligence (such as the JAIC Smart Sensor). In Ukraine, counter-UAS efforts have involved trying to break the kill chain between the operator and the UAS. Russian and Ukrainian UASs have suffered high rates of attrition. Many have been shot down on the battlefield or have been subject to electronic jamming. For example, TB2s have been vulnerable to air defense systems, air attacks, and electronic warfare. Russian UASs, such as the Orlan-10 and Forpost, have also suffered a high rate of attrition.

Conducting these types of missions will require a broad suite of UASs and loitering missions that vary in range, payload, and capability. The rest of this section provides an overview of some of the primary missions UASs can perform as part of combined arms operations.

Domain Awareness and Early Warning: UASs will play an important role in ISR in large geographic expanses around the world in the land, maritime, and air domains. UASs can be designed with range, endurance, and ISR capabilities that are well suited to operations in and around expansive areas such as the Indo-Pacific. In the 2022 Rim of the Pacific exercise, UASs such as the SeaGuardian supported maritime domain awareness and anti-submarine operations through intelligence payloads—including synthetic aperture radar, inverse aperture radar, electro-optical and infrared sensors, ELINT, communications intelligence (COMINT), and various other sensors.[17]

Of particular use will be continued developments in advanced sensing with multifunction processors and multifunction apertures, longer range and persistence, enhanced command and control, and improved data exploitation for domain awareness. UASs can collect signals intelligence (SIGINT), ELINT, COMINT, measurement and signature intelligence (MASINT), and imagery intelligence. For maritime domain awareness, for example, UASs can play an increasingly helpful role using maritime wide-area search radar, synthetic aperture radar, inverse aperture radar, ground moving target indicator technology, and weather collection capabilities.

UASs can also provide airborne early warning by combining advanced sensors with networks of UASs. They are a low-cost alternative to fixed-wing early warning aircraft. In the Arctic, for example, UASs could provide early warning capabilities along the northern approaches to monitor and, if required, engage hostile aircraft and cruise missiles over extended distances. As part of airborne early warning, UASs can exchange information from other platforms and systems using TTNT command and control, multispectral targeting system/synthetic aperture radar, and the Multifunction Advanced Data Link (MADL).

In addition, there are options for domain awareness missions using contractor-owned and -operated activities. This option makes access to ISR from UASs potentially affordable to allies and partners; provides the capability to a country when a foreign military sale may not be quickly approved by the United States; and can deliver that capability in a few months rather than the several years it might take to complete an acquisition. There is also a possibility of multicountry contractor-owned and -operated activities to reduce partner costs while generating multilateral cooperation where little might currently exist.

Battlefield Awareness: In war, UASs can provide ISR of enemy activity. As the 2022 Rim of the Pacific exercise highlighted, such UASs as the MQ-9B SeaGuardian and smaller V-Bat streamed live video and data feeds back to command centers on shore for battlefield awareness.[18] For long-range operations, UAS tankers may also be able to refuel UASs and manned systems, though effective teaming will require continuing technological advances.[19]

The three cases examined in this report—Nagorno-Karabakh, Ukraine, and NE21—highlighted the utility of UASs for battlefield awareness. In Ukraine, the Russian Orlan-10 has carried photo and video cameras, a gyro-stabilized television camera, an infrared imager, and—especially with the Orlan-30 and Orlan-50—SIGINT sensors (including direction finders).[20] These capabilities have also allowed UASs to be useful for battle damage assessment. NE21 emphasized the utility of UASs as communications hubs in joint operations, including the capacity to collect data from air, land, sea, space, and cyberspace and relay this data back to decisionmakers and joint fires.

Targeting for Standoff Strikes: In addition to general battlefield awareness, UASs can provide information to other ground, air, or maritime systems for strikes in wartime. This role allows UASs to help close the long-range kill chain by delivering persistent effects at range and scale, and it makes UASs useful as collaborative platforms and systems in a contested battlespace. In the Ukrainian war, Russia and Ukraine have used UASs to identify targets for artillery, aircraft, and maritime platforms as part of combined arms operations. More broadly, UASs have been an important part of Russia's reconnaissance strike complex.

UASs can also be used for decoys. In Nagorno-Karabakh, Azerbaijan used An-2s as decoys against Armenian air defense systems. In several instances, Armenian air defense systems targeted An-2s and revealed their positions, allowing Azerbaijan to identify and target the now-exposed air defense systems. In the opening hours of the Ukraine war, Russia dispatched E95M UASs that were attacked by Ukrainian air defenses, similarly exposing Ukrainian radars and launchers to Russian suppression of enemy air defense strikes.

Strike: UASs will continue to be useful in conducting air-to-ground, air-to-air, and air-to-sea strikes in contested and uncontested environments, requiring them to be larger, faster, and able to carry larger and more lethal payloads. To conduct strikes, UASs will need to include improved infrared sensors, cameras, laser designators, and laser illuminators. In addition to UASs, cheaper, more lethal, and longer-range loitering munitions will likely be helpful in conducting strikes.

In Nagorno-Karabakh, Azerbaijan utilized Bayraktar TB2s for strike operations against Armenian T-72 tanks and other targets. The TB2s operated with lower-altitude, smaller UASs, such as Orbiters. In Ukraine, both Russia and Ukraine have utilized UASs for strike operations against land, air, and maritime targets. Ukrainian TB2s have struck numerous Russian targets, such as howitzers, main battle tanks, towed artillery, maritime vessels, logistics depots, and air defense systems. Russia has also conducted strikes with UASs, including Orlan-10s.

Electronic Warfare: UASs will also play an important role in electronic attack against land, maritime, and air targets, including degrading, neutralizing, or destroying enemy combat capabilities and communications. In Ukraine, Russia and Ukraine have utilized UASs for warfare. For example, Russia has used the RB-341V Leer-3 electronic warfare payloads mounted on Orlan-10 UASs to target Ukrainian cell phone networks. More broadly, Russia has utilized UASs, such as the Orlan-10, to jam GSM 900, GSM 1800, 3G, and 4G signals.

Information Operations: Finally, UASs can play a helpful role in real-time information operations during warfare or as part of broader competition. For example, videos of strikes or other activity by U.S., allied, or partner forces can be downloaded, declassified, and distributed either overtly on government websites and digital platforms or provided to news outlets or digital platforms, such as Twitter, Instagram, Telegram, YouTube, Facebook, and TikTok, for distribution. The same can be done with videos and other information collected by UASs regarding Russian, Chinese, or other adversary activity.

During skirmishes in July 2020, for example, Azerbaijan's Ministry of Defense posted several videos of air, missile, and artillery strikes on YouTube. Beginning on September 27, the first day of the war, Azerbaijan began posting multiple videos each day of raw drone footage of air and artillery strikes. These videos were derived from a variety of UASs and loitering munitions, as well as the Spike NLOS guided missile. The primary purpose of this propaganda was likely to solidify domestic public support for the war and the ruling administration. In Ukraine, both Russia and Ukraine have used UAS footage to show successful strikes and place them—overtly or covertly—on social media platforms.

Despite the growing use of UASs in combined arms—from strike to information operations—there will still be limitations with UASs. One example is weather, since even advanced systems face significant challenges operating in heavy rain, high winds, icy conditions, snow, and other types of poor weather. As one U.S. Department of Defense investigation concluded, "Ice and extreme wind limit UAS operations . . . Specifically, ice buildup on UAS wings reduces lift, increases drag, amplifies vibrations, and jeopardizes stability."[21] As noted at the beginning of this chapter, another challenge will likely include responding to the evolution of counter-UAS tactics, techniques, procedures, and technologies.

CONCLUSIONS

Military innovation is always difficult. As this report shows, however, there has been notable innovation in the use of UASs for combined arms operations. Over 400 years ago, Machiavelli wrote: "And it should be considered that nothing is more difficult to handle, more doubtful of success, nor more dangerous to manage, than to put oneself at the head of introducing new orders."[22] Machiavelli's insight is prescient today for innovation in UASs—both with their technology and how they are used in competition and warfare.

However, innovation in the use of UASs for combined arms operations will require the continuous modernization of critical components that go on the platforms, such as sensors, communications, and payloads. Continuous modernization is essential because sensors are improving at the speed of electronics, with new generation capabilities coming out every few years. This type of modernization will be challenging to implement since the U.S. Department of Defense's acquisition system is not set up for continuous modernization. Instead, it is set up for the acquisition of platforms that last 30 years or more.

In the future, the front lines of battlefields may be increasingly saturated by UASs performing a plethora of missions. Over the last several decades, UASs—such as the MQ-9 Reaper and MQ-1 Predator—were used by the United States and other governments to collect intelligence on, and conduct strikes against, terrorist networks. As recent wars and exercises suggest, however, they will play a notably different role in the future. Their primary utility will likely not be executing unilateral operations, but in conducting a range of missions—from battlefield awareness to strike, electronic warfare, and information operations—as part of combined arms operations.

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Appendix 1

UASs AND OTHER SYSTEMS USED BY AZERBAIJAN IN THE 2020 NAGORNO-KARABAKH WAR

Aerostar

Type: Fixed-wing ISR UAS
Description: A medium-altitude, long-endurance (MALE) tactical UAS; marketed for ISR, targeting, and electronic warfare missions.
Range: 200 km
Endurance: 12 hours
Origin: Israel
Manufacturer: Aeronautics Defense Systems

An-2

Type: Single-engine biplane
Description: Flying unmanned or as remote-controlled drone to draw out air defenses.
Range: 845 km
Endurance: 6 hours
Origin: Russia
Manufacturer: Antonov

Bayraktar TB2

Type: Fixed-wing ISR and precision strike UAS
Description: A medium-altitude, long-endurance (MALE) tactical UAS; marketed for ISR, targeting, and precision strikes; payload carries four smart munitions.
Range: 300 km
Endurance: 27 hours
Origin: Turkey
Manufacturer: Baykar

Harop

Type: Fixed-wing loitering munition
Description: A long-endurance loitering munition UAS carrying a 26 kg explosive; designed for suppression of air defense operations.
Range: 1000 km
Endurance: 6 hours
Origin: Israel
Manufacturer: Israel Aerospace Industries

Hermes-180/200

Type: Fixed-wing ISR UAS
Description: A tactical, close-range UAS for brigade-level ISR missions; designed for high mobility, forward tactical deployment, and minimum logistical footprint.
Range: 150 km
Endurance: 10 hours
Origin: Israel
Manufacturer: Elbit Systems

Hermes-450

Type: Fixed-wing, multirole UAS
Description: A tactical, long-endurance UAS primarily for ISR missions; designed for many configurations; an armed version is thought to exist.
Range: 200 km
Endurance: 17 hours
Origin: Israel
Manufacturer: Elbit Systems

Hermes-900	**Type:** Fixed-wing ISR UAS **Description:** A medium-altitude, long-endurance (MALE) tactical UAS principally designed for ISR operations; designed for multipayload configurations. **Range:** 2,500 km **Endurance:** 36 hours **Origin:** Israel **Manufacturer:** Elbit Systems
Heron	**Type:** Fixed-wing ISR UAS **Description:** A medium-altitude, long-endurance (MALE) tactical UAS principally designed for ISR operations; designed for multipayload configurations. **Range:** >1,000 km **Endurance:** >30 hours **Origin:** Israel **Manufacturer:** Israel Aerospace Industries
Kargu	**Type:** Rotary-wing ISR and precision strike UAS **Description:** Designed to collect tactical ISR and carries 1.3 kg warhead for self-destruct precision strikes. **Range:** 10 km **Endurance:** 30 min **Origin:** Turkey **Manufacturer:** Bluebird
Orbiter-1K	**Type:** Fixed-wing loitering munition **Description:** Designed for loitering attack missions against soft-shell and human targets; carries >3 kg warhead with guidance capabilities. **Range:** 100 km **Endurance:** 2.5 hours **Origin:** Israel **Manufacturer:** Aeronautics Defense Systems
Orbiter-2	**Type:** Fixed-wing, man-portable ISR UAS **Description:** Designed for ISR use at tactical levels. **Range:** 100 km **Endurance:** 4 hours **Origin:** Israel **Manufacturer:** Aeronautics Defense Systems
Orbiter-3	**Type:** Fixed-wing Small Tactical ISR UAS (STUAS) **Description:** Designed to operate with and support the higher tactical echelon with ISR. **Range:** 150 km **Endurance:** 7 hours **Origin:** Israel **Manufacturer:** Aeronautics Defense Systems
Searcher	**Type:** Fixed-wing ISR UAS **Description:** UAS principally designed for ISR operations. **Range:** 350 km **Endurance:** 17 hours **Origin:** Israel **Manufacturer:** Israel Aerospace Industries

Skylark	**Type:** Fixed-wing, hand-launched ISR UAS **Description:** Designed for all-weather, close-range ISR missions. **Range:** 10 km **Endurance:** 2 hours **Origin:** Israel **Manufacturer:** Elbit Systems
Skystriker	**Type:** Fixed-wing loitering munition **Description:** A long-range loitering munition UAS carrying a 5 kg or 10 kg explosive; electric propulsion offers low acoustic signature. **Range:** 100 km **Endurance:** 2 hours **Origin:** Israel **Manufacturer:** Elbit Systems
Spike NLOS	**Type:** 5th-generation precision-guided missile system **Description:** Multipurpose electro-optical/infrared missile system designed for air, land, and naval platforms; enables warfighters to remain outside of attack range. **Range:** 32 km **Endurance:** N/A **Origin:** United States **Manufacturer:** Rafael and Lockheed Martin
ThunderB	**Type:** Fixed-wing Small Tactical ISR UAS (STUAS) **Description:** A small, tactical, long-range, long-endurance UAS that can conduct covert, extended-range day and night ISTAR; can also drop capsules. **Range:** 150 km **Endurance:** 24 hours **Origin:** Israel **Manufacturer:** Bluebird

Appendix 2

UASs AND OTHER SYSTEMS USED BY UKRAINE IN THE 2022 RUSSIA-UKRAINE WAR

A1-SM Furia	**Type:** Fixed-wing ISR and targeting UAS **Description:** Multipurpose system designed to conduct day and night reconnaissance and set and adjust artillery fire. **Range:** 50 km **Endurance:** 3 hours **Origin:** Ukraine **Manufacturer:** Athlon Avia
Bayraktar TB2	**Type:** Large fixed-wing ISR and precision strike UAS **Description:** A medium-altitude, long-endurance (MALE) tactical UAS used for ISR, targeting, and precision strikes; payload carries four smart munitions. **Range:** 300 km **Endurance:** 27 hours **Origin:** Turkey **Manufacturer:** Baykar
EVO II	**Type:** Small quadcopter UAS **Description:** Short-range UAS used for ISR and to deliver small munition payloads targeting personnel. **Range:** 13 km **Endurance:** 40 minutes **Origin:** China **Manufacturer:** Autel Robotics
FlyEye	**Type:** Small, fixed-wing ISR UAS **Description:** Small, hand-launched UAS used to monitor troop movements and direct artillery fire. **Range:** 180 km **Endurance:** 2.5 hours **Origin:** Poland **Manufacturer:** WB Systems
Golden Eagle	**Type:** Small quadcopter UAS **Description:** Highly autonomous system designed to conduct ISR. **Range:** 3 km **Endurance:** 30 minutes **Origin:** United States **Manufacturer:** Teal Drones
Leleka-100	**Type:** Fixed-wing ISR UAS **Description:** Brigade-level drone capable of aerial reconnaissance, patrol, and mapping. **Range:** 45 km **Endurance:** 2.5 hours **Origin:** Ukraine **Manufacturer:** DeViRo

Magylas	**Type:** Hybrid, fixed-wing/VTOL small ISR UAS **Description:** Electric UAS designed to conduct ISR and provide targeting information. **Range:** 120 km **Endurance:** 2 hours **Origin:** Estonia **Manufacturer:** Threod Systems
Mavic series	**Type:** Small quadcopter ISR UAS **Description:** The most popular commercial drones in the world; Mavic UASs have been used by both Ukrainian and Russian soldiers for tactical reconnaissance purposes. **Range:** 1–8 km **Endurance:** 30 minutes **Origin:** China **Manufacturer:** DJI
Medical Response Drone	**Type:** Heavy-lift quadcopter UAS **Description:** Provides first responders with visual oversight of a scene and the timely delivery of temperature-sensitive medical supplies. **Range:** Unknown **Endurance:** Unknown **Origin:** Canada **Manufacturer:** Draganfly
Mini UAS	**Type:** Hand-launched, fixed-wing miniature ISR UAS **Description:** Hand-launched, portable UAS system, designed to operate under harsh geographic and meteorological conditions. **Range:** 15 km **Endurance:** 80 minutes **Origin:** Turkey **Manufacturer:** Baykar
PD-1	**Type:** Hybrid fixed-wing/VTOL ISR UAS **Description:** Designed for aerial observation, ISR, and photomapping. **Range:** 100 km **Endurance:** 7 hours **Origin:** Ukraine **Manufacturer:** UkrSpecSystems
PD-2	**Type:** Hybrid fixed-wing/VTOL ISR UAS **Description:** Designed a variety of ISR missions, artillery fire spotting and correction, and general support missions. **Range:** 200 km **Endurance:** 10 hours **Origin:** Ukraine **Manufacturer:** UkrSpecSystems
Phoenix Ghost	**Type:** Small loitering munition **Description:** Delivers explosive munition payload to human-selected target. **Range:** Unknown **Endurance:** 6 hours **Origin:** United States **Manufacturer:** Aevex Arospace

Punisher	**Type:** Tactical airstrike drone **Description:** Can be fitted with a variety of munitions to strike targets with high precision behind enemy lines. **Range:** 45 km **Endurance:** 3 hours **Origin:** Ukraine **Manufacturer:** UA Dynamics
Quantix	**Type:** Hybrid fixed-wing/VTOL small ISR UAS **Description:** Capable of surveying and mapping a 400-acre area and then returning with the data without operator assistance. **Range:** 2 km **Endurance:** 45 minutes **Origin:** United States **Manufacturer:** AeroVironment
R18	**Type:** VTOL octocopter **Description:** Created by specialist Ukrainian drone operators; used primarily to conduct anti-tank and night operations. **Range:** 4 km **Endurance:** 40 minutes **Origin:** Ukraine **Manufacturer:** Aerorozvidka
Rotor Riot FPV	**Type:** Small quadcopter ISR UAS **Description:** Provides cheap, fast, nimble capabilities for ISR operations. **Range:** Unknown **Endurance:** Unknown **Origin:** United States **Manufacturer:** Rotor Riot
RQ-20 Puma	**Type:** Hand-launched ISR and targeting UAS **Description:** Conducts surveillance and intelligence gathering using an electro-optical and infrared video camera. **Range:** 20 km **Endurance:** 3 hours **Origin:** United States **Manufacturer:** AeroVironment
Sparrow	**Type:** Small, flying-wing ISR UAS **Description:** Multipurpose system designed to conduct reconnaissance and set and adjust artillery fire. **Range:** 70 km **Endurance:** 85 minutes **Origin:** Spain **Manufacturer:** Spaitech
Spartacus Hurricane	**Type:** Small quadcopter UAS **Description:** Used for inspections, search and rescue, and delivery of relief items such as medication and water. **Range:** Unknown **Endurance:** Unknown **Origin:** United States **Manufacturer:** Aquiline Drones

Spectator-M1	**Type:** Small, fixed-wing ISR UAS **Description:** Compact, man-portable capability for tactical air reconnaissance and aerial battlefield surveillance. **Range:** 200 km **Endurance:** 3 hours **Origin:** Ukraine **Manufacturer:** JSC Meridian
ST-35 Silent Thunder	**Type:** ISR and loitering munition UAS **Description:** Precision-guided weapon system that can destroy enemy targets with minimal risk to nearby people and infrastructure. **Range:** 30 km **Endurance:** 1 hour **Origin:** Ukraine **Manufacturer:** Athlon Avia
Switchblade 300	**Type:** ISR and loitering munition UAS **Description:** Small UAS with ISR and precision strike capabilities effective against soft-skinned vehicles and groups of personnel. **Range:** 10 km **Endurance:** 15 minutes **Origin:** United States **Manufacturer:** AeroVironment
Tupolev Tu-141	**Type:** Large reconnaissance UAS **Description:** Originally produced in the 1970s to perform reconnaissance missions at transonic speeds; Ukraine may be repurposing the dated platform to draw out enemy anti-air systems. **Range:** 1,000 km **Endurance:** Unknown **Origin:** Soviet Union **Manufacturer:** Modified by the Ukrainian Armed Forces
Tupolev Tu-143	**Type:** Short-range tactical reconnaissance UAS **Description:** Originally produced in the 1970s to perform reconnaissance missions; Ukraine may be repurposing the dated platform to draw out enemy anti-air systems. **Range:** 200 km **Endurance:** Unknown **Origin:** Soviet Union **Manufacturer:** Modified by the Ukrainian Armed Forces
UJ-22	**Type:** Fixed-wing, multipurpose UAS **Description:** Primarily used for intelligence, surveillance, and artillery spotting; can carry 20 kg munition payload and other weapons. **Range:** 800 km **Endurance:** 7 hours **Origin:** Ukraine **Manufacturer:** UkrSpecSystems
Vector	**Type:** Hybrid fixed-wing/VTOL ISR UAS **Description:** Fixed-wing or quadcopter swappable design that allows for a variety of ISR missions. **Range:** 15 km **Endurance:** 2 hours **Origin:** Germany **Manufacturer:** Quantum Systems

Warmate	**Type:** Small loitering munition **Description:** Designed to search, track, and attack a designated target **Range:** 30 km **Endurance:** 50 minutes **Origin:** Poland **Manufacturer:** WB Electronics
X2	**Type:** Small quadcopter UAS **Description:** Used for situational awareness, asset inspection, and security patrol. **Range:** 10 km **Endurance:** 35 minutes **Origin:** United States **Manufacturer:** Skydio

Appendix 3

UASs AND OTHER SYSTEMS USED BY RUSSIA IN THE 2022 RUSSIA-UKRAINE WAR

E95	**Type:** Fixed-wing target UAS **Description:** Target UAS used to draw fire and reveal the position of enemy anti-air systems. **Range:** 50 km **Endurance:** 30 minutes **Origin:** Russia **Manufacturer:** Eniks
Eleron-3	**Type:** Short-range ISR UAS **Description:** Rail-launched UAS designed to perform a variety of ISR missions. **Range:** 250 km **Endurance:** 100 minutes **Origin:** Russia **Manufacturer:** Eniks
EVO II	**Type:** Small quadcopter UAS **Description:** Short-range UAS used for ISR and to deliver small munition payloads targeting personnel. **Range:** 13 km **Endurance:** 40 minutes **Origin:** China **Manufacturer:** Autel Robotics
Forpost-R	**Type:** Large, fixed-wing, multipurpose UAS **Description:** Russian licensed-produced version of the Israeli IAI Searcher II UAS; designed for long-range ISR and can carry anti-tank missiles or laser-guided bombs. **Range:** 450 km **Endurance:** 20 hours **Origin:** Russia-Israel **Manufacturer:** Israel Aerospace Industries
Granat	**Type:** Fixed-wing ISR UAS **Description:** Used to conduct reconnaissance of terrain, observation flights, and search and rescue operations; can be equipped with a SIGINT payload. **Range:** 70 km **Endurance:** 6 hours **Origin:** Russia **Manufacturer:** Izhmash
KBLA-IVT	**Type:** Large helicopter UAS **Description:** Typically used as a target UAS for training and testing; equipped with cameras and reconnaissance gear and may possibly be used to reveal anti-air systems. **Range:** 180 km **Endurance:** 6 hours **Origin:** Russia **Manufacturer:** Technodinamika

KYB Kub	**Type:** ISR and loitering munition UAS **Description:** Used for reconnaissance or as a loitering munition when armed with a 3 kg warhead. **Range:** 40 km **Endurance:** 30 minutes **Origin:** Russia **Manufacturer:** ZALA Aero Group
Lancet-3	**Type:** ISR and loitering munition UAS **Description:** Used for reconnaissance or as a loitering munition when armed with a 3 kg warhead; successor to the ZALA KYB Kub loitering munition. **Range:** 40 km **Endurance:** 40 minutes **Origin:** Russia **Manufacturer:** ZALA Aero Group
Lastochka-M	**Type:** Small, fixed-wing strike UAS **Description:** Designed for precision strikes and can carry a variety of air-dropped ordnance. **Range:** 45 km **Endurance:** 2 hours **Origin:** Russia **Manufacturer:** Unknown
Mavic series	**Type:** Small quadcopter ISR UAS **Description:** The most popular commercial drones in the world, Mavic UASs have been used by both Ukrainian and Russian soldiers for tactical reconnaissance purposes. **Range:** 1–8 km **Endurance:** 30 minutes **Origin:** China **Manufacturer:** DJI
Merlin-VR	**Type:** Fixed-wing ISR UAS **Description:** Reconnaissance UAS with a payload of 6.5 kg and capable of flying at an altitude of up to 5 km. **Range:** Unknown **Endurance:** 10 hours **Origin:** Russia **Manufacturer:** Smolensk Research Institute of Modern Telecommunication Technologies
Orion	**Type:** Medium-altitude strike UAS **Description:** Base variant can carry up to four guided bombs with a maximum payload of 200 kg for precision strikes. **Range:** 250 km **Endurance:** 24 hours **Origin:** Russia **Manufacturer:** Kronstadt Group
Orlan-10	**Type:** Multipurpose fixed-wing ISR UAS **Description:** Medium-range UAS designed for a variety of ISR missions and equipped with electronic warfare capabilities; can be upgraded to carry high-explosive fragmentation munitions. **Range:** 600 km **Endurance:** 18 hours **Origin:** Russia **Manufacturer:** Special Technology Center

Orlan-30	**Type:** Fixed-wing ISR UAS **Description:** Medium-range UAS with increased payload designed for a variety of ISR and strike missions. **Range:** 600 km **Endurance:** 16 hours **Origin:** Russia **Manufacturer:** Special Technology Center
Shahed-131	**Type:** Long-distance, swarming loitering munition **Description:** Delivers explosive munition payload to human-selected target. **Range:** 900 km **Endurance:** Unknown **Origin:** Iran **Manufacturer:** Iran Aircraft Manufacturing Industries Corporation
Shahed-136	**Type:** Long-distance, swarming loitering munition **Description:** Delivers explosive munition payload to human-selected target. **Range:** 1,800 km **Endurance:** Unknown **Origin:** Iran **Manufacturer:** Iran Aircraft Manufacturing Industries Corporation
Supercam S450	**Type:** Fixed-wing ISR UAS **Description:** Converted civilian drone used for surveillance and targeting missions. **Range:** 100 km **Endurance:** 7 hours **Origin:** Russia **Manufacturer:** Unmanned Systems Group
Takhion	**Type:** Small, fixed-wing ISR UAS **Description:** Used to conduct reconnaissance missions in support of ground troops. **Range:** 40 km **Endurance:** 6 hours **Origin:** Russia **Manufacturer:** Izhmash
Zastava	**Type:** Small, fixed-wing ISR UAS **Description:** Russian licensed-produced version of the Israeli IAI Bird Eye 400 UAS; designed for long-range ISR and can carry anti-tank missiles or laser-guided bombs. **Range:** 15 km **Endurance:** 80 minutes **Origin:** Russia-Israel **Manufacturer:** Israel Aerospace Industries
421-16E2	**Type:** Small, fixed-wing ISR UAS **Description:** Designed for day and night reconnaissance with the live video stream at range up to 35 km. **Range:** 50 km **Endurance:** 4 hours **Origin:** Russia **Manufacturer:** ZALA Aero Group

421-08M	**Type:** Small, fixed-wing ISR UAS **Description:** Hand-launched, lightweight, and quiet micro UAS designed for frontline reconnaissance and surveillance. **Range:** 30 km **Endurance:** 1.5 hours **Origin:** Russia **Manufacturer:** ZALA Aero Group

ENDNOTES

Chapter 01: Introduction

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