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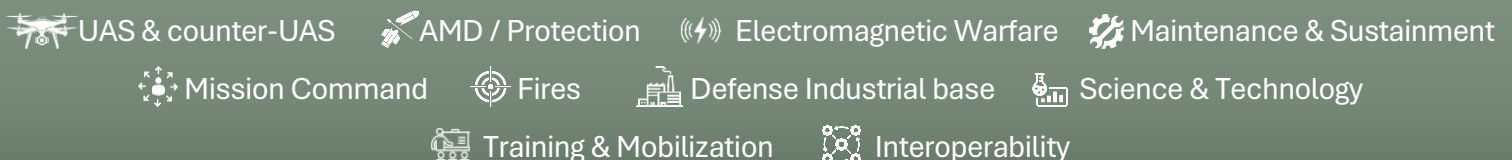
Ukraine Insights

Newsletter Issue # 2, April 2026

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- Ukrainian Experience of Electronic Warfare against OWADs
- Specifics of Combat Operations Conducted by Helicopters from Army Aviation of the Armed Forces of Ukraine
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Editors: COL James Smith (Australian Army) & Mr. Jackson Clemens

Graphic Design: Dr. Thomas Lee

A MESSAGE FROM THE COMMANDING GENERAL

By LTG Curtis Buzzard

Welcome to the second edition of our Operational Insights Newsletter. The work we do every day remains at the heart of the most significant European conflict in generations. We are laser-focused on enabling our partners to defend their sovereignty and achieve a just and lasting peace. This commitment continues to offer unique and valuable access into the realities of this high-speed, hi-tech large-scale combat operation. The insights we gather are not just for this theater; they benefit the entire joint and allied forces now and are likely to shape the very future of our military's approach to warfare.

The insights and lessons in Ukraine have a direct and profound impact on our preparedness for all aspects of NATO militaries. This can be most clearly seen now in the CENTCOM area of responsibility.

The proliferation of long-range, one-way unmanned systems, the sophisticated use of electronic warfare, and the adaptation of commercial technology for military effects are trends that transcend geography. By analyzing and understanding the tactics and technologies being forged in the Ukraine-Russo conflict, we are better equipping our forces globally to deter aggression and, if necessary, to fight and win.

“Let us continue to be relentless in our pursuit of knowledge, ensuring the insights gained here today provide a decisive edge for our forces tomorrow”



Recent events on the world stage reinforce the moral and professional obligation we have to learn as much as we can, as fast as we can, from our partners in contact. We are constantly translating raw data and observations into actionable lessons for use and implementation across the DOTMLPF-P spectrum now and in the future. Failing to adapt rapidly is not an option. I am immensely proud of our efforts but never satisfied – you can't learn too much from this conflict. Let us continue to be relentless in our pursuit of knowledge, ensuring the insights gained here today provide a decisive edge for our forces tomorrow, wherever they may be. Be intellectually curious and we should always be asking ourselves, are we learning more than our adversaries?



Ukraine lessons learned discussion at the 2025 U.S. Army Combined Support Command/Sustainment Center of Excellence Sustainment Warfighting Forum

Countering One-Way Attack Drones (OWAD) of the Shahed Type

By: LTC Vicktoz Romaniyuk, Armed Forces of Ukraine



Air Defense System DASH

The Russian invasion of Ukraine marked the first large-scale strategic use of OWAD. Since October 2022, Russia has launched Iranian-supplied Shahed-131/136 drones to strike Ukrainian energy infrastructure and cities. The relatively low cost and simplicity of production enabled mass use of these OWADs*, while the difficulty of interception made them one of the key threats in modern warfare.

Since early 2023, Ukrainian air defense forces have actively used medium- and short-range surface-to-air missile systems as well as fighter aviation capabilities to counter them. At the same time, expensive interceptor missiles were used against relatively cheap targets, creating an economic imbalance between the sides.

The characteristics of these systems must be considered. The range of Shahed-family OWADs can exceed 1,000 km, and the warhead weight ranges from 50 to 90 kg. Navigation is carried out using satellite and inertial systems. Their

relatively low radar visibility and ability to fly at low altitudes complicate detection by conventional air defense radars. However, the piston engine produces a characteristic sound, enabling acoustic detection.

An important aspect is the continuous improvement of tactics by Russian forces. These include simultaneous attacks from multiple directions, programmed maneuvers in vertical and horizontal planes, and combined use with missile strikes.

This forces Ukraine to continuously adapt its air defense system, develop new countermeasures, and integrate various technical means. A comprehensive approach is essential and can be divided into three main components:

BLUF BOX

Ukraine's uses a multi-layered strategy to counter Russia's widespread use of low-cost, Shahed-type attack drones. They developed a comprehensive defense system integrating advanced detection methods (radar, acoustic, and optical), automated alerting, and efficient target allocation. Engagement involves traditional air defense, mobile fire teams, and electronic warfare. A key innovation is the successful deployment of interceptor drones, which have proven highly effective and are considered a decisive future countermeasure.

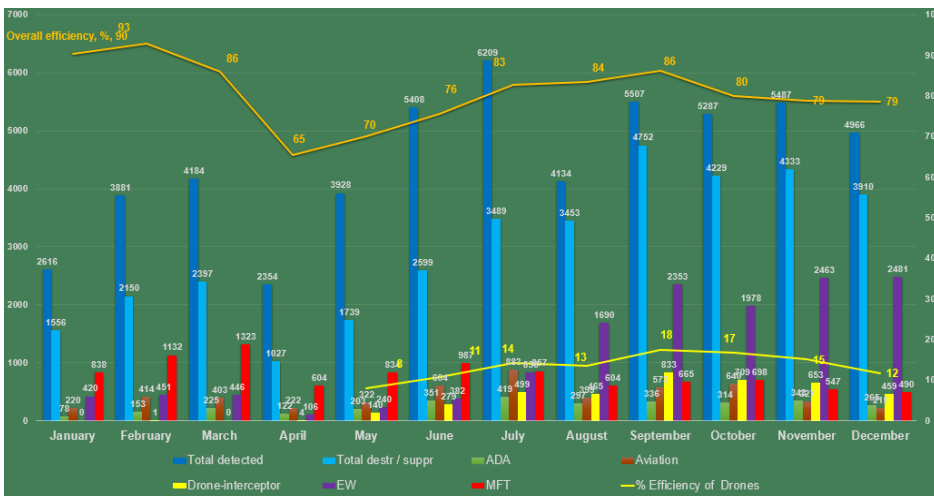


detection, target allocation, and engagement.

For timely **detection** of OWADs, a unified surveillance and



A Ukrainian Mobile Fire Team



Effectiveness of strike OWADS in 2025 year

warning system has been created using various means:

- radar systems of different frequency bands capable of detecting small aerial targets.
- electro-optical surveillance systems (including thermal imaging devices);
- acoustic sensor systems (capable of detecting the characteristic sound of Shahed-type drone engines);
- visual observation posts.

This increases detection probability and reduces reaction time.

Operational alerting of units is carried out via the automated control system “Virazh” and the information and communication system “Kropyva”, significantly reducing response time.

Target allocation is performed through automated command and control systems at air defense command posts, considering distance, altitude, speed, availability of assets

and ammunition. The goal is efficient use of forces, avoiding overload, and ensuring protection of critical infrastructure.

The following are involved in **engagement**:

- units equipped with Short Range Air Defence (SHORAD) and Very Short-Range Air Defence (VSHORAD) systems, as well as self-propelled anti-aircraft artillery, deployed along predicted routes.
- mobile fire teams (MFT**), capable of rapid maneuvering.
- army aviation units using helicopters with onboard weapons (12.7 mm or 7.62 mm);
- fighter aircraft of the Ukrainian Air Force, mainly during mass attacks.
- electronic warfare units suppressing satellite navigation signals, reducing accuracy.

Special attention should be given to interceptor drones. First used in April 2025, they proved effective and promising. Since May 2025,

dedicated units were formed, showing high efficiency against Shahed targets.

Further development followed the creation of the Unmanned Systems Command in 2025, coordinating UAV warfare technologies. By the end of 2025, about 20% of destroyed OWADs were neutralized by interceptor drones.

Countering Shahed-type OWADs has become a key element of modern warfare. Further technological development and scaling of interceptor drones will be decisive.

* According to official Ukrainian data, in 2025 Russia launched 53,961 Shahed drones, about 31,578 strike variants.

** MFT typically consists of 5–10 personnel, a vehicle with a machine gun, searchlights, MANPADS, and a tablet.



Drone-interceptor PI-SUN

Ukrainian Experience of Electronic Warfare against OWADs

By: MAJ Vladyslav Smaha, Armed Forces of Ukraine

In September 2022, Ukraine for the first time faced a new challenge of modern warfare – the massive use of Shahed/Geran One-Way Attack Drones (OWAD), (hereinafter referred to as Shahed). The quantity deployed increased rapidly from approximately 700 pieces in 2022 to more than 53,000 pieces in 2025. The large-scale use and the resulting saturation of air defense systems (hereinafter referred to as air defense) prompted the search for new technological solutions that can scale quickly. This gave an impetus to the development of the air defense electronic warfare subsystem (hereinafter referred to as EW).

Advantages of using the air defense electronic warfare subsystem to protect critical infrastructure:

- a decrease in the targeting accuracy of high-precision enemy weapons;
- all-weather operation;
- reusability;
- an increase in the cost of air attack assets for the adversary;
- an increase in the quantity of weapons the enemy must expend to successfully strike a target.

The results of the analysis of the wreckage of downed Shaheds (Fig. 1) revealed a vulnerability to radio interference: their reliance on satellite navigation for course correction, route control, and high-precision targeting without real-time human intervention. At the same time, the inertial navigation system creates an error of about 5% (depending on the direction and speed of the wind) of the distance traveled. Since this method of guidance is also used in cruise missiles, Ukraine has implemented



Figure 1 -- Shahed attack UAVs suppressed by electronic warfare systems without signs of kinetic impact.

BLUF BOX

Ukraine developed a scalable EW subsystem targeting the Shahed drones' vulnerable satellite navigation. Despite Russian upgrades, like jam-resistant antennas and FPV controls, Ukraine's EW system adapted; suppressing approximately 40% of destroyed Shaheds in 2025. While EW is a critical, non-destructive tool, its integration with other air defense components like missiles and interceptor drones is essential for a comprehensive defense strategy.



projects to "turn off" the navigation field.

In November 2023, in an interview with the then Commander-in-Chief of the Armed Forces of Ukraine, for the first time, it was indicated that the deployment of the nationwide Pokrova electronic warfare system to counter Russia's missile and long-range drone strikes. Originally a research initiative, the task of which was to suppress a conventional single-element satellite navigation receiver. However, the enemy evolved the Shaheds technology, the original Pokrova system became less effective. In 2026, a new generation of the AD EW subsystem is in use. The specific number of units and coverage area are not disclosed, however, according to the official statistics of the Air Force of the Armed Forces of Ukraine for 2025, the number of Shaheds suppressed by electronic warfare

systems is approximately **40%** of the total number destroyed.

In order to reduce the impact of electronic warfare systems, the enemy spent more than **\$1.5 billion** on the modernization of Shaheds. Jammed-resistant satellite navigation receivers with CRPA antennas of 4, 8, 12 and 16 elements began to be used (Fig. 2). To counteract such receivers, it is

“The enemy spent more than \$1.5 billion on the modernization of Shaheds”

solution, while antennas manufactured by NATO member countries, as a rule, do not exceed the 8-element antennas.

suppression of satellite navigation and even strike at moving objects, such as trains (Fig. 3c). This requires a combination of electronic warfare means of satellite navigation, electronic warfare means with UAVs (Fig. 3d) and tactical direction finding systems for monitoring the electromagnetic spectrum (Fig 3e).

The risk of using the air defense electronic warfare subsystem is the potential interference with friendly forces equipment. Risk reduction is achieved by: providing units with interference-resistant satellite navigation receivers, using antenna systems with an upward radiation pattern in electronic warfare systems and installing metal shields under omnidirectional antennas, coordinating actions at air command control posts, introducing bans on radiation to electronic warfare equipment.

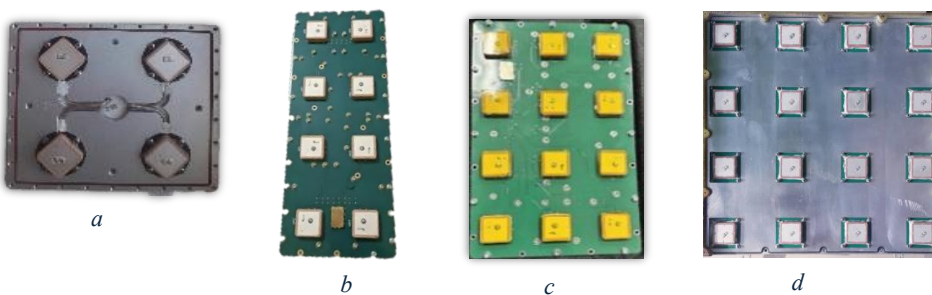


Figure 2 – CRPA antennas used in Shaheds: a. 4-element (until the end of 2024); b. 8-element (until the end of 2024); c. 12-element (from the beginning of 2025 to the present); d. 16-element (from spring 2025 onwards).

necessary to create multiple overlaps with obstacles within a radius of at least 40 km from the covered object. The placement of funds is selected for each object individually, taking into account the terrain and the density of urban buildings. It is worth noting that a 16-element CRPA antenna is an extremely complex technological

The next step in evolution was the use of Mesh communication networks (Fig. 3a) in combination with a system of ground and air signal repeaters from the spring of 2025. This technology allows real-time control in FPV (First Person View) mode using a video camera on board (Fig. 3b), hit targets in conditions of



Figure 3 – a. Video camera installed on board the Shahed; b. Train after the hit of 3 Shaheds on 27.01.2026; c. electronic warfare device from the Dam UAV; d. tactical radio direction finder Bukovel-RP; e. communication modem XK-F358

In conclusion, the satellite navigation and control channels of Shahed drones are highly vulnerable to electronic warfare. The AD EW subsystem—which integrates satellite navigation jamming, UAV-specific EW, and tactical direction-finding—does not aim for physical destruction. Therefore, effectively repelling enemy air attacks requires the comprehensive integration of EW

with other air defense components, such as anti-aircraft missile forces, mobile fire groups, and interceptor drones. Radio channels of satellite navigation and control are vulnerable to the influence of electronic warfare in Shaheds. The air defense electronic warfare subsystem includes electronic warfare systems with satellite navigation, electronic warfare systems with UAVs and

tactical direction finding systems. AD EW does not have aim to physically destroy Shahed drones, therefore, effective repulsion of enemy air attacks is achieved only by comprehensive work with other components of air defense, such as: anti-aircraft missile forces, mobile fire teams, interceptor drones, and others.



Specifics of combat operations conducted by helicopters from Army Aviation of the Armed Forces of Ukraine

By: LTC Stanislav Shevchenko, Armed Forces of Ukraine



Since 2022, the tactics, Techniques and procedures (TTPs) for combat operations by Ukrainian helicopters, mainly Mi-8 and Mi-24 types, has been transformed under the influence of the enemy's dense layered integrated air and missile defense (IAMD) and the massive usage of different types of one way attack drones (OWAD).

The main aspects of this experience are:

- adaptation to fly at extremely low altitudes and conduct Lofting Maneuver (tilts its nose upward to fire rockets);
- search and rescue (SAR) missions;
- aeromedical evacuation (MEDEVAC) missions;
- -expanding the role of army aviation in the IAMD system.

Nowadays, Armed Force of Ukraine have abandoned close air support (CAS) missions due to the threat of been detected by radar and risk of shoot down by man-portable anti-aircraft missiles (MANPADS). In order to avoid those threats, pilots fly at altitudes of 5 -10 meters (15 – 30 feet) above terrain. At the precise moment of the climb, pilots conduct a Lofting Maneuver (pitching up an angle typically between 20° and 45°), to fire a large salvo of unguided rockets like Hydra 70 or S-8. Due to the pitch angle of the helicopter during the launching, the missiles do not fly straight, but upwards, along a high ballistic trajectory to increase the maximum range of the rockets without entering the enemy's



Helicopter Mi-8 (NATO codename – Hip)

BLUF BOX

Ukrainian Army Aviation has adapted its helicopter tactics in response to dense Russian air defenses and drone threats. Traditional close air support has been replaced by low altitude "lofting" rocket attacks. Medical and search and rescue missions have become complex, multi-stage operations. A significant new role is using helicopters to intercept slow-moving drones like the Shahed, proving to be a cost-effective and mobile component of Ukraine's air defense.



engagement area. Immediately after firing, the pilot performs a "break turn" (a sharp turn and dive) to return to low altitude in combination with firing countermeasures (chaff and flares) to escape before enemy air defenses and MANPADS can react.



Helicopter Mi-24 (NATO codename – Hind)

Conducting combat search and rescue operations (CSAR) in conditions of high intensity engagements are the most difficult type of missions because the helicopter becomes too visible as a target. In the minutes from the moment the "Mayday" signal is received (from the pilot of the downed aircraft or a group in the

“Direct helicopter flights to the forward line of own troops have become extremely risky”

helicopter to ensure safety on the ground during the landing. Today, UAVs are used more often to locate the pilot of the downed aircraft or group in the encirclement and observe the area. The helicopter flies up only when the evacuation location is confirmed and a safe corridor is cleared.



encirclement) until the arrival of the helicopter, enemy SAR groups also move to the location. Usually, a couple of helicopters are flying for the mission. One conducts the evacuation directly while the other covers it from the air, ready to strike at the enemy if they try to approach the evacuation area. There is always a fire support group (SOF or CSAR team personnel) in the cargo compartment of the

Aeromedical evacuation (MEDEVAC) in conditions of modern warfare has transformed from a routine procedure to a complex special operation. Due to the high density of IAMD systems and the activity of UAVs in the "gray zone", direct helicopter flights to the forward line of own troops has become extremely risky and exceptional. Instead of the classic "battlefield

hospital" way, the risks of evacuation are divided by:

- Evacuation by land routes (CASEVAC): The wounded are taken from the battlefield by armored vehicles, pick-ups or ground robotic systems to a stabilization point (commonly located 15 – 30 km from the "gray zone" outside of FPV drone engagement areas.
- Air evacuation (MEDEVAC): Helicopters pick up critically wounded personnel from stabilization points in relatively safe areas and quickly deliver them to specialized hospitals.

Since 2024, the Armed Forces of Ukraine were the first in the world to begin systematically using Army

Aviation helicopters to intercept kamikaze drones such as Shahed (Geran) as part of an integrated and layered IAMD network. Using helicopters to intercept OWADs helps save expensive anti-aircraft missiles and provides high mobility in destroying enemy targets. In just a year from August 2024 to August 2025, helicopters intercepted more than 3200 Russian OWADs using 12.7mm nose machine guns or onboard 7.62mm machine guns operated by gunners to shoot down UAVs, similar to World War II tactics. In addition, helicopters have been upgraded with advanced foreign-made sensors (thermal imagers, infrared systems) to be capable of detecting OWADs at night and in bad weather conditions. They usually work in formation of two

helicopters: one helicopter with an electro-optical sensor (FLIR) to detect and track the target, and a second helicopter to destroy it when clear of populated areas to avoid debris falling on people. This tactic allows Ukraine to quickly respond to massive attacks, using helicopters to protect critical infrastructure when air defense systems are not available or their use is economically impractical.

The change in TTPs of combat operations by Ukrainian helicopters during a full-scale war is an example of the extreme adaptation of legacy Soviet equipment to the conditions of the densest IAMD and the massive use of OWADs by the enemy.



What is the DELTA System?

By: SGT Maksym Lytvynenko & COL Yurii Blishun, Armed Forces of Ukraine

DELTA originally emerged as a “bottom-up” solution. Its development began as a volunteer initiative, initially focused on a single application—a digital map for situational awareness. This initial capability later expanded into an entire ecosystem of software applications. The first DELTA prototype was unveiled in 2016, and its deployment began that same year in the Joint Forces Operation zone in eastern Ukraine. Active use continued with the onset of the full-scale Russian invasion, and in February 2023, the Ukrainian government approved the implementation of the DELTA system within the Armed Forces of Ukraine.

Today, DELTA is a national military situational awareness system that integrates information on the location of enemy forces and assets, enabling real-time tracking of enemy troops positions, rapid registration of

detected enemy targets, planning of combat missions, and secure exchange of information regarding enemy force deployments.

The system integrates enemy data from various sources—including satellite imagery providers, radar, sensors, GPS trackers, and intercepted radio transmissions—onto a digital map. This allows DELTA users to respond in a timely manner to changing situations on land, at sea, in the air, and in cyberspace. One of the advantages of this system is that it can run on any device: a laptop, tablet, or smartphone. Both troops on the front lines via mobile devices and senior military leadership have simultaneous access to DELTA.

The main components of the DELTA system are a set of built-in tools (modules), namely:

BLUF BOX

The DELTA system is a comprehensive military situational awareness platform used by Ukraine's Armed Forces. Originating as a volunteer project, it has evolved into a multi-module ecosystem built on NATO standards. DELTA integrates real-time data from diverse sources like satellites and sensors onto a digital map, accessible on any device. With tools for mission planning, secure messaging, and intelligence analysis, all protected by a "zero-trust" security model, it provides a unified operational picture to enhance coordination and firepower.



“DELTA MONITOR” (Fig. 1) is a tool for collecting, processing, and displaying information about the enemy to ensure coordination of the Armed Forces of Ukraine actions, as well as situational awareness in accordance with NATO standards. Users enter information on over 600,000 enemy targets every month. Each target on the digital map includes a classification, an image, and information about the source that detected it, allowing users (if necessary) to contact the person who reported the enemy target directly to obtain additional details. Additionally, data entered into the system is never deleted from DELTA, allowing for tracking changes and analyzing trends;

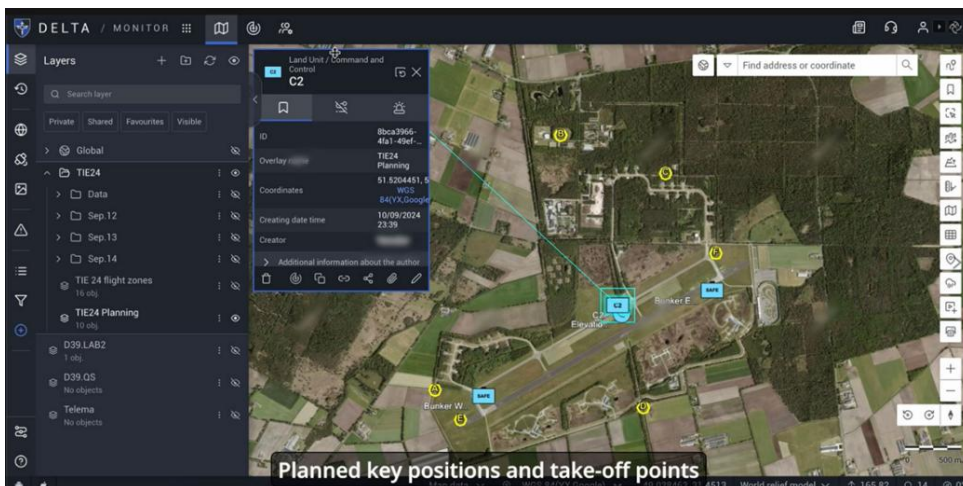


Figure 1. DELTA MONITOR Module interface

“ELEMENT” is a secure messaging app for communication and coordination among units of the Armed Forces of Ukraine.

“VEZHA” is an aerial reconnaissance module that integrates video sensors into a unified situational awareness environment with capabilities for collective analysis and distribution of received data among units of the Ukrainian Defense Forces to accelerate the destruction of enemy targets. This module allows for the daily processing of over 4,000 reconnaissance targets, while users can communicate via voice in a secure environment and jointly analyze video footage.

“MISSION CONTROL” (Fig. 2) is a module designed for mission planning and coordination among unmanned aerial vehicle (UAV) crews, with the aim of allocating flight zones and jointly planning tasks. This helps to intelligently plan the deployment of UAVs—for example, determining which ones are

best suited for engaging specific targets. Every month, drone operators plan approximately 106,000 missions using MISSION CONTROL.

“TARGET HUB” is a module for developing, maintaining, and managing targets and fire missions during enemy engagement.

“ORBIT” is a separate module of the DELTA system, designed to maintain, structure, and provide rapid access to centralized, up-to-date, and verified information on the organizational structure, personnel, and armaments of enemy units. All information in ORBIT is organized around a hierarchical tree of units. This structure allows for linking information about units between higher and lower levels. The module reflects the chain of command, where each unit inherits general information from the higher level.

“BATTLESPACE MANAGEMENT” (BSM) is an administrative module of the DELTA system that combines the

“The system generates an average of 35,000 reports per month and saves approximately 17,000 hours of staff work”

functionality necessary for convenient management of units within the system and their capabilities. BSM is available to users with the roles of “unit administrator” and “assets administrator”;

“DELTA INTELLIGENCE” is a platform for integrating various types of data from external systems, including the chatbots “eVorog” and “STOP Russian War,” providers of satellite imagery, radars, sensors, GPS trackers, weapons, and more, to perform analytical intelligence tasks. It also serves as an effective interface for data exchange with allies in accordance with NATO standards.

In addition to the above, DELTA enables its users to save a significant amount of time when creating reports. For example, the system generates an average of 35,000 reports per month and saves approximately 17,000 hours of staff work, which is equivalent to 700 days or nearly two years of work.

The DELTA platform and services are built to NATO standards and support the MIP (Multilateral Interoperability Programme) specification, which enables network-

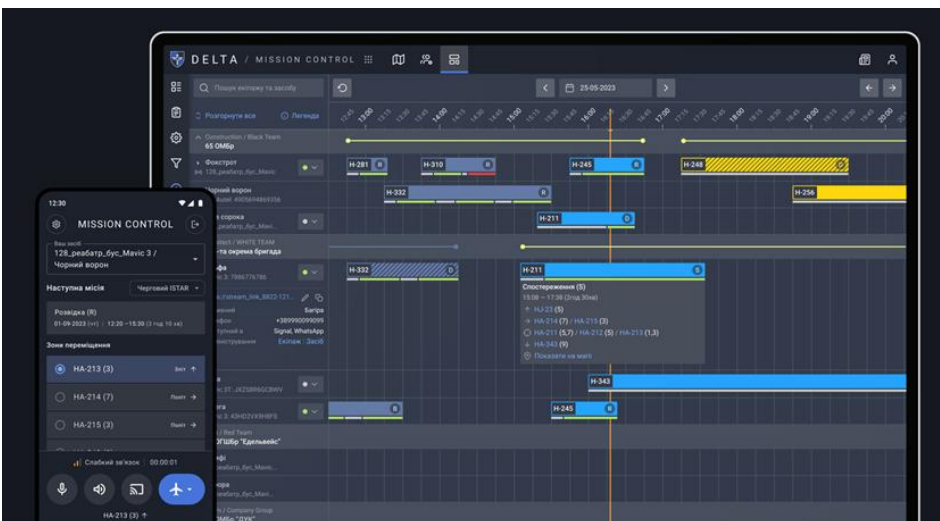


Figure 2. MISSION CONTROL Module interface

UKRAINE INSIGHTS

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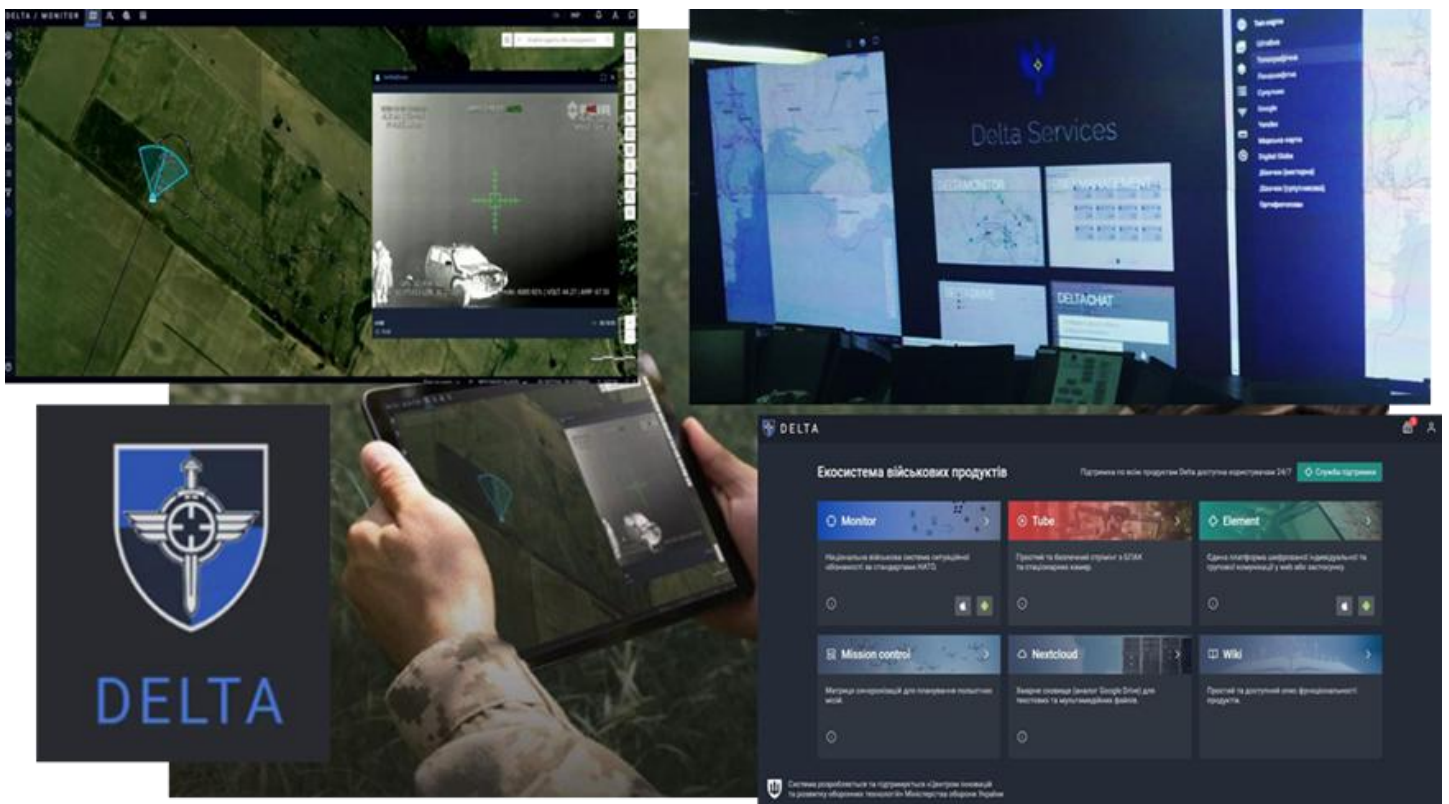
centric warfare; meaning it is compatible with similar solutions used by the armed forces of NATO member countries. However, DELTA is capable of flexibly adopting modern approaches. For example, DELTA operates in a cloud environment, while some partners are only planning to transition to the cloud by 2030–2035.

When it comes to a secure environment, it should be noted that access to DELTA is multi-tiered, meaning that different levels of

command have separate permissions and varying levels of access to system data. DELTA's security is built on a "zero-trust" model, which ensures a high level of security and is equipped with automated monitoring of suspicious activity and hacking attempts.

It is precisely the availability of a wide range of effective tools for information exchange, the implementation of robust system security against unauthorized external intrusions, continuous vulnerability

testing, and the existence of data leak prevention protocols that enable the DELTA system to be used by the Armed Forces of Ukraine for the following tasks. These include combat planning, execution of combat missions, coordination of unit actions, and secure exchange of information regarding the location of enemy forces and assets. All of this contributes to the effective delivery of firepower against the enemy.



Building Resilience in Army Integrated Air and Missile Defense

By 1LT Christopher Burlison, U.S. Army, SAG-U AMD

Executive Summary

Strategic capabilities, such as long-range strikes, can serve a valuable tactical role in the initial stage of conflict. The June 2025 Iranian attack on Al Udeid Air Base reveals how these strategic fires will likely act as the opening move for future conflicts [1]. As the United States prepares for large-scale combat operations (LSCO), the U.S. Army must prepare its ground-based air defenses (GBAD) to survive against this opening phase of conflict to preserve America's capability to sustain a response to its adversaries. This preparation must take the form of building resilience in air defense systems. Although U.S. air defense systems are the most capable systems in the world against aerial threats, increasingly complex and maneuvering threats mean the Army can no longer solely rely upon system performance for survival. In Ukraine, site hardening and layered medium-tier air defense systems have saved lives and mitigated damage to

exquisite systems from complex Russian strikes [2] [3]. The U.S. Army must learn from this conflict and implement air defense emplacement site hardening in the short-term, and layered medium-tier systems in the long-term, to survive the opening phase of LSCO, enabling U.S. forces to sustain a response to our adversaries.

Introduction

The Russo-Ukrainian War features increasing employment and intensity of long-range strikes by the Russian military against Ukraine's Critical National Infrastructure (CNI). These Russian strikes aim to break the Ukrainian people's will to fight and destroy Ukraine's ability to resist invasion. To increase the success of these long-range strikes, Russia employs mass swarms of hundreds of one-way attack drones (OWADs) and maneuvering short-range ballistic missiles (SRBMs) to prevent a complex threat to Ukrainian defenders [4]. Russia's increased focus on targeting Ukrainian CNI has

BLUF BOX

Drawing lessons from the Russo-Ukrainian War, U.S. Army air defense must build resilience to survive initial enemy strikes. First, there needs to be a hardening of air defense sites with physical protection measures. Second, the Army must invest in the acquisition of layered, medium-tier systems to fill the capability gap between Patriot and Stinger platforms. This approach aims to ensure system survivability and preserve the U.S.'s ability to sustain a response in future conflicts.



led to a corresponding increase in the importance Ukraine places on air defense systems. However, the increasing intensity and complexity of Russian long-range strikes has also increased the risk to these air defense systems, exposing the importance of developing resilient air defenses, which Ukraine has accomplished through emplacement site hardening and the layering of medium-tier systems [2] [3]. Although current U.S. Army GBAD systems are the most capable in the world against aerial threats, we must build resilience in these systems to survive the initial phase of conflict. In the short-term, this resilience can be achieved through emplacement site hardening, until the Defense Industrial Base (DIB) can fill the gap in layered medium-tier systems in the long-term.

“Increasingly complex and maneuvering threats mean the Army can no longer solely rely upon system performance for survival”

Emplacement Considerations and Applications

Digging in air defense equipment requires considerable engineering materiel, time, and personnel, and the time added precludes hasty or rapid emplacement and displacement options [5]. Additionally, the feasibility of up-armor air defense shelters with hardening materials must be considered, as metal plates may add protection, but limit mobility and add weight and costs. In Ukraine, Patriot Fire Units have conducted site hardening prior to emplacement, with the Engagement Control Station (ECS) position dug previously and the shelter protected prior to movement [6]. This allows the Fire Unit to emplace without significant increases to emplacement time, however it may contribute to RUSMIL targeting, as significant site preparations can cue adversary intelligence, surveillance, and reconnaissance (ISR) assets to planned emplacement positions. While site preparations likely lead to easier targeting of Patriot Fire Units in Ukraine, the site hardening certainly led to increased crew survivability and greatly decreased repair time and costs [6].

There are two main materials used to enhance positions and nodes, steel and Kevlar [6]. Steel provides the greatest protection, but due to its weight it limits the mobility of the system. Kevlar is lighter and provides protection but does not provide the same protection capability of steel. When assessing what materials to use in protecting GBAD systems one

must analyze the need for mobility with the need for protection. The use of Kevlar coverings for shelters can mitigate the potential impact to mobility from up-armor with steel, although Kevlar is more costly. Heavier materials make the mobility tradeoff less favorable for short emplacements, but more favorable for longer term emplacements.

USINDOPACOM and USCENTOM feature long-term emplacement sites for air defense systems, with deployed units falling in on similar sites as their predecessors for years at a time due to the nature of their mission and available terrain. With such mission sets, mobility is restricted, therefore effort must be allocated to deliberate site hardening to enable the systems to survive the first engagement. For example, an ECS located on Guam can be substantially hardened with metal plates without concern for site jumps due to the relatively small size of the island of Guam. In Qatar, Al Udeid Air Base is a fixed asset that Army GBAD defended against an Iranian ballistic missile raid in June 2025, but displacement and re-emplacement is not feasible due to the nature of the fixed asset [1]. Hardening these sites in USINDOPACOM and USCENTCOM AORs would increase the survivability of both the air defense units and their protected assets, especially in the opening phases of conflict.

Layering of Medium Tier Systems

Although site hardening is effective in mitigating damage from

attack, layered air defense is vital in preventing damage entirely. Ukraine currently employs a mix of medium and lower tier air defense systems in a layered approach to air defense. Donated weapon systems such as NASAMS, IRIS-T, and HAWK complement gaps in Ukrainian air defenses left by legacy Soviet-era systems such as the SA-10, SA-3, and SA-6 [2]. These medium-tier systems serve two valuable functions. Firstly, they provide cruise missile and air breathing threat (ABT) defense to critical assets so that Patriot can focus on Ballistic Missile Defense (BMD). Secondly, the mix of systems creates resilience through redundancy, both in force operations and engagement operations. By providing cruise missile and ABT defense, these medium-tier systems generate magazine depth for more expensive Patriot munitions by decreasing the volume of threats Patriot must engage. Additionally, force operations are made resilient as the mix of interceptors and systems creates diversity in supply chains. As one system, munition, or supporting industrial base falters or is countered, another system or supply chain can maintain support and capability. Resiliency in engagement operations is developed by forcing adversary munitions to contend with a mix of capabilities and engagement methods, such as active seekers, passive seekers, and differing radar search and track frequency bands.

The U.S. Army currently has a gap in medium-tier air defenses between Patriot and Stinger-based short-range air defense platforms. Ukraine covered this gap with a variety of weapon systems. The U.S.

Army seeks to cover this gap in the future with the Integrated Battle Command System (IBCS) and Indirect Fire Protection Capability (IFPC) [7] [8]. These programs seek to create a layering and integration through the “any sensor, any shooter” concept with a mix of kinetic and non-kinetic effectors. However, the adoption and refinement of this technology force-wide is still years away, and no medium-tier program of record currently exists to fill the gap between Patriot and Stinger-based platforms. Current ground-based medium-tier cruise missile defense is reliant on Patriot as the single point of failure or success, with additional support provided by Defensive Counter-Air (DCA) sorties. More limited short-range capability against rockets, artillery, and mortars is provided by the Land-based Phalanx Weapon System (LPWS) [9]. Thus, the Army currently has lower resilience in force and engagement operations due to the lack of redundant systems or mix of medium-tier systems for cruise missiles and ABT defense.

Recommendations

- The U.S. Army should develop standardized methods of shelter hardening (metal plates, thickness, material, etc.) and allocate these materials to air defense units.

- The U.S. Army should determine engineer equipment and time requirements to dig in air defense systems.
- The U.S. Army should add air defense site emplacement positions to engineer priorities of work.
- The U.S. Army should determine impact to emplacement and displacement times and provide trade-off analysis to unit commanders for tactics, techniques, and procedures (TTPs) development and risk acceptance.
- The U.S. Army should integrate within the Joint Force Concept by collaborating with Navy, Marine, and Air Force units capable of supporting site hardening efforts, such as the Navy Construction Battalions and Air Force REDHORSE engineer units.
- Headquarters, Department of the Army (HQDA) should advocate for medium-tier air defense systems as a requirement for GBAD to expedite acquisitions.

Conclusion

The Russo-Ukrainian War demonstrates the increased importance of air defense systems to protect critical assets from long-range strikes by peer adversaries. As their importance has increased so has the risk posed to these systems from

“The U.S. Army must prepare now to build resilience into these high-value systems to ensure that critical assets remain protected from air attack.”

direct attacks by capable adversarial threats. Therefore, the U.S. Army must prepare now to build resilience into these high-value systems to ensure that critical assets remain protected from air attack. To accomplish this, the Army must formalize methods to harden air defense emplacement sites and expedite the development and integration of medium-tier systems.

Author Biography

Christopher Burlison is an Air Defense Artillery Officer in the U.S. Army currently stationed in Wiesbaden, Germany with Security Assistance Group - Ukraine. He has spent the past three years planning and executing short-range air defense operations with NATO allies across Europe and Africa.



Survivability and Protection in the Future Conflict

By MAJ Andrew Schmidt, U.S. Army, SAG-U Engineer/CUOPS

A trend amongst many Brigades conducting LSCO rotations at Army Training Centers is placing all the air defense responsibilities of an entire brigade on the air defense officer. Brigades that have a singular focus on lethality without protection see significant losses at the tactical level that frequently render whole

“Brigades that have a singular focus on lethality without protection see significant losses”

companies combat ineffective. The knee-jerk reaction to this catastrophic loss is to blame the air defense officer. This misnomer is false because protection of formations rests on the shoulders of the leaders of the whole organization. Protection is not the responsibility of just one branch in the Army. Operational insights from Ukraine prove that the best protection against UAS permissive environment is a layered defense of both passive and active measures. Active measures include kinetic interception capabilities including Patriot, Hellfire, and Stinger missiles as well as the now, world-renown, Ukrainian Merops CUAS drone systems. Passive measures are just as important and include the suite of detection



Russian Geran-5 UAV / Photo credit: The Defense Intelligence of Ukraine

BLUF BOX

Survivability in modern conflict against UAS is a command-wide responsibility, not just the air defense officers. As seen in Ukraine, a layered defense against drones, focusing on passive measures is necessary. These include engineer-led constructive defenses like fortifications and netting, the tactical use of concealment such as smoke and camouflage, and military deception through decoys. All leaders must integrate these protective measures to ensure force survivability.



systems (radar, acoustic, visual, etc.), passive electronic warfare, and the final defense of C-UAS netting, overhead protection, camouflage and obscurity, and underground fortifications. In the conflict in the CENTCOM AOR, military leaders are looking to Ukraine for operational insights on how to protect their critical infrastructure and key nodes. In the future conflict, key passive protective measures of constructive defenses, use of concealment, and use



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UKRAINE INSIGHTS

APRIL 2026

of decoys and Military Deception (MILDEC) enable formations to defend against the UAS permissive environments.

Engineers are critical in providing passive defense measures for Type 3 UAS (Shaheed) in the layered integrated defense against OWADs. These include digging in underground facilities, providing overhead detonation standoff, and installing heavy steel, anti-drone netting over critical facilities and infrastructure. Ukraine's application of underground fortifications has evolved over time from the trench networks and underground structures modeled from World War I into the more modern and robust construction we are now seeing. The Ukraine State Special Transportation Service (SSTS) has been incorporating stronger and robust obstacle belts integrated with sensor networks and underground fortifications to improve their defensive lines. The concrete tunnels leading to the forward observation posts made of pre-cast, rebar reinforced, concrete positions can be either manned or unmanned with automated firing positions, similar to the US CROWS. Key to effective standoff and fortifications is the ability to conceal the site from enemy targeting.

Operational insights from Ukraine identify that the use of concealment is a tactical and operational level task. The use of smoke for obscuration not only masks optical observation of drones, but the heat from the flames also can distract and desensitize UAS operators using IR to target personnel. The use of IR ponchos to hide heat signatures of

Soldiers in the open has proven ineffective in mitigating as a single protective source, however, use of IR

focusing in areas friendly forces do not occupy, and even cause the enemy to use their higher cost precision



ponchos in conjunction with other concealment methods increases the likelihood of survival. Soldiers along the front build their own underground positions, covering them with tree branches, debris, camo netting, or anything that can conceal the site from observation and increase standoff from FPV drones. To build fortifications and protective measures, engineers and their equipment are invaluable to protect key assets and terrain, making engineers and their equipment at High Value Target of the enemy.



Engineering equipment is a priority target in the enemy High Value Target List (HVTL). The use of decoys enables protection in deceiving the enemy of friendly intentions, distracting their ISR in

weapons to engage decoys instead of real equipment. Evidence of Ukraine's successful decoy and deception campaign is the Russian propaganda claiming they have destroyed more HIMARs in Ukraine than there are HIMARs in the entire world. Ukraine has proven time and time again that effective use of decoys has been an effective means to both enable maneuver and protect their forces from effective targeting of artillery and UAS.

The current conflicts in Ukraine and across CENTCOM AOR demonstrate the need for all leaders to incorporate important insights on protecting the force. These insights include applying passive protective measures of constructive defenses, use of concealment, and use of decoys and MILDEC enable formations to defend against the UAS permissive environments. The victor in war is the one that adapts to the battlefield the quickest.

Alive or KIA: Battlefield Telehealth and the Collapse of Predictive Triage

By COL Debra Sims, U.S. Air Force, SAG-U/NSATU OSURG

The Ukrainian battlefield reveals a fundamental rupture in Western military medical doctrine: continued reliance on predictive triage models crafted for a battlefield defined by maneuver, communication, and temporal predictability. That battlefield no longer exists. Modern large-scale combat operations shaped by persistent ISR, FPV drone saturation, long-range fires, and pervasive electronic warfare have transformed the essential determinant of survivability. It is no longer injury severity or evacuation speed. It is the persistence of a signal, any viable link that can be maintained under conditions explicitly designed to extinguish it. Ukrainian medical leadership captured this reality during a MEDNET exchange: “We do not have four categories, delayed, immediate, minimum and expectant (DIME). We have two: alive or KIA.” This was not hyperbole; it is operational truth.

“We do not have four categories, delayed, immediate, minimum and expectant (DIME). We have two: alive or KIA.”

Contrary to NATO doctrine, Ukrainian medics operate without direct communication capability. The 2025/26 Tactical Medical Support Structure makes clear that only the battalion commander is authorized, and often technologically able to transmit. Medics cannot request evacuation, coordinate patient movement, or report casualties from point of injury to the casualty collection point. Their situational awareness is shaped by silence: casualties cannot signal their injuries, and medics cannot update their movements. Russian UAS dominance, electronic warfare denial, and the targeted destruction of medical assets further restrict communication. As a result, frontline medics must physically travel to the casualty collection point multiple times per day to determine whether casualties exist, a process that itself carries lethal risk under drone surveillance and indirect fire. This requirement produces a fundamentally different casualty discovery cycle centered on the casualty collection point (CCP). In Ukrainian operations, the CCP functions not simply as a holding location for wounded personnel but as a critical node of battlefield awareness. Because forward medics cannot transmit casualty reports and units cannot reliably signal medical needs, the CCP becomes the only location where casualty status can be confirmed. Medics therefore conduct

BLUF BOX

Modern warfare is defined by persistent surveillance and communications denial, has rendered Western medical doctrine obsolete. Drawing from Ukrainian experience, it asserts that survivability no longer depends on injury severity or evacuation speed, but on maintaining a "signal" or any form of contact. Medics, unable to communicate, rely on physical checks and unmanned systems for care. The U.S. must adopt this new "signal-driven" triage logic, prioritizing persistence over proximity, to avoid systemic failure.



periodic physical checks of CCP sites throughout the day, often under conditions of drone surveillance and indirect fire risk. These inspections are not administrative; they are the primary mechanism through which the existence of wounded personnel is discovered. In effect, the CCP replaces radio reporting as the battlefield's casualty notification system.

This communications-denied environment collapses the foundations of Western predictive triage. Traditional models assume maneuverable medics, accessible casualties, and evacuation chains that, even when strained, can still be anticipated. In Ukraine, continuous detection and denied airspace have erased predictability. Movement once considered central to medical care is now an operational liability, as every

step forward increases risk of detection and attack. The established relationship between time, injury, and survivability no longer applies.

This shift has produced a doctrinal inversion. In Western practice, the “expectant” category indicates medical futility. On the Ukrainian battlefield, it often reflects temporary inaccessibility rather than hopelessness. A wounded soldier may be salvageable, but only when the battlespace allows access. Thus, the decisive variable is no longer physiology; it is connectivity.

Within this reality, battlefield telehealth has become the essential mechanism of immediate and delayed care. With medics unable to communicate or maneuver, unmanned systems frequently serve as the only method of extending medical capability. Telehealth is no longer defined by advanced devices or digital networks. It is defined by low-signature, asynchronous delivery of medical instruction and sustainment under threat of detection.

A 2023 case illustrates the paradigm. A Ukrainian soldier isolated in contested terrain was discovered by drone. Electronic communication was unsafe, so the drone delivered water, medical supplies, and handwritten instructions. He survived for days until recovery was possible. This was battlefield telehealth reduced to its most survivable form: care without presence and communication without emission, preserving life through the thinnest thread of contact.

From this environment emerges a distinct Operational Behavior

“[Telehealth] is defined by low-signature, asynchronous delivery of medical instruction and sustainment under threat of detection”

Pattern (OBP), the observable behavior of forces under stress when communications, evacuation timelines, and casualty reporting mechanisms are degraded or absent. In Ukraine, the lack of medic-to-medic and medic-to-unit communications produces a pattern far removed from Western assumptions. Casualty discovery therefore becomes episodic, shaped by the inspection cycles of casualty collection points rather than continuous casualty reporting. Unmanned systems become persistent medical presence. Recovery efforts continue if a soldier is believed to be alive, even when classical triage models withdraw resources. Mortality prediction, a conservation tool in Western systems, becomes a liability when communication, not physiology, determines death.

The resulting triage logic is signal-driven rather than injury-driven. Medical effort persists as long as some form of connection persists, direct, indirect, analog, or unmanned. When connectivity fails, survivability collapses, even when injuries are theoretically survivable. Loss of signal becomes a clinical inflection point preceding physiological decline.

The United States has not yet absorbed the doctrinal implications of this shift. Future LSCO environments

will likely mirror Ukraine: prolonged isolation, denied evacuation windows, unmanned sustainment, irregular casualty discovery, and medical timelines far exceeding current operational planning. Evacuation may occur only during brief periods of reduced aerial threat. Direct human presence may be intermittent at best. Medical continuity will depend heavily on unmanned systems and low-signature communication pathways.

If U.S. doctrine remains anchored to mobility-based triage logic, predictable evacuation assumptions, and algorithmic survivability models developed for maneuver-centric battlefields, operational abandonment will occur, not through intent, but through systemic design. Ukraine’s experience presents a critical recognition: survivability in modern war is governed by persistence, not proximity; by connection, not classification. A doctrine that fails to internalize this will fail the wounded long before it fails the adversary.



Select the Attachments Icon in Acrobat  to Open the Vignette

Tactical Communication Survivability in the Hyper-Lethal Battlespace

By CPT Josiah Turner, U.S. Army, Former SAG-U J6 Planner

INTRODUCTION

The conflict in Ukraine demonstrates a new warfare paradigm defined by ubiquitous sensors and a compressed enemy kill chain, which can prosecute targets in as little as three minutes from detection. In this environment, communication equipment is a critical liability. The monthly loss of over 3,000 Motorola radios and 300 Starlink terminals in Ukraine is a metric of this vulnerability. This paper translates tactical observations from the Armed Forces of Ukraine into a framework for U.S. Military and NATO units. Survival and mission success require a shift from legacy concepts to a model built on tactical discipline, signature management, and decentralized innovation. Tactical elements must operate at a high tempo to master sensory evasion and rapid adaptation. This document provides actionable recommendations to implement these changes, transforming formations from targets into survivable, decisive assets.

“Static sites, large elements, and cumbersome communication kits are liabilities near the FLOT”

VIGNETTE: The Battalion TOC

A battalion Tactical Operations Center (TOC) is operating in the field. To save time, a signal team runs a 100-meter MILSAT cable across an open field. At dawn, a Russian Orlan-10 drone’s automated imagery analysis flags the unnatural dark, and straight line. The drone follows it to the TOC and passes the coordinates. A Lancet drone strikes the generators seven minutes later. A second Lancet hits the command post thirty seconds after, eliminating the battalion command element in under ten minutes. The kill chain was initiated not by RF intercept, but by cabling complacency. This illustrates that for this signal asset, the distinction between communicator and target has been eliminated. In a software-defined conflict, where innovation and speed determine outcomes, the central task for tactical units is ensuring survivability to maintain relevance.

BLUF BOX

In a modern, hyper-lethal battlespace, communication gear is a critical liability. Survival demands a new paradigm focused on extreme tactical discipline, rigorous signature management, strict emission control, and decentralized mission command. The U.S. military must implement organizational changes that foster bottom-up innovation and diversify technologies to enhance resilience. Soldiers must evolve into "sensory evaders" to survive in an environment where detection means destruction.



THE NEW BATTLEFIELD PARADIGM

COMMUNICATION EQUIPMENT AS A LIABILITY

The battlespace is saturated with low-cost, disposable, and rapidly deployable sensors. This reality has collapsed the enemy kill chain to between three and fifteen minutes. Static sites, large elements, and cumbersome communication kits are liabilities near the forward line of troops (FLOT). Every piece of equipment that emits heat or RF, every cable laid, and every footprint left creates a point of failure for the mission. High equipment losses in Ukraine confirm this. To remain effective, units must provide a multi-faceted PACE plan composed of interconnected military and Commercial-Off-The-Shelf (COTS) solutions that are small, agile, quick

to deploy, and employ Low Probability of Intercept/Low Probability of Detection (LPD/LPI) characteristics.

TACTICAL IMPERATIVES: THE HUMAN ELEMENT

The operator's discipline determines the effectiveness of the equipment. Survival requires mastery of fieldcraft, signature management, and emission control.

Physical Signature Management

Survivability begins with disciplined site selection. Low Earth Orbit (LEO) and Middle Earth Orbit (MEO) satellite constellations are reliable, but their terminals are primary targets. Terminals must be positioned 80-100 meters from the command post. Standard 30-meter commercial cables are insufficient, forcing Ukrainian operators to construct custom-length cables. This must be a core soldier skill. All cables must then be buried or camouflaged. Antennas will not be placed on command posts, vehicles, or prominent terrain. Terminals must be concealed within the environment (e.g., in trash piles, vegetation, or structures) to break up their shape. Furthermore, adversaries use thermal emissions to locate terminals. Thermal covers, which reduce heat signatures while allowing traffic to flow, must be standard issue, along with varied camouflage covers for

“enemy drones hunt for "patterns of life" such as footprints, trash, and signs of maintenance. All personnel must minimize these signatures.”

“Survival requires mastery of fieldcraft, signature management, and emission control.”

woodland, desert, urban, and snow environments.

Emission Control (EMCON) and Fieldcraft

Strict EMCON is mandatory. Non-essential communications must be powered off. During movement, units must operate with radios in receive-only mode or powered off. The use of concise burst transmissions reduces the probability of detection. This discipline extends beyond the electromagnetic spectrum; enemy drones hunt for "patterns of life" such as footprints, trash, and signs of maintenance. All personnel must minimize these signatures.

Mission Command as a Force Multiplier

This level of discipline is enabled by Mission Command. Commanders must communicate their intent with enough clarity to preclude the need for clarifying radio traffic. This empowers junior leaders to exercise disciplined initiative and make decisions that accomplish the mission without creating electromagnetic or physical signatures. Trust, built on competency and character, is the

foundation of this command philosophy.

ORGANIZATIONAL ADAPTATION: FOSTERING SPEED AND INNOVATION

The innovation cycle in Ukraine is approximately forty to eighty days, where one side's tactical or technological adjustment forces the other to counter at speed. The U.S. Army processes must be evaluated and adapted to ensure they can match this tempo.

Empowering Bottom-Up Solutions

The Army cannot wait for formal defense innovation channels to solve problems that soldiers have already addressed at the unit level. Ukrainian success derives partly from a decentralized system that provides battalions with funds (e.g. 100,000 Euros annually) for innovation, experimentation, and local vendor agreements. This approach bypasses standard procurement timelines.

Creative Application of Technology

Drones must be incorporated into signal kits for site reconnaissance, communications relays, and establishing mobile mesh networks. Dependencies must be diversified by using a variety of commercial SATCOM and radio vendors across different bands and orbital planes to complicate enemy targeting. The Army must also invest in hardened cellular capabilities and decoy emitters that replicate thermal

and RF signatures, forcing the enemy to expend resources on false targets.

RECOMMENDATIONS

1. **Revise TTPs for Signature Reduction.** Mandate 80–100-meter standoff distances for all terminals. Make thermal covers and multi-environment camouflage standard issue. Enforce the burying or concealment of all cables as a non-negotiable task.
2. **Master Core Fieldcraft Skills.** Train all signal soldiers to be proficient in fabricating extended cables in all conditions. Drill rapid site setup, teardown, and displacement.
3. **Restructure for Agile Operations.** Organize around small, four-to-six-person multi-skilled teams. Empower these teams to operate with minimal oversight and configure all PACE systems.

4. **Fund and Foster Decentralized Innovation.** Provide company commanders with a discretionary budget for COTS experimentation. Establish a process to capture, validate, and scale innovations from the lowest echelons.
5. **Diversify the Communications Portfolio.** Identify, test, and integrate a variety of commercial SATCOM, radio, and hardened cellular technologies. Avoid dependence on a single vendor, band, or constellation.
6. **Embrace Deception and Unmanned Systems.** Invest in and deploy decoy emitters that replicate the signatures of real terminals. Integrate small drones into signal kits for reconnaissance, relay, and network extension.

The lessons from Ukraine are an immediate directive for change. Our equipment is a liability. Every watt of power, degree of heat, and straight line is a beacon for an enemy with a

kill chain measured in minutes. Soldiers and Signalers must evolve from technicians into sensory evaders. This requires an organizational culture that operates at a high tempo, where the 80% solution is embraced and improved. It demands unwavering discipline in fieldcraft and strict adherence to emission control, underwritten by a command climate where competency and character foster the trust required for Mission Command. The principles of maneuver, surprise, and security must now be applied to a transparent, lethal battlespace. The relevance of modern military operations depends on it.

About the Author:

Captain Josiah Turner is a Signal Corps Officer in the US Army. He served as the SAG-U J69 Advice/Assist.



Vignette: Rocket Artillery Life on the Front

By Lt Volodymyr H., Armed Force Ukraine
CPT Patrick Visser, U.S. Army, SAG-U

The attached vignette is based off the combat experiences of Lt Volodymyr H. and his time as a Multiple Launch Rocket System (MLRS) platoon leader. He discusses and shows examples of how his unit constructed hide sites, the battlefield geometry of their employment, security positions, and actions on contact. In-depth discussion and pictures are given to how to build, camouflage, and maintain living areas along the front.

Given that prolonged field conditions are an almost certainty for any contingency operation for the 2nd Cavalry Regiment (2CR), it is crucial to plan for long-term sustainability.

Whether a conflict results in a decisive victory, requiring the unit to remain on the frontline during stabilization, or settles into a protracted stalemate like the one in Ukraine, 2CR must be prepared to live and operate within the enemy's engagement zone for months or even years. Surge-level intensity is not sustainable indefinitely; maximizing soldiers' quality of life becomes a military imperative. It directly affects the unit's morale, endurance, health, and readiness. Thus, it is vital to recognize the operational shift from mobile to positional warfare and to have a deliberate plan ready to maximize protection and maintain

“Surge-level intensity is not sustainable indefinitely”



Figure 1. LT Volodymyr H. constructing a dugout

BLUF BOX

Drawing from a Ukrainian officer's experience in building sustainable frontline positions, the article and attached vignette argues that U.S. Army rocket artillery must develop their own organic capabilities to ensure readiness and long term force endurance during large scale combat operations..



readiness under those static and enduring conditions.

To enhance long-term unit health and readiness during extended deployments, it is recommended that 2CR, and other units, develop robust and self-sufficient construction capabilities. Units need to acquire essential equipment like chainsaws, portable stoves, battery banks for low-signature power, and various construction materials. Units must identify soldiers with DIY and construction talents and have them practice building all-season hide sites and shelters. Developing these unit-level skills is crucial and will enable the force to construct its own hide sites, shelters, security positions, command posts, sanitation facilities, and mess areas primarily using its own resources. Doing this will create an environment that can sustain the unit at the front.



Select the Attachments Icon in
Acrobat  to Open the Vignette

Development, Capabilities, and Implications for U.S. Defense Acquisition within the DOTMLPF-P Framework

A Comparative Analysis of the Ukrainian FP-5 Flamingo Missile and the U.S. BGM-109 Tomahawk

By COL Joseph (JJ) Serowik, U.S. Army, CALL

Executive Summary

This paper is geared towards those within the Army Acquisition Workforce (AAW) and for those who ultimately make the decisions about what systems to acquire for the United States Army. This comparative analysis examines the Ukrainian FP-5 Flamingo missile and the U.S. BGM-109 Tomahawk, focusing on their development, capabilities, and the implications for U.S. defense acquisition strategies within the DOTMLPF-P framework. The FP-5, a product of Ukraine's innovative wartime ecosystem, showcases rapid development and low-cost production, while the Tomahawk represents decades of meticulous design and integration. By assessing their development timelines, manufacturing costs, payload and range capabilities, and the distinct industrial models that produced each system, the paper highlights key lessons the U.S. defense industrial base can learn from Ukraine's approach. The findings suggest that integrating these lessons into the U.S. Army's acquisition processes could enhance agility and responsiveness in developing future capabilities.

“Our arms must be mighty, ready for instant action, so that no potential aggressor may be tempted to risk his own destruction”

-President Dwight D. Eisenhower's Farwell Address (1961)



FP-5 Flamingo



Tomahawk

Development Timeline: 2 yrs (2023-2025)	Development Timeline: 11 yrs (1972-1983)
Per missile cost: \$500K-\$1M	Per missile cost: \$1.8M-2.4M
Payload: 1000-1150kg	Payload: 300-700 kg
Range: 3,000 km	Range: 1,666 km

(U) Figure 1: Comparison

Observation

Ukraine's wartime defense innovation ecosystem has produced several low-cost, high-performance long-range strike systems, among them the FP-5 Flamingo. In contrast, the U.S. Tomahawk missile represents a mature, meticulously developed system with a decades-long acquisition lineage. This

comparison illuminates divergent approaches to missile development—one optimized for speed and battlefield feedback, the other for reliability, certification, and long-term sustainment. Understanding these differences provides insight into how the U.S. defense establishment might accelerate acquisition processes while preserving safety and interoperability.

BLUF BOX

The contrasts of the Ukrainian FP-5 Flamingo with the U.S. BGM-109 Tomahawk missiles advocates the need for reform in U.S. defense acquisition. Ukraine's agile, commercially driven ecosystem rapidly produces effective, low-cost systems like the Flamingo. While the U.S. relies on slow, expensive legacy processes. The U.S. must integrate these lessons, using the DOTMLPF-P framework to foster a "good enough" approach that prioritizes speed and iterative design. This shift is crucial for enhancing responsiveness and maintaining a strategic advantage against adversaries in future conflicts.



Discussion

Development Timelines

FP-5 Flamingo

The FP-5 Flamingo, developed by the Ukrainian private firm Fire Point, emerged from the country's rapid wartime innovation cycle. Public reporting indicates development between 2023 and 2025, with the system entering serial production in 2025.¹ This compressed timeline reflects Ukraine's reliance on commercial engineering talent, iterative prototyping, and streamlined

era demands for precision, survivability, and long-term sustainment.

Manufacturing Cost Comparison

FP-5 Flamingo

Reports from Ukrainian officials, Fire Point statements, and independent analyses place the per-unit cost of the Flamingo at approximately US\$500,000 to US\$1 million.³ The low-cost results from commercial components, modular design, and dispersed production.

The FP-5 Flamingo was

requirements, and strict certification standards.

The newest variant of the Tomahawk (Block V) is produced solely by Raytheon, the business unit of RTX Corporation, major defense contractor with 2024 sale revenues of \$21.6 billion.⁶

Payload and Range Comparison

As seen in Figure 1, based on the payload and range comparison of these two systems, the FP-5 Flamingo thus exceeds the Tomahawk in both warhead mass and advertised range,



procurement mechanisms.

BGM-109 Tomahawk

The Tomahawk's development began in 1972, with the first operational deployment occurring in 1983, a roughly eleven-year development cycle.² This period included extensive testing, integration with naval launch systems, and refinement of complex guidance technologies such as Terrain Contour Matching (TERCOM) and Digital Scene Matching Area Correlator (DSMAC.) The Tomahawk's developmental arc reflects Cold War-

developed and build by Fire Point, a Ukrainian defense startup founded by a group of friends from non-military backgrounds—including construction, game design, and architecture.⁴

Tomahawk

Unit costs for Tomahawk Block IV and V variants range from US\$1.8 million to over US\$2.4 million depending on fiscal year and configuration.⁵ These costs incorporate advanced guidance systems, Navy integration

though it may lack some of the Tomahawk's advanced survivability and guidance features.

Key Factors Enabling Ukraine's Rapid Production

Analysts from RAND, CSIS, and other institutions highlight several enablers behind Ukraine's accelerated missile development:

1. Commercial-Led Innovation — Private firms lead R&D, using consumer-grade components where acceptable.⁷

2. Rapid Iteration Based on Battlefield Feedback — Prototypes are field-tested and refined in months, not years.
3. Distributed Manufacturing — Production is dispersed across small workshops and civilian suppliers to ensure scalability and resilience.
4. Flexible Funding and Procurement — Crowdfunding, flexible contracting, and lower bureaucratic barriers accelerate acquisition.⁸

These conditions, though forged in wartime necessity, provide insight into how the United States might accelerate certain acquisition pathways.

Lessons for the U.S. Defense Industry

The U.S. defense ecosystem traditionally prioritizes reliability, interoperability, and life-cycle sustainability, often at the expense of agility. Lessons from Ukraine include:

1. Expanded use of commercial off-the-shelf components for non-critical subsystems.
2. Shortened prototyping cycles through field experimentation and iterative design.

“These conditions—though forged in wartime necessity—provide insight into how the United States might accelerate certain acquisition pathways”

3. Greater reliance on small, innovative firms to supplement traditional prime contractors.
4. Risk-tolerant acquisition pathways for certain categories of weapons during urgent operational needs.

Although the above lessons from Ukraine cannot fully replace traditional acquisition processes for strategic systems, they can accelerate development of selected capabilities.

Integrating Ukrainian Lessons into the DOTMLPF-P Framework

Organization

Our military-industrial complex must adapt to the changing environment. The days of lengthy R&D development (sometimes taking years or decades) for the perfect 100% solution—which in turn increases the cost of the weapon system and results in over-complex systems—cannot be sustained. A low-cost, rapidly produced system that achieves “good enough” performance is what we need to strive for, especially since U.S. industry is lagging our adversaries. Establish hybrid organizations combining operators, engineers, and program managers to enable continuous feedback loops.

Training

Train units to integrate rapidly developed systems and perform basic acceptance testing and sustainment tasks.

Material

As stated under Organization, the development and procurement of further weapons systems should focus on rapid R&D, along with lower production costs, and, if possible, interoperability and parts exchange among the systems. The FP-5 should be used as a case study for how to produce a similar weapon system cheaply and with less R&D. One way would be to promote open-architecture designs, modular components, and smaller production lots that allow rapid scaling.

Leadership & Education

Educate senior leaders on risk-balanced acquisition strategies modeled on Ukrainian practices.

Personnel

Recruit engineers and technologists into rapid-fielding task forces and create surge contractor pools.

Policy

DOW-wide policies must be adapted to address the increasing technology gap being observed in Ukraine, China, and even Iran, as well as the acquisition of weapon systems. It is known that our Achilles' heel is the acquisition process. Strides are being made to shorten timelines and allow for broader adaptation of equipment, but this is not happening quickly enough.

Recommendation

The comparative analysis of the FP-5 Flamingo and the BGM-109 Tomahawk underscores the stark differences in missile development approaches between Ukraine and the United States. The FP-5 Flamingo demonstrates how a wartime, commercially driven defense ecosystem can rapidly produce

advanced, cost-effective long-range precision weapons, leveraging innovation, flexibility, and a decentralized production model. In contrast, the Tomahawk epitomizes a legacy of rigorous engineering, extensive testing, and long-term sustainment strategies developed over decades.

The lessons learned from Ukraine's rapid development cycle are invaluable for the U.S. defense establishment, particularly in addressing the challenges posed by China's growing military capabilities in the Indo-Pacific region. By adopting practices that emphasize agility—such as utilizing commercial off-the-shelf components, shortening prototyping timelines, and fostering collaboration with smaller firms—the U.S. can enhance its responsiveness to emerging threats in a dynamic and contested environment.

Integrating these insights into the DOTMLPF-P framework will enable the U.S. Army and the broader Department of Defense to refine their acquisition processes, ensuring they remain effective and relevant in the face of evolving operational demands. This approach is critical for developing a robust, adaptable military posture capable of countering China's assertiveness in the Indo-Pacific, where rapid response and precision strike capabilities are essential for deterrence and operational success.

Ultimately, by balancing the need for speed and innovation with the critical standards of reliability and interoperability, the U.S. defense industrial base can better prepare for the complexities of future Large Scale Combat Operations (LSCO). This readiness is vital not only for addressing the immediate challenges for INDOPACOM but also for maintaining a strategic advantage in an increasingly competitive global landscape.



USS Thomas Hudner (DDG 116) fires a Tomahawk land attack missile in support of Operation Epic Fury, Mar. 1, 2026

Shades of Commercial Shipping

By CAPT Lee Dortzbach, US Navy, SAG-U Deputy J3

Transporting bulk petroleum is most cost effective on land through pipelines and by sea utilizing tankers and barges. Like cars, ships need to be registered, inspected, insured, and used for legal purposes. The Paris and Tokyo Memoranda of Understanding (MoU) on Port State Control plays a fundamental role in maritime safety, security, and environmental stewardship. Ship owners and operators can be summarized into three categories:

- **White Shipping:** Represents flag states and ships with the highest standards of safety and regulatory compliance. Ships flying these flags are considered low-risk vessels and are subject to fewer inspections by port authorities.
- **Grey or “Shadow” Fleet:** Indicates an intermediate level of compliance. Ships under these flags have a moderate risk profile and are subject to more frequent inspections compared to white-flagged vessels.
- **Black or “Dark” Fleet:** Assigned to flag states or ships with poor safety records and low regulatory compliance. These ships are considered high-risk and are subject to the highest frequency of inspections and scrutiny by port authorities.

When U.S., E.U. and G7 established sanctions and set Russian oil price caps to reduce Russian

revenue, many white shipping companies chose not to accept this cargo. The group of 12 maritime Protection and Indemnity (P&I) Clubs who ensure commercial ships would either deny or raise the insurance rates for these ships.

Market forces increased the number of grey and black fleet vessels transporting Russian oil, some for higher than the price cap and earning individual sanctions on the vessel. As of February 6, 2026, the E.U. sanctioned 597 vessels and the U.S.



Bahamian-flagged oil tanker Andromeda seen from an MH-65 Dolphin Helicopter

BLUF BOX

In response to the Russian invasion of Ukraine, the U.S., E.U., and the G7 implemented sanctions and an oil price cap to reduce Russian revenue. This action prompted an increase in the use of "grey" and "black" fleet vessels by Russia, which have lower safety and compliance standards. These sanctions, combined with asset freezes, have had significant economic and diplomatic repercussions for Russia.



Office of Foreign Asset Control showed 451 sanctioned vessels for Russian violations, up from 183 in January 2025.

Fourteen shadow fleet vessels sailing with improper registration, to skirt sanctions, were seized, detained or boarded by U.S., Indian and European Union authorities since December 2025. These efforts have both economic and diplomatic implications for Russia.

Following the February 2022 Russian invasion of Ukraine, Russia received sanctions on oil exports, a

“Fourteen shadow fleet vessels sailing with improper registration, to skirt sanctions, were seized, detained or boarded by U.S., Indian and European Union authorities since December 2025.”

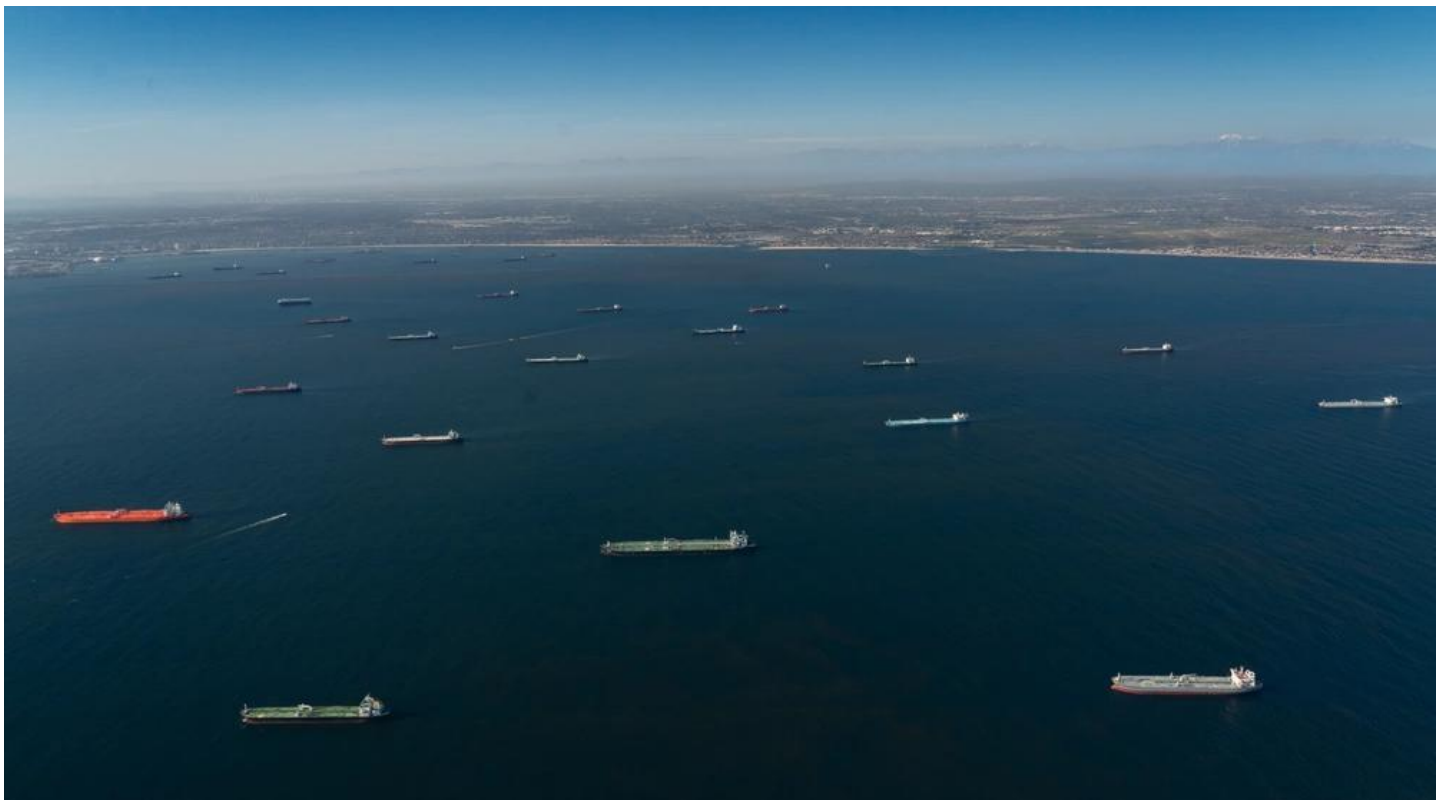


significant source of revenue for their economy. Sanctions are a diplomatic and political tool for an economic effect, restricting access to capital markets. There are four ways U.S., E.U. and G7 nations seek to financially deprive Russia:

- **Asset Freezing:** Roughly **\$285 billion** in Russian Central Bank foreign currency reserves remain immobilized within G7 and EU jurisdictions.
- **Revenue Curtailment:** Sanctions have denied Russia access to an

estimated **\$450 billion** since February 2022.

- **Sectoral Bans:** Broad bans on technology, dual-use goods, and luxury items aim to cripple Russia's industrial base.
- **Oil Price Cap:** The G7 and EU use an [Oil Price Cap mechanism](#) to limit Russian energy income while keeping global markets stable.
 - In February 2026, the cap was lowered to **\$44.10 per barrel**.
 - While the U.S. temporarily waived some oil sanctions in March 2026 to stabilize surging prices, the EU and UK have pushed for [stricter enforcement](#).



Oil tankers at anchor

The Fight for Power: The Strategic Significance of the Zaporizhzhia Nuclear Power Plant

By: Mr. Jacob Ellis, U.S. Army & MAJ Kristin Onofrio, USMC

The Zaporizhzhia Nuclear Power Plant (ZNPP) stands as one of the most strategically significant energy assets in the ongoing war in Ukraine. Located near the city of Enerhodar in southeastern Ukraine, along the Dnipro River, it is the largest nuclear power plant in Europe and one of the largest globally. The power plant houses six advanced reactors, each capable of producing approximately 1,000 megawatts of electricity. Before Russia's full-scale invasion in 2022, ZNPP played a vital role in Ukraine's energy supply,

generating about 20% of the country's electricity. As one of the most nuclear-dependent countries in the world, ZNPP was a cornerstone of Ukraine's energy grid and economy, providing strategic stability and resilience in times of need.

Ukraine's reliance on nuclear energy dates back to the Soviet era, when large nuclear power plants were built to support heavy industry, urban centers, and strategic facilities. During this time, Ukraine was a highly industrialized region,

“ZNPP played a vital role in Ukraine's energy supply, generating about 20% of the country's electricity”

BLUF BOX

The Zaporizhzhia Nuclear Power Plant, Europe's largest, was a cornerstone of Ukraine's energy grid, providing 20% of its electricity. Its unprecedented capture by Russia in 2022 transformed it into a "strategic hostage," giving Moscow significant military and political leverage over regional energy security. For Ukraine, the loss is a severe blow to its economy, post-war recovery plans, and national sovereignty, symbolizing an attack on its post-Chornobyl progress and energy self-sufficiency.



integrated into the Soviet Union's unified power system. Major nuclear plants like Zaporizhzhia, Rivne, South Ukraine, Khmelnytskyi, and Chornobyl were constructed to provide reliable, continuous electricity for the growing energy demands of the time.



When the Soviet Union dissolved in 1991, Ukraine inherited this extensive nuclear fleet but faced new challenges as an independent state. With limited domestic fossil fuel resources, especially natural gas, and high demand for heating, industry, and power generation,

to work under heavy pressure and in conditions that the International Atomic Energy Agency (IAEA) described as unsafe and unsustainable. This situation has raised significant concerns about the safety and security of the plant amidst the ongoing conflict.

affordable energy for Ukraine, especially during peak demand periods.

“Never before had a large, operational nuclear power plant been captured by invading forces during active combat”

Ukraine became heavily reliant on gas imports from Russia. This dependency gave Moscow significant leverage through pricing and supply control. Nuclear energy, on the other hand, offered a critical advantage, it provided domestically operated, reliable electricity that did not depend on daily fuel deliveries through pipelines, helping Ukraine maintain energy independence in the face of external pressures.

The war in Ukraine drastically changed the situation at ZNPP. In early March 2022, Russian forces advanced into the Zaporizhzhia region and illegally occupied the plant after intense fighting near its perimeter. This marked an unprecedented event in history-never before had a large, operational nuclear power plant been captured by invading forces during active combat.

Following the takeover, both the city of Enerhodar and the plant came under Russian military occupation. Despite this, Ukrainian staff remained at the plant to continue operating the reactors. However, they were forced

In an effort to mitigate the risk of a serious accident amid ongoing instability, the plant’s reactors were gradually taken offline and placed into either a cold or hot shutdown. As of late 2025-2026, all units remained non-operational. However, the shutdown of ZNPP is far more than just the loss of energy generation, it has fundamentally disrupted the flow of power across Ukraine’s energy grid. Other power plants must now step in to compensate for the lost generation, often at a higher cost and with less efficient technical performance.

During the winter months, when heating demand is high and hydroelectric output is typically low, the absence of ZNPP’s reliable energy supply significantly raises the risk of power shortages and rolling blackouts. Replacing this lost capacity with other sources, such as gas-fired or coal-fired plants, is not a quick fix. It requires years of planning, construction, and substantial investment. This disruption highlights the critical role ZNPP played in ensuring stable and

Controlling ZNPP provides Russia with significant military and political advantages. First, the plant serves as a form of strategic leverage. Any serious damage to the plants containment or cooling systems could result in a dangerous release of radiation, which would not be confined to Ukraine’s borders. Depending on weather patterns, radioactive contamination could spread to Russia, neighboring countries, and even the broader Black Sea and European regions. This positions the power plant as a “strategic hostage” with all parties (including Russia) having strong reasons to avoid a catastrophic incident.

Second, if Russia succeeds in fully integrating ZNPP into its occupied territories and connecting it to the Russian power grid, the plant could supply electricity to the occupied regions of Ukraine and possibly to Russia proper. This would allow Moscow to power local economies, industries, and households in those areas, further deepening their economic influence, and creating a long-term strategic advantage.

“The power plant provided massive amounts of domestically controlled electricity, stabilized the high-voltage grid, and played a key role in Ukraine’s efforts to reduce dependence on Russian energy”

For Ukraine, the importance of ZNPP cannot be overstated. If Russia were to permanently take control of the plant, Ukraine would lose 6,000 megawatts of energy generation, which historically provided about 20% of the country’s electricity. ZNPP has also been a critical stabilizing anchor for Ukraine’s high-voltage power grid.

As Ukraine looks toward postwar recovery, the country will require large volumes of reliable and substantial power to rebuild damaged infrastructure, revive industries, and support economic growth. Nuclear power is a key part of Ukraine’s future energy plans because it provides a low-carbon profile and reduces the country’s reliance on imported fossil fuels, which are subject to price fluctuations and geopolitical risks, and ultimately undermining Ukraine’s energy sovereignty.

ZNPP holds profound historical and emotional significance for Ukraine, symbolizing the country’s progress in overcoming the legacy of the 1986 Chernobyl disaster, which occurred under Soviet rule. Following independence, Ukraine made significant strides in building a strong nuclear regulatory framework,

improving safety standards, and fostering international cooperation. As the largest and most productive nuclear plant in the country, ZNPP became a powerful emblem of Ukraine’s commitment to safe and independent energy management. However, the power plant’s forced occupation by Russia, the sidelining of Ukrainian regulators, and the coercion of Ukrainian staff are viewed as not only the physical seizure of critical infrastructure but also an attack on decades of progress in asserting Ukraine’s sovereignty and dedication to global safety standards.

Although the reactors at ZNPP remain shut down, the political and military battle over its control continues. Ukraine firmly rejects Russia’s claimed annexation of the plant and the surrounding territory, maintaining that ZNPP is a Ukrainian facility that must operate under the authority of Energoatom and the State Nuclear Regulatory Inspectorate of Ukraine. Ukraine remains firmly committed to upholding international safety standards and ensuring oversight by the IAEA.

By asserting its legal and political claims over the plant, Ukraine keeps the option open for

future rehabilitation and reintegration into the Ukrainian and European power systems. However, if Russia were to solidify its control over the plant, connect it to the Russian power grid, and relicense it under Russian regulatory institutions, ZNPP could become a long-term tool for Russia’s energy dominance and influence in the region for decades to come. The plant’s future remains a critical issue in the broader conflict and Ukraine’s fight for sovereignty.

ZNPP is far more than just a technical facility, it is a critical strategic cornerstone for Ukraine. Before its shutdown, the power plant provided massive amounts of domestically controlled electricity, stabilized the high-voltage grid, and played a key role in Ukraine’s efforts to reduce dependence on Russian energy. Beyond its practical importance, ZNPP also holds symbolic value as a testament to Ukraine’s competence and sovereignty, especially in the wake of Soviet mismanagement and the Chernobyl disaster.

ZNPP’s sheer size, strategic location, and integration into both Ukrainian and now European energy systems makes it incredibly difficult to replace in the short or medium term. This combination of technical, economic, and political significance explains why ZNPP remains one of the most sensitive and closely monitored sites in the ongoing war. Its future status will have a lasting impact on Ukraine’s energy security and strategic position, shaping the country’s recovery and independence long after the fighting ends.

SAG-U & NSATU Published Articles

Members of SAG-U and NSATU have written and published the following articles while serving in their organization. If you would like to publish in an academic journal, please contact a member of the SAG-U J37.

“This Century’s Billy Mitchell Moment.”

CAPT Dan Breeden, USNI,
Oct 2025.

CAPT Breeden argues that with the rise of drones the US Navy is facing a "Billy Mitchell moment", like a century ago when aircraft rendered battleships vulnerable. He highlights that modern naval vessels are ill-equipped for defending against massed attacks from cheap drones. He suggests that to counter this threat the US Navy needs to invest in short-term solutions, such as adding guns, developing laser weapons, and enhancing EW. However, his long-term solution is a strategic shift to integrating a large, networked armada of unmanned, autonomous systems into the naval forces. This will allow the US Navy to maintain maritime superiority while reducing the risks to human crews. [LINK](#).

“From Front Lines to Factory to Factory.”

1LT Kai Youngren, MWI, 28
Oct 25.

1LT Youngren argues that the rapid, dynamic evolution of unmanned and counter-unmanned

systems, as seen in Ukraine, has rendered the traditional US defense acquisition process dangerously slow and inflexible. To address this, he proposes that the U.S. Army adopt a model inspired by Ukraine’s success: embedding small, collaborative "workshop cells" of industry engineers and military experts directly within frontline units and training centers. This approach would create a real-time feedback loop, allowing for the rapid iteration and adaptation of low-cost, modular systems based on immediate operator input, thereby bypassing bureaucratic hurdles. [LINK](#).

“Guns and Ammo”

MAJ Eric Johnson, MWI, 07
Nov 26.

The war in Ukraine has shown that while NATO's 155-millimeter artillery ammunition is generally compatible and safe to fire from various howitzers, it lacks true interoperability. Genuine interoperability is not just about physical compatibility, but the ability to achieve accurate first-round effects, a capability that has been proven difficult as Ukrainian forces struggle to pair dozens of different shell and propellant types with seventeen different howitzer models. The lack of shared, predictive firing data for these mixed combinations leads to inaccuracy, increased ammunition consumption, and safety risks. The author contends that for NATO to be truly prepared, it must move beyond basic compatibility and actively develop comprehensive

firing tables and further standardize the ballistic characteristics of its ammunition. [LINK](#).

“The Ukrainian Underground”

COL Joseph (J.J.) Serowik,
U.S. Army, CALL, Aug 25.

Drawing lessons from the conflict in Ukraine, where the vulnerability of traditional medical infrastructure has been starkly exposed, a new model of battlefield medicine has emerged. Ukraine has successfully adapted by creating a decentralized network of underground medical facilities and "stabilization points" near the front lines, which provide advanced Role 2 care and focus on prolonged field care due to the constant threat drones pose to medical evacuations. This author strongly recommends that the U.S. Army Medical Command (MEDCOM) adopts a similar strategy by prioritizing dispersed and hardened medical facilities, investing in advanced patient stability training for medics, and streamlining acquisition processes through collaboration with private industry. This will increase survivability and ensure that medical sustainment is better prepared for future large-scale combat operations. [LINK](#).

“The Role of Tranexamic Acid”

COL Joseph (J.J.) Serowik,
U.S. Army, CALL, Jun 25.

COL Serowick strongly advocates that MEDCOM implements the widespread use of tranexamic acid (TXA) across all levels of military medical care to

significantly reduce trauma-related mortality. He draws on convincing evidence from both major civilian and military studies, and from the conflict in Ukraine where TXA has been associated with a 33% reduction in deaths from hemorrhage. The paper highlights that TXA is a cost-effective intervention, costing approximately \$30 per dose. Given that hemorrhage is the most common cause of preventable death in trauma and considering the likelihood of prolonged pre-hospital care in LSCO, the paper recommends that MEDCOM prioritize TXA implementation. He further recommends a collaboration with international partners to develop a TXA auto-injector so the drug can be administered rapidly to enhance battlefield survivability. [LINK](#).

“Forging the Future of US Army Military Engineering”

LTC Brittany Riebold, CALL,
Mar 26.

Based on lessons learned from the war in Ukraine it is evident that US Army Engineers must proactively adapt to the realities of LSCO to enhance its survivability and lethality. The conflict serves as a crucial case study, underscoring the transformative impact of new technologies like the widespread use of drones, complex obstacle systems, and the resurgence of subterranean warfare. All of this demands a fundamental re-evaluation of current Engineer doctrine, training, and technological investment. To maintain relevance, Engineers must prioritize research in autonomous systems, subterranean warfare, and

counter-drone technologies while accelerating development cycles to rapidly adapt equipment for the field.

“Employment of Multi-Domian Effects in the Russia-Ukraine War and Implications for the Indo-Pacific”

MAJ David Seers, SAG-U
White Paper, Mar 26.

The Russia-Ukraine War models the modern battlefield's evolution into a war of attrition. A lethal "kill zone," created by pervasive drone surveillance and precision fires, has neutralized massed armor and infantry. Consequently, forces have adopted decentralized, survival-based tactics like small-team infiltration. Unmanned systems, and electronic warfare are now decisive, driving a relentless cycle of technological adaptation. As potential adversaries like China are learning from this conflict, allied forces must urgently re-evaluate doctrine, training, and procurement to enhance sovereign capabilities and prepare for decentralized combat in a contested environment.

“Warfare Dominance Through Rapid Innovation”

CPT Josiah Turner, SAG-U
White Paper, Mar 26.

The Ukraine conflict demonstrates that the speed of technological adaptation is a decisive component of modern warfare. This paper contrasts Ukraine's agile, battlefield-driven innovation model

with the slow, bureaucratic systems of the U.S. and the complex, multi-national approach of NATO. U.S. shortcomings, exemplified by the stalled JADC2 program, create a lethal "valley of death." To fix this, the report recommends strategic resourcing reform, empowering tactical units with innovation cells, and creating new career paths for technical experts, all underpinned by a culture that rewards calculated risk-taking.

“Technology Without Doctrine is Not Transformation: Integrating Operational Art”

LTCOL Brendon Gledhill,
SAG-U White Paper, Mar 26.

The article argues that UAS, despite their tactical success, remains underutilized at the operational level. Historical lessons show that new technologies are only transformative when integrated into coherent doctrine, a lesson the current employment of UAS has yet to fully absorb. The paper advocates for a doctrinal shift from using UAS for attrition to employing them as instruments of manoeuvre, capable of disrupting enemy systems in depth. To achieve this, it recommends doctrinal reform, campaign-level planning, and organizational adaptation, ensuring UAS are not just tools, but catalysts of modern operational art.

Developmental Articles

“Inside the ‘kill zone.’”

Chris Campbell et al,
Financial Times, 23 Feb 26.

This brief article provides a great overview of how the latest drone developments are reshaping the front line. The article is full of infographics, images, and short videos. [LINK](#).

“Mapping the MilTech War: Eight Lessons from Ukraine’s Battlefield.”

Bohdan Kostyuk et al, French Institute of International Relations (IFRI) 12 Feb 26.

This is a report that discusses how UxS, EW, AI, and other technologies have evolved over the past four years of war. This product provides in-depth analysis for each field but also includes key lessons in bulletin form. [LINK](#).

“Lessons from the Ukraine for Defending Gulf Airspace from Shaheds.”

Dimko Zhluktenko, War on the Rocks, 11 Mar 26.

A very timely article from a member of the Ukrainian Unmanned Systems Force on how the defend against Shaheds and other one-way attack drones. The author discusses what Ukraine has done, and how these lessons can be applied to the Gulf States. [LINK](#).

“Four Years On – Ten lessons from Russia’s War in Ukraine.”

Basil Gavalas and Dr. Greg Mills, RUSI, 15 Jan 26.

This article brings forward ten strategic takeaways from the four years of full-scale Russian invasion. It places the effects of the war in a broader geopolitical context. [LINK](#).

“Is the Age of Drones Really the Age of Poor Maneuver?”

Antonio Salinas and Jason Levay, War on the Rocks, 06 Feb 26.

The authors make the case that drones may not be the transformational weapon that many claim them to be. Using historical examples, they argue that drones rose to prominence due to weakness in Russia’s ability to conduct movement and maneuver. [LINK](#).

“Modern war requires moving away from infantry warfare.”

Yuri Zoria, EuroMaidan Press, 04 Feb 26.

Along the front many of Ukraine’s soldiers are being replaced by drones. A Ukrainian commander from the Kostiantynivka front explains that 70% of the brigade’s logistics is handled by UGVs. [LINK](#).

“When Patriot Launchers Go Empty.”

Defense Express, 01 Feb 26.

The article discusses how Ukraine has used Patriot launchers to defend itself. It uses missile expenditure rates to calculate how many PAC-3 interceptors the country needs to react each month to sustain itself. [LINK](#).

“Russia has learned from Ukraine and is now winning the drone war.”

David Kirchenko, Atlantic Council, 04 Dec 25.

Russia has continued to adapt throughout the war, especially in the field of drone warfare. This is best embodied by the establishment of Rubicon, and its effect on the battlefield. [LINK](#)

“Ukraine fired its NATO trainers.”

Hans Midttun, Euromaidan Press, 31 Mar 26.

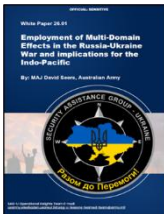
Recent NATO exercises have starkly revealed the Alliance’s unpreparedness for modern drone warfare, as small, battle-hardened Ukrainian teams repeatedly defeated larger NATO forces. Lessons are not learned when they are identified, they are only learned when you develop new concepts and implement these changes. [LINK](#).

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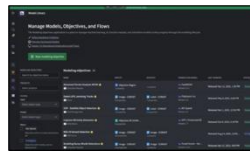
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Editors: COL James Smith (Australian Army) & Mr. Jackson Clemens

Graphic Design: Dr. Thomas Lee