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Abstract

The evolution of warfare is increasingly centred on the integration of First-Person View (FPV) armed drones that combines low-cost accessibility with high-precision lethality. This paper explores the mechanics, tactical roles, and psychological aspects of FPV combat flying, particularly in High-Altitude Areas (HAA) and Line of Control (LC) scenarios. Unlike advanced UAVs and guided munitions, FPV drones provide operators with real-time manual control, agility, and adaptability in contested and GPS-denied environments. Drawing from recent conflicts such as the Russia-Ukraine war, the study highlights FPV drones' dual role in reconnaissance and strike operations, while also addressing limitations including payload capacity, electronic warfare threats, and extreme environmental conditions. Future recommendations emphasise structured training, troop selection, AI-assisted simulation, and battlefield innovation to enhance combat effectiveness. FPV drones are reshaping the tactical and psychological landscape of modern warfare and remains a critical determinant of future combat outcomes.

Keywords: FPV drones, combat flying, high-altitude warfare, Ukraine-Russia conflict, drone tactics, electronic warfare, infantry integration, battlefield innovation

Introduction

As warfare evolves, so does the technology behind it. Since the early 1900s, the pursuit of flight has transformed battlefield dynamics, now culminating in First-Person View (FPV) armed drones. These systems offer pilots a bird's-eye perspective and unmatched agility, enabling rapid decision-making and precision strikes once reserved for fighter pilots. More than a tool, FPV flying marks a tactical and psychological shift (Kozatskyi, 2023), creating a near-instinctive connection between man and machine. Their impact has been particularly evident in conflicts like the Ukraine-Russia war, wherein FPV drones have proven indispensable for reconnaissance, fire support and direct engagement with enemy assets (Ibrahim A. , 2024). Unlike traditional aerial platforms, these drones thrive in contested environments, slipping past conventional air defences to deliver lethal payloads with pinpoint accuracy. This paper examines the intricate mechanics of FPV combat flying, the tactical role of these drones in high-altitude warfare especially in LC scenario and the operational challenges they face in HAA and the growing need to adapt and evolve drone operations in modern warfare.

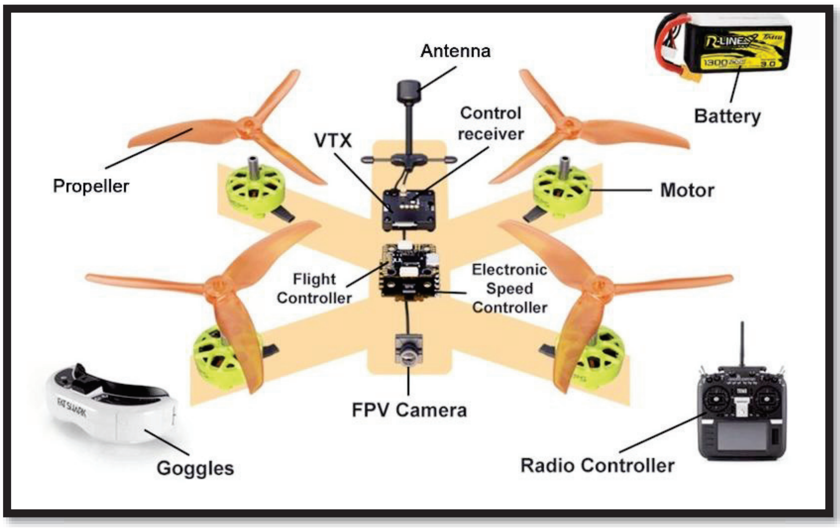
Flight Mechanics and Core Movement

This section breaks down the core technology and flight mechanics of FPV drones to build a foundational understanding of their combat potential. Grasping how each component functions— both individually and as a system, and is essential for appreciating the drone's tactical capabilities, limitations and adaptability. This technical insight sets the stage for the upcoming sections, where flying, tactics and training are explored in greater detail.

Understanding Flight Mechanics

FPV drones rely on several critical components to ensure operational effectiveness in combat. Just as the human body functions as an integrated system, each part of an FPV drone serves a specific purpose, working in unison to enable agility, precision and lethality in battle. The airframe of an FPV drone acts as its skeletal structure, providing the necessary strength to endure high-G manoeuvres while remaining lightweight for agility. Similar to the human musculoskeletal system, which balances strength and flexibility, drone frames must be both rigid enough to withstand impacts and light enough to achieve rapid acceleration. The propulsion system—comprising brushless motors and propellers—acts as the muscles, generating thrust to overcome high-altitude air density limitations. This is particularly crucial in HAA scenarios, where thinner air affects lift and power efficiency, demanding optimised motor-propeller combinations to maintain combat effectiveness. The payload serves as the drone’s striking capability, akin to the hands of a soldier delivering a precise attack. Small 500g or lower warheads are sufficient to the neutralise enemy infantry, light vehicles and critical positions while maintaining the drone’s manoeuvrability. These drones also excel in bunker-busting operations along the LC, where entrenched enemy positions require precision strikes in hard-to-reach areas. The FPV pilot's goggles act as the eyes, transmitting real-time battlefield imagery through low-latency analog video feeds, much like a soldier scanning the battlefield for threats.

Figure 1: Parts of FPV drone

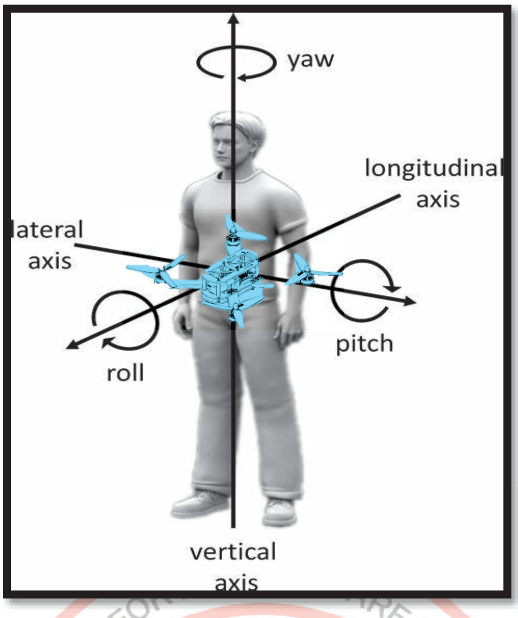


Source: Oscar Liang

Core Movement

The core of FPV drone manoeuvrability lies in its four fundamental control inputs viz. pitch, roll, yaw and throttle. These controls mimic human movement, with 'pitch' corresponding to forward/backward head tilts; 'roll' representing lateral balance; 'yaw' controlling directional shifts; and 'throttle' regulating movement intensity like a soldier's stride. A drone pilot, through fine-tuned radio controller inputs, can seamlessly execute complex manoeuvres in combat dodging counter-fire, adjusting attack vectors mid-flight and exploiting six degrees of freedom that no conventional missile or aircraft can match. This human-like dexterity makes FPV drones an extension of the operator's will, bridging the gap between man and machine and offering a level of situational awareness and control, unmatched by traditional weaponry.

Figure 2: Comparison of FPV with Human Body



Source: Annotated by Author

Understanding Role of FPV Drones

This section compares ATGMs and existing UAVs with FPV drones to highlight the evolving nature of battlefield technology. As modern conflicts demand greater adaptability and affordability in high-altitude and LC scenarios, understanding the functional and tactical differences between these systems helps establish the unique role FPV drones play in shaping the future of frontline warfare.

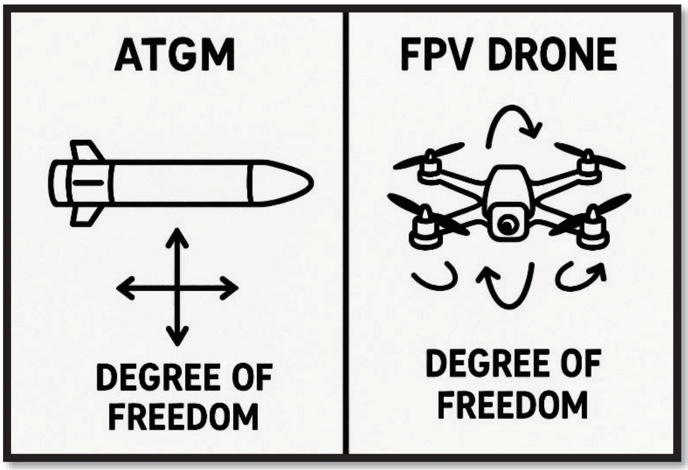
FPV Drone Flight vs High-End UAVs and Quadcopters

Unlike high-end military UAVs like TAPAS-BH-201 or Rustom-II, FPV drones lack autonomous navigation, GPS stabilisation and AI-assisted controls. These advanced UAVs are built for high-altitude surveillance and precision strikes, operating with minimal human input. In contrast, FPV drones are fully manual systems requiring constant pilot engagement, especially in turbulent or hostile environments. Compared to quadcopters like the Q6 Switch UAV or Trinetra, which offer stable hovering, waypoint navigation and ISR capabilities, FPV drones demand far more skill. They react sharply to even minor control inputs, making them difficult to fly—especially with payloads or in narrow, mountainous terrain. FPV pilots use goggles to navigate through low-latency analog feeds, often disrupted by interference. With battery life under 10 minutes and speeds exceeding 100 km/ especially during dives, every second counts. Pilots operate without external orientation, increasing stress and the risk of disorientation. Unlike operators of advanced UAVs with failsafe features and telemetry, FPV pilots rely solely on instinct and real-time judgment. Despite these challenges, FPV drones excel in high-altitude Line of Control (LC) scenarios. Their small size, agility and low cost make them ideal for terrain-hugging flight, surprise attacks and kamikaze missions (Sheikh, 2025). In contested or GPS-denied zones, their manual control becomes a tactical advantage over automated systems.

Drone vs ATGM: Tactical and Functional Edge

Both FPV drones and anti-tank guided missiles (ATGMs) operate using the basic principles of flight viz. pitch, roll, yaw and throttle—but differ greatly in agility and control due to their design and purpose. ATGMs follow a largely predetermined path with limited manoeuvrability, offering only minor in-flight corrections. In contrast, FPV drones are fully manual and utilises six degrees of freedom (6DOF), allowing real-time, dynamic movement in all directions. Drones can sharply adjust pitch to dive or skim terrain, roll to dodge obstacles, yaw to reorient mid-flight and modulate throttle to hover or accelerate instantly. This high level of control gives FPV drones a distinct tactical edge, especially in complex and high-altitude environments wherein terrain and enemy defences demand adaptability. ATGMs are vulnerable to active protection systems due to their predictability, while FPV drones, with their erratic movement and real-time piloting, are harder to track or intercept (Ibrahim A. , 2024). Additionally, drones are far more cost-effective, being priced just under ₹ 25,000 compared to lakhs for ATGMs, as also offers dual functions—live reconnaissance and precision strike (Kozatskyi, 2023). Unlike ATGMs, they face no limitations of back blast, minimum range, or fixed trajectory. The ability to reposition, abort, or strike from multiple angles makes FPV drones a versatile and affordable alternative in modern warfare. Infantry has long employed the principles of flight while manually manoeuvring ATGMs—and now the same instincts and skills can be seamlessly transferred to FPV drone operations.

Figure 3: Comparison of ATGM and FPV



Source: Annotated by Author

Learning the Way of Flying

This section highlights the personal experiences of soldiers learning FPV drone. It covers the mental challenges, such as overcoming fears and mastering a sensitive system, while dealing with real-world difficulties like wind, terrain and temperatures.

FPV Flying Experience

At the tactical level, it has been observed that troops undergoing FPV drone training often experience Barophobia (fear of falling or breaking) and Atelophobia (fear of imperfection or failure), making the learning process mentally challenging. FPV drones are highly sensitive and requires precise control inputs, making them difficult to master initially. However, much like learning to drive a car, with consistent training and practice, proficiency can be achieved. It is essential for operators to develop a comprehensive understanding of FPV drone flight, repair and troubleshooting, as hands-on experience in building and maintaining drones not only enhances operational efficiency but also helps troops overcome Barophobia and Atelophobia, hence, instilling confidence in their flying capabilities. In a two-month battalion-level training course, only 5 out of 20 selected troops are able to fly an FPV drone with confidence, thus, highlighting the steep learning curve involved. FPV simulator training plays a crucial role in preparing operators by enhancing hand-eye coordination, reaction speed and familiarity with drone behaviour across diverse environments. Simulators effectively replicate wind resistance, altitude variations and manoeuvrability constraints, allowing pilots to refine their precision strike techniques in a controlled setting. However, the transition from simulation to real-world combat flying introduces several additional challenges. At high altitudes, unpredictable wind currents can suddenly destabilise a drone mid-flight, extreme cold can impact battery efficiency and drone responsiveness and real-time enemy countermeasures such as signal jamming can disrupt control. These factors make real-world flying significantly more difficult than any simulated training. While simulators provide a foundational skill set, only live training in actual combat conditions can prepare operators for the unpredictable and high-stakes nature of FPV drone warfare.

Figure 4: Phobias of drone Training

Source: Annotated by Author

Tactical Challenges of flying FPV in HAA

Flying an FPV drone in high-altitude combat scenarios presents a range of environmental challenges, demanding exceptional piloting skills and real-time adaptability. Terrain variations and unpredictable weather significantly impacts drone performance, with wind direction affecting both the drone's flight stability and the audibility of its sound. The wind chill factor poses a challenge for the operator, making precise joystick control difficult, especially during prolonged missions. The positioning of the VTX (video transmitter) antenna is crucial, as maintaining a clear signal between the drone and the pilot can be hindered by mountainous obstructions, leading to potential signal loss. Landing in rugged terrain is another major challenge, as uneven ground and strong gusts complicate retrieval and safe descent. Engaging a target through a dive attack is also far more difficult in high-altitude conditions due to turbulence, updrafts and the phenomenon of volumetric lift caused by strong winds interacting with valley systems. Additionally, the natural camouflage provided by mountainous terrain makes it harder for pilots to maintain visual line of sight (LOS), thus increasing the risk of disorientation. These factors require pilots to develop acute situational awareness and finely tuned control over pitch, roll, yaw and throttle to navigate effectively, counteracting wind disturbances and ensuring precision strikes. The extreme cold further affects battery efficiency, reduces operational flight time and demands careful power management to maximise combat effectiveness. High-altitude FPV drone operations, therefore, necessitates not only technical expertise but also an in-depth understanding of environmental variables to ensure mission success in hostile conditions.

Figure 5: Environment effects on FPV

Source: Photo by Author

Recommendation and Future Developments

Improving FPV Flying

It is important to focus on practical and accessible training methods. First, we can simplify the learning process by focusing on core functions like take-off, flight path control and target engagement. This ensures soldiers understand the basic mechanics without feeling overwhelmed. Additionally, creating a structured training program, that includes both theoretical knowledge and hands-on practice, and will allow operators to gain confidence. Introducing FPV drone operation in phases, starting with simple flight drills and progressing to more complex missions, ensures soldiers build the necessary skills progressively. A key factor in improving FPV flying is establishing a buddy system, where experienced operators mentor newcomers. This fosters a collaborative learning environment, enhancing overall proficiency. Regular practice and real-world scenarios should be integrated into the training program to help soldiers adapt to various battlefield conditions, from rugged terrain to high-altitude operations. Furthermore, incorporating the drone operator's role into existing infantry units, similar to other specialised roles, ensures that the responsibility is shared, making it easier to integrate drone usage. Lastly, using operational feedback from real missions to continually refine techniques, identify pain points and adjust training methods will keep the FPV flying process evolving and relevant to combat needs.

Troops Selection and Future Developments

To enhance FPV drone training and troop selection, priority should be given to individuals with strong hand-eye coordination, quick reflexes and resilience under pressure. Practical assessment through multiplayer on smart phones can help identify candidates with natural spatial awareness and reaction speed. Competitive learning with leader boards and incentives can boost motivation (Satam, 2024), while mission-based exercises should include reconnaissance, precision strikes and integration with infantry and artillery. Future developments should focus on AI-assisted training environments replicating real-world combat conditions, night-flying and extreme weather adaptation and custom drone fabrication for battlefield innovation. Encouraging troops to troubleshoot, repair and modify drones will not only enhance operational efficiency but also help them overcome psychological barriers like Barophobia and Atelophobia, thus ensuring that FPV drones are fully exploited as a cost-effective and lethal asset in combat.

Figure 6: Simulator Training

Source: Annotated by Author

Conclusion

FPV armed drones provide low-cost, high-precision strike capabilities, reshaping modern combat (Kesteloo, 2024). Their integration into infantry, mechanised units and fire support roles has revolutionised battlefield tactics in high-altitude environments. However, payload limitations, EW threats and extreme weather conditions present challenges and hence requires further innovation. As military forces adapt, FPV drones will remain a critical asset in future high-altitude conflicts, shaping the evolution of drone warfare.

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About the Author

Captain Aniket Sunil Phadtare is an alumnus of NDA Khadakwasla. The Officer was commissioned into the Kumaon Regiment in 2022 and has taken keen interest in mastering the art of FPV flying and has gained expertise in operations of the same. The Officer is currently posted as Coy Cdr along LoC in Western Ladakh.