Racing to Warfare: The Sociotechnical Evolution of FPV Drones in Ukraine

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Over the past three years, the war in Ukraine has shown the brutal capabilities of modern warfare. While a majority of the battlefield is still dominated by conventional weapons such as artillery, tanks, and small arms, a surprising new feature has defined the ground war in Ukraine: first-person view (FPV) drones. These small drones, which were once racing tools, are now piloted by operators in the battlefield to increase their squads' reconnaissance, anti-vehicle, and anti-personnel capabilities. However, the war in Ukraine marks the first conflict with the mass-adoption of FPV drones in warfare. This begs the question; *what factors have driven the sociotechnical evolution of FPV drones from hobbyist racing tools to frontline combat weapons in Ukraine?*

By understanding why and how a piece of technology such as FPV drones has evolved into a tool for warfare, we can better grasp the broader implications of decentralized military innovation. The adaptation of FPV drones in Ukraine highlights a shift in modern warfare: one where low-cost, commercially available technologies can be rapidly modified for military use outside of traditional state-controlled channels. Unlike conventional military drones, which are expensive and require state-controlled infrastructure, FPV drones rely on open-source modifications, volunteer-driven development, and grassroots ingenuity.

Studying the sociotechnical evolution of FPV drones provides insight into the interaction between relevant social groups, technology, and battlefield necessity. By applying the Social Construction of Technology (SCOT) framework, this paper explores how drone hobbyists, volunteers, soldiers, and military leaders have collectively shaped the transformation of FPV drones into battlefield weapons. This analysis not only sheds light on the emergence of new

military technologies but also raises questions about the potential for global proliferation of DIY military-grade drones.

Sociotechnical Situation

Russia's invasion in 2022 caught Ukraine by surprise and without the means to match Russia's manpower or military industry ("Russia-ukraine war 2022…", 2025). Without an answer to the waves of Russian troops and the shortage of munitions such as artillery shells, the military leaders of Ukraine needed a way to counter the Russian offensive. Taking a step closer to the battlefield, Ukrainian soldiers were struggling to hold their positions against a larger and more equipped army (Chivers & Guttenfelder, 2024). Behind the frontline, civilians of the invaded country sought a way to support their nation lest their homes become the frontline. It is from the needs of these social groups that FPV drones would transform from racing tools into weapons.

Drone warfare is not by any means new to modern military doctrines or strategies with wide use of Unmanned-Aerial-Vehicles (UAVs) for surveillance and combat. However, the introduction of FPV drones is new and a defining trait of the war in Ukraine. FPV drones are small, lightweight drones that are piloted through a camera on the drone, giving the pilot a live feed from the drone's perspective (Dean, 2021). This technology allows pilots to provide reconnaissance and combat capabilities for a relatively low cost and without need for specialized skills. For only a few hundred dollars, fpv drones can be produced and modified to carry explosives. This allows drone operators, with little specialized skill, to destroy multi-million dollar tanks or other important infrastructure critical to the war effort.

During the three years that the war in Ukraine has lasted there has been an exponential growth in FPV drone usage and production (Saballa, 2024). Both the Ukrainian and Russian militaries have incorporated FPV drone warfare into their doctrine and FPV drone production is continuing to increase. From what was a hobbyist and civilian tool, the accessibility and effectiveness of FPV drones has transformed them into a key tool for modern, unconventional warfare, setting the stage for broader implications in future conflicts.

Literature Review

FPV drones have never been used at the scale seen in Ukraine, making this war a turning point for drone warfare. As FPV drone warfare is a somewhat new concept, the literature on how it has developed and is currently changing is scarce. However, there are studies on how similar technologies have evolved such as the plane in World War 1. A paper by Eberhardt (2015) details how planes started out as frail, unarmed reconnaissance vehicles and evolved over the course of the first world war into specialized warfare machines. This path from a relatively new technology used for reconnaissance into a specialized tool for warfare is very similar to the evolution of FPV drones in Ukraine and provides a basis for the ideas behind this research.

While research on FPV drones in warfare is scarce, there are still some reputable sources that detail the impacts of FPV drones on modern warfare as a whole. Kunertova (2023) points out that before this conflict, drones weren't taken as seriously in military strategy, but their widespread use now makes studying them essential. Molloy (2024) looks at their effectiveness on the battlefield, showing how they enhance both offense and defense. However, Kreps et al. (2023) debates whether drones have truly revolutionized warfare or if they're just an extension of existing technology, noting that while drones provide many advantages, they aren't an

all-powerful solution to modern warfare. From these sources, while it is unclear how FPV drone usage will change in the future, they have been established as a potent tool of warfare.

Another area of research that overlaps with FPV drone usage in Ukraine is the repurposing of technology for warfare. In a book by Neville and Dennis (2018), they describe how technicals, or non-standard tactical vehicles, are used and adapted for warfare. Specifically, they describe how Chadian forces gained an advantage over Libya in the Toyota War by repurposing toyota pickup trucks. Similar to this research, FPV drones have and are being repurposed in Ukraine to gain the advantage. This shows that this kind of sociotechnical development is not new and that the concept of repurposing technology for combat purposes is not unique to this study. This study, in fact, builds on this pre-existing literature of repurposing technology due to battlefield necessity.

Theoretical Framework

This paper uses the SCOT framework as a guide to explain how FPV drones went from a racing tool to a battlefield weapon in Ukraine. The SCOT framework claims that technology is shaped by human action and perception and uses terms such as interpretive flexibility and closure to describe how a technology is perceived and used (Bijker et al., 2012). Interpretive flexibility is used to describe how different social groups can view a piece of technology in different ways. For example, FPV drones were widely viewed as racing and hobbyist tools before the war in Ukraine. It is only through the concept of interpretive flexibility that FPV drones can evolve to develop a new meaning as tools of warfare. Closure is when a technology's purpose is ‘stabilized’ and is widely accepted by society. While FPV drones may not solely be

thought of as tools of warfare, they are undoubtedly recognized as a military tool and no longer as just a civilian racing tool.

Methods

The war in Ukraine is a recent event and as such is lacking in major scholarly research, especially in niche areas such as FPV drone usage. This is why the majority of the evidence I have collected is from direct sources such as news articles, military reports, and social media posts. These sources cover content from FPV drone usage to drone production and provide insight into how the use of FPV drones have changed over time in Ukraine and why. However, direct sources like the ones previously listed are vulnerable to bias and are often used as propaganda by both sides of the conflict. This means that the selection and analysis of the evidence must be done properly in order to avoid this bias.

I have selected my evidence mainly from trusted news sources as well as the Armed Conflict Location & Event Data (ACLED), a non-profit, independent data collection organization, for the most accurate quantitative data regarding FPV drones in Ukraine. I have also selected sources from official military reports to explore the insight of militaries on the use of FPV drones in warfare. Finally, I also make use of less reliable sources on social media such as Medium or local news articles to explore the impact of volunteers, DIY and open source innovations, and grassroots movements in the sociotechnical evolution of FPV drones.

I have analyzed the evidence collected through the scope of the Social Construction of Technology framework to better understand the sociotechnical evolution of FPV drones from a racing tool to combat equipment. Using a mainly qualitative analysis strategy, I have determined

what factors and social groups have contributed to the FPV drones' interpretive flexibility and closure as a tool for warfare.

Results and Analysis

Through the research I have done and the evidence I have collected, the factors that have contributed to the sociotechnical evolution of FPV drones can be separated into three main categories: battlefield necessity, civilian and open-source contributions, and full-scale military implementation.

Facing a surprise invasion and a military and industrial disadvantage, Ukraine needed something to balance battlefield dynamics. It is with this need that the concept of "problems and solutions" from SCOT can be applied to analyze how FPV drones were developed into tools of warfare. Within the SCOT framework it is said that the development of technology is shaped by the way social groups define and address perceived problems (Bijker et al., 2012). From the beginning of the conflict to the present day, the Russian forces have pressed their advantage of significantly more manpower and equipment. The Ukrainian forces were drastically unprepared, having to rely on foreign aid to relieve their equipment deficits, especially for costly munitions such as artillery shells. However, this foreign aid was not enough to supply the Ukrainian defense and the defense forces needed to look elsewhere for ways to combat Russia's manpower and heavy equipment.

One solution that began to emerge from volunteer groups were FPV drones that were modified to suit combat, either by attaching explosives to run drone suicide attacks or optimizing them for reconnaissance runs. FPV drones began to flourish within the battlefield for a multitude of reasons. Firstly, they are effective. FPV drones allow ground-infantry squads to have modern

real-time reconnaissance abilities as well as destructive capabilities to counter Russia's manpower and heavy-equipment advantage (Porter, 2024). Secondly, they are cheap. FPV drones are easy and cheap to manufacture, allowing for a resource limited nation such as Ukraine to produce them not only at a civilian level but eventually mass-produce them on a national level. Thirdly, they are not difficult to operate. Compared to equipment such as fighter-planes which can take years to master, soldiers can learn how to operate FPV drones within a couple of weeks and without high operating costs.

It is from the problem of battlefield necessity that a technology such as FPV drones can have their meaning change from a hobbyist racing tool to a combat weapon. This falls in line with the concept of interpretive flexibility from SCOT as the soldiers and volunteers sought to find a solution to Ukraine's lack of resources and numerous disadvantages through the use of FPV drones. This process of interpretive flexibility on FPV drones was started well before the conflict in 2022 by a volunteer group called Aerorozvidka who used FPV drones for reconnaissance against Russia's annexation of Crimea in 2014 (Parker, 2022).

Volunteer forces, civilians, and open-source contributions played a large role in the interpretive flexibility of FPV drones before and during the start of the conflict in Ukraine. As mentioned before, the Aerorozvidka volunteer unit began experimenting with FPV drone usage in combat in 2014 as a reconnaissance tool. While the unit had proven effective in the 2014 skirmish, it wasn't until 2022 and the full-scale Russian invasion that FPV drones would become a proven battlefield weapon. While FPV drones were used effectively as combat weapons by soldiers, they also had a secondary, more social, purpose. With a camera already attached to aid the pilot, recording and uploading war footage from the FPV drones perspective became trivial. A countless number of these videos depicting the destruction of heavy equipment, infrastructure,

and infantrymen began to circulate on social media, showing the world the destructive power of FPV drones (Chivers & Guttenfelder, 2024). These videos were used to both improve the morale of soldiers on the frontline and inspire civilians domestically and worldwide. The proliferation of these videos on the internet contributed to the interpretive flexibility of FPV drones by influencing the world's perceptions on the capabilities of the drones and their pilots. What was once viewed as a niche hobbyist tool was now a cheap, accessible, and powerful combat weapon.

The effectiveness of the FPV drones and their videos had a large effect on public support for FPV drones. Because FPV drones are comparatively cheap to make and easy to assemble, it allows civilians to contribute to the war effort significantly without the need for massive donations or risking their lives. Crowdsourcing efforts became popular after the start of the conflict in 2022 with millions being raised worldwide to provide drones for the Ukrainian frontline (Loh, 2024, "Drones for Ukraine Fund", 2025). Many civilians in Ukraine also participate in assembling drones either in their homes or in hidden facilities, benefitting from the open-source development of FPV drones and their modifications (Chivers & Guttenfelder, 2024, LaFranchi, 2024). Since the start of the war, many different online sources and forums provide people with instructions on how to assemble different FPV drones as well as modify them for combat (Sazonov, 2024). With FPV drones becoming one of the major ways for civilians around the world to support Ukraine's war effort, the meaning and purpose of FPV drones has changed from simply a racing tool to an effective and versatile combat weapon through the concept of interpretive flexibility.

It wasn't long after the start of the conflict that both the Ukrainian and Russian militaries realized how effective FPV drones were in combat. Both military forces began integrating FPV drones into their armies, with Ukraine adding a new branch to their armed forces dedicated

solely to unmanned weapons (Bondar, 2024). From the first year in the war, air and drone strikes have increased tenfold from around 3,000 strikes to 30,000 strikes in the past year ("Ukraine Conflict Monitor…", 2025). While Ukraine's air force has also grown, FPV drones account for a majority of these strikes as well as the majority of Russian casualties in Ukraine (Kirichenko, 2025). Production of FPV drones also increased drastically up to 2025 with Ukraine now being able to produce over 4 million drones a year and Russia following closely behind (Saballa, 2024). With most of Ukraine's hits on Russian troops and vehicles being with FPV drones, this escalation by both sides is not surprising. It is with this mass implementation of FPV drones on a national scale that a closure is being reached for FPV drones as a combat weapon. FPV drone warfare is a staple of the war in Ukraine and is Ukraine's primary method of inflicting casualties and disrupting enemy equipment. This trend has not gone unnoticed by foreign militaries and the implications of FPV drone warfare are already being discussed and explored (Magill, 2025). While the exact effect FPV drones will have on future conflicts remains to be seen, it is not a stretch to assume that FPV drones will play a non-trivial role.

Conclusion

FPV drones underwent a sociotechnical evolution from hobbyist racing tools to proven combat weapons, not through any single factor alone, but through a combination of social, political, and practical needs emerging from the war in Ukraine. While civilians, volunteer groups, and open-source development helped to change the meaning of FPV drones through interpretive flexibility, it wasn't until the full-scale implementation by the militaries of Ukraine and Russia that FPV drones reached closure as a combat weapon rather than just a racing tool.

While FPV drones have reached a closure as a combat weapon, their meaning and purpose can still change through interpretive flexibility based on the context and needs of the

relevant social groups. The war in Ukraine and the use of FPV drones is constantly changing with a cyclical fight between FPV drone and anti-drone technology. If either side of the conflict were to discover a way to completely counter FPV drone warfare, FPV drones as a combat weapon would become obsolete and regress in their sociotechnical evolution.

Beyond the scope of the war in Ukraine, the access to FPV drone technology by the public can also lead to a negative sociotechnical evolution in the form of terrorism (Pledger, 2021). While the open-source development and civilian contributions are currently benefiting the war effort in Ukraine, in the wrong hands, military grade equipment with the capability to carry high-yield explosives poses a potential danger to the public. With the ability to be remotely controlled, protecting their pilot, FPV drones can maneuver in tight spaces over long distances with incredible accuracy. It could potentially only take one deadly attack for FPV drones to be seen as a dangerous weapon used for terrorism rather than as a solution to Ukraine's battlefield disadvantages.

This demonstrates that behind all the many factors that contributed to the sociotechnical evolution of FPV drones in Ukraine are the needs of relevant social groups for a solution to their problems. When those needs change, so too can the meaning of a technology.

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