sciendo International Conference KNOWLEDGE-BASED ORGANIZATION
Vol. XXXI No 3 2025

THE OPERATIONAL BENEFITS OF FUNCTIONAL AND STRUCTURAL OPTIMIZATION OF FIRST PERSON VIEW UAVS IN THE ROMANIAN ARMED FORCES

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Abstract: *The modernization of Romania's military capabilities requires the adoption of technological solutions that can effectively address the demands of contemporary operational environments. This study analyses the functional and structural optimization of a First Person View (FPV) unmanned aerial vehicle (UAV), emphasizing its potential in tactical missions, reconnaissance, and operational support. The core research question focuses on how such a platform can enhance operational efficiency and reduce logistical footprint.*
Using a qualitative methodology based on documentary analysis and functional modelling, the study proposes a UAV architecture tailored to the current requirements of the battlefield. Results highlight significant advantages in terms of mobility, decision-making speed, and tactical integration. The paper concludes with a set of recommendations for integrating FPV systems into Romania's military structures as a strategic element in defence capability transformation.

Keywords: FPV drone, functional optimization, national defence, hybrid conflict, operational integration, functional modelling

1. Introduction

The rapid transformation of the international security environment, alongside the increasing prevalence of hybrid threats and the accelerating role of technology in modern warfare, calls for the doctrinal and technological adaptation of armed forces. In this context, the current article explores the functional and structural optimization of First Person View (FPV) Unmanned Aerial Vehicles (UAVs), with the aim of evaluating their integration potential into the operational structure of the Romanian Armed Forces.
The research problem addressed stems from the absence of a clearly defined doctrinal and operational framework for the use of FPV drones in Romania, despite extensive evidence of their tactical utility in recent conflicts such as the Russian-Ukrainian war. FPV systems have demonstrated significant cost-effectiveness and operational impact, particularly in reconnaissance, precision strike, and electronic warfare missions.
The main research objective is to assess the extent to which FPV drones can enhance operational efficiency, tactical flexibility, and logistical sustainability within the Romanian military. From this general objective, three secondary objectives were derived:
To identify and analyze the key technical and structural parameters relevant to FPV drones (speed, autonomy, payload, resilience, integration into C4ISR systems);
To extract applicable lessons from current military conflicts, with a focus on Ukraine's

DOI: 10.2478/kbo-2025-0079

experience with FPV drone integration;
To formulate a set of strategic recommendations for the adaptation of Romanian defense structures to incorporate such systems.
Given the exploratory nature of the topic, the research adopts a qualitative methodological approach, combining two primary instruments:
Documentary analysis – involving a structured review of military doctrines, technical specifications, field reports, NATO and DoD classifications, and academic publications on unmanned systems;
Functional modeling – used to evaluate the mission suitability, control architecture, and tactical integration of FPV drones in various operational scenarios (e.g., within a mechanized brigade), through hypothetical deployment schemes and system diagrams.
This article is structured into three main sections:
(1) strategic and doctrinal contextualization of FPV UAVs;
(2) technical–tactical evaluation of their performance characteristics and comparative advantages over traditional UAVs;
(3) operational recommendations tailored to Romania's defense context.
Author's original contributions include:
A simplified comparative classification of UAV systems based on NATO/DoD standards;
The development of an original conceptual model for the integration of FPV drones in a Romanian tactical unit structure;
A scenario-based estimation of equipment, personnel, and cost requirements;
The identification of obstacles specific to the Romanian defense landscape and proposals for mitigation based on international best practices.

2. Unmanned Aerial Systems – Classification and Utility in Military Operations

Over the past decade, the concept of the "drone" has gained significant traction in both military operations and public discourse, often associated with targeted strikes, strategic dominance, and privacy concerns. These associations are largely the result of a limited understanding of the capabilities and intended uses of Unmanned Aerial Systems (UAS).
NATO defines drones—referred to professionally as Unmanned Aerial Vehicles (UAVs) or Unmanned Aerial Systems (UASs)—as "aerial vehicles that do not carry a human operator, use aerodynamic forces to fly, are capable of autonomous operation or remote piloting, and may be recoverable or expendable, with or without lethal payloads" [1]. This definition excludes ballistic or cruise missiles and artillery projectiles. The absence of an onboard pilot is the key feature, reducing risks to military personnel.
Another definition emphasizes UAVs as non-passenger aerial platforms capable of autonomous or remote-controlled flight, sometimes utilizing artificial intelligence. UAVs are employed in research, surveillance, target acquisition, and intelligence gathering (ISR), offering the advantage of remote operation from secure distances, which enhances operator safety. However, control centers can also become strategic targets.
In combat contexts, UAVs provide enhanced precision and situational awareness. A notable example is the MQ-1 Predator [2], initially developed for ISR missions. Deployed during the 2003 Iraq invasion, it was later upgraded to carry offensive payloads, supporting ground operations. Its successor, the MQ-9 Reaper [3], marked a significant advancement with capabilities for both strategic ISR and precision strikes. These Unmanned Combat Aerial Vehicles (UCAVs) have played key roles in operations across Yemen, Pakistan, and Somalia.
While UAVs are widely used by military and governmental agencies, their legal regulation under International Humanitarian

Law remains ambiguous. Drone operations are typically assessed based on the operator's location and adherence to the laws of armed conflict. According to Boyle M. J, the applicable legal norms in the use of unmanned systems are determined primarily by the operational context, rather than by the system's level of autonomy [4].
To provide a more structured understanding of UAV types, *Table 1* presents a classification based on NATO and U.S. DoD standards, covering weight, altitude, range, endurance, and operational roles:

Class I (Small) • Weight: < 20 kg • Operational Altitude: < 150 m • Range: < 10 km • Endurance: 1–2 hours • Primary Role: Tactical ISR (platoon/company level) • Examples: RQ-11 Raven, Black Hornet
Class II (Medium) • Weight: 20–150 kg • Operational Altitude: 150–900 m • Range: 50–200 km • Endurance: 5–10 hours • Primary Role: Extended ISR, light support (battalion level) • Examples: ScanEagle, Puma AE
Class III (Large) • Weight: > 150 kg • Operational Altitude: > 900 m • Range: > 200 km • Endurance: 24+ hours • Primary Role: Strategic ISR, precision strike (brigade/corps level) • Examples: MQ-1 Predator, MQ-9 Reaper

Table 1: Simplified NATO/DoD UAV Classification

To illustrate the key architectural and operational distinctions, *Figure 1* presents a comparative diagram between FPV drones and conventional UAVs. Conventional UAVs typically rely on structured command-and-control architectures and incorporate varying degrees of autonomy. In contrast, FPV drones are characterized by direct, real-time human control through simplified systems, prioritizing low-latency responsiveness over autonomous function.

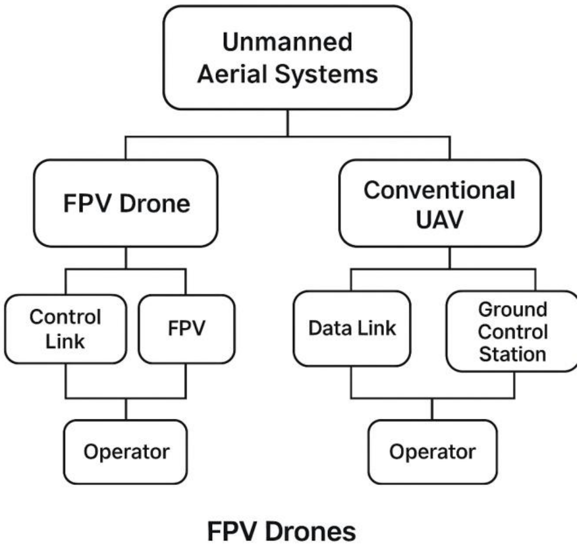

Figure 1: Comparative architecture of FPV vs. conventional UAV systems

3. The Impact of Unmanned Aerial Systems in the Russian-Ukrainian conflict

In the ongoing Russian-Ukrainian conflict, UAVs have been used extensively by both sides. Ukraine has employed a variety of systems, ranging from the Turkish-made Bayraktar TB-2 to hobbyist drones that support civilian resistance efforts. Although evidence of UAV use by Russian forces was limited at the beginning of the conflict, it was later confirmed that they deployed systems such as the Orlan-10 and KUB-BLA (Aleph News, 26.05.2025). Drones have been used in multiple scenarios with varying roles — from carrying out precision strikes to guiding artillery and conducting surveillance and reconnaissance missions.
This conflict offers valuable lessons regarding the use of UAV systems and should influence the thinking of commanders, policymakers, and military leaders within NATO concerning strategies related to the role, positioning, and methods of employing UAVs in combat. Additionally, significant attention should be given to adjusting traditional concepts of air superiority in armed conflict.

A conflict that began with Russian tanks crossing into Ukraine and Soviet-style artillery bombarding targets in a manner reminiscent of World War I has now evolved into a more modern dimension. Soldiers are monitoring troop movements on screens connected to small drones flying over the battlefield. With hundreds of reconnaissance and attack drones flying over Ukraine every day, the war—initially waged to seize territory—has transformed into a digital competition, where technological superiority in drone warfare plays a crucial role.

Ukrainian attacks weakened Russian forces and paved the way for the advance of ukrainian troops. UAVs enabled the operation commander to monitor the troops' progress in real time. "We had the complete picture of the battle," said Colonel General Oleksandr Syrsky, commander of the Ukrainian ground forces. The result was a remarkable withdrawal of Russian forces.

Although Russia had developed its UAV capabilities in recent years, these systems were not widely used at the beginning of the conflict. The exact reasons remain unclear, but it is believed that a lack of training and military preparedness hindered their effective deployment by Russian forces.

Drones provide essential visibility on the battlefield. To monitor enemy movements, the Ukrainian army established a reconnaissance drone unit called "Eyes" in the spring of 2022. The teams, made up of four members each, were deployed along the eastern front and operated UAVs daily, except on rainy days [5].

In September 2022, while monitoring various areas, members of one such team spotted several Russian soldiers near a cart in a cornfield located in the Russian-occupied region of Kharkiv. The drone continued to track them to see if they would return to their base, demonstrating the effectiveness of drones in enemy surveillance.

The Matrice 300, a drone weighing approximately 8 kg and costing around $40,000 including its accessories, is one of the most affordable tools of war. This small and relatively inexpensive commercial drone has made the war in Ukraine unique by providing unprecedented visibility and high precision for artillery fire. Traditional attack drones, such as the Turkish-made Bayraktar TB2 used by Ukraine or the Iranian Shahed-136 used by Russia, play a significant role in combat. However, there is a growing preference for commercial drones, which can drop various types of bombs on groups of soldiers or other targets.

The Russian-Ukrainian conflict has become a true testing ground for new military technologies, with First Person View (FPV) drones emerging as one of the most effective and accessible tools for engaging enemy forces. Unlike traditional reconnaissance or strike UAVs, FPV drones stand out due to their low cost, extreme maneuverability, and tactical efficiency that far exceeds their investment.

These drones are operated by human controllers in real time using VR goggles or video screens, allowing them to navigate complex environments and strike precise targets directly — from tanks and armored vehicles to artillery positions and sensitive electronic equipment. Some units are equipped with high-resolution cameras and improvised explosive payloads, adapted for kamikaze missions or hit-and-return operations.

One of the reasons FPV drones have become essential in Ukrainian military doctrine is their ability to neutralize expensive Russian platforms, such as T-72 and T-90 tanks, using equipment that rarely costs more than a few hundred dollars. While Russia invests millions in armored vehicle protection, Ukraine responds with a cheap, mobile, and lethal solution—often built with commercial off-the-shelf (COTS) components or through 3D printing [6].

By early 2025, Ukraine had succeeded in producing over 200,000 FPV drones per month, using decentralized networks of workshops and state-coordinated startups. This asymmetric industrial mobilization has changed the dynamics of the conflict: the Ukrainian army is not only able to respond to attacks but also to develop tactical initiative on multiple fronts through surveillance, reconnaissance, strike missions, and artillery fire adjustment.

Integrating these drones into digital command and control networks, such as Kropyva or Delta, significantly boosts operational efficiency. Data collected by FPV drones is transmitted in real time to support units, which can then launch counterattacks or adjust artillery trajectories with centimeter-level accuracy. In this way, drones become nodes in a distributed military network, contributing to information superiority and reduced response times.

In the long term, the use of FPV drones in Ukraine represents more than just a technological innovation—it is a model of adaptive, decentralized warfare characterized by high resilience and intense civil-military cooperation. The production and operation of these drones involve not only soldiers, but also engineers, volunteers, private sponsors, and software developers, forming a networked warfare ecosystem [7].

The tactical success of FPV drones was no accident—it was the result of a coherent, adaptive strategy supported by close collaboration between the military sector, the private sector, and civil society. What sets Ukraine apart from other states is its ability to innovate rapidly, prototype locally, and scale production in a very short time, effectively turning drones into a true force multiplier.

A notable example is the "Queen of Hornets" model, an FPV drone developed by Ukrainian producers such as Wild Hornets, capable of carrying and launching 2 kg grenades with high precision. It adds a new dimension to combat tactics—combining the stealth and mobility of a small drone with the firepower needed to neutralize fortified targets. With a range of up to 5 km and a speed of approximately 120 km/h, it is well-suited for dynamic operations deep within enemy territory.

From a technical-tactical perspective, the FPV drones used in Ukraine exhibit the following common characteristics [7]:

- **Flight speed:** between 100–120 km/h
- **Operational range:** 3–5 km (with experimental versions reaching up to 40 km)
- **Payload capacity:** between 0.5 and 2 kg
- **Average/standardized cost:** between $300 and $800 per unit
- **Components:** mostly COTS (Commercial Off-The-Shelf), often 3D printed or manually assembled
- **Control:** real-time FPV with secure digital video transmission, and in some cases, fiber-optic flight systems for jamming immunity.

A key element in fully leveraging these platforms is their integration into digital command and control networks such as **Kropyva** (an open-source developed system) or **Delta** (an operational platform at NATO level). These networks enable real-time information fusion, allowing data transmitted by FPV drones to be instantly processed for [8]:

- guiding artillery fire,
- adjusting tactical plans,
- dynamically monitoring the battlefield.

Drones are no longer merely tools for isolated strikes but are now components of an interconnected combat system capable of functioning even under conditions of enemy technological superiority (e.g., jamming, electromagnetic disruption, air superiority).

In addition to offensive capabilities, Ukraine has also developed interceptor drones—fast FPV units capable of destroying enemy drones mid-flight. These represent a low-cost but highly effective solution in response to the proliferation of kamikaze systems used by the Russian Federation (e.g., Shahed-136). Unlike surface-to-air missiles or traditional anti-aircraft weapons, interceptor FPVs are scalable, fast, and accessible, providing a viable option for defending critical points.

Ukraine has managed, in just a few years, to become a model drone superpower—not through massive budgets, but through organizational agility, decentralization, and adaptability. The experience gained offers important strategic lessons for NATO, especially for Eastern European countries like Romania that aim to enhance their autonomous defense capabilities within moderate budget constraints.

The large-scale deployment of Unmanned Aerial Systems (UAS) by Ukraine during the conflict with the Russian Federation offers Romania several concrete and applicable lessons, as well as important warnings:

Replicable Elements

a) Decentralized drone production

• Description: Ukraine successfully coordinated national production through small workshops, startups, and academia.

• Applicability in Romania: Romania has a growing tech/startup ecosystem and engineering universities that could be mobilized similarly.

b) COTS component use

• Description: Use of commercial parts and 3D printing for FPVs significantly reduced costs and simplified logistics.

• Applicability in Romania: Romania can access EU supply chains and stimulate local COTS innovation and manufacturing.

c) Civil-military collaboration

• Description: Ukrainian success was built on strong cooperation between military structures, civilian volunteers, and private entities.

• Applicability in Romania: Romania could replicate this through defense-industry partnerships, dual-use technology incentives, and volunteer tech initiatives.

d) Rapid prototyping and adaptation

• Description: Ukraine developed and tested new drone models in weeks rather than years.

• Applicability in Romania: Romania's SMEs and research centers can develop similar agile prototyping frameworks under MOD coordination.

Potential Obstacles

a) Regulatory rigidity

- Challenge: Existing Romanian legislation may lack flexibility for rapid drone acquisition, testing, or local production.
- Mitigation: Legislative updates enabling emergency procurement and simplified certification for dual-use drones.

b) Lack of digital C2 infrastructure

- Challenge: Ukraine’s success relied heavily on systems like Kropyva and Delta for real-time ISR fusion.
- Mitigation: Romania must invest in secure, integrated battlefield management systems tailored to drone operations.

c) Electronic warfare vulnerability

- Challenge: FPV systems are often exposed to jamming without fiber-optic or anti-jamming tech.
- Mitigation: Investment in hardened FPV variants and EW-resilient control technologies.

d) Bureaucratic inertia

- Challenge: Slow institutional coordination may block decentralized innovation.
- Mitigation: Establishing interagency coordination cells focused on UAS innovation and rapid acquisition.

Key Contextual Differences

Ukraine:

• War on national territory, existential threat.

Romania:

• NATO member, facing primarily deterrence missions.

Ukraine:

• Full mobilization of society and industry.

Romania:
• Partial mobilization, peacetime regulations still apply.
Ukraine:
• Immediate operational needs prompted innovation.
Romania:
• Romania must prepare preemptively, not reactively.

Romania can draw on Ukraine's successful drone strategy to modernize its military capabilities at low cost and high speed. However, this requires both a **strategic vision** and **operational flexibility**, alongside legal, institutional, and technological reforms. The Romanian Armed Forces must proactively adapt to the emerging paradigm of decentralized, resilient, and networked warfare to remain relevant in the evolving security environment of NATO's eastern flank [9].

Figure 2: Venn diagram comparing applicable lessons for Romania with the Ukrainian experience

4. Advantages of Integrating FPV Drones into the Romanian Armed Forces

The integration of First Person View (FPV) drones into the Romanian Armed Forces could represent one of the most effective and sustainable responses to modern operational challenges. The recent experience of the Ukrainian armed forces in the war with the Russian Federation has demonstrated that these seemingly simple and low-cost drones can produce disproportionately large tactical and strategic effects relative to the required investment. Far from being just improvised flying devices, FPV drones have become key tools for surveillance, reconnaissance, precision strikes, and even active air defense—especially in the context of high-intensity conventional warfare.

Tactical Scenario: FPV Drone Support for a Romanian Mechanized Brigade

Hypothetical Context

A Romanian mechanized brigade conducts a defensive operation across a 20 km sector in southern Dobrogea. The area is exposed to both conventional threats (tanks, artillery) and asymmetric threats (infiltration teams, kamikaze drones).

Roles of FPV Drones:

- **Continuous surveillance** along potential enemy approaches
- **Precision strikes** against armored vehicles or supply columns
- **Tactical air denial** (neutralizing enemy drones)
- **Artillery fire correction** and target acquisition

Resource Estimate for One Mechanized Brigade:

Component and estimated value

- Number of FPV drones (combat + ISR): ~300 units / month;
- Ground control stations (GCS/VR sets): 40 units (minimum 1 per operator pair);
- FPV operating cells (2–3 personnel): 20 active teams (with 3-shift rotation);
- Unit cost per FPV (with payload): $500–800;
- Estimated monthly operational cost: ~$250,000;
- Additional equipment: antennas, portable routers, power sources;
- C2 network integration: 5–10 terminals/brigade + secure battlefield network;
- Required training: ~2 weeks/operator (including VR simulation).

Systematic integration of FPV drones to support mechanized brigades could significantly enhance Romania's operational flexibility, survivability, and precision strike capability. With relatively modest investments in training, equipment, and network infrastructure, Romania could develop a drone-enabled combat force that complements traditional assets, increases deterrence, and improves resilience in both conventional and hybrid warfare scenarios.

5. Conclusions

The scientific undertaking aimed to explore and substantiate the advantages offered by the functional and structural optimization of First Person View (FPV) drones for their integration into the operational structure of the Romanian Armed Forces. The main objective—evaluating the potential of these platforms to enhance the efficiency, flexibility, and logistical sustainability of the armed forces—was achieved through a structured qualitative study based on documentary analysis, functional modeling, and relevant case studies.

The three proposed secondary objectives were also achieved in a coherent manner:

- The essential technical and structural parameters for tactical-operational efficiency were identified and analyzed: speed, payload, unit cost, autonomy, maneuverability, and capacity for integration into C4ISR networks;
- Lessons drawn from the Russian-Ukrainian conflict highlighted the crucial role of FPV drones in redefining the balance of power through their use in reconnaissance missions, precision strikes, and electronic warfare;
- Concrete proposals were formulated for the development of a national capability based on decentralized production, doctrinal adaptation, and specialized training.

Regarding the research questions, the conclusions obtained are as follows:

- Optimizing FPV drones requires a modular and adaptive approach that allows for payload customization, increased resistance to jamming, and integration into digital command networks; The comparative advantages over traditional UAVs lie in their lower cost, ability to operate in difficult terrain, tactical flexibility, and rapid responsiveness in dynamic environments;
- Conditions for effective integration include: a clear doctrinal framework, technological training for personnel, civil-military partnerships for local production, and investments in supporting digital infrastructure.

The research results indicate that Romania has the opportunity to implement a sustainable model of military modernization through the integration of FPV drones—at low cost but with high operational impact. This model, partially inspired by Ukraine's success, is well-suited to Romania's geopolitical context and budgetary realities.

My personal conclusion is that the future of military operations will not be defined solely by complex and expensive technologies, but by the ability of states to adopt fast, intelligent, and scalable solutions. The FPV drone represents not just a technical resource, but a paradigm shift in military thinking: from centralization to decentralization, from reaction to anticipation, from volume to precision.

This paper is intended to serve as a starting point for military and civilian decision-makers interested in redefining defense capabilities in an efficient, realistic, and fully aligned manner with the trends of contemporary warfare.

References

[1] NATO. (n.d.). Glossary of Terms and Definitions (APP-6). NATO Standardization Office. https://www.cimic-coe.org/resources/external-publications/app-6-c.pdf.

[2] U.S. Air Force. (n.d.). MQ-1B Predator. https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104469/mq-1b-predator/.

[3] U.S. Air Force. (n.d.). MQ-9 Reaper. https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104470/mq-9-reaper/.

[4] Boyle, M. J. (2020). The Drone Age. Oxford University Press.

[5] Bocancea, S. (Coord.). (2023). Războiul din Ucraina. Un conflict regional cu efecte globale. Editura Polis Books. https://revistapolis.ro/wp-content/uploads/2023/10/Razboiul-din-Ucraina-TIPO-1.pdf.

[6] Gosselin-Malo, E. (2024, August 8). Cheap first-person-view drones now hunting larger prey in Ukraine. Defense News. https://www.defensenews.com/global/europe/2024/08/08/cheap-first-person-view-drones-now-hunting-larger-prey-in-ukraine/.

[7] Khurshudyan, I., Ilyushina, M., & Khudov, K. (2022, December 2). Russia and Ukraine are fighting the first full-scale drone war. The Washington Post. https://www.washingtonpost.com/world/2022/12/02/drones-russia-ukraine-air-war/.

[8] Milasauskas, T., & Jaškūnas, L. (2024, June 20). FPV drones in Ukraine are changing modern warfare. Atlantic Council. https://www.atlanticcouncil.org/blogs/ukrainealert/fpv-drones-in-ukraine-are-changing-modern-warfare/.

[9] Molloy, O. (2024). Drones in Modern Warfare: Lessons Learnt from the War in Ukraine (Occasional Paper No. 29). Australian Army Research Centre. https://researchcentre.army.gov.au/sites/default/files/241022-Occasional-Paper-29-Lessons-Learnt-from-Ukraine_2.pdf.