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Key Points

The key lesson to date from the Russian-Ukraine war is the absolute necessity of air superiority to achieve a decisive advantage.

Limitations on Ukraine to employ U.S.-provided weapons in Russia have ceded a sanctuary for Russian forces to operate and have yielded them a significant advantage. As a result, Russia possesses air superiority over its own territory and some portions of the battlespace in Ukraine.

To secure air superiority in the times and places of its choosing, Ukraine must modify its historical doctrine and design and conduct an integrated air-ground campaign. Only with the kind of integration that creates a synergy between surface and air operations can Ukraine further its military's momentum on the battlefield.

Uninhabited aerial vehicles have emerged as a significant capability in the battlespace and present the opportunity for new concepts of operation, one of which is to contribute to achieving air superiority.

Air superiority can provide Ukrainian ground forces the freedom from attack and the freedom to attack that is necessary for them to achieve advantages relative to the larger and stronger Russian forces.

Ukraine requires weapon systems and munitions in numbers sufficient to achieve strategic gains in the battlespace—inhabited, uninhabited aircraft, precision surface-to-surface weapons, cyber operations, electronic warfare, intelligence, and special operations can all play a significant role if coordinated in an integrated campaign.

The Significance of Air Superiority: The Ukraine-Russia War

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Abstract

The conduct of the war in Ukraine to date has been a lesson in two distinct parts on the importance of air superiority. The first is the failure of the Russian Air Force to establish air superiority and overwhelm Ukrainian forces to achieve a decisive victory at the start of the conflict. The second part concerns the difficulty of establishing air superiority with insufficient resources and capabilities—a situation the Ukrainian Air Force has lived with for over three years as Ukraine has endured costly attacks on its territory. The lethal air defenses on both sides are denying each air force the ability to penetrate the opposing battlespace—a condition in which no force has control of the air. Unfortunately, without the advantages that air superiority ensures—namely freedom from attack and freedom to attack—this attrition-based conflict will be won by the side with the most warfighting personnel and materiel—Russia.

This paper focuses on how Ukraine could conduct an integrated air-ground campaign to secure air superiority in the times and places of its choosing, and thus further its military's momentum on the battlefield and begin reversing the territorial gains the Russian army has achieved up to this point. This approach has high potential to overcome the size disadvantage that Ukraine has relative to the Russian military, and it requires Ukraine to plan and execute operations that integrate their long-range surface-to-surface weapons with combat aircraft, drones, cyber operations, electronic warfare, and special operations. Achieving air superiority could provide Ukraine with the edge it needs to gain an advantage over the Russians, break through their front lines, and change the course of the war.

Figure 1: The Danish Air Force training Ukrainian fighter pilots to fly the F-16 at an airbase in Denmark.

Source: NATO courtesy video

Introduction

F-16s are about to enter Ukrainian service in the ongoing conflict between Ukraine and Russia. The effect that they could have in the evolution of the conflict depends on many factors: the number of F-16s and F-16 pilots available for combat operations; the level and type of pilot training and pilot proficiency and experience; the capability or block of the F-16s provided; the weapons provided; the numbers, level of training, and proficiency of F-16 maintenance personnel; and the ability of the aircraft to survive and operate under Russian attack, among others. This paper focuses on fighter operations at the operational level of war to optimize the use of the relatively small number of F-16s and pilots Ukraine will have to operate in the near term. By conducting an integrated air-ground campaign to secure air superiority in the times and places of its choosing, Ukraine can further its military's momentum on the battlefield and begin reversing the territorial gains the Russian army has achieved up to this point. This proposed approach has high potential to overcome the size disadvantage that Ukraine has with both its air and ground forces relative to the Russian military. It requires Ukraine to plan and execute operations that integrate their long-range surface-to-surface weapons with combat aircraft, drones, cyber operations, electronic warfare, and special operations in a combined campaign. Air superiority can provide Ukrainian forces the freedom from attack and the freedom to attack that is necessary for them to achieve advantages relative to the larger and stronger Russian forces, ultimately leading to the ejecting of Russian forces from Ukraine.

Air superiority can provide Ukrainian forces the freedom from attack and the freedom to attack that is necessary for them to achieve advantages relative to the larger and stronger Russian forces.

Currently, neither the Russian nor Ukrainian forces are using combat aircraft to conduct deep strikes, relying instead on missiles and drones. The lethal air defenses on both sides are denying each air force the ability to penetrate the opposing battlespace—defined as a state of air parity—a condition in which no force has control of the air.[1] Ukrainian air defenses, combined with innovative indications and warning practices, have also successfully reduced the damage caused by Russian air attacks. This is important, given that Russia enjoys a dominant air position with a large number of Russian Aerospace Forces (VKS) aircraft that pose a significant threat.

Russia possesses another advantage—the freedom to operate from a sanctuary, provided in part by the U.S. restrictions imposed on Ukraine that limit the employment of weapons provided by the U.S. to Ukrainian territory and airspace. They likewise have significant advantages in terms of the number of combat aircraft, stand-off weapons, and ground-based air defenses (GBAD), as well as the relative sanctuary from attack by long-range weapons from Ukraine. As a result, Russia possesses air superiority over its own territory and some portions of the battlespace in Ukraine. President Zelenskyy recently highlighted this condition as his military's number one concern.[2] Fortunately, the poor leadership, lack of training, and ground-centric doctrine of the VKS limit the potential of its forces. Russian airpower subsequently impacted the war much less than originally expected, but the VKS is learning from its earlier mistakes—and improving.

This report provides an overview of how Ukraine could now construct and execute an integrated campaign to gain air superiority—a necessary condition to change the course of the war. It describes the character of the opposing air forces and

the conduct of the air war, explaining both Russia's and Ukraine's failure to establish air superiority in the opening phases of the conflict, as well as the conditions these opening phases created that present barriers to achieving air superiority today. It describes the increasing reliance on cheaper, uninhabited aerial vehicles (UAV) to conduct strike, which has helped Ukraine and Russia achieve some of their respective air warfare goals. However, UAVs could additionally be employed in ways that help enable Ukraine to instead establish windows of air dominance that can meaningfully change the tide of combat. Ukraine's F-16s can also play a key role in this integrated campaign.

If there is any lesson from the Russian-Ukraine war to date, it is the absolute necessity of air superiority to achieve a decisive advantage. Without it, the conflict has devolved into a relative stalemate resembling—literally—the trench warfare of World War I. And, without the advantages that air superiority ensures—namely freedom from attack and freedom to attack—an attrition-based conflict will be won by the side with the most warfighting personnel and materiel. Today that is Russia—a situation that cannot be allowed to prevail.

If there is any lesson from the Russian-Ukraine war to date, it is the absolute necessity of air superiority to achieve a decisive advantage.

The Theater Airpower Balance[3]

Ukraine fields the Ukrainian Air Force (UkAF), an independent service, which it reorganized in 2004 through the integration of aviation and the missiles, guns, and radar of its GBAD forces. The coordination of GBAD and combat aviation assets is critical not only to defend Ukrainian air space but also to enable the development of integrated air campaign plans to gain a military advantage.[4] As outlined in this report, these plans will require close coordination with the Ukrainian army for maximum effect.

Russia also maintains an independent air force, which was reorganized in 2015 to include the space forces, called the Russian Aerospace Forces or VKS. Like Ukraine, the VKS comprises aviation and GBAD units (though the Russian army also maintains separate air defense capabilities). That said, among the branches of the Russian military, the ground forces are more equal than others, and coordination of air operations is done by ground force commanders, not the VKS. As highlighted by a British analysis of the conflict, "Russian jointery functions as a hierarchy in which the Navy and VKS are subordinated to the Ground Force's needs."[5] This inhibits Russian forces from exploiting the full potential of airpower. After the opening phase of the conflict, prioritizing the demands of the Russian forces fighting on the ground quickly compelled a significant shift in VKS strategy and objectives that constrained their ability to focus on air superiority.

In the buildup to war, the balance of airpower was strongly in favor of Russia, which fielded 350 combat aircraft in the region, capable of generating hundreds of sorties per day. These included some of Russia's most advanced combat aircraft, such as the Su-30, Su-34, and Su-35S. Besides a numerical advantage, VKS aircraft also enjoyed a significant qualitative edge, with better radars and longer-range missiles. For example, Russian fighters demonstrated the capability to gain a radar lock and execute "fire and forget" missile launches at 50 nautical miles in combat.[6] A Russian fighter also reportedly shot down a UkAF fighter at a range of 95 nm.[7] The VKS fielded significant and effective electronic warfare (EW) capabilities and a small fleet of AWACs aircraft, whose long-range radar provided early warning to Russian combat air patrols of approaching UkAF sorties. The vast majority of the VKS

fighter aircrews had rotated through Syria and had flown "combat" missions there. However, they had limited experience with more complex operations and delivering precision-guided munitions (PGMs).

At the start of the war, the UkAF fielded a much smaller and less capable force—roughly 50 MiG-29s and 32 Su-27s and approximately 40 Su-24 and Su-25 ground attack aircraft. Regardless, the Ukrainian pilot force possessed the ability to rapidly adapt during their trial by fire in the first days of the war. They initially started operations at higher altitudes but shifted to low-altitude operations as a self-protection measure due to the threats posed by advanced Russian surface-to-air missiles (SAMs) and Su-35s.

Because air defense was a key task for the former Soviet armed forces, both Russia and Ukraine inherited and maintained large GBAD establishments, with Ukraine having the second highest density of GBAD in Europe next to Russia. Ukraine's layered GBAD capabilities consisted of an extensive set of air defense radars, long-range (SA-10) and medium-range (SA-11 and SA-8) SAM batteries, anti-aircraft guns, and thousands of man-portable air-defense missiles (MANPADS). Following the Russian invasion in 2014, the UkAF made modernizing this force an urgent priority, and as the war progressed, these systems would be augmented by contributions from NATO, such as Patriot/Hawk SAMs and mobile short-range air defense systems (such as Gepard and Avenger).

Russia fielded a similar, though larger, more modern, and more capable set of GBAD forces, including the SA-21 that, when combined with modern tracking and targeting radars, can deliver a three-fold increase in engagement range over the SA-10.[8] In combat operations, for example, a long-range Russian SAM reportedly shot down a Ukrainian aircraft flying at low level at a range of 80 nm.[9] To date, the lethality of Russian and Ukrainian defenses against penetrating aircraft has dominated the course of the air war.

Russia Invades & Seeks Air Superiority[10]

As tensions rose and Russian forces moved to attack positions, the UkAF implemented its plans to disperse its aviation assets from main bases to secondary and tertiary airfields and rotate its aircraft to prevent consolidation and negate Russian attacks. The UkAF developed deployable support kits to enable the maintenance of aircraft in the field for a limited period and conducted training of support personnel to carry out maintenance and pre-flight inspections at dispersal fields. Munitions stocks were moved from peacetime storage to less vulnerable locations. For the GBAD forces, the Ukrainians set up dummy batteries and radar sites, augmented by signals deception, to draw attacks. Just hours before the Russian assault, GBAD units also began to disperse. Although a significant proportion of the GBAD force survived, the haste of their dispersal prevented the Ukrainian forces from mounting a coordinated defense in the opening phase of the conflict. The initial burden of air defense would fall on UkAF aviation.

Based on faulty intelligence, the Russians expected that their invading forces would be greeted across Ukraine with open arms, a belief that proved to be a stunning miscalculation. Russia's concept of operations was to employ special forces to eliminate Ukraine's political leadership in Kyiv—a task planned to take just a few days—while ground forces sought to trap Ukraine's army units in the east and southeast. Russia's airpower forces were tasked to degrade Ukraine's air defense capabilities and gain control of the air.

The VKS launched a traditional counterair campaign with the opening of hostilities on February 24, 2022. Preceded by a widespread electronic attack to disrupt air defense radars, particularly in the north, and extensive use of aerial drones to bait UkAF SAM batteries into revealing their positions, Russia employed penetrating aircraft and long-range missiles to strike against roughly 100 Ukrainian air defense targets (air bases, radars, SAM and anti-aircraft batteries, and command and control nodes).[11] Russia's strikes against the initial target list (which had been developed using spies and border reconnaissance sorties) knocked out multiple radars and SAM batteries across the country. As described above, though, Ukraine's pre-war dispersal ensured that the majority of Ukraine's aviation and GBAD units survived this initial assault.[12] Furthermore, Russia's dynamic targeting and battle damage assessment capabilities proved slow and unequal to the task of locating mobile UkAF GBAD units and dispersed aircraft in the days following. Nonetheless, the disruption of Ukraine's GBAD resulted in UkAF combat aircraft playing the dominant role in countering Russian air operations until the GBAD could reconstitute.

In the initial assaults, Russian fighter bombers flew about 140 sorties per day on average, typically at medium altitudes to depths of 150 nm. VKS fighters, flying in single-ship to six-ship formations, struck the initial target set, typically with unguided weapons and poor accuracy. Russian Su-35 and Su-30 fighters flew medium- and high-altitude combat air patrols in support of the penetrating aircraft during the first three days, reportedly scoring multiple kills of Ukrainian MiG-29, Su-27, Su-24, and Su-25 aircraft. Ukrainian fighters, flying at low level to reduce radar detection, also managed to reportedly score multiple kills. Heavy aerial combat operations took place around Kyiv.

The Russian special forces and airborne operation against a critical airfield north of Kyiv was also disrupted by tenacious Ukrainian defenders in the first days of the conflict. UkAF fighters and drones, in combination with ground forces, inflicted heavy casualties on Russian armored forces advancing in a single column to seize the Ukrainian capital. These forces were expecting to conduct occupation duties, not execute ground combat operations, and thus were unprepared for dealing with the fierce Ukrainian resistance and were bottled up in massive traffic jams along the single approach axis. After three days, Russia stopped flying penetration sorties into Ukraine as a rule, although isolated sorties continued, particularly as the attack on Kyiv progressed. In part, this was prompted by Russian attrition from the UkAF's fighters and delays in reconstituting their GBAD, but it was also because the attempt to decapitate the Ukrainian government had failed. Russia's ground offensive against Kyiv was bogged down, and their ground forces needed fire support; the VKS accordingly switched from focusing on control of the air to supporting the ground forces. A role supporting primarily ground forces is one that the VKS is historically very familiar with, having supported Red Army movements in WWII in just the same fashion as "aerial artillery." However, in a modern war, this may have been their most major strategic miscalculation. If the VKS had continued prosecuting the counterair campaign, it is possible that Russia could have gained air superiority and doomed Ukraine's chances. However, their ability to press well beyond the forward line of troops (FLOT) was hampered by a lack of multi-element long-range sweep tactics, little real-time reconnaissance updates of the threats along their route, and very limited training in multi-aircraft employment as part of routine unit training prior to the war.

Figure 2: Polish Pilica anti-aircraft system tracking a drone.

Source: NATO courtesy video

For deeper penetration strikes, the VKS elected to launch missile attacks against radars, bases, and infrastructure targets. Russia fired about 24 missiles per day on average over the first three months of the war—roughly 2,000 cruise missiles and 240 ballistic missiles.[13] However, their inability to respond to the rapidly changing battle space prevented them from significantly degrading Ukraine's IADS or gaining momentum of their ground forces. The problems Russia encountered in dynamic targeting not only delivered limited effects against the Ukrainian military but also resulted in significant civilian casualties.

Due to the medium-altitude threat posed by the UkAF GBAD, VKS fighters began executing low-level strikes, delivering unguided bombs and rockets against Ukrainian forces in the front lines, typically flying single-ship and two-ship formations. However, these sorties flew in predictable flight routes day after day, exposing jets to the thousands of MANPADS in the Ukrainian army. The VKS lost an estimated eight fighters in a week. Fratricide also played a role in VKS losses, a problem that persists to this day. The VKS switched to night attacks along the front lines to reduce losses using some of the Su-34 force. They also were able to muster Su-35S strikes with anti-radiation missiles, particularly in the north around Kyiv, as well as some limited Su-24/FENCER strikes using PGMs.

With the collapse of the attack on Kyiv and the initial Ukrainian counterattacks that regained territory there and in Kharkiv, Russia elected to focus efforts on Donbas and the southeast. Ground offensives in the latter region made significant gains. The VKS continued efforts to degrade the UkAF GBADs using Su-30 and Su-35 fighters and Uninhabited Aerial Vehicles (UAVs) as bait. Once a UkAF battery attempted to engage, the VKS fighters would fire Anti-Radiation Missiles (ARMs) while low-level SU-25 ground attack aircraft would attempt to bomb the position with rockets. Losses forced the UkAF to move GBAD assets back from the front lines, allowing Russian aircraft to operate at higher altitudes near the front lines, although they remained wary of crossing into Ukrainian airspace.

Overall, Russia largely stopped using inhabited aircraft for deep penetrations and instead employed stand-off weapons and missiles. As Russian forces encountered difficulties in seizing Ukrainian cities in the east and southeast, the VKS switched to area bombing of urban areas instead of ground force positions.

Despite the VKS problems in implementing an effective counterair campaign against the UkAF, within 10 days of combat, Ukraine was also struggling in mounting defensive counterair missions and ground attack sorties. Russian AWACS provided warning of Ukrainian sorties, and Russian electronic warfare disrupted Ukrainian operations. The reconstitution of Russian GBAD also made it difficult for Ukraine to provide close air support to its engaged forces.

By the fall of 2022, the air picture had reached a period of stasis that has largely continued to the present day. MANPADS rendered daytime low-level sorties too dangerous, while SAMs and fighters made medium- and high-level altitudes lethal to penetrating sorties on both sides. Russia succeeded in pushing UkAF GBAD units back from the front lines, which enabled the VKS to use aircraft to deliver glide bombs against Ukrainian positions, but the VKS was deterred from flying inhabited aircraft in deeper penetration sorties and continued to launch drones, cruise missiles, and ballistic missiles. Against these weapons, UkAF aviation and GBADs proved highly effective. For instance, in May 2023, Ukraine reported shooting down around 90 percent of Russian cruise missiles and drones and nearly 80 percent of air- and ground-launched ballistic missiles nationwide. For areas defended by Patriot, 100 percent of ballistic missiles were shot down.[14] Such success illustrates why VKS combat aircraft were reluctant to penetrate these defenses.

In some respects, the air environment that evolved in Ukraine by the summer of 2022 illustrates the same fears held by the U.S. Air Force regarding GBADs following the 1973 Arab-Israeli War, when Soviet-supplied SAMs and guns shot down 60 Israeli fighters in four days.[15] The lethality of modern GBADs in that conflict is what led to the United States to develop stealth technology in the 1970s, in which aircraft designed with a very low radar signature could penetrate survivably at medium and high altitudes. The value of these aircraft was demonstrated with the use of the F-117 stealth fighter in the first Gulf War in 1991. These apparent conditions of modern war are, indeed, what led to the development of multiple generations of U.S. stealth aircraft: the B-2, F-22, F-35, and B-21. However, Ukraine has no stealth aircraft, and Russia has so far elected not to employ its small force of first-attempt stealth aircraft, the Su-57, except in rare instances that are likely associated with the aircraft program's development.[16] But the threat of the larger Russian air force looms over the battlefield, as demonstrated by increasing numbers of attacks using large glide bombs against Ukrainian positions. As a RUSI analysis stated:

> *The challenge for Ukraine is that Russian fast air, and particularly its large extant attack aviation fleet, could inflict massive damage if committed in numbers, even if this would be costly. So long as this represents a latent threat, it must have a shaping effect on Ukrainian offensive operations, as advancing Ukrainian forces are likely to face similar challenges to the Russians in advancing their air defence coverage.*
>
> *The prize to be fought for in this regard is the ability to operate at medium altitude beyond the engagement ceiling of shoulder-fired man-portable air-defence*

> *systems (MANPADS). Whichever side can operate sustainably in this altitude band can more easily identify targets and bomb with much greater range and accuracy. At present, the VKS is deterred by the SAM threat from adopting such a profile over the Ukrainian frontlines. However, probably the single greatest extant threat that could change the tactical dynamics on the ground is if the VKS gains the freedom to operate at medium altitude over Ukrainian positions.*[17]

Likewise, the single objective that would give the greatest advantage to Ukraine is the ability to operate without interference over Russian ground positions. However, today, the Ukrainians lack enough strike aircraft and an integrated air and ground campaign to affect anything but specific points along the front.

Do Not Allow Russia an Operational Sanctuary

In mid-May 2024, one author of this proposed approach to air operations in this paper (Lt Gen Deptula, USAF (Ret.)) had the opportunity to visit Kyiv, Ukraine, to discuss options for optimally employing Ukrainian air forces with senior personnel in the Ukrainian Ministry of Defense, the General Staff of the Armed Forces of Ukraine, and the Ukrainian Air Force. If there is any one item that these discussions highlighted as imperative, it is the need for air superiority. Removing the constraints on U.S. weapons would facilitate that objective. While some of these restrictions are gradually easing, it is only in very limited and geographically constrained areas.[18] The restrictions against the use of weapons on Russian forces posing a threat to Ukraine must be removed if Ukraine is to have a chance to defend its territory and freedom against its much more powerful and well-equipped invader.

No one with a knowledge of the principles of warfare, or anyone familiar with the losing U.S. policies in the Korean and Vietnam wars, can logically argue that Ukraine should have to wait until Russian forces cross into or over Ukraine before attacking them. These constraints not only prevent effective weapons employment against Russian military forces but disproportionally advantage Russia by ceding them a sanctuary from which to operate—a luxury not enjoyed by Ukraine. The principles of offense and security demand that Ukraine seize the initiative and not allow its enemy to secure and maintain such an advantage.[19]

Uninhabited Aerial Vehicles

An important element in gaining air superiority in this modern battlespace will be leveraging the potential offered by uninhabited aerial vehicles (UAVs) conducting long-range strike operations. The conflict has seen the rapid development and employment of uninhabited systems—both by Ukraine and Russia. Although UAVs have been employed in multiple wars dating back to World War II, we have never seen the use of such large numbers in combat and are still grappling with the implications. For example, in 2023, Ukraine sent 100,000 small drones to the front[20] and conducted almost 200 long-range strikes using kamikaze/attack drones against such targets as Moscow and bomber bases.[21] Russia, in turn, fired thousands of ballistic and cruise missiles as well as attack drones against Ukraine over the past two years. While short-range systems, such as the quadcopters currently flying over the front lines, already provide surveillance and targeting information, along with some limited precision strike capabilities, the longer-range uninhabited systems now proliferating across the battlefields in Ukraine represent the real potential offered (and the threat posed) by this class of lower-cost precision strike systems.

Figure 3: A U.S. airman explains drone capabilties to Chief Master Sergeant of the Air Force of the Armed Forces of Ukraine Kostiantyn Stanislavchukat at the Hercules Innovation Lab at Ramstein Air Base.

Source: U.S. Air Force photo by Airman 1st Class Jared Lovett

Historically, developing nations attempting to use airpower for offensive strikes have not fared well when confronting advanced Western powers: think of Egyptian and Syrian aircraft losses at the hands of Israel in the 1967 and 1973 wars or the fate of the Iraqi Air Force at the hands of allied forces in 1991 and 2003. For decades, long-range precision strike conferred a significant military advantage to the United States and other Western powers. However, it is an expensive capability requiring a network of sophisticated high-tech systems to close the kill chain. In other words, these capabilities remained out of reach of governments and other forces that could not afford the resources needed to employ these systems.

However, the fielding of a new generation of UAVs has now placed the potential for precision long-range strike capability in the hands of smaller, less developed forces, including those employing irregular warfare tactics and terrorists. Not only are these weapons effective long-range strike systems, but they are also relatively low-cost and can be manufactured in quantity by non-state actors. Some suggest that they are difficult to defend against in a cost-effective manner since interceptor missiles must offer high performance and accuracy, which means that the defending missile will typically cost much more than the inbound uninhabited vehicle.[22] However, Iran's massive air attack against Israel in April 2024 consisted of hundreds of these UAVs, as well as cruise and ballistic missiles, and nearly all were shot down or ignored if they did not have a lethal trajectory.[23]

Ukraine and Russia now fly thousands of sorties per month in the battlespace using short-range small UAVs, typically referred to as drones. Carrying video cameras to provide real-time imagery or other payloads, these drones are now widely used in commercial businesses such as real estate, agriculture, and package deliveries.[24] Both Russia and Ukraine use these commercial drones—and military variants, which can fly further and see deeper—along the front lines. The conflict

has seen the employment of literally dozens of different types of small and medium-sized UAVs.[25] Indeed, Ukraine recently formed a separate branch of their Armed Forces to accelerate innovation in ground, maritime, and aerial uninhabited system development.[26] However, the organizational, functional, and execution elements of this branch are still being determined.[27]

Experience in the conflict provides some insight into the potential impact of small drones on military operations. These drones, roughly the size of a football, can be used for surveillance of the battlefield or direct attacks, where the drone is fitted with a small explosive charge and flown by an operator with a first-person view (FPV) camera directly into Russian armored vehicles, bunkers, and trenches.[28] Buoyed by operational success, Ukraine is constructing thousands of small drones, using commercial components fitted into a 3D printed airframe. After deploying 100,000 small drones to the front in 2023, Ukraine plans to build one million of these in 2024 in 200 workshops distributed around the country—about 3,000 a day. These drones also give platoon-sized elements their own inherent ISR capability, a unique addition to their survival in the stalemated front lines.

Although Ukraine was the first to use these small drones on the front lines, Russia quickly responded with its own set of drone forces. Both sides are now flying thousands of small and medium drone sorties each day. Loss rates are high—the small drones are vulnerable to electronic attack and typically only survive for a few sorties—but their low cost allows both sides simply to buy and field more.[29] The small drones perform important roles in surveillance and targeting, making hidden ground maneuver extremely difficult while providing precise targeting information to artillery, contributing to the current stalemate on the ground.

Longer-range attack drones have also seen widespread use. The Iranian Shahed loitering munition provides a useful illustration. Iran began development of UAVs some forty years ago during the Iran-Iraq war when the nation encountered difficulties maintaining its combat aviation assets and suffered high losses. Iran now fields and exports a wide array of UAVs for reconnaissance/surveillance and strike—including the Shahed. Iran has since supplied Shahed 131/136 attack drones to Russia during this conflict, and Russia is now in the process of manufacturing thousands of its own improved variant for employment.

Shaheds can be launched from ground sites or the back of trucks using a boost rocket. The airframe, made of composite materials, is powered by a small gas engine driving a wooden propeller. Guidance is provided by satellites and an inertial navigation system. Shaheds fly at low altitudes at 115 knots to deliver 30–50 lbs of explosive payload. A cruise missile on the cheap, Shaheds offer a long range of 700-800 nm (similar to a fighter aircraft), making it difficult to locate and strike launch locations.[30] The estimated cost of a Shahed UAV ranges from $20,000 to $50,000[31]—roughly the price of a mid-size car. Russia first employed Iranian-provided Shaheds in the fall of 2022. Russia's tactics involving these attack drones have evolved over time. Sometimes, a group of Shaheds is used to force UkAF defenses to reveal themselves and help identify corridors for follow-on missile strikes. Increasingly, Russia has employed Shaheds in combination with missiles to mount complex massed missile and drone attacks on Ukrainian infrastructure to stress Ukrainian defenses, notably on electrical generation plants. Between September 2022 and August 2023, Russia fired roughly 1,600 Shahed drones and 1,651 missiles. UkAF GBAD prefers to use guns, if possible, to shoot down

Figure 4: President Volodymyr Zelensky made an address on efforts to counter Russian drones next to a downed Shahed 136.

Source: Office of the President of Ukraine

the Shaheds to preserve its SAM stocks.[32] Though the slow-speed drones are vulnerable to defenses, executing strikes at night reduces the effectiveness of defenses, and the scale of these attacks results in some "leakers." Russia has also now made EW-hardening standard to their production variant of the Shahed-136, known as the Geran-2 (Geranium) in the Russian inventory.

Ukraine now plans to build thousands of systems like the Shahed—long-range attack drones capable of deep strikes. After the launch of a development effort in spring 2022, ten companies in Ukraine are now making drones that can reach Moscow and St. Petersburg. As Ukraine's digital minister stated, "The category of long-range kamikaze drones is growing with a range of 300, 500, 700, and 1,000 kilometers. Two years ago, this category did not exist." [33] New Ukrainian long-range UAV types are being field tested and incorporated into the inventory. Ukraine now fields and has used UAVs out to a range of 1,500 km against Russian infrastructure targets, as well as a new MQ-9-like variant that has an advertised range of 3,300 km.[34]

Ukrainian operations employing these systems have ramped up over time. Ukrainian long-range attack drones hit a Russian oil refinery in June 2022 near Rostov, then conducted strikes against Crimea, including an attack against the headquarters of the Black Sea Fleet and Saki airbase, reportedly damaging or destroying ten aircraft. In October 2022, Ukraine hit the Tu-22M3/ BACKFIRE at Shaykovka, damaging two bombers. By mid-2023, Ukraine's efforts to increase the employment of long-range attack drones showed progress. From January through September, Ukraine conducted 190 long-range drone attacks. Targets included oil fields, air bases, and the Kremlin in Moscow. In August 2023, Ukraine hit six locations in Russia and Crimea, including Pskov Air Base, which is roughly 350 nm from the Ukrainian border. Four military airlifters were damaged.[35] In April 2024, UkAF long-range strike drones attacked Russia's factory for building Shaheds and an oil refinery some 700 nm from the Ukrainian border.[36] This is the first time an attack drone has attacked a plant building attack drones. More recently,

Ukraine fired an estimated 50 long-range attack drones against the Morozovsk, Kursk, and Yeysk fighter-bomber bases in Russian territory, reportedly destroying six combat aircraft and damaging others.[37] It is clear that in this war, drones will continue to play an important role in the larger battle for air superiority.

With that summary and background of the progress of air operations since the Russian invasion of Ukraine proper in 2022, the fundamental element in gaining a relative advantage over the Russian military in future operations is for Ukraine to achieve air superiority. Once it establishes air superiority in times and places of its choosing, and in conjunction with surface operations integrated with air operations, the Ukrainian military could gain localized advantages to reclaim territory while pushing back Russian forces.

Gaining Air Superiority

If there is any lesson to extract from the Russian-Ukraine war to date, it is the absolute necessity of air superiority to achieve a decisive advantage. Without it, the conflict has devolved into a relative stalemate, resembling—literally—the trench warfare of World War I. Neither side has achieved the advantages of freedom of maneuver and attack that air superiority enables, and the ultimate winner of this attrition-based conflict will go to the side with the most warfighting personnel and materiel. Today that is Russia—a situation that cannot be allowed to prevail.

Air superiority is defined as "that degree of control of the air by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats." In other words, air superiority is transient in time, location, and coverage. It can be thought of as achieving "windows of dominance." The definition of air supremacy is "that degree of control of the air wherein the opposing force is incapable of effective interference within the operational area using air and missile threats." Permanency of air superiority is another way of describing "air supremacy." The distinction between the two is important but often confused.[38]

The elements required to achieve air superiority vary depending on the situation and the capabilities of an adversary. Generally, they can be divided into offensive and defensive air operations, defined as offensive counterair and defensive counterair missions. Overall, the purpose of offensive counterair missions (OCA) is to gain control of the airspace and provide friendly offensive forces (in the air and on the ground) the freedom of maneuver to execute offensive operations without adversary air interference. OCA operations allow friendly forces to attack critical nodes and protect friendly forces. By neutralizing enemy air threats and air defense systems, OCA operations support the broader military objectives of protecting friendly forces, facilitating follow-on operations, and achieving air superiority in the theater of operations. In other words, OCA provides the freedom to attack at a time and place of Ukraine's choosing. It can be decomposed into the following elements:

- **Neutralizing Enemy Air Threats**: OCA missions aim to target and destroy enemy aircraft, including fighters, bombers, and reconnaissance platforms, as well as other airborne threats such as drones. By eliminating or suppressing hostile air assets (through air-to-air engagements and strikes against aircraft and associated ground support infrastructure), the mission reduces the adversary's capability to conduct offensive operations. This includes attacking an adversary's bomber and fighter forces before they launch weapons.

- **Destroying/Suppressing Enemy Air Defense Systems**: OCA operations may also target enemy air defense systems, such as surface-to-air missile sites, radar installations, and anti-aircraft artillery. By neutralizing or suppressing these threats, OCA missions pave the way for follow-on operations, including close air support, interdiction, and conventional strategic attacks against key enemy centers of gravity.
- **Protecting Friendly Forces and Assets**: By gaining control of the airspace, OCA missions enhance the protection of friendly ground forces, naval assets, and critical infrastructure from enemy air attacks. This enables friendly forces to maneuver more effectively and operate with reduced risk of aerial threats.
- **Facilitating Follow-On Operations**: Establishing air superiority through OCA missions creates favorable conditions for subsequent offensive and defensive operations. Once the airspace is secure, friendly forces can conduct reconnaissance, surveillance, and strike missions with reduced interference from enemy air defenses.
- **Supporting Overall Campaign Objectives**: OCA operations contribute to achieving broader campaign objectives by degrading the adversary's ability to project power, control territory, and sustain military operations. By disrupting enemy air operations, OCA missions help shape the operational environment in favor of friendly forces.

The purpose of defensive counterair (DCA) missions is to protect friendly airspace, forces, and assets from enemy air threats, ensuring the integrity of national airspace, defending vital areas, and maintaining operational freedom for friendly forces. DCA can be used to achieve a condition of freedom from attack. It can be decomposed into the following elements:

- **Protection of Friendly Forces**: The primary objective of DCA missions is to safeguard friendly ground forces, naval assets, airbases, and critical infrastructure from enemy air attacks. By intercepting and neutralizing incoming enemy aircraft, missiles, and drones, DCA operations mitigate the threat to friendly forces and reduce the risk of casualties and damage.
- **Securing Air Sovereignty**: DCA missions contribute to maintaining control of sovereign airspace and defending national territory from hostile incursions. By intercepting unauthorized or hostile aircraft entering the airspace, DCA operations uphold national sovereignty and prevent airspace violations.
- **Air Defense of Vital Areas**: DCA missions focus on protecting vital areas, such as command centers, logistics hubs, communication nodes, and population centers, from enemy air threats. This involves deploying air defense assets, including fighter aircraft, SAMs, and anti-aircraft artillery, to provide layered defense against aerial attacks.
- **Maintaining Operational Freedom**: Neutralizing enemy air threats and denying adversary air superiority allow for the unhindered generation of air and ground operations, as well as the supporting logistical activities without the constant threat of enemy attacks.
- **Protecting Strategic Assets**: DCA missions aim to protect strategic assets, such as airbases, ports, air defense installations, and critical infrastructure, from enemy strikes. By securing these assets, DCA operations ensure the continuity of military operations and national defense capabilities.
- **Escorting and Protecting Friendly Aircraft**: DCA missions may involve providing escort and protection for friendly aircraft, including bombers,

reconnaissance aircraft, and strike fighters, during their missions. Fighter aircraft assigned to DCA duties accompany and defend these assets against potential enemy interceptions and attacks.

For Ukraine to make gains on the battlefield, it must shift the current state of air parity to air superiority in times and places of its choosing to facilitate its ground force objectives and employment of a broader range of airpower capabilities. This will be a difficult and challenging task, but it is feasible with the right aircraft, weapons, and concept of operations. With control of the air in critical areas, UkAF airpower assets such as the F-16s now entering service can deliver heavy weapons to disrupt Russian ground forces, smash artillery positions, and pave the way for Ukrainian army breakthroughs on the ground.

The most important step to achieving air superiority for Ukraine will be the development of an integrated air and ground campaign that leverages a wide range of capabilities.

A necessary step in optimizing the potential of the F-16 will be to evolve the current Ukrainian ground control intercept (GCI) and command and control doctrine. Under current Ukrainian procedures, GCI personnel controlling aircraft do not have a means to immediately coordinate with their GBAD counterparts to deconflict friendly SAMs with friendly fighters. The consequences can lead to fratricide and cannot be tolerated for the small force of F-16s (and Mirage 2000s)[39] that Ukraine will soon be operating. Therefore, this issue must be resolved as quickly as possible. A recent white paper, "Ukrainian Tactical Command And Control," outlines five recommendations to make the changes necessary to resolve the challenges of introducing new western fighter aircraft to optimize their safe integration with GBAD units.[40]

The most important step to achieving air superiority for Ukraine will be the development of an integrated air and ground campaign that leverages a wide range of capabilities: UkAF aviation and GBAD, persistent surveillance and reconnaissance, long-range attack drones, army long-range fires, electronic warfare, cyber-attacks, deception, special operations forces, timely intelligence from NATO allies, and tight coordination with the ground forces. Developing an integrated campaign of this nature and acquiring the required resources necessary to conduct it will require detailed planning and a concerted effort over the coming months. If successful, it can change the course of the war.

Concept of Operations

Using an effects-based planning methodology and assessment process will be critical to this effort. The U.S. Government Accounting Office (GAO) description of the 1991 Operation Desert Storm air campaign stated that "it was perhaps the most successful war fought by the United States in the 20th century."[41] The basis of that air campaign was an effects-based approach to its planning, execution, and assessment.[42] This kind of planning approach ties the tactical level military actions planned and executed to the ultimate political objectives for which military force is being applied. The effects-based approach is a methodology, a way of addressing a complex set of problems. It is not a checklist or proscriptive in its application, and as such, it can be applied to any military operation.

Effects-based campaign planning begins with setting the strategic end state in mind upfront. It then unfolds by identifying the operational level centers of gravity as target sets, as well as subsequent tactical level targets that must be engaged to achieve those operational objectives. Cyber

operations, deception, special operations, drones, anti-radiation missiles, decoys, electronic attack, and lethal precision attacks from both air- and ground-based weapons must all be coordinated in a cohesive campaign to achieve air superiority. This requires a comprehensive plan, as well as an effective command and control philosophy of mission command.[43]

In this case, the first step is to work with the Ukrainian army to determine, across the entire Ukrainian line of engagement with the Russians, the optimal location (potentially multiple locations) and times to gain air superiority. The desired effect is to use control of the air to give the Ukrainians momentum on the battlefield and begin reversing the gains the Russian army has achieved up to this point. With the initial breaching of Russian lines, UkAF airpower would be employed not only to assist in the attack but also, as importantly, to interdict Russian efforts to rush reinforcements to the area. This would, however, require a broader suppression of enemy air defenses (SEAD) effort than required to initially achieve a ground breakthrough. Yet, such a breakthrough and penetration would allow the Ukrainians to regain lost territory, put pressure on Russian leadership, and create a stronger position for post-war negotiations.

With the location of the assault identified, intelligence is the next area of focus—an area where Ukraine has a significant advantage. U.S. and allied nations in NATO can provide timely intelligence on the location of key Russian units and capabilities such as radars, SAMs, airbases, artillery batteries, jammers, and other high-value targets. Providing the Ukrainian Air Force with its own ISR-capable aircraft, like the MQ-9 Reaper, would also help in this regard, given the aircraft's ability to be employed at range and for long duration. As the campaign progresses, critical intelligence data must be rapidly updated and provided to Ukrainian military leadership for distribution to combat units. Intelligence support is where the nations of the Western alliance can play a vital role.

As part of campaign preparation, an important step is the building and fielding

Figure 5: French Mirage 2000 Fighters refueling from a K C-130J. France plans to send a number of Mirage 2000-5 fighter aircraft to Ukraine

Source: U.S. Air Force Photo by Tech. Sgt. Daniel Asselta.

of thousands of long-range attack drones. Ukraine already has a head start on this venture and has demonstrated the potential in strikes over the past year. This would require ironclad cooperation between those elements in the Ukrainian Armed Forces that operate these systems and the ground forces, something that continues to be a friction point. Ukraine's allies could provide valuable assistance—the drones are low-tech and low cost and can be manufactured in small factories in multiple nations. Harnessing additional advanced economies in this task could enable the rapid establishment of significant attack drone inventories. The key will be fielding mass fleets of these important weapons.

Ground forces must likewise be integrated to assist in the suppression of enemy air defenses by employing long-range fires, such as the High Mobility Artillery Rocket System (HIMARS), ground-launched cruise missiles, and the Army Tactical Missile System (ATACMS). These long-range missiles can reach into Russian-occupied territory to eliminate key GBAD targets, such as radars and SAM batteries, and are more difficult to counter than slow-speed drones. However, current restrictions on the use of these systems to strike into Russia negate some of the value these weapons bring to the fight. These restrictions must be removed. As previously described, providing Russia a sanctuary to conduct unhindered assembly of strike forces and a panoply of other operations in preparation for the conduct of assaults against Ukraine is counter to all the tenets of warfare and provides Russia a significant—and unnecessary—advantage. Special operations forces and cyber-attacks also have a role to play in this phase of the campaign. The UkAF and the Ukrainian ground forces must work in a truly integrated fashion to target and suppress Russian air defense systems.

UkAF GBAD units, notably the long-range S-200s, S-300s, Patriots, and other air defense systems, can also play an important part. From forward positions, these assets can threaten Russian fighter combat air patrols (CAPs), forcing them back from the breakout zone. The general idea would be to set up a "missile trap." The Ukrainian push would naturally attract the attention of Russian fighters—and the SAMs could provide a lethal welcome to these aircraft. Moving the long-range systems into more forward positions, however, is not without risk.

Electronic warfare (EW) assets could "sanitize" the airspace of reconnaissance and surveillance drones as well as degrade Russian SAM radars. Both sides currently use EW to disrupt small drone operations on the front lines, though these have less effect on more advanced Russian reconnaissance drones. One potential initiative might be the employment of a new generation of radars that can disrupt the avionics of UAVs over large areas of the front.[44] Providing these systems in an expeditious manner to Ukraine could provide important insights into countering the drone threat in future battlefields.

Potential Integrated Air Superiority Campaign

How might such a campaign develop? UkAF planners should work with their ground force counterparts to develop a supporting deception plan. In general, Ukraine would need to position forces on multiple axes as part of a deception operation and not reveal the true location of the major offensive thrust to the Russians.

As ground units begin to move into position, Ukraine would launch hundreds, preferably thousands, of attack drones against a wide variety of targets, including fuel production and storage, electricity generation, and other targets associated with supporting the Russian military effort. Targeting Russian dual-use infrastructure would force Russia

to respond and expend SAMs and fighter sorties to intercept, generate general confusion, and distract Russian leadership. Counterair targets would include airbases, command and control facilities, SAM sites, warning radar sites, and associated military support. Interdiction targets would include military supply and transportation nodes, railroads, bridges, and other critical infrastructure. Attacks on airbases are required as part of OCA operations to disrupt Russian sortie production and damage or destroy their aircraft. Striking Russian command and control nodes is a high priority due to the highly centralized Russian command structure. Airbases have historically proven resilient targets, but support equipment and fuel supplies could be damaged, and the resulting chaos and confusion would degrade operations. Attacks on GBAD radars would also be significant. Without radar, the SAM batteries are far less effective. Overall, Ukraine should seek to generate mass attacks—hundreds, potentially thousands of drone strikes per day. Though many will be shot down, current experience indicates that some will get through, and intercepts will draw down Russian missile stocks. In addition, the confusion resulting from striking hundreds of targets in multiple locations will help disguise the movement of ground forces and SAM batteries to the front.

Air superiority could provide Ukraine with the edge it needs to gain an advantage over the Russians, break through their front lines, and change the course of the war.

These drone strikes should be supplemented by Ukrainian army attacks using long-range fires against Russian radars, SAM batteries, and artillery positions. ATACMS, HIMARS, and cruise missiles are more formidable offensive weapons than attack drones. The UkAF could contribute by launching ARMs against Russian GBAD radars to further degrade capabilities. Timely intelligence provided by Ukraine's allies would enable precise targeting to eliminate medium- and high-altitude defenses and help open the skies to UkAF fighters. These strikes could be accompanied by extensive electronic jamming to ground drones, thus degrading Russian surveillance and reconnaissance capabilities.

As the ground forces begin their advance, UkAF long-range SAMs could be moved forward to engage Russian fighters entering the battlespace. In general, the UkAF would seek to be able to provide SAM coverage into Russian territory—as in the situation today with Russian GBAD assets denying UkAF combat aircraft from operating near the front lines. Ukraine has claimed some success against Russian bomber aircraft launching missiles against Ukraine from Russian airspace. On April 19, 2024, Ukraine's military stated that they shot down a Tu-22M3 long-range bomber using their long-range SAMs.[45] Using surprise and deception would be the basis of the campaign to deal with any Russian fighters flying to the area of penetration, where GBAD units in the right position could inflict significant Russian losses.

Against this backdrop of hundreds of strikes in Russia and occupied Ukrainian terrain, confusion on the part of the Russians as to where the Ukrainian army planned to strike, damage to Russian GBAD radars and SAMs, difficulty in maintaining drone surveillance, and surprise long-range SAM intercepts of Russian bombers and fighters, the Ukrainian army would have sufficient opportunity to penetrate through Russian defenses in specifically targeted areas. This is a formidable challenge given the extensive fortifications the Russians have developed, but it is critical to breaking the current stalemate.

With air superiority over selected areas, UkAF fighters could operate freely in these areas to deliver ordnance against Russian army units, strike logistics and transportation infrastructure with heavy weapons, and interdict Russian forces attempting to reinforce the area. Exploitation of the breakthrough has the potential to lead to a collapse of Russian positions.

Ukrainian forces face several challenges in attempting to reach this end state. First and foremost, they currently lack sufficient weapons, training, and maintenance of combat aircraft to perform the air superiority mission and sustain any effort for the time required to truly exploit the situation and make a real difference along the front. Secondly, the Ukrainian army must have the number of trained and capable ground forces required to exploit the localized breakthrough. However, an integrated air-ground campaign has the potential to overcome the force-size disadvantage that Ukraine has relative to the Russian military. Senior Ukrainian Armed Forces leaders must rid themselves of the Soviet/Russian doctrine and tactics, techniques, and procedures in which they have been trained. Old habits die hard. They must be willing to embrace new concepts and training—as well as a willingness to "rewrite the books" on military employment. Finally, Ukrainian Air Force leadership must be incorporated into the Ukrainian General Staff to foster and facilitate integrated, all-domain concepts, planning, and employment.

Air superiority is achievable if the tools outlined above are integrated into a cohesive, comprehensive, and integrated plan. Air superiority could provide Ukraine with the edge it needs to gain an advantage over the Russians, break through their front lines, and change the course of the war.

Summary & Recommendations

The conduct of the war in Ukraine to date has been a lesson in two distinct parts on the importance of air superiority. The first is the failure of the more sophisticated VKS to employ its forces wisely and strategically to establish air superiority and overwhelm Ukrainian forces to achieve a decisive victory at the start of the conflict. Instead, the VKS opted to quickly fall back on traditional Soviet doctrine in which air forces are merely a means to an end for ground force operations. This decision ultimately entrenched their forces in a predictable pattern that resembles the wars of the early twentieth century.

The second part of the lesson concerns the difficulty of establishing air superiority with insufficient resources and capabilities, as well as restrictions placed on weapons that have been provided by supporting nations—a situation the UkAF has lived with for over three years while holding off the invading force. Despite some limited successes using cheap, uninhabited systems for precision strikes, this has not been enough to turn the tide of the war, much less secure a decisive end to Russian aggression in Ukraine.

Drawing on these lessons, as well as those from more modern air wars, the comprehensive, integrated campaign proposed here would accomplish the following:

- Lead with an effects-based strategy that focuses on achieving larger war objectives rather than small wins in a reactionary and survivalist mode that currently characterizes both forces in the conflict.
- Integrate Ukrainian air and ground forces, special operations, cyber operations, GBAD, and EW assets, along with U.S. and NATO intelligence, to create integrated strategic effects.
- Focus Ukrainian ground forces and GBAD in ways to suppress Russian air and missile forces to deny their penetration of Ukrainian airspace.
- Capitalize on the advantages that low-cost UAVs confer for more than limited long-range precision strikes and use them in an integrated fashion for strikes to create confusion and deny Russian penetration of Ukrainian airspace. In this way, they can help establish

air dominance in times and places of Ukraine's choosing in which much larger maneuvers on the ground and in their airspace can succeed.
- Use F-16s to create effects across a much broader and strategic target set. Inhabited fighters can deliver heavy weapons in mass that can disrupt Russian ground forces and pave the way for Ukrainian army breakthroughs.

In order to achieve these objectives, there are many measures the United States, its NATO allies, and the UkAF can take: some of the more critical ones include:

- The United States should immediately remove constraints on U.S. weapons that would help Ukraine defend itself against its much more powerful and well-equipped invader. These constraints disproportionally advantage Russia by ceding them a sanctuary from which to operate.
- The United States and NATO should provide Ukraine directly with the timely intelligence it needs to make quick and decisive determinations on when and where to employ its forces to achieve windows of air dominance.
- The United States and NATO must ensure its military aid to Ukraine is sufficient to enable strategies that can achieve decisive outcomes and move Ukraine toward victory. Anything less is only ensuring their survival against a greater force for a little bit longer, until those supplies are expended.
- Ukraine should change its Soviet-based military doctrine at all levels and focus its air forces on establishing air superiority instead of expending them for ground maneuvers with only limited and temporary gains.
- Ukraine must evolve its current ground control intercept, and command and control doctrine to ensure that SAMs and friendly fighter aircraft can operate in the same airspace simultaneously. This will require changes to assure immediate communications for coordination are put in place between GCI and GBAD controllers.
- Ukrainian Air Force leadership must be incorporated into the Ukrainian General Staff to foster and facilitate integrated, all-domain concepts, planning, and employment. ✪

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