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ISSN 0793-1042
August 2025

Cover image: IDF spokesperson

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Executive Summary

The FPV drone revolution represents a paradigm shift in modern warfare, fundamentally altering tactical operations, force organization, and strategic thinking across all military dimensions. Combat evidence from the Russia-Ukraine conflict demonstrates the unprecedented lethality, operational scale, and tactical versatility of FPV systems. Yet most military establishments remain anchored to obsolete paradigms, failing to comprehend the implications of this transformation.

This analysis examines the cognitive and structural barriers impeding effective military adaptation, outlines the transformative potential of mass FPV deployment, and provides a strategic framework for integrating this capability into modern armed forces. FPV warfare signals a generational shift in military affairs—one that rewards early adopters and severely punishes those who hesitate.

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Introduction

The FPV revolution is fundamentally transforming ground warfare while extending its influence across all operational domains. This represents far more than the introduction of a new weapon system. It constitutes a genuine revolution that is reshaping combat methodology, force structure, and tactical doctrine, ultimately demanding a complete reconceptualization of large-scale military operations.

The seemingly simple attack drone is driving a fundamental shift in military doctrine, discarding legacy concepts rooted in Cold War or counterinsurgency frameworks that no longer meet modern battlefield demands. Ukraine's failed counteroffensive in summer 2023—executed using NATO doctrine and Western weapon systems—serves as conclusive evidence that yesterday's solutions are inadequate for today's challenges.

Many NATO commanders have yet to internalize the depth of battlefield transformation now underway—a transformation that cannot be ignored or addressed through incremental modifications. For over three years, Russian and Ukrainian forces have confronted this reality directly, compelled by necessity to learn, adapt, and transform in real time.

FPV drones: Battlefield game-changers

The revolutionary impact of First-Person View (FPV) drones extends far beyond their emergence as a new weapon category. Their unique technological and operational characteristics are reshaping the fundamental principles of modern land warfare.

Operational range and precision

FPV drones operate effectively at ranges up to 10 kilometers, with advanced variants reaching 20 kilometers. The tactical implications are profound: these weapons allow precision strikes at extended ranges without exposing operators to direct threat. While ranges beyond 20 kilometers remain uncommon, Russian forces have demonstrated integrated drone operations combining fixed wing

UAS, Orlan ISR platforms, and Lancet loitering munitions across 30-50 kilometer ranges.

Real-time camera systems enable live battlefield observation and precise target guidance, making these platforms exceptionally lethal against small, mobile targets. FPV drones excel in specialized missions: engaging armored vehicles' weak points; delivering precision strikes against fortified positions through windows or small openings; and eliminating high-value personnel, including snipers and anti-tank operators. The long range of these drones enables strikes deep in the rear, disrupting the movement of forces before contact.

Revolutionary close support capabilities

FPV drones provide close air support to advancing combined arms formations that traditional air and artillery assets cannot match, particularly regarding precision and proximity to friendly forces—capabilities previously impossible due to safe distance requirements. These platforms serve as cost-effective counter-air assets, capable of intercepting fixed-wing tactical ISR drones through their combination of precision and low-altitude maneuverability.

Maneuver superiority and electronic warfare resistance

FPV drones demonstrate clear maneuver superiority, bypassing obstacles and altering flight paths mid-mission while adapting to terrain and enemy activity. This agility enables access to unconventional spaces, achieving tactical surprise through a new form of aerial envelopment. Their extended range permits the concentration of drone swarms from multiple dispersed launch points, enabling geographically distributed teams to deliver synchronized firepower against concentrated targets—a novel fusion of tactical dispersion with centralized fire control.

The transition to fiber-optic control systems has rendered the FPV platforms immune to jamming and interception. This resistance extends beyond the drones themselves to their operators, as fiber-optic control prevents enemy detection or targeting during operations, dramatically reducing disruption probability.

Tactical transformation: The collapse of classical doctrine

Rapid FPV development and deployment have triggered profound changes in tactical battlefield dynamics and ground force combat techniques. Classical battle doctrine—relying on massed formations, defined centers of gravity, and concentration principles—is collapsing under the persistent, lethal surveillance of miniaturized drones.

Force dispersion and defensive adaptation

One of the most consequential operational shifts is the loss of the ability to mass forces above company echelon without triggering near-immediate detection, targeting, and engagement by enemy sensor-shooter networks.

Defensive evolution

Defenders must disperse formations across wider areas, heavily employing decoys and unmanned positions as essential deception and survivability components. The era of "key strongpoints" and traditional fortified positions has ended. Defensive fronts have become thinner and deeper**.**

Offensive evolution

Assault tactics have fundamentally changed. Operations no longer rely on deep maneuver by massed forces, instead executing through dispersed "arrows"— short-range thrusts by mechanized platoon-sized task forces or small infantry assault groups. These units advance using speed and dispersion, relying on drone and artillery support to replace traditional massed land firepower with decentralized, synchronized aerial strikes. Victory is achieved through concentrated low altitude aerial fire rather than mass.

Operational transformation

Modern maneuver unfolds across broader fronts. Armored vehicles must maintain constant motion as any halt risks immediate destruction. Transitioning from staging areas to tactical deployment demands dispersion, emphasizing single-vehicle or single-squad positioning to prevent effective enemy targeting.

Sustainment forces and the enabling capabilities that support their operational effectiveness have undergone radical transformation. Ammunition stockpiles, casualty evacuation points, and supply hubs are pushed further to the deep rear. Small, agile mobile units now execute resupply and MEDEVAC missions.

Command posts have become high-value, highly detectable targets, requiring underground locations, hardened communications, and drastically reduced electronic emissions.

Despite dramatic transformation at every echelon, the brigade remains the core tactical unit. Brigade-level engagements are now longer in duration. They are composed of diverse, small, dispersed units maintaining tactical deception through concentrated precision fire support—drones and artillery—as part of an integrated air and ground combined force system.

Integrated capability: From tactical innovation to comprehensive doctrine

What began as innovative irregular weaponry has evolved within the Russia-Ukraine conflict into a central pillar of modern warfare—an operational transformation unfolding over the last three years of war. At the heart of this evolution lies the transition from dispersed tactical employment to integrated, structured operational concepts wherein FPV drones are employed systematically as integral combined arms formation components.

Organizational evolution

Core doctrine establishes a clear division between "spotters"—light, inexpensive drones operating deep within enemy territory to identify targets—and "hunter" drones, which receive target data, prioritize threats, and execute precision strikes. This represents an operational evolution. FPV drones are no longer auxiliary tools but enterprise-level capabilities demanding organization, command, control, and logistical support from general staff to platoon level.

Recent data indicate that thousands of FPV drones are produced each day by both sides—numbers sufficient to reshape warfare

fundamentals. FPVs have been fully integrated into combined arms battle systems, supporting fire support, reconnaissance, strike, and ISR missions. Seamless coordination with ground forces enables lethal, rapid, and precise operations.

Battlefield transformation

The close combat zone has become a "death crater" —a decisive engagement area—where exposure in open terrain for more than fifteen minutes frequently results in destruction. The tactical boundary between the forward line and the rear area has effectively collapsed and reaches across a 40-kilometer depth. Static positions, both tactical and operational, are rapidly detected, targeted, and neutralized. As a result, the forward area has effectively evacuated rearward, eliminating traditional sanctuary zones and requiring continuous mobility and dispersion.

Commanders attempting to counter FPV swarms through deep-area fire saturation achieve limited success. As drone strike ranges extend beyond 45 kilometers, legacy firepower effectiveness declines, and conventional tactics become obsolete. Victory requires precise system-level management rather than massed firepower alone.

Cost revolution and functional substitution

As FPV drones become entrenched within structured operational frameworks, they force military thinkers worldwide to face profound questions, particularly regarding cost-effectiveness.

Economic analysis

An armed FPV drone costs approximately $500. Assuming only 20% hit probability, successful strikes cost around $2,500. Comparative analysis:

- Javelin missile: ~$78,000
- Basic 155mm artillery shell with fuse: ~$3,000
- Kornet anti-tank missile: ~$30,000
- Hellfire missile: ~$150,000

Functional displacement

Beyond economics, FPV drones pose deep functional and structural challenges as substitutes for multiple existing platforms. Across Ukrainian battlefields, they have become near-universal replacement weapons.

In intelligence target acquisition, FPVs have assumed roles previously filled by tactical UAVs—not through superior quality but through greater survivability and volume. In precision strike roles, they have supplanted traditional firepower (anti-tank guided missiles, direct-fire artillery, tank guns, and conventional tube artillery).

The integrated impact extends even further. Attack helicopter units—once essential to combined arms warfare—have lost relevance. Helicopters have effectively disappeared from the Ukrainian front lines, as they are susceptible to instant destruction by FPVs. Long-range intelligence, surveillance, and reconnaissance platforms have been similarly sidelined as FPVs approach, identify, confirm, and strike targets within single operational cycles.

Air superiority challenged

The FPV revolution profoundly affects air dominance. Traditional air forces increasingly cannot maintain low-altitude superiority—the very airspace where ground forces operate. Combat and transport helicopters have vanished from front lines due to FPV threats.

Ground forces now often "fight alone" in the aerial domain, conducting both attack and defense in close airspace without support from other services. This marks a fundamental break from joint warfare principles. Airspace, once considered safe or supportive, is now an independent combat arena contested in its own right. A new paradigm of the "air ground littoral" (AGL) has arisen. This is a new type of battlefield, one deeply connected to the effectiveness of ground maneuver in its new incarnation.

Human-machine integration

The human-machine relationship in the FPV era continues to evolve. Most current FPVs employ fiber-optic connections offering robust, interference-resistant communications while enabling powerful future capabilities. AI and machine learning integration into operational deployments will soon optimize entire FPV swarms.

Rather than manually controlling individual drones, operators will assign missions to drone clusters according to parameters including range, munitions, sensors, target types, and terrain. This paradigm will dramatically reduce operator requirements, lower training costs, and improve response speed and strike precision with minimal human involvement.

Military thinking: Cognitive barriers and strategic opportunities

Despite clear tactical evidence, repeated battlefield validation, and extraordinary FPV effectiveness, military thinking in most armed forces lags operational reality. Deep-seated conceptual barriers prevent appropriate response development, leaving operational formations trapped in pre-drone paradigms while battlefields have shifted into different operational categories.

Conceptual challenges

Attack drones were initially perceived as limited tools for overhead munitions delivery, prompting irrelevant responses like cage armor and vehicle netting. However, FPV resilience to electronic warfare and transition to horizontal attack profiles have created threats unmatched by existing means.

Rigid bureaucratic structures, hierarchical inertia, and fragmented responsibilities prevent most militaries from systemically conceptualizing this phenomenon. This produces intellectual fragmentation in which each service considers single aspects rather than comprehensive implications.

Scale appreciation

The most significant conceptual blind spot involves scale appreciation. The fact that Russia and Ukraine now produce over one million FPV drones annually—independent of Chinese or Western production—remains perceived through traditional frameworks as unrealistic. Internalizing the implications of mass production—such as coordinated 10,000-drone swarms across 10-kilometer fronts—reveals deep operational and strategic shifts with no current effective countermeasures.

Implications for modern armed forces:
Operational urgency and strategic opportunity

While only Russia and Ukraine have achieved full-scale FPV operational capacity, modern armed forces must advance beyond pilot programs toward systemic transformation. The reasonable working assumption regarding adversaries is full FPV doctrine adoption**.**

Development acceleration

Tactical and systemic approaches to FPV warfare must be adopted, ensuring broad operational deployment across forces. Recent combat experience reveals existing gaps: drones entered battlespace through *ad hoc field-driven adaptation rather than structured planning, with cultural friction and inter-service rivalries impeding integration.*

Integration domains

Two principal domains are emerging around FPV warfare:

1. **Combined arms maneuver:** Ground forces must incorporate FPV as organic enablers within operational frameworks, integrating them into combined arms maneuver to enhance lethality, situational awareness, and tactical reach. These systems should be employed while maintaining air-ground integration and ensuring effective force protection against hostile FPV threats—preserving freedom of action for maneuver elements.

2. **Air defense:** FPV drones constitute a low-altitude lateral threat vector with engagement ranges extending up to 20 kilometers and the potential for saturation attacks. Their employment necessitates the development and fielding of completely new weaponry, tactical concepts of counter-UAS (C-UAS) capabilities, revised engagement procedures, and the establishment of integrated force protection frameworks at the tactical and operational levels.

Implementation requirements

Progress requires large-scale integration of standardized FPV platforms across all units, creating critical mass for new operational forms and full force-wide structuring. These demands must overcome bureaucratic barriers, particularly in safety and command-control pathways, to enable frontline units to employ cost-effective weaponry. Dedicated branch officers must centralize all professional domain aspects. Dedicated armaments directorates should be established for entire low-altitude near-ground domains—unlike the current fragmented divisions between artillery, air defense, air force, and intelligence services.

There is a clear need for dedicated FPV simulators enabling high-quality rapid training, as well as for maintenance framework adaptation to support uninterrupted field operations. All initiatives must establish a mass-production framework for the required supply volumes.

Defensive considerations

FPV represents a revolutionary offensive capability. This demands not only operational deployment but parallel development of effective defensive technologies. Currently, attack costs significantly exceed defense costs—but history demonstrates that effective defensive counters can decisively shift the strategic advantage.

Conclusion

FPV warfare is fundamentally reshaping modern battlefield rules, enabling precise, effective strikes against targets at extended ranges and in complex terrain while dramatically reducing soldier risk and integrating seamlessly into broader combat systems.

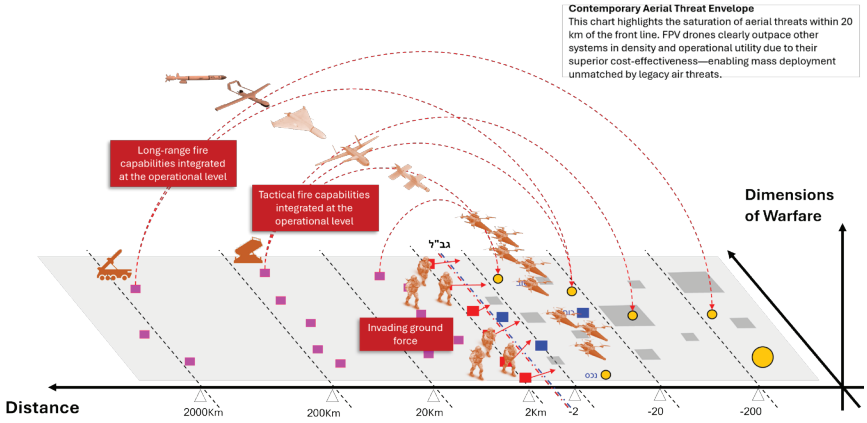
The true power of this challenge lies not merely in low cost or advanced technology. It lies in the broad range of operational applications it enables when approached as a coherent systemic doctrine encompassing multi-service coordination, intelligence, strikes, command, and maneuver.

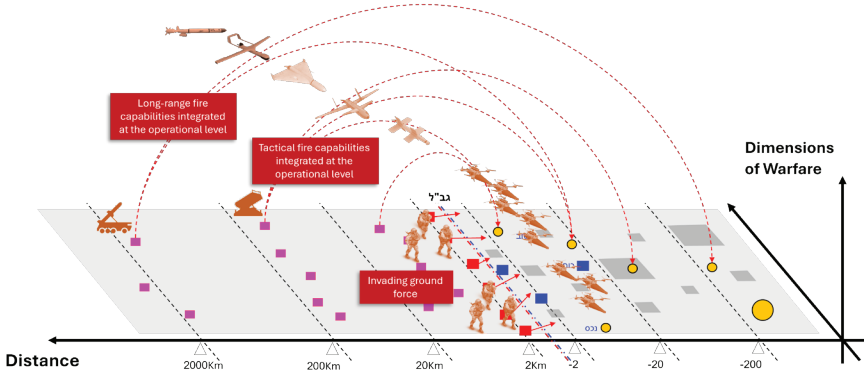
While initially appearing to be simply a disruptive threat, FPV warfare represents a major opportunity. A new, effective, operationally decisive weapon has entered the arena—one that offers a clear advantage to early adopters who integrate it as a core pillar of operational superiority.

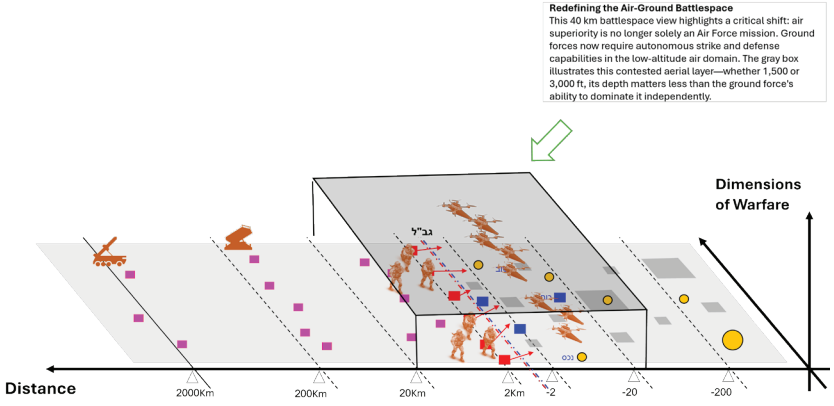
Conversely, those who fail to adapt face doubly steep prices. Military organizations unprepared for both legacy and emerging threats will find themselves at a significant disadvantage, confronting the dual burden of simultaneously solving yesterday's problems while addressing tomorrow's challenges.

The FPV revolution is not coming—it has arrived. The question is not whether to adapt but how quickly and comprehensively adaptation can be achieved.

Illustrations







Supporting links

Needless to say, there are thousands of relevant videos and articles floating around the web. We have chosen to include here the videos that, in our opinion, clarify and illustrate what is written in this paper.

"A-10 Thunderbolt II in Action • Heavy Hitting Air Power. "YouTube video, 8:11. Posted by "US Military Channel," March 1, 2024. https://www.youtube.com/watch?v=zBPdqXs8klw.

"AUSA 2023 - Army Modernization and Future Capabilities." YouTube video, 1:23:24. Posted by "Defense Now," October 10, 2023. https://www.youtube.com/watch?v=69IQUCXmvbI.

"How the US Military's Drone Swarms Will Dominate Future Wars." YouTube video, 8:08. Posted by "Sandboxx," August 29, 2023. https://www.youtube.com/watch?v=qWr75snGRyw.

"Inside Ukraine's Drone War | WSJ Documentary." YouTube video, 26:32. Posted by "Wall Street Journal," February 16, 2024. https://www.youtube.com/watch?v=P0CcM7dM7NI.

"Inside Ukraine's Surprising Success Against Russia's Military." YouTube video, 12:48. Posted by "Vox," December 21, 2022. https://www.youtube.com/watch?v=I_8hh7iNqdE.

"Russia's War in Ukraine: Explaining the Conflict | Start Here." YouTube video, 12:36. Posted by "Al Jazeera English," February 28, 2022. https://www.youtube.com/watch?v=Xs8Wa8lXjf8.

"The Evolution of Warfare in Ukraine | FRONTLINE." YouTube video, 26:23. Posted by "FRONTLINE PBS | Official," February 13, 2024. https://www.youtube.com/watch?v=DtSrjVb3E9U.

"Why the US Military is Developing Thousands of Drones." YouTube video, 11:15. Posted by "CNBC," October 1, 2023. https://www.youtube.com/watch?v=g730zKnitNY.

Bibliography

Giffen, David M. "The Air-Ground Littoral and Great Power Conflict." *Æther: A Journal of Strategic Airpower & Spacepower* 3, no. 3 (2024): 53–66.

Gventer, Celeste Ward. "Army Aviation and Decisiveness in the Air-Ground Littoral." *Association of the United States Army (AUSA)*, December 18, 2023. https://www.ausa.org/publications/army-aviation-and-decisiveness-air-ground-littoral.

Horn, Daniel, and **Ryan M. Hohman.** "Full Speed Ahead: Integrating Kinetic Drones into the Combined-Arms Battalion." *Association of the United States Army (AUSA)*, February 21, 2024. https://www.ausa.org/publications/full-speed-ahead-integrating-kinetic-drones-combined-arms-battalion.

Kofman, Michael, and **Jack Watling.** "Tactical Developments During the Third Year of the Russo–Ukrainian War." *Royal United Services Institute (RUSI)*, February 22, 2024. https://rusi.org/explore-our-research/publications/commentary/tactical-developments-during-third-year-russo-ukrainian-war.

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