EXECUTIVE SUMMARY

This report provides a frontline-based assessment of the current landscape of defense technology, drawn directly from operators, commanders, and technologists embedded in active combat zones. By focusing on real-time feedback from the field — particularly Ukraine — this report identifies which technologies are proving effective, where critical capability gaps remain, and where we would encourage future investment and innovation to be directed.

Since 2019, VC investment in defense start-ups in NATO countries has increased fourfold, rising to $3.9bn by the end of 2024. The US accounts for 83 percent of VC defense tech investment, with EU countries and the UK recording 15 percent since 2018.[1] The US Department of Defense has taken steps to access commercial technology through new acquisition and budgeting authorities: for example, increasing the prominence of the Defense Innovation Unit and establishing the Replicator initiative in 2023 to rapidly field autonomous, attritable systems.[2] NATO has formed an innovation accelerator (DIANA) to foster collaboration with start-ups and other tech companies, and has announced the €1 billion NATO Innovation Fund focused on dual-use technologies. While the overall flow of capital into defense tech has surged in recent years, it has not always aligned with operational urgency. Certain categories, such as drone platforms and ISR (intelligence, surveillance, reconnaissance) software, are oversaturated, attracting flow of capital despite diminishing returns or clear redundancy. At the same time, less glamorous but strategically vital domains — such as electronic warfare, mine clearance, anti-drone systems, secure comms, logistics, and power management — remain chronically underfunded and underdeveloped.

This reflects a broader disconnect between investor perception and frontline reality, where funding decisions are shaped by business narratives, not battlefield outcomes. This report aims to anchor investment strategy in real-world utility by highlighting which technologies are being used effectively in Ukraine, which are not, and what's urgently needed next.

1. John Thornhill, "The Conflicted Investment Case for Defence Tech," Financial Times, October 3, 2024, https://www.ft.com/content/791a26fa-fca1-4293-bf87-787bc62c9f58.
2. Jesse Klempner, Christian Rodriguez, and Dale Swartz, "A Rising Wave of Tech Disruptors: The Future of Defense Innovation?," McKinsey & Company, February 22, 2024, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/a-rising-wave-of-tech-disruptors-the-future-of-defense-innovation.

WHAT'S HAPPENING ON THE FRONTLINES?

AI ON THE BATTLEFIELD

Over the last three years since Russia's full-scale invasion, breakthroughs in defense technologies have had an outsized impact on the Ukrainian battlefield — first and foremost in the area of unmanned systems, but also within surrounding ecosystems such as systems software and counter-unmanned solutions.

This past year, multiple new technologies, as well as innovations in existing systems, have been validated under fire. AI-enhanced and autonomous features are increasingly maturing and integrating into proven systems, although the battlefield remains less "unmanned" up close than external observers may assume.

Ukraine is rapidly advancing its development of AI-powered drones, and over the past year, there's been a particular focus on machine vision, which enables drones to independently recognize and track (and ideally, subsequently hit) targets, improving precision and increasing autonomy.

In March 2024, Ukrainian developers successfully tested FPV drones with automated targeting capabilities in real combat situations. Now, more than ten companies are working to integrate machine vision into their drone systems. Mykhailo Fedorov, Ukraine's Minister of Digital Transformation, reported in November of 2024 that the first batch of 3,000 FPV drones with machine vision and target guidance technologies has already been ordered by the government, and that the next tender for 10,000 units has also been launched.[3]

Yet despite autonomous tracking being one of the most sought-after capabilities due to its capability to withstand adversary electronic warfare, real-world results are still mixed. Significant opportunities remain for solutions to disrupt the current battlefield, particularly because approximately 60-80% of Ukrainian FPV drones still fail to reach their targets, according to RUSI.[4]

3. "The First 3,000 Drones with Machine Vision for the Armed Forces of Ukraine Are Ordered; Another 10,000 Are on the Way," Defense Express, November 5, 2024, https://en.defence-ua.com/weapon_and_tech/the_first_3000_drones_with_machine_vision_for_the_armed_forces_of_ukraine_are_ordered_another_10000_are_on_the_way-12423.html.
4. Jack Watling and Nick Reynolds, Tactical Developments During the Third Year of the Russo–Ukrainian War (London: Royal United Services Institute, February 2025),

“Nowadays, Russian forces do not rely heavily on armored vehicles during assault operations,” says Michael, Commander of the Typhoon drone unit of the National Guard of Ukraine. “Instead, they primarily use small infantry teams. Even if the system is able to recognize a target in the forest, I’m not sure it will be able to navigate around all the obstacles on the way to the target. Target acquisition is especially difficult in summer conditions.” [i.e. when there is dense foliage].[5] This underscores a core issue: even with accurate visual identification, the navigation and targeting challenges in complex terrain remain unsolved for many AI-powered drones.

Another major challenge is to effectively train the AI models to accurately identify military targets. The war constantly introduces new types of drones, camouflage techniques, and vehicle models, making it difficult for AI to keep up.

To enhance recognition capabilities, AI models require a vast and up-to-date dataset of images. The Ukrainian Ministry of Defense has stated that for years, frontline soldiers have been uploading images and videos of Russian military equipment into Delta through the Avengers system, and this growing database is now being leveraged to train AI models for drone targeting. While Ukraine relies on combat-acquired imagery, U.S. companies often train their models using synthetic or publicly available datasets (like ImageNet, COCO, and OIRDS) — a contrast that highlights both the challenge and opportunity in bridging the gap between simulation and real-world performance.

Companies such as Shield AI, Anduril, and others use these resources to train machine vision systems to identify vehicles, personnel, and infrastructure from drone-captured footage. Synthetic datasets, in particular, have become increasingly important for simulating combat or cluttered urban environments where real data is scarce or classified. For example, NVIDIA’s Cosmos platform is being used to generate photorealistic scenes to help drones recognize targets and navigate autonomously.[6] However, the lack of access to up-to-date battlefield imagery, especially from active warzones, limits the real-world performance of these models. That’s why Ukraine’s growing database of annotated enemy assets, collected directly from the front, presents a valuable opportunity: foreign drone companies can greatly improve the reliability of their AI models by validating and fine-tuning them using Ukrainian data under real combat conditions.[7]

5. David Hambling, “Ukrainian FPV Operator Reviews AI-Enabled ‘Lock On Target’ Drones,” Forbes, March 5, 2025, https://www.forbes.com/sites/davidhambling/2025/03/05/ukrainian-fpv-operator-reviews-ai-enabled-lock-on-target-drones/.
6. "NVIDIA Introduces Breakthrough Cosmos World Foundation Models For Physical AI And Synthetic Data Generation," Quantum Zeitgeist, March 21, 2025, https://quantumzeitgeist.com/nvidia-introduces-breakthrough-cosmos-world-foundation-models-for-physical-ai-and-synthetic-data-generation/.
7. Oleksandr Matviienko, Bohdan Miroshnychenko, and Zoriana Semenovych, "How Ukraine Integrates Machine Vision in Battlefield Drones," Counteroffensive Pro, March 11, 2025, https://newsletter.counteroffensive.pro/p/how-ukraine-integrates-machine-vision-in-battlefield-drones.
8. David Kirichenko, "Ukraine’s Robotic Army Is Bringing the Fight to Russia," The Kyiv Independent, February 4, 2025, https://kyivindependent.com/ukraines-robotic-army-is-bringing-the-fight-to-russia/.

Despite these promising developments in artificial intelligence, it's important to emphasize that Ukraine's battlefield still heavily relies on the skill sets of human pilots. The current AI targeting systems, while advancing quickly, remain unreliable in many real-world scenarios, particularly in complex terrain, under signal degradation, or when facing unconventional enemy tactics. At this stage, it is still the pilot who makes the critical judgment calls that AI cannot yet consistently replicate.

Until machine vision becomes more adaptable and dependable in dynamic combat environments, human decision-making remains essential to mission success. This gap between AI potential and battlefield reliability presents a significant market opportunity for companies that can develop more robust, adaptive, and combat-tested autonomous targeting systems.

UKRAINE'S UGV EVOLUTION: FROM LOGISTICS TO COMBAT

Following the same path as aerial drones, UGV development is increasingly shifting toward smaller, cheaper platforms that can be quickly manufactured, tested in the field, and easily replaced if destroyed. Ukrainian forces are now preparing to deploy tens of thousands of these inexpensive and rapidly replaceable ground systems.[8]

UGVs in Ukraine are designed to perform diverse roles in combat, significantly expanding their battlefield utility. These missions include:

1. **Logistics and Supply Missions**: Robots like the electric-powered Tarhan are increasingly used to deliver ammunition, resupply frontline troops, and retrieve lost drones.
2. **Mining and Demining**: UGVs handle hazardous tasks such as mine clearance and obstacle breaching, significantly reducing risk to personnel and improving operational tempo. For instance, units from Ukraine's 3rd Separate Assault Brigade have integrated small tracked UGVs to support demining operations in contested gray zones. These platforms have been employed to remotely deploy explosive charges, clear paths through minefields, and conduct engineering reconnaissance—enabling sappers to operate with reduced exposure in high-risk environments.
3. **Evacuation and Rescue**: Compact autonomous platforms like the Tarhan can be used to evacuate wounded personnel under fire, providing critical support in situations where traditional evacuation methods are too dangerous.
4. **Combat and Fire Support**: The TerMIT unmanned ground vehicle is a modular, armed platform used to deliver direct firepower in frontline conditions. It can be equipped with systems like grenade launchers or heavy machine guns, allowing operators to engage enemy positions remotely. This reduces the risk to soldiers while providing effective support in complex environments such as trenches or urban areas.

In December 2024, the 13th Brigade "Khartiia" showcased a new level of battlefield automation by deploying multiple ground robotic systems — including kamikaze drones, mobile turrets, and demining platforms — in a coordinated operation.
Colonel Maksym, Brigade Chief of Staff, emphasized the goal: "Our objective is to remove soldiers from harm's way by replacing them with unmanned and robotic solutions. This demands meticulous planning, continuous innovation, and a brigade-wide culture of experimentation."

This shift is actively supported by Ukraine's Ministry of Digital Transformation, which has launched programs to scale up unmanned ground systems across military formations. The 3rd Assault Brigade, for instance, accounts for nearly 60% of all UGV deployments, underscoring its leading role in operational integration. With over 200 domestic companies currently working on UGVs and more than 40 platforms aligned with NATO standards, Ukraine has cultivated a robust and rapidly growing defense manufacturing base — a key asset for long-term resilience.[9]

A large proportion of battlefield casualties occur not during active engagements but along logistical corridors, particularly during personnel rotations, casualty evacuations, and resupply operations. These activities frequently expose troops to indirect fire, improvised explosive devices, and unmanned aerial threats. Integrating UGVs into logistical frameworks is emerging as a critical factor in reducing preventable losses. While UGV adoption across most brigades remains largely unsystematic, the 3rd Assault Brigade—particularly its 2nd Assault Battalion—has set a notable precedent. With only three dedicated UGV operator teams, the unit is capable of transporting up to 15,000 kilograms of supplies per month, significantly reducing reliance on manned convoys in high-risk areas. The brigade now accounts for nearly 60% of all UGV operations on Ukraine's frontline, actively demonstrating the transformative potential of unmanned logistics.

ADAPT, ADAPT, ADAPT

Platforms like the Tarhan illustrate how Ukraine is pushing modularity and flexibility. Originally developed as a silent, electric-powered logistics UGV, the Tarhan has evolved into a versatile system that can be rapidly reconfigured for different tasks, from drone delivery missions (extending FPV strike range) to high-risk extraction operations.[10]

Similarly, the TerMIT UGV offers a tracked chassis with a 300-kilogram payload and 20-kilometer range. It's adaptable for logistics, evacuation, mining, and offensive operations. When combined with the Burya remote weapon station, TerMIT enables precision firing on the move at distances of up to 1,800 meters. The TerMIT can also be configured for various tasks, including logistics, evacuation, mining, and offensive operations.[11]

9. More than 200 Companies in Ukraine Involved in Ground Drone Production," Militarnyi, February 26, 2025, https://mil.in.ua/en/news/more-than-200-companies-in-ukraine-involved-in-ground-drone-production/.
10. How Tarhan UGV Helps Ukrainian Forces Evacuate Drones and in Other Combat Missions," Defense Express, February 9, 2025, https://en.defence-ua.com/weapon_and_tech/how_tarhan_ugv_helps_ukrainian_forces_evacuate_drones_and_in_other_combat_missions-13479.html.

This emphasis on agility, rapid prototyping, and low-cost production mirrors Ukraine's earlier success with aerial drone systems. It also reflects global trends: the UGV market, valued at $2.92 billion in 2022, is projected to grow to $5.62 billion by 2030.[12] Ukraine's innovation-driven model positions it to help shape this global market — not only as a buyer or tester, but as a strategic contributor and accelerator.

UGVS LOOKING FORWARD

Extensive combat testing has revealed both the promise and the limitations of current UGVs. Key challenges include:

- **Mobility Limitations**: UGVs often struggle with traction, incline handling, and muddy terrain due to suboptimal wheel or track design.
- **Reliability Issues**: Some platforms experience rapid battery drainage or total power loss, even when properly charged—issues often linked to faulty battery management systems or exacerbated by extreme weather conditions such as cold temperatures, moisture, or dust exposure.
- **Mechanical Failures**: Steering systems have failed after limited use, often due to loose bolts or weak construction, hindering operational control.
- **Logistical Complexity**: Larger UGVs require specialized transport, complicating rapid field deployment due to weight and bulk.

These practical issues point to crucial areas requiring improvement: increased ruggedness, better battery reliability, improved mobility through all-wheel drive adaptations, and more efficient field serviceability.

Ukraine's approach to UGV development stands out globally. Currently, less than 5% of all UGVs tested by the 3rd Assault Brigade were manufactured abroad, and none of these foreign-made systems have seen combat deployment. While international companies have brought prototypes for testing, most have failed to meet the rigorous, fast-moving requirements of active warfare — where speed of iteration, ruggedness, and tactical adaptability are non-negotiable.

11. "Ukrainian Burya Turret and TerMIT Tracked Platform United into a Single Combat System for War Against Russia," Army Recognition, September 19, 2024, https://armyrecognition.com/news/army-news/army-news-2024/ukrainian-burya-turret-and-termit-tracked-platform-united-into-a-single-combat-system-for-war-against-russia.
12. Grand View Research, "Unmanned Ground Vehicles Market Size, Share & Trends Analysis Report By Operation, By Mobility, By Size, By System, By Application, By Region, And Segment Forecasts, 2023 - 2030," https://www.grandviewresearch.com/industry-analysis/unmanned-ground-vehicles-market-report.

This dynamic represents a significant opportunity: foreign companies willing to co-develop with Ukrainian units, adapt quickly, and engage deeply with frontline needs stand to gain invaluable operational insight — and real-world validation that is hard to find elsewhere.

ADAPTATION & INNOVATION BY UKRAINIAN FORCES

A defining feature of Ukraine's approach is rapid, battlefield-driven innovation, where soldiers and engineers in the field continuously modify existing technology to maximize effectiveness. Frontline units customize equipment in ways manufacturers hadn't anticipated, driven by sheer necessity. One of the most striking examples is drone repurposing, with fighters frequently converting civilian drones into combat platforms by attaching grenade release mechanisms or enhancing range with improvised signal boosters. In some cases, off-the-shelf DJI quadcopters are completely reengineered using 3D-printed airframes, allowing for increased payload capacity and greater tactical versatility.

But this adaptability extends far beyond drones. Vehicles are being up-armored or retrofitted with improvised weapon systems. Consumer electronics, often purchased online, are integrated into legacy hardware to enhance targeting or improve communication. Even ground robots are being reimagined for new tactical roles.

For instance, while the Estonian-made THeMIS UGV was initially promoted as a potential solution for evacuation and logistical missions, its actual deployment in Ukraine has been far more constrained. In practice, it has seen limited use, primarily in rear areas for tasks like mine clearance. Despite its robust design, the platform has faced challenges adapting to the dynamic and rugged conditions of the front lines, where more agile, easily modifiable systems have proven more effective.

KEY TECH ADAPTATIONS HAVE INCLUDED:

- **Creative Drone Repurposing**: Civilian drones have been converted into bombers, surveillance platforms, and even electronic warfare tools, highlighting the adaptability of commercial technology for military use.
- **Field-Modifying Armored Vehicles**: Older Soviet-era tanks and APCs are being upgraded with additional reactive armor, improvised counter-drone defenses, and enhanced optics.
- **DIY Anti-Drone Measures**: Frontline units have developed low-cost net launchers, jamming devices, and even AI-assisted sniper systems to counter enemy UAVs.
- **Improvised Camouflage & Deception**: Inflatable decoys, radar reflectors, and manipulated electronic signatures are used to mislead enemy targeting systems.
- **Integration of Consumer Tech into Military Operations**: Tablets and smartphones, loaded with battlefield management software, provide real-time situational awareness at a fraction of the cost of traditional military systems.

CHALLENGES TO SCALING INNOVATION

Despite its effectiveness, this frontline-driven innovation model faces clear limitations in terms of scalability. Most adaptations are developed by small R&D teams or improvised workshops embedded within military units, and while these units excel at rapid prototyping and field deployment, they lack the resources to produce equipment at scale.

Ukrainian brigades cannot sustainably manufacture the volume of FPV drones, UGVs, and intelligence platforms they require for sustained operations. As a result, the demand for scalable, production-ready solutions continues to outpace what frontline innovation hubs can deliver.

This presents a major market opportunity. Why this matters for companies:

1. **Battlefield-Proven Advantage**: Technology validated and proven effective in Ukraine is likely to succeed in future NATO or similar high-intensity conflicts.
2. **Rapid Iteration Accelerates Innovation**: Combat-zone testing allows companies to accelerate R&D cycles and achieve rapid, real-world validation of products.
3. **Competitive Edge**: Early involvement provides a strategic edge by demonstrating product effectiveness in the most demanding environments.
4. **Market Opportunity for Scalable Production**: Ukrainian brigades need industrial partners who can translate frontline ingenuity into mass-produced systems — creating substantial opportunities for co-development and manufacturing partnerships.

CAPABILITY GAPS

FIBER-OPTIC DRONES

Fiber-optic guided drones have emerged as a critical technological innovation on Ukraine's frontline, offering a tactical solution to the rising challenge of electronic warfare (EW).[13] Unlike traditional radio-controlled drones vulnerable to signal jamming, drones guided by fiber-optic cables provide significant operational advantages:

1. **EW Resistance**: Fiber optics are resistant to electronic jamming, enabling drone operation in environments saturated with radio interference.
2. **High-Quality Imagery**: Fiber-optic cables deliver superior real-time video feeds up until detonation, crucial for precision targeting.
3. **Operational Freedom**: Unlike radio-controlled drones, fiber-optic platforms avoid frequency conflicts, enabling multiple units to operate in the same airspace without interference or delays.
4. **Extended Reach**: Theoretically unlimited operational range, constrained primarily by payload capacity and spool weight.

13. Tim Mak and Oleksandr Matviienko, "FPV Optic Fiber Drone Concepts," Counteroffensive Pro, November 5, 2024, https://newsletter.counteroffensive.pro/p/fpv-optic-fiber-drone-concepts.

However, despite these advantages — and the fact that fiber-optic guidance appears to offer the most promising countermeasure to one of the biggest challenges in drone warfare — only a limited number of manufacturers have proven capable of delivering reliable, battlefield-ready systems. Most platforms suffer from inconsistent quality, mechanical fragility, or lack of scalability, leaving frontline units to rely on a small pool of trusted suppliers.

CHALLENGES

1. **Increased Size and Weight**: Fiber-optic drones must carry spools that weight between 1.5–2.5 kg, significantly limiting payload capacity for munitions or sensors. This reduces overall speed and agility, making drones easier targets for kinetic defenses such as firearms or anti-drone nets.
2. **Mobility Issues**: The 0.2 mm cable, while durable, is prone to tangling on branches, wires, or debris, often leading to mobility loss or total mission failure.
3. **Complex Deployment**: Preparation and deployment times are substantially longer than wireless drones, making them less responsive for rapidly evolving tactical scenarios. According to Illia from Ukraine's 13th National Guard Brigade (Khartiia), despite excellent operational performance, preparation times currently remain a notable drawback.[14]
4. **Payload and Range Trade-off**: Current drone payload limitations significantly restrict operational range. Achieving ranges beyond several kilometers requires reducing spool weight and enhancing spool unwinding mechanisms, directly impacting the drone's payload and flight endurance.

Real-world tests have highlighted these vulnerabilities clearly: drones frequently encounter mechanical issues such as delayed command responses, battery power inconsistencies, and critical system malfunctions. These shortcomings underline the necessity for targeted technical improvements.

Given these identified gaps, significant opportunities exist for innovators and investors to advance the development and deployment of fiber-optic drone solutions:

1. **Lightweight Spool Systems**: Reducing spool weight without compromising cable strength would improve drone speed, range, and payload options.
2. **Automated Cable Management**: Smart spooling systems could prevent tangling, enhance reliability, and support more agile maneuvers in cluttered environments.
3. **Rapid Deployment Solutions**: Faster launch systems would allow fiber-optic drones to match the responsiveness of their radio-controlled counterparts.
4. **Enhanced Battery and Power Systems**: Reliable battery management with accurate charge monitoring and field-swap capability would significantly increase uptime and reduce mission failures.

14. David Kirichenko, "A New and More Deadly Drone on Russia's Battlefields," CEPA, March 3, 2025, https://cepa.org/article/a-new-and-more-deadly-drone-on-russias-battlefields/.

5. **Detection and Countermeasure Solutions**: As adversaries begin to adopt similar systems, there's rising demand for detection and interception tools—such as radar-based identification or mobile interception units, like those developed by Ukraine's Magyar Birds Brigade.

Ukraine's Ministry of Defense has already recognized the urgent need for technological innovation, launching hackathons such as "Attack of the Machines 2.0" to stimulate solutions specifically designed to counter and improve fiber-optic drone capabilities. On May 22-25, AB3Tech, the technology department of 3rd Assault Brigade, is hosting the very first army-organized defense tech hackathon, focusing on AI for the battlefield. Ukrainian manufacturers are actively receiving substantial orders, indicating both growing demand and investor interest in enhancing this emerging drone segment.

As fiber-optic drones increasingly reshape drone warfare tactics, addressing these identified capability gaps presents substantial opportunities for technologists and investors. Addressing these issues will not only meet frontline demands but potentially establish new global market standards for unmanned aerial systems in contested environments.

DRONE HUNTERS/MOBILE AIR DEFENSE

As drone use on Ukraine's battlefield continues to surge, the limitations of traditional air defense systems have become increasingly apparent. Large, stationary platforms, while effective against conventional aerial threats, struggle to respond to the agility, speed, and low cost of small UAVs, particularly first-person view (FPV) drones. This growing threat underscores an urgent need for mobile, cost-effective, and rapidly deployable counter-drone systems.

Smaller-scale, mobile air defense platforms, particularly drone-hunters equipped with automated turrets, have emerged as a promising solution. In January 2025, Ukraine's 13th Brigade "Kara Dag" successfully tested an innovative drone turret designed by the volunteer group Dron ZP. This turret, leveraging existing drone platforms, incorporates precision targeting capabilities, suitable for intercepting small and fast-moving targets such as FPV drones.[15]

Advantages of these solutions include:

1. **Rapid Deployment**: Highly mobile and easily repositioned to match shifting frontline conditions.
2. **Cost-Effectiveness**: Far cheaper than conventional missile-based air defenses — ideal for neutralizing low-cost enemy drones.
3. **Precision Targeting**: Integrated AI-powered targeting enables effective engagement of small, agile UAVs that often evade traditional systems.

15. Oleksandr Matviienko, "Turrets on Ground Drones: Air Defense Concepts," Counteroffensive Pro, February 25, 2025, https://newsletter.counteroffensive.pro/p/turrets-on-ground-drones-air-defense-concepts.

However, significant technical challenges remain to fully exploit these advantages:

1. **Detection Range**: Current systems struggle to detect FPV drones beyond a few hundred meters, severely limiting their protective radius.
2. **Target Acquisition Speed**: With FPV drones flying at speeds over 120 km/h and at very low altitudes, existing turrets often lack the speed and responsiveness for timely interception.
3. **Altitude Limitations**: Most turret-equipped drones cannot engage high-altitude reconnaissance drones like the Orlan, which operate at altitudes above 2 km—requiring alternate solutions or upgraded weapons.
4. **Operator Dependency**: Effectiveness often hinges on operator skill, creating scalability issues and demanding extensive training.
5. **Cost and Complexity of Sensor Integration**: Advanced detection tools (radar, thermal imaging) greatly improve performance but add weight, cost, and complexity—potentially compromising the platform's mobility and affordability.

DRONE-TO-DRONE INTERCEPTION: A GRASSROOTS RESPONSE

In parallel with hardware-based solutions, Ukrainian units are increasingly adopting drone-to-drone interception tactics. This bottom-up adaptation, driven by small-unit operators, offers a fast, responsive countermeasure when conventional detection or turret systems fall short. Importantly, 100% of FPV drones used for interception are manually tailored or modified before deployment—none are ready-to-go out of the box for this purpose. Modifications range from upgraded antennas and payload tweaks to creative physical enhancements like adding a protruding stick to physically disable enemy rotors mid-flight.

Despite the improvisational nature of these methods, their effectiveness is measurable. An air defense FPV platoon in the 3rd Assault Brigade now reports taking down over 100 aerial targets using FPV interceptors, with success rates approaching 70%. The cost of such interceptions can be extraordinarily low—some effective setups cost as little as $3, underscoring the value of agile, operator-driven innovation on the battlefield.

While the method remains skill-dependent and operator-intensive, it reflects a broader shift in doctrine: distributed air defense rooted in field-level creativity and rapid iteration. It also reinforces Ukraine's strategic edge in leveraging low-cost, high-impact solutions that scale in both production and deployment. At the same time, it highlights a clear market gap—an urgent need for scalable, user-friendly technologies that can automate or simplify drone interception and make these capabilities accessible beyond elite or highly trained units.

While this method is highly skill-dependent and operator-intensive, it provides a fast, flexible response when conventional systems fall short. It also reflects a broader trend in Ukraine's warfighting approach: leveraging off-the-shelf tech and human ingenuity to create asymmetric advantages.

Recognizing these challenges, Ukrainian developers and military units are actively exploring innovative approaches, creating substantial opportunities for investors and technology developers:

1. **Enhanced Detection Capabilities**: Companies like UGV Robotics and DevDroid are refining machine vision systems for faster, automated target detection and turret engagement, reducing operator workload and improving hit rates.[16]
2. **Interception Drones with Elevated Platforms**: Aerobavovna is developing FPV drone-interceptor balloons—tethered high-altitude platforms that extend line-of-sight detection and launch range, particularly effective against night-time threats like Shahed drones.[17]
3. **Automated Target Tracking**: Next-generation tracking systems capable of millisecond-level response times will greatly enhance turret effectiveness against high-speed drones.
4. **Cost and Scalability Improvements**: Innovations that lower cost, simplify design, and enable mass production will be essential for widespread battlefield adoption—especially given high drone attrition rates.
5. **Mobility and Modularity**: Future systems must prioritize ease of transport, rapid deployment, and plug-and-play modularity to meet dynamic frontline demands.

The growing threat of low-cost drones has redefined the air defense equation. Ukraine's frontline innovations point the way toward a new generation of mobile, precise, and affordable counter-drone systems. As battlefield requirements outpace traditional procurement models, companies that can deliver scalable, adaptable, and combat-tested solutions will be best positioned to lead in this emerging global defense market.

COUNTER GLIDE-BOMB SOLUTIONS

Russian glide bombs have emerged as one of the most destructive and difficult-to-counter threats on Ukraine's frontlines. By equipping cheap, unguided munitions with wing kits and satellite navigation systems, Russia has created a low-cost, precision weapon with devastating impact. Thousands of these glide bombs are now dropped monthly, overwhelming traditional air defenses and causing severe destruction, creating urgency for new technological responses.[18]

16. "Ukraine Deploys Droid Fighter Robot," Defense Mirror, December 28, 2024, https://www.defensemirror.com/news/38494/Ukraine_Deploys_Droid_Fighter_Robot.
17. "Balloon-Launched Interceptor Drones: Ukraine Developing New System to Counter Shahed Drones," Militarnyi, March 13, 2025, https://mil.in.ua/en/news/balloon-launched-interceptor-drones-ukraine-developing-new-system-to-counter-shahed-drones/.
18. David Hambling, "A Ukrainian Mystery Weapon Is Shooting Down Russian Glide Bombs," Forbes, February 13, 2025, https://www.forbes.com/sites/davidhambling/2025/02/13/a-ukrainian-mystery-weapon-is-shooting-down-russian-glide-bombs/.

KEY CHALLENGES OF COUNTERING GLIDE BOMBS:

- **Difficult Detection and Tracking**: Weighing under a ton and with wingspans of less than seven feet, glide bombs are difficult for conventional radar systems to detect and track.[19]
- **Immunity to Infrared Missiles**: Unlike powered aircraft or cruise missiles, glide bombs produce no exhaust or heat signature, rendering heat-seeking missiles like the Stinger ineffective.
- **Robust and Numerous Targets**: Steel-cased, with minimal vulnerable components, glide bombs are hard to disable with traditional firepower. Their mass deployment further strains existing defense systems.

These characteristics underline a critical gap: Ukraine urgently needs novel, scalable, and economically viable countermeasures.

Ukraine recently reported its first successful intercepts of Russian glide bombs near Zaporizhia. While official details remain classified, past successes against similar threats (e.g., Shahed drones) suggest a potential counter-glide bomb model combining three key components:

- **Sensor Networks & Centralized Control**: Ukraine has previously neutralized aerial threats through distributed sensor systems—combining radar, acoustic, and optical inputs with AI-powered software for fast, accurate targeting. These networks enhance detection and enable rapid engagement coordination.[20]
- **Rapid Response Mobile Units**: Light, mobile air defense teams have proven highly effective against Shahed drones, achieving interception rates over 90% using automatic cannons, machine guns, and searchlights. A similar approach linked to centralized sensor networks could offer a scalable solution for intercepting glide bombs.[21] Speed is essential. Interception systems must be able to deploy quickly and respond in seconds to unpredictable glide bomb flight paths.

Recognizing the growing threat, NATO's latest Innovation Challenge specifically prioritizes counter-glide bomb solutions. Key criteria include:

- **Integration with NATO Standard**s: Solutions must integrate seamlessly into NATO's broader sensor and defense networks.
- **Ease of Deployment and Training**: Effective systems should require minimal operator training and support rapid deployment in frontline scenarios.
- **Cost Efficiency & Scalability**: Solutions must be economically viable to counter thousands of glide bombs sustainably.

19. Hambling, David. "A Ukrainian Mystery Weapon Is Shooting Down Russian Glide Bombs." Forbes, February 13, 2025. https://www.forbes.com/sites/davidhambling/2025/02/13/a-ukrainian-mystery-weapon-is-shooting-down-russian-glide-bombs/.
20. Hambling, David. "A Ukrainian Mystery Weapon Is Shooting Down Russian Glide Bombs." Forbes, February 13, 2025. https://www.forbes.com/sites/davidhambling/2025/02/13/a-ukrainian-mystery-weapon-is-shooting-down-russian-glide-bombs/.
21. Hambling, David. "A Ukrainian Mystery Weapon Is Shooting Down Russian Glide Bombs." Forbes, February 13, 2025. https://www.forbes.com/sites/davidhambling/2025/02/13/a-ukrainian-mystery-weapon-is-shooting-down-russian-glide-bombs/.

To close capability gaps, a few of the following areas represent significant opportunities for technologists and investors:

- **AI-Powered Detection & Tracking Systems**:
  - Advanced radar and optical systems augmented with AI to improve real-time detection of low-signature glide bombs.
  - Machine learning algorithms to predict bomb trajectories at the moment of release, allowing earlier and more accurate intercepts.
- **Networked Sensor Integration**:
  - Investment in integrated acoustic, radar, and optical sensor systems to automatically detect, classify, and track glide bombs with minimal operator input.
- **Cost-Effective, Scalable Interceptors**:
  - Development of specialized, low-cost guided missiles such as laser-guided systems (similar to the U.S. Vampire missile) optimized specifically for glide bomb interception.
  - Innovative interceptor drones (e.g., Wild Hornets' "Sting" drone) providing rapid, automated air-to-air targeting capabilities, particularly valuable in close-range engagements.

Successfully intercepting even a portion of incoming glide bombs would represent a major strategic shift, limiting Russia's offensive options and reducing pressure on frontline units. Technologies validated in Ukraine will not only enhance national defense but position developers for NATO and allied procurement as glide bombs become a standard tool in modern arsenals.

The implications extend beyond Ukraine. The U.S. Air Force's reliance on JDAM-ER glide munitions reflects a broader trend toward these weapons in future conflicts. As a result, effective glide bomb countermeasures developed in Ukraine are poised to set the standard for next-generation air defense across NATO and beyond.[22]

COUNTER-BATTERY SYSTEMS

Counter-battery systems — technologies designed to detect and neutralize enemy artillery — have become a strategic necessity for Ukrainian forces under constant Russian bombardment. Russia's artillery-heavy doctrine, now enhanced by widespread drone-based targeting, severely constrains Ukraine's maneuverability, position security, and offensive capabilities. Ukrainian artillery crews routinely face precise strikes directed by enemy drones, highlighting a critical gap in detection, rapid response, and neutralization technologies.[23]

22. "Joint Direct Attack Munition-Extended Range (JDAM-ER) Precision-Guided Bombs, USA," Airforce Technology, March 27, 2023, https://www.airforce-technology.com/projects/joint-direct-attack-munition-extended-range-jdam-usa/.
23. Dan Peleschuk, "Fire and Hide: Ukraine's Artillery Pinned Down by Russian Drones," Reuters, May 7, 2024, https://www.reuters.com/world/europe/fire-hide-ukraines-artillery-pinned-down-by-russian-drones-2024-05-07/.

Current challenges include:

- **Drone Surveillance & Precision Targeting**: Russian reconnaissance drones continuously monitor Ukrainian artillery, coordinating strikes using Lancet loitering munitions and other precision-guided weapons. Units like Ukraine's 43rd Artillery Brigade, operating Panzerhaubitze 2000s, report frequent direct hits and near-constant aerial harassment, limiting both survivability and freedom of movement.[24]
- **Limited Operational Tempo & Mobility**: To avoid detection, Ukrainian crews are forced to fire fewer shells (averaging just 8–15 per day) and relocate frequently under tree cover or into complex terrain. This significantly reduces their battlefield impact while increasing logistical complexity and operational risk.[25]
- **Inefficient Existing Detection Systems**: Radar-based counter-battery systems are increasingly compromised by Russian electronic warfare (EW) tactics and evasive drone behavior. Many enemy platforms remain undetectable through conventional means, creating an urgent need for alternative or complementary detection technologies that are resistant to electronic suppression.

Ukraine is actively implementing new solutions involving acoustic sensors, AI-driven detection, and sensor-integrated drones to address these critical gaps.

Some Ukrainian units are trying to deploy audiometric systems that detect enemy artillery acoustically, analyzing battlefield sounds with AI algorithms. These sensor networks identify enemy positions precisely, transmitting target coordinates directly to artillery units, factoring in weather conditions and positioning errors. The operational range starts from approximately 10 kilometers, scalable according to tactical needs.[26]

German drone manufacturer Quantum Systems, in collaboration with its Polish subsidiary Weles Acoustics, is developing ultra-light acoustic sensors integrated into reconnaissance drones (such as the Quantum Twister). This system detects artillery and mortar fire from distances up to 15 kilometers, automatically adjusting drone-mounted cameras to locate firing positions accurately within five degrees of precision. AI-supported sound signature analysis distinguishes between artillery and mortar fire, enabling tailored countermeasures.[27] These sensor-equipped drones are meant to significantly enhance artillery units' situational awareness, extending the effective operational area of artillery systems.

24. Peleschuk, Dan. "Fire and Hide: Ukraine's Artillery Pinned Down by Russian Drones." Reuters, May 7, 2024. https://www.reuters.com/world/europe/fire-hide-ukraines-artillery-pinned-down-by-russian-drones-2024-05-07/.
25. Peleschuk, Dan. "Fire and Hide: Ukraine's Artillery Pinned Down by Russian Drones." Reuters, May 7, 2024. https://www.reuters.com/world/europe/fire-hide-ukraines-artillery-pinned-down-by-russian-drones-2024-05-07/.
26. "AI Counter-Battery Fight Project for 406th Separate Artillery Brigade," Reactive Post, https://reactivepost.org/en/projects/ai-counter-battery-fight-project-for-406th-separate-artillery-brigade-mqgmvd.
27. Waldemar Geiger, "Akustische Artillerieortung – Quantum Systems bringt neue Fähigkeiten auf seine Aufklärungsdrohnen," Hartpunkt, February 11, 2025, https://www.hartpunkt.de/akustische-artillerieortung-quantum-systems-bring-neue-faehigkeiten-auf-seine-aufklaerungsdrohnen/.

By rapidly pinpointing enemy firing positions, Ukrainian artillery units could engage targets with improved accuracy, speed, and lethality, disrupting Russian artillery operations before they inflict significant damage.

Given the established effectiveness of acoustic sensor networks and AI-based counter-battery systems, significant opportunities exist for technological advancements and investment in the following areas:

1. **Advanced Acoustic Detection Networks**: Scaling and refining sensor arrays to increase range, accuracy, and resilience against EW interference. Advances in miniaturization, NATO-standard interoperability, and AI-driven classification will be key to improving operational reliability.
2. **AI-Powered Targeting & Predictive Algorithms**: Development of software capable of rapidly calculating artillery trajectories, predicting firing patterns, and automating target assignment will significantly compress detection-to-engagement times and increase kill rates.
3. **Sensor-Integrated UAV Platforms**: Investments in UAVs equipped with advanced multi-sensor packages (optical, acoustic, radar), seamlessly integrated into frontline artillery networks, would provide an unprecedented degree of battlefield situational awareness, further shortening reaction times and enhancing precision.
4. **Counter-Drone & Electronic Warfare Integration**: Innovations that combine acoustic sensors with electronic warfare capabilities to neutralize enemy reconnaissance drones and disrupt enemy artillery command and control communications represent a crucial growth area. Such integrated solutions would significantly degrade Russia's primary targeting capabilities.

Advancing counter-battery capabilities has the potential to alter the strategic balance in Ukraine. Disrupting or neutralizing Russian artillery assets would lower casualty rates, restore Ukraine's ability to maneuver on the battlefield, and degrade Russia's offensive and defensive operations alike.

Beyond the current war, the lessons learned in Ukraine—particularly in the use of acoustic sensors, AI, and UAV-based detection—will inform future NATO doctrines and procurement strategies. Given Russia's historically dominant artillery capabilities, any system that proves effective in this environment is likely to hold significant global commercial value.[28]

Defense firms that lead in this space—through frontline-proven, scalable, and integrated solutions—are positioned to shape the future of artillery warfare and secure long-term roles in next-generation defense programs.

28. David Hambling, "Russia's Artillery Advantage in the Ukraine War Is Slipping Away," 19FortyFive, January 24, 2025, https://www.19fortyfive.com/2025/01/russias-artillery-advantage-in-the-ukraine-war-is-slipping-away/.

MOBILE AIR DEFENSE

Ukraine's battlefield experience has revealed a critical gap in rapidly deployable short-range air defense (SHORAD). While Western partners have supplied man-portable systems like Stingers, along with limited numbers of mobile platforms such as Germany's Gepard and the U.S. Avenger, coverage remains insufficient. Frontline units frequently report acute vulnerabilities to helicopters, low-flying attack jets, cruise missiles, and especially low-cost drone threats like Shaheds.Current systems are often too sparse, expensive, or logistically burdensome and struggle to provide consistent protection at the tactical level.

The sheer scale of drone deployments — especially loitering munitions like Shaheds — has overwhelmed traditional SHORAD systems. These legacy platforms were never designed to counter mass-produced, attritable UAVs deployed daily in high numbers, often during night operations or in saturation waves.

In response, Ukraine has adopted highly mobile fire groups: pickup trucks and tactical vehicles equipped with sensors, thermal optics, and rapid-response weapons. These agile, low-cost systems have proven effective, showcasing the potential of modular, scalable SHORAD solutions.[29]

The UK's Gravehawk system uses containerized, ground-launched air-to-air missiles, leveraging existing munitions to reduce logistics complexity while enhancing mobility.[30]

The Pentagon's FrankenSAM program integrates donated components from multiple systems, creating modular and adaptive air defense platforms that fill capability gaps without requiring advanced systems like NASAMS.[31]

Together, these efforts reflect a growing shift toward decentralized, mobile, and cost-effective air defense: a shift validated by Ukraine's combat experience and increasingly relevant to global defense planning.

The continuous nature of drone threats demands SHORAD platforms that are not only mobile but persistent, autonomous, and able to operate with minimal downtime. This has accelerated interest in semi-autonomous systems with AI-driven target detection that reduce operator fatigue and increase engagement speed.

29. "The Foundation has strengthened mobile air defense firing groups," Come Back Alive, May 15, 2024, https://savelife.in.ua/en/materials/news-en/en-3/.
30. Inder Singh Bisht, "UK to Send Novel Mobile Air Defense System to Ukraine," The Defense Post, January 17, 2025, https://thedefensepost.com/2025/01/17/uk-air-defense-ukraine/.
31. Thomas Newdick, "Ukraine's FrankenSAM Air Defense Concept Could Be Used to Protect USAF Bases," The War Zone, July 10, 2024, https://www.twz.com/news-features/ukraines-frankensam-air-defense-concept-could-be-used-to-protect-usaf-bases.

Detection remains the most critical bottleneck in SHORAD performance. Many FPV drones fly too low and too fast to be picked up by conventional radar in time. As a result, integrated visual/thermal AI-based sensors are becoming central to the next generation of mobile SHORAD platforms.

Ukraine's experience also reveals a need for SHORAD systems to be logistically modular — using commercially available components, swappable power sources, and off-the-shelf munitions where possible. This modularity ensures faster resupply, broader interoperability, and less dependence on strategic manufacturing pipelines.

These frontline insights underscore an essential investment opportunity: the development and production of highly mobile, scalable, and cost-effective air defense platforms. Such solutions could significantly address current shortfalls while creating a replicable global model for tactical air defense, meeting rising international demand driven by contemporary battlefield realities.

TESTING IN UKRAINE

Ukraine offers an unparalleled opportunity for defense technology companies to validate and refine their systems under real-world combat conditions. Unlike laboratory environments or advanced simulations, frontline deployment in Ukraine exposes technologies to the full spectrum of battlefield variables—providing critical insights that accelerate development, strengthen market positioning, and enhance operational credibility.

1. **Live-Fire Environments Expose Design Flaws Early:** Controlled laboratory conditions or even advanced simulations can never fully replicate the complexities of actual combat. In Ukraine, systems are deployed under real-time conditions, exposing design flaws and operational vulnerabilities early in the development cycle. This accelerates iterative improvements and significantly reduces long-term development costs and timelines. Real battlefield scenarios — electronic warfare, enemy interference, environmental variability, mechanical stresses — quickly uncover problems that may otherwise remain unnoticed until it's too late or costly to correct. For example, the mechanical vulnerabilities observed in some UGVs (such as rapid battery drainage and mobility limitations) were only identified during real frontline operations. Similarly, fiber-optic drone issues such as cable management or deployment complexity were only fully understood when tested under actual battlefield constraints.
2. **Direct Operator Feedback Accelerates Iteration:** Ukrainian military personnel offer some of the most experienced combat feedback in the world today. Their continuous exposure to evolving threats gives them deep, practical insight into system performance, usability, and tactical value. This real-time adaptation drives immediate, meaningful iterations which far exceed the pace of conventional development cycles. Ukrainian soldiers have already demonstrated exceptional adaptability, rapidly modifying and improving technologies such as FPV drones, ground robotics, and mobile air defense units.

3. **Proven Tech Will Win Contracts**: As NATO and U.S. defense agencies adopt more risk-averse and performance-based procurement models, battlefield-proven systems are increasingly prioritized. This battlefield validation significantly streamlines and accelerates adoption by NATO forces, translating directly into faster, larger-scale contracts. As defense agencies worldwide become more cautious and selective in their acquisitions, products with demonstrable battlefield performance in Ukraine gain decisive competitive advantages. Companies that seize this opportunity for real-world testing position themselves to become market leaders in global defense procurement cycles.

WHAT THIS MEANS FOR INVESTORS & DEFENSE TECH COMPANIES

For Investors:

While certain areas of defense technology are saturated with capital and limited to incremental improvements, Ukraine's battlefield experience has spotlighted several emerging sectors undergoing rapid, combat-driven innovation yet undercapitalized.

These underserved categories present high-potential opportunities for differentiated returns and long-term global relevance:

- **AI-Driven Autonomous Systems**: Machine vision, AI-enhanced target identification, and autonomous drone operations remain highly promising but insufficiently funded relative to their potential.
- **Advanced Counter-Drone Systems and Mobile Air Defense**: Scalable, cost-effective systems to neutralize low-cost UAVs and glide bombs are in urgent demand. The global defense market is actively seeking alternatives to expensive, slow-deploying traditional systems.
- **Fiber-Optic Drone Solutions**: Innovations addressing critical technical gaps (e.g., lightweight cable management, agile deployment mechanisms) remain significantly underfunded despite high operational demand.
- **Sensor Integration and Counter-Battery Fire Technology**: Acoustic and AI-powered detection systems have high frontline demand but still lack dedicated investment compared to conventional radar solutions.
- **Unmanned Ground Vehicles (UGVs)**: Smaller, modular, multi-purpose robotic platforms capable of performing diverse frontline missions (logistics, combat, rescue, demining) are poised for rapid growth, particularly those offering modularity, cost-efficiency, and ruggedness.

For Companies:

Companies aiming to build competitive, combat-proven defense technologies should actively engage with Ukrainian forces and specialized adaptation units.

Ukraine presents a unique opportunity to test and refine products under the most demanding real-world conditions — offering insights, credibility, and acceleration unmatched by traditional R&D environments.

AB3TECH is the frontline technology unit of Ukraine's 3rd Assault Brigade — an umbrella initiative that unites drone, AI, and ground robotics innovation under one combat-tested structure. Operating directly from active warzones, AB3TECH specializes in evaluating, adapting, and scaling new technologies in real combat conditions. By collaborating with AB3TECH, companies gain access to structured testing environments, rapid iteration cycles, and real-time feedback from some of the most experienced operators in the world. This integration accelerates development timelines, enhances system reliability, and significantly strengthens product readiness for large-scale procurement.

The high operational tempo, a broad range of mission sets, and access to both Soviet-era and NATO systems in Ukraine have produced an open innovation ecosystem rarely seen in modern warfare. Unlike in peacetime settings, the feedback loops are immediate, sometimes occurring within hours or days. According to U.S. military experts, the window between the first deployment of an improved drone design and the appearance of countermeasures in Ukraine is usually just over a month.[32] This has allowed Ukrainian forces, and the tech developers supporting them, to experiment, adapt, and scale solutions with unprecedented speed.

The competitive advantages of battlefield validation include:

1. **Systems proven effective in Ukraine gain stronger appeal in both commercial and defense markets**. Technologies that perform successfully under real combat conditions carry greater weight with defense buyers and investors alike. Field-tested systems are more attractive in procurement cycles due to their demonstrated reliability, effectiveness, and lower perceived risk. Once validated in Ukraine, these systems are well-positioned for global sales and long-term defense contracts.
2. **Faster product iteration in high-pressure environments enables companies to remain ahead of competitors**. Live combat environments quickly expose design flaws and usability issues that lab testing often misses. This enables faster iteration and refinement, reducing costly R&D phases and ensuring only the most viable solutions advance to production. Companies working with frontline units can incorporate real-time feedback to optimize performance, survivability, and mission relevance.
3. **Early adoption by Ukrainian forces provides a valuable endorsement that can influence NATO and U.S. acquisition decisions**. As allied militaries prioritize systems that are adaptable, interoperable, and combat-proven, products tested in Ukraine gain a competitive edge in defense procurement cycles.

CONCLUSION

Ukraine's battlefield has become the world's most dynamic proving ground for defense technology. In this environment, innovation is no longer theoretical — it's tactical, urgent, and iterative. Technologies that succeed here are not only saving lives, but shaping the future of modern warfare.

This report highlights a crucial reality: from fiber-optic drones and acoustic counter-battery systems to AI-enabled targeting and mobile air defense platforms, the most valuable defense innovations today are being forged under fire.

For investors, this presents a rare opportunity: to deploy capital where it's needed most, in categories with clear operational demand, global scalability, and long-term relevance.

For companies, the path to market leadership runs through combat validation. Those who engage directly with frontline users, iterate quickly, and solve real problems will not only accelerate procurement timelines — they will define the next generation of defense capability.

The stakes are high. So is the potential. Ukraine is reshaping the defense innovation cycle. Those who act with us will help build the future of deterrence, security, and strategic advantage.

32. Edward Verona, "The West Must Learn Defense Tech Lessons on the Ukrainian Battlefield," Atlantic Council, October 8, 2024, https://www.atlanticcouncil.org/blogs/ukrainealert/the-west-must-learn-defense-tech-lessons-on-the-ukrainian-battlefield/.

REFERENCES

- "AI Counter-Battery Fight Project for 406th Separate Artillery Brigade." Reactive Post.https://reactivepost.org/en/projects/ai-counter-battery-fight-project-for-406th-separate-artillery-brigade-mqgmvd.
- "Balloon-Launched Interceptor Drones: Ukraine Developing New System to Counter Shahed Drones." Militarnyi,March 13, 2025. https://mil.in.ua/en/news/balloon-launched-interceptor-drones-ukraine-developing-new-system-to-counter-shahed-drones/.
- Bisht, Inder Singh. "UK to Send Novel Mobile Air Defense System to Ukraine." The Defense Post, January 17, 2025. https://thedefensepost.com/2025/01/17/uk-air-defense-ukraine/.
- "The First 3,000 Drones with Machine Vision for the Armed Forces of Ukraine Are Ordered; Another 10,000 Are on the Way." Defense Express, November 5, 2024. https://en.defence-ua.com/weapon_and_tech/the_first_3000_drones_with_machine_vision_for_the_armed_forces_of_ukraine_are_ordered_another_10000_are_on_the_way-12423.html.
- "The Foundation has strengthened mobile air defense firing groups." Come Back Alive, May 15, 2024. https://savelife.in.ua/en/materials/news-en/en-3/.
- Geiger, Waldemar. "Akustische Artillerieortung – Quantum Systems bringt neue Fähigkeiten auf seine Aufklärungsdrohnen." Hartpunkt, February 11, 2025. https://www.hartpunkt.de/akustische-artillerieortung-quantum-systems-bring-neue-faehigkeiten-auf-seine-aufklaerungsdrohnen/.
- Grand View Research. "Unmanned Ground Vehicles Market Size, Share & Trends Analysis Report By Operation, By Mobility, By Size, By System, By Application, By Region, And Segment Forecasts, 2023 - 2030." https://www.grandviewresearch.com/industry-analysis/unmanned-ground-vehicles-market-report.
- Hambling, David. "A Ukrainian Mystery Weapon Is Shooting Down Russian Glide Bombs." Forbes, February 13, 2025. https://www.forbes.com/sites/davidhambling/2025/02/13/a-ukrainian-mystery-weapon-is-shooting-down-russian-glide-bombs/.
- Hambling, David. "Russia's Artillery Advantage in the Ukraine War Is Slipping Away." 19FortyFive, January 24, 2025. https://www.19fortyfive.com/2025/01/russias-artillery-advantage-in-the-ukraine-war-is-slipping-away/.
- Hambling, David. "Ukrainian FPV Operator Reviews AI-Enabled ‘Lock On Target’ Drones." Forbes, March 5, 2025. https://www.forbes.com/sites/davidhambling/2025/03/05/ukrainian-fpv-operator-reviews-ai-enabled-lock-on-target-drones/.
- "How Tarhan UGV Helps Ukrainian Forces Evacuate Drones and in Other Combat Missions." Defense Express,February 9, 2025. https://en.defence-ua.com/weapon_and_tech/how_tarhan_ugv_helps_ukrainian_forces_evacuate_drones_and_in_other_combat_missions-13479.html.

- "Joint Direct Attack Munition-Extended Range (JDAM-ER) Precision-Guided Bombs, USA." Airforce Technology,March 27, 2023. https://www.airforce-technology.com/projects/joint-direct-attack-munition-extended-range-jdam-usa/.
- Kirichenko, David. "A New and More Deadly Drone on Russia's Battlefields." CEPA, March 3, 2025. https://cepa.org/article/a-new-and-more-deadly-drone-on-russias-battlefields/.
- Kirichenko, David. "Ukraine’s Robotic Army Is Bringing the Fight to Russia." The Kyiv Independent, February 4, 2025. https://kyivindependent.com/ukraines-robotic-army-is-bringing-the-fight-to-russia/.
- Klempner, Jesse, Christian Rodriguez, and Dale Swartz. "A Rising Wave of Tech Disruptors: The Future of Defense Innovation?" McKinsey & Company, February 22, 2024. https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/a-rising-wave-of-tech-disruptors-the-future-of-defense-innovation.
- Mak, Tim, and Oleksandr Matviienko. "FPV Optic Fiber Drone Concepts." Counteroffensive Pro, November 5, 2024. https://newsletter.counteroffensive.pro/p/fpv-optic-fiber-drone-concepts.
- Matviienko, Oleksandr. "Turrets on Ground Drones: Air Defense Concepts." Counteroffensive Pro, February 25, 2025. https://newsletter.counteroffensive.pro/p/turrets-on-ground-drones-air-defense-concepts.
- Matviienko, Oleksandr, Bohdan Miroshnychenko, and Zoriana Semenovych. "How Ukraine Integrates Machine Vision in Battlefield Drones." Counteroffensive Pro, March 11, 2025. https://newsletter.counteroffensive.pro/p/how-ukraine-integrates-machine-vision-in-battlefield-drones.
- "More than 200 Companies in Ukraine Involved in Ground Drone Production." Militarnyi, February 26, 2025. https://mil.in.ua/en/news/more-than-200-companies-in-ukraine-involved-in-ground-drone-production/.
- Newdick, Thomas. "Ukraine’s FrankenSAM Air Defense Concept Could Be Used to Protect USAF Bases." The War Zone, July 10, 2024. https://www.twz.com/news-features/ukraines-frankensam-air-defense-concept-could-be-used-to-protect-usaf-bases.
- "NVIDIA Introduces Breakthrough Cosmos World Foundation Models For Physical Al And Synthetic Data Generation." Quantum Zeitgeist, March 21, 2025. https://quantumzeitgeist.com/nvidia-introduces-breakthrough-cosmos-world-foundation-models-for-physical-ai-and-synthetic-data-generation/.
- Peleschuk, Dan. "Fire and Hide: Ukraine's Artillery Pinned Down by Russian Drones." Reuters, May 7, 2024. https://www.reuters.com/world/europe/fire-hide-ukraines-artillery-pinned-down-by-russian-drones-2024-05-07/.
- "The West Must Learn Defense Tech Lessons on the Ukrainian Battlefield." Atlantic Council, October 8, 2024. https://www.atlanticcouncil.org/blogs/ukrainealert/the-west-must-learn-defense-tech-lessons-on-the-ukrainian-battlefield/.
- "Ukraine Deploys Droid Fighter Robot." Defense Mirror, December 28, 2024. https://www.defensemirror.com/news/38494/Ukraine_Deploys_Droid_Fighter_Robot.

- "Ukrainian Burya Turret and TerMIT Tracked Platform United into a Single Combat System for War Against Russia." Army Recognition, September 19, 2024. https://armyrecognition.com/news/army-news/army-news-2024/ukrainian-burya-turret-and-termit-tracked-platform-united-into-a-single-combat-system-for-war-against-russia.
- Verona, Edward. "The West Must Learn Defense Tech Lessons on the Ukrainian Battlefield." Atlantic Council, October 8, 2024. https://www.atlanticcouncil.org/blogs/ukrainealert/the-west-must-learn-defense-tech-lessons-on-the-ukrainian-battlefield/.
- Watling, Jack, and Nick Reynolds. Tactical Developments During the Third Year of the Russo–Ukrainian War. London: Royal United Services Institute, February 2025. https://static.rusi.org/tactical-developments-third-year-russo-ukrainian-war-february-2205.pdf.
- Thornhill, John. "The Conflicted Investment Case for Defence Tech." Financial Times, October 3, 2024. https://www.ft.com/content/791a26fa-fca1-4293-bf87-787bc62c9f58.