

AUTONOMOUS DRONES: EMERGING TRENDS FROM UKRAINE

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INTRODUCTION

The ongoing conflict in Ukraine is characterised by an extensive use of drones which are now a cornerstone of the asymmetric strategy adopted by Ukraine's armed forces. Ukraine's armed forces are using drones for "reconnaissance, target acquisition, and precision strikes—often beyond the effective range of conventional direct-fire weapons."¹ The key trends emerging from Ukraine's usage of autonomous drones include autonomous navigation, execution of autonomous strikes, generation of a common operating picture integrating drones, synergy of drones with conventional weapons, an indigenous defence ecosystem and innovative tactics, as used in Operation Spider's Web. This paper employs exploratory qualitative research of primarily secondary sources of literature to define

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1. Matthew Slusher, "Lessons from the Ukraine Conflict: Modern Warfare in the Age of Autonomy, Information, and Resilience", Center for Strategic and International Studies, May 2, 2025, p. 2, <https://www.csis.org/analysis/lessons-ukraine-conflict-modern-warfare-age-autonomy-information-and-resilience>. Accessed on July 7, 2025.

key conceptual terms regarding autonomous drones, identify the contours of Ukraine's drone strategy and discern trends emerging from Ukraine's employment of autonomous drones. Given the trends emerging from Ukraine's usage of autonomous drones, the paper attempts to provide certain policy options for India (Fig 2).

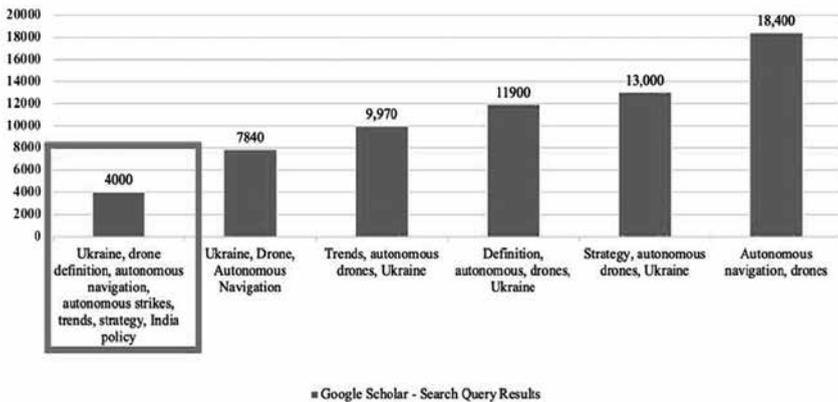
In 2024, Ukrainian President Volodymyr Zelensky created the Drone Systems Force, a separate branch within the Ukrainian armed forces.² Operation Spider's Web launched by Ukraine in June 2025, utilised 117 drones, each with its own operator, to cause damage reportedly worth US\$ 7 billion in Russia.³ Ukraine's increasing focus on autonomous drones is confirmed by statements by Ukraine's officials as well as news reports.

Ukraine is leveraging Artificial Intelligence (AI) to empower drones for autonomous strikes as well as navigation. News reports confirm that in 2023, Ukraine executed autonomous drone strikes on the Russian forces.⁴ In May 2025, Ukraine's Digital Transformation Minister Mykhailo Fedorov, announced the development of an AI enabled "mother drone" which can release two "AI-guided FPV (First-Person View) strike drones" capable of autonomously detecting and engaging targets at ranges of up to 300 km.⁵ Fedorov has also alluded to a significant increase in "autonomous drones with targeting" in 2025 along with the "first real drone swarm use".⁶

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2. "The Armed Forces of Ukraine Introduce a New Unit – Drone Systems Forces", <https://nako.org.ua/en/news/u-zsu-zyavilasya-nova-struktura-sili-bezpilotnix-sistem>. Accessed on July 7, 2025.
 3. "Operation Spiderweb: How Ukraine's Daring Top Secret Drone Assault Unfolded", *Newsweek*, June 2, 2025, <https://www.newsweek.com/russia-drone-operation-spiderweb-aircraft-2079823>. Accessed on July 7, 2025.
 4. David Hambling, "Ukraine AI Drones Seek, Attack Russian Forces Without Humans Oversight", *Forbes*, <https://www.forbes.com/sites/davidhambling/2023/10/17/ukraines-ai-drones-seek-and-attack-russian-forces-without-human-oversight/>. Accessed on July 6, 2025.
 5. "Ukraine's AI-Powered 'Mother Drone' Sees First Combat Use, Minister Says", *The Kyiv Independent*, 29 May 2025, <https://kyivindependent.com/ukraines-ai-powered-mother-drone-sees-first-combat-use-minister-says/>. Accessed on July 6, 2025.
 6. "Ukraine Plans to Increase Use of AI-Powered UAVs, Drone Swarms May Appear: Minister of Digital Transformation: *Ukrainska Pravda*", December 2, 2024, <https://www.pravda.com.ua/eng/news/2024/12/2/7487246/>. Accessed on June 21, 2025.

A prominent research gap that stands out on comparing various papers on the subject is that papers which address the usage of autonomous drones in Ukraine in relation to India’s policy options are limited. Furthermore, papers which holistically explore building-block concepts regarding autonomous drones, study Ukraine’s drone strategy, and discern trends of autonomous drone usage in Ukraine are relatively fewer in number, as compared to the majority of the papers which primarily address select focus areas for autonomous drones. The same is also indicated by the smallest bar of the Google search query results depicted as a bar chart in Fig 1. Each bar in the bar chart is a total of the search hits of publications since 2021, based on search query key words placed at the bottom of the bar.

Fig 1: Google Search Query Results for Published Documents Since 2021

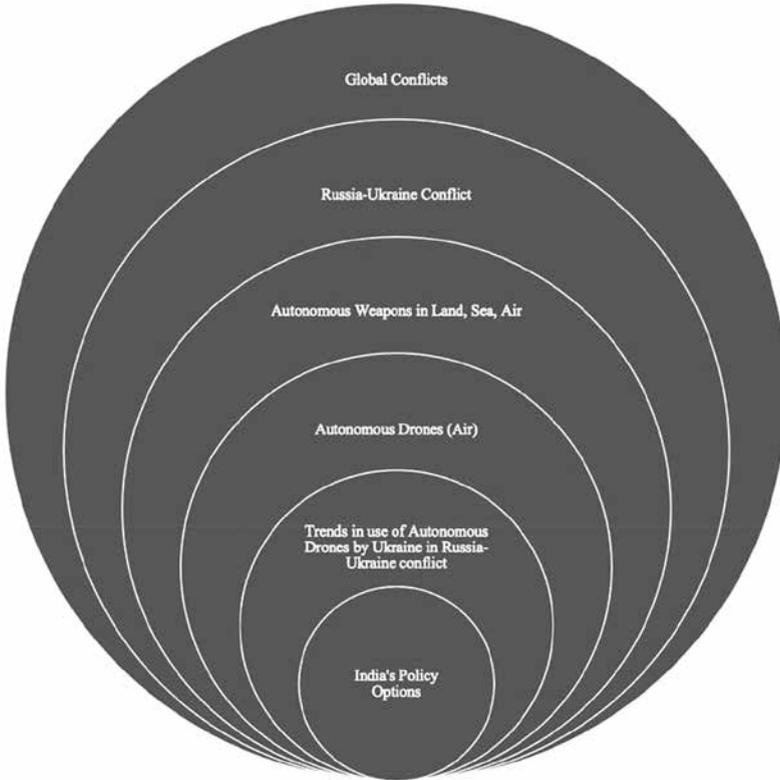


Source: Figure made by the author.

KEY TERMS

In order to better understand the usage of autonomous drones in Ukraine, clarity on the conceptual building-block terms was identified as the first research objective. This part of the paper reviewed literature to progressively define various terms such as weapon systems, artificially intelligent systems, autonomy, autonomous weapon systems and loitering munitions among others.

Fig 2. Research Focus



Source : Figure made by the author.

Weapon System

The U.S. Department of Defence (DoD), defines a weapon system as a group of “one or more weapons with all related equipment, materials, services, personnel, and means of delivery and deployment (if applicable) required for self-sufficiency.”⁷

7. Department of Defence, “DoD-Dictionary-of-Military-and-Associated-Terms-2017”, 2017, <https://www.tradoc.army.mil/wp-content/uploads/2020/10/AD1029823-DOD-Dictionary-of-Military-and-Associated-Terms-2017.pdf>, p. 253. Accessed on June 21, 2025.

Artificially Intelligent Systems

Scholars categorise artificially intelligent systems in four categories: (i) systems that can think like humans; (ii) systems that can act like humans; (iii) systems that can think rationally; and (iv) systems that can act rationally.⁸

Autonomy

The United Nations Office for Disarmament Affairs (UNODA) delineates autonomy as a weapon system's ability to function "in the absence of direction or input from a human actor".⁹ AI empowers such autonomous weapon systems to "derive behavior from data, thus, allowing the system to make independent decisions or adjust behavior based on changing circumstances."¹⁰

Autonomous Weapon System

The U.S. DoD defines an Autonomous Weapon System (AWS) as:

A weapon system that, once activated, can select and engage targets without further intervention by an operator. This includes, but is not limited to, operator-supervised autonomous weapon systems that are designed to allow operators to override operation of the weapon system, but can select and engage targets without further operator input after activation.¹¹

On reviewing the literature on AWS, the two broad classifications of AWS are tabulated in Table 1.

8. Joost N. Kok, et al., "Artificial Intelligence: Definition, Trends, Techniques and Cases", *Encyclopedia of Life Support Systems*, 2009, p. 2, <https://www.eolss.net/Sample-Chapters/C15/E6-44.pdf>. Accessed on June 15, 2025.

9. "Lethal Autonomous Weapon Systems (LAWS) – UNODA", <https://disarmament.unoda.org/the-convention-on-certain-conventional-weapons/background-on-laws-in-the-ccw/>. Accessed on June 15, 2025.

10. Ibid.

11. Kathleen H. Hicks, "DoD Directive 3000.09: Autonomy in Weapon Systems," *DoD Directive 3000.09*, January 25, 2023, p. 21, <https://www.esd.whs.mil/portals/54/documents/dd/issuances/dodd/300009p.pdf>. Accessed on June 20, 2025.

Table 1: Broad Classifications of AWS

Based on Human Right's Watch Model ¹²		Based on Sharkey's Model ¹³	
Type of Weapon	Description of Weapon	Type of Weapon	Description of Weapon
Human-in-the-loop weapons	Robots that can select targets and deliver force only with a human command	In-the-loop	Humans deliberate about specific targeting decisions before initiating an attack, often through a visual inspection of the target
Human-on-the-loop weapons	Robots that can select targets and deliver force under the oversight of a human operator who can override the robots' actions	In-the-loop	Humans choose from a list of targets generated by the system to attack
Human-out-of-the-loop weapons	Robots that are capable of selecting targets and delivering force without any human input or interaction	On-the-loop	Humans approve attacks against targets identified by the system
		On-the-loop	The system selects targets and allocates humans a time-restricted veto before commencing an attack
		Out-of-the-loop	The system selects targets based on pre-programmed target profiles and initiates attacks without direct human involvement

Source: Adapted from Bonnie Docherty, "Losing Humanity" (Human Rights Watch, November 19, 2012) and Noel Sharkey, "Staying in the Loop: Human Supervisory Control of Weapons," *Autonomous Weapons Systems: Law, Ethics, Policy*, 2016.

12. Bonnie Docherty, "Losing Humanity", *Human Rights Watch*, November 19, 2012, <https://www.hrw.org/report/2012/11/19/losing-humanity/case-against-killer-robots>, p. 2. Accessed on July 20, 2025.

13. Noel Sharkey, "Staying in the Loop: Human Supervisory Control of Weapons," *Autonomous Weapons Systems: Law, Ethics, Policy*, 2016, pp. 34-37, <https://doi.org/10.1017/CBO9781316597873.002>. Accessed on June 21, 2025.

Semi-Autonomous Weapon System

A semi-autonomous weapon system is intended to engage operator selected targets, once activated.¹⁴

Loitering Munitions

Scholars define Loitering Munitions (LMs) as “expendable uncrewed aircraft, which can integrate sensor-based analysis to hover over, detect and crash into targets.”¹⁵ The warheads of LMs are explosive, the targets are generally beyond visual line of sight and LMs execute pre-programmed missions autonomously, with no requirement of human oversight post launch.¹⁶

Gettinger and Holland note that LMs, “blur the line between the drone and missile” and also call them “suicide drones”.¹⁷ LMs hover over the intended target area, “for an extended period of time before striking, giving the targeter time to decide when and what to strike.”¹⁸

Unmanned Aerial Vehicle, Unmanned Aircraft System or Drone

The U.S. military’s Joint Publication 3-30, defines an Unmanned Aerial Vehicle (UAV) as an “aircraft that does not carry a human operator and is capable of flight with or without human remote control.”¹⁹ Colloquially, the U.S. military uses the term “UAV” synonymously with “drone”.²⁰

The Government of India defines an Unmanned Aircraft System (UAS) as an “aircraft that can operate autonomously or can be

14. Hicks, n. 11, p. 23.

15. Tom FA Watts and Ingvild Bode. “Loitering Munitions and Unpredictability: Autonomy in Weapon Systems and Challenges to Human Control—AutoNorms,” *AutoNorms—Weaponised Artificial Intelligence, Norms, and Order (blog)*, April 30, 2024. <https://www.autonorms.eu/loitering-munitions-and-unpredictability-autonomy-in-weapon-systems-and-challenges-to-human-control>. Accessed on June 29, 2025.

16. Ibid.

17. Dan Gettinger, and Arthur Holland Michel, “Loitering Munitions,” in Maggie Barnett and Erin O’Leary, eds., *The Centre for the Study of the Drone at Bard College*, 2016, <https://dronecenter.bard.edu/files/2017/02/CSD-Loitering-Munitions.pdf>. Accessed on June 29, 2025.

18. Ibid.

19. Lieutenant General Daniel J. O’Donohue, USMC Director, Joint Force Development Joint Air Operations, Joint Publication 3-30 (U.S. Department of Defense, July 25, 2019), https://irp.fas.org/doddir/dod/jp3_30.pdf.

20 “Send in the Drones”, www.army.mil, October 17, 2024, https://www.army.mil/article/280609/send_in_the_drones. Accessed on June 29, 2025.

operated remotely without a pilot on board”, wherein the term drone refers to an unmanned aircraft system.²¹

Remotely Piloted Aircraft

The term Remotely Piloted Aircraft (RPA) as defined by the Ministry of Civil Aviation, Government of India, Drone Rules 2021, refers to “an unmanned aircraft that is piloted by a remote pilot.”²² The associated system includes “remote pilot stations, the required command and control links and any other components as specified in the type design.”²³

This paper shall be using the umbrella term drones to refer to the RPA, UAS or UAV.

Kill Chain

The term kill chain is frequently used to describe the detection-to-engagement cycle for drones. In 2013, Admiral Jonathan Greenhart who was then Chief of Naval Operations, U.S. Navy, amplified on the kill chain approach in four steps for a successful attack,

1. Find the target;
2. Determine target’s location, course and speed;
3. Communicate that information coherently to the platform launching the weapon; and,
4. Launch the attack using anything from a kinetic weapon to electromagnetic systems to cyber.²⁴

Christian Brose alludes to “closing the kill chain” as the U.S. military’s process of comprehending, making a decision, and taking action against a target, whereas “breaking the kill chain” refers

21. Ministry of Civil Aviation Notification, “Drone Rules 2021”, August 25, 2021, <https://www.dgca.gov.in/digigov-dgca/portal/jsp/homePage/viewPDF.jsp?page=InventoryList/headerblock/drones/Drone%20Rules%202021.pdf>. Accessed on June 29, 2025.

22. Gazette Notification, Drone Rules 2021. Accessed on July 9, 2025.

23. Ibid.

24. “Kill Chain Approach: Chief of Naval Operations”, June 13, 2013, <https://web.archive.org/web/20130613233413/http://cno.navylive.dodlive.mil/2013/04/23/kill-chain-approach-4/>. Accessed on July 2, 2025.

to preventing a rival military force from doing so against the U.S. military.²⁵

UKRAINE'S DRONE STRATEGY

Ukraine's Military Doctrine

Ukraine's asymmetric military doctrine is based upon "technological superiority and innovative combat approaches, aiming to offset Russia's numerical advantage."²⁶ Given the Russian manpower advantage, the Ukrainian military increasingly faces the necessity to leverage technology by deployment of autonomous systems, in order to reduce troops from the battlefield. Moreover, deploying soldiers in the battlefield requires resources as well as time, compounding the inherent vulnerabilities faced by soldiers due to stress, fatigue and the vagaries of weather.²⁷

The Ukrainian military, hence, identifies "removing warfighters from direct combat as its central objective in shaping the future battlefield."²⁸ In order to achieve the same, Ukraine leverages a "network-centric warfare model, integrating weapons, intelligence systems, and command infrastructure into a unified information network", with the aim of shortening the kill chain.²⁹ In this regard, Ukraine exploits drones as force multipliers, for reconnaissance, strike missions and communication relay.³⁰

In achieving the stated central objective, Ukraine aims to integrate "AI-enabled autonomous systems with real-time situational awareness", wherein AI permits analysis of data inputs from multiple sources.³¹ For AWS, Ukraine currently visualises a "human-in-the

25. Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York: Hachette Books, 2020). Accessed on July 5, 2025.

26. Mykhailo Samus, "Drone-Centric Warfare", International Centre for Defense and Security (ICDS), January 2025, <https://icds.ee/en/russias-war-in-ukraine-drone-centric-warfare/>. Accessed on July 4, 2025.

27. Kateryna Bondar, "Ukraine's Future Vision and Current Capabilities for Waging AI-Enabled Autonomous Warfare", March 6, 2025, p. 7, <https://www.csis.org/analysis/ukraines-future-vision-and-current-capabilities-waging-ai-enabled-autonomous-warfare>. Accessed on July 2, 2025.

28. Ibid.

29. Samus, n. 26.

30. Ibid.

31. Bondar, n. 27, p. 7.

loop role” which permits overriding AWS by the human operator; however, in the long term, Ukraine looks at maximising autonomy for increased battlefield efficiency with “human input limited to engagement decisions”.³²

Delta: The Digital Backbone

Ukraine’s command and control system known as the Delta Situational Awareness and Battlefield Management System was developed together by Ukraine’s private industry and volunteers. Delta securely provides comprehensive situational awareness by fusing, consolidating and mapping intelligence data from “combat units, sensors, intelligence assets, surveillance satellites, and geolocated drone feeds”. Delta’s comprehensive operational picture is accessible on laptops as well as smart phones.³³

To safeguard against threats, Delta is hosted in a “secure cloud infrastructure outside Ukraine” and cyber security is ensured through “multi-layered infrastructure protection, data encryption, real-time monitoring, multi-factor authentication, and regular security audits” while system resilience is ensured by focussing on a “‘zero trust’ policy along with data redundancy.”³⁴

Brave 1

Brave 1 was established in April 2023, by the Ukrainian government as a technology ecosystem for Ukraine’s domestic industry to develop and flourish as an effort towards leveraging technology in the conflict with Russia. In April 2025, an online technology market place, Brave1 Market, was also launched by Brave 1 to facilitate the innovation-to-deployment of technologies such as “short-range electronic warfare systems, interceptor drones, AI-enabled drones, and fiber-optic drones.”³⁵

32. Ibid.

33. Samus, n. 26.

34. Ibid.

35. “Ministry of Digital Transformation and Brave1 Launch Defense Technology Marketplace For The Military”, Brave1, <https://brave1.gov.ua/>. Accessed on July 2, 2025.

Drone Companies to Drone Strike Brigades

As a part of Ukraine's drone-centric doctrine, 60 drone companies were created by Ukraine's military in 2023, to be employed as part of Ukraine's combat brigades as well as separate combat groups. Since 2023, some of the drone companies have been organised into drone strike battalions and selected drone strike battalions expanded to drone strike brigades.³⁶

Drone Inventory and Production in Ukraine

In May 2022, the Ukraine armed forces used U.S. supplied Switchblade 300 drones, against Russian targets, and in April 2023, usage of U.S.-supplied, anti-armour warhead-equipped Switchblade 600 drones by Ukraine was also confirmed.³⁷ In addition, the Ukraine armed forces have employed Polish Warmate drones, the Australian drone 40s as the well as U.S. manufactured Phoenix Ghosts.³⁸

As part of Ukraine's commitment towards employing autonomous systems, in 2024, 10,000 AI-enhanced drones were purchased. Ukraine also indigenously built almost two million drones in 2024, which included "strike quadcopter bombers, kamikaze drones, winged reconnaissance drones, and long range deep-strike drones."³⁹ From 2022, almost 200 different indigenously manufactured drones were inducted in Ukraine's armed forces: most of the induction occurred in 2024, demonstrating a significant boost of manufacturing self-sufficiency as well as the resilience of Ukraine's supply chains.⁴⁰

Ukraine's armed forces use Ukrainian built FPV drones, apart from the commercially available off-the-shelf Chinese DJI Mavic. In 2022, FPV drones, with 7-inch diameter propellers were commonly used due to ease of availability and assembly; today, FPV drones, with 9 to 10-inch propellers, are being predominantly used by the Ukrainian armed forces.⁴¹ Ukraine's drone production utilises a

36. Samus, n. 26.

37. Tom F.A. Watts and Ingvild Bode, "Automation and Autonomy in Loitering Munitions Catalogue (v.1)" (Zenodo, 2023), <https://doi.org/10.5281/ZENODO.7860762>. p. 62. Accessed on July 2, 2025.

38. *Ibid.*, p. 38.

39. Bondar, n. 27, p. 10.

40. *Ibid.*

41. *Ibid.*, p. 10.

modular mechanism of assembling FPV drones, wherein the same superstructure can be used for various roles as well as payloads.

The modular design of autonomous drones enhances flexibility in both drone production as well employment in the battlefield. Production of modular drones entails fabrication of electronic and software component modules for the drones, which are platform agnostic, can be integrated with existing drones and empower critical autonomous functions such as environment perception, target discernment and autonomous “last-mile navigation”.⁴²

Ukraine’s Drone Strategy

On viewing this part of the paper from the lens of an ends-ways-means construct, certain contours emerge clearly. The ends of Ukraine’s drone strategy are removal of soldiers from direct combat. The means of this strategy include a large inventory of FPV drones, a rapidly growing number of autonomous drones, Delta communication backbone, Brave1, drone strike brigades as well as companies and relevant ministries of the Government of Ukraine such as the Ministry of Digital Transformation. The ways include the employment of drones as the centrepiece of Ukraine’s military strategy, executing autonomous strikes using drones, and incentivising innovation in, and domestic production of, drones. The next part of this paper shall look at certain emerging trends from Ukraine’s usage of autonomous drones.

KEY TRENDS IN UKRAINE’S USAGE OF AUTONOMOUS DRONES

Autonomous drones overcome a significant number of shortcomings of non-autonomous drones such as range of employment, operator limitations and electronic warfare. Drones in Ukraine are using AI enabled technologies such as autonomous navigation and autonomous strikes. In order to shorten the drones’ kill chain, development of an ecosystem with a common operating picture and integration with conventional weapons have been carried out.

42. Ibid.

Shortcomings of Non-Autonomous Drones

In interviews with the Centre for Strategic and International Studies (CSIS), Ukrainian drone operators acknowledged that the success rates of inexpensive FPV drone missions were between 10 to 15 per cent, and even experienced operators flying such drones were unable to muster success rates beyond 50 per cent.⁴³ The report attributes the relatively low success rates to the limitations of human drone operators, Russian Electronic Warfare (EW), and limitations with radio waves' horizon and skills required to engage moving targets.⁴⁴ For overcoming these challenges, "autonomous navigation" through a convergence of AI and drones, offers a viable solution.⁴⁵ AI empowered autonomy in drones enhances navigation, target identification and engagement all of which are enablers for executing autonomous strikes.

Autonomous Navigation

Leveraging AI algorithms and on-board sensors, autonomous navigation allows a drone to "map surroundings, pinpoint its location without the Global Positioning System (GPS), and dynamically chart a course around unforeseen hazards."⁴⁶ AI-enabled autonomous navigation reduces the costs of executing strike missions by reducing the number of drones required for a mission, reducing drone losses during the mission as well as permitting multiple mission attempts due to the reusability of the drones.⁴⁷

Ukraine's use of AI-enabled autonomous navigation in drones, precludes drone vulnerabilities due to limited pilot skills and EW, consequently an increase in the success rate by almost three to four times has been noticed in such drones.⁴⁸

43. Ibid.

44. Ibid.

45. Aditya Vardhan and Katkuri Reddy, et al., "Autonomous UAV Navigation Using Deep Learning-Based Computer Vision Frameworks: A Systematic Literature Review", *Array* 23, September 1, 2024, p. 100361, <https://doi.org/10.1016/j.array.2024.100361>. Accessed on July 4, 2025.

46. Bondar, n. 27, p. 29.

47. Ibid.

48. Ibid., p. 29.

Autonomous Strikes

Drone strikes by Ukraine, without the use of human operators have been confirmed, along with the usage by the Ukrainian armed forces of the Saker scout drones, which possess the capabilities to “find, identify and attack 64 different types of Russian ‘military objects’ on their own, operating in areas where radio jamming blocks communication and prevents other drones from working.”⁴⁹

The Australians-supplied loitering munitions, the Drone 40, which are being used in Ukraine, include autonomous capabilities to allow identifying and tracking of targets based on radar profiles; however, the system is designated as “human-in-the loop” and requires human intervention for engagement of targets.⁵⁰

In 2023, key officials such as Ukraine’s Digital Transformation Minister Mykhailo Fedorov and Lieutenant Colonel Yaroslav Honchar alluded to the inevitable use of autonomous weapons without a human in the loop.⁵¹ Ukraine’s first fully unmanned operation was carried out in December 2024, near the village Lyptsi, close to Kharkiv, wherein multiple remotely operated FPV drones in the air, along with Uncrewed Ground-based Vehicles (UGVs) executed operations without infantry operations. Although the FPV drones and UGVs were remotely operated by human operators, the operation serves as a demonstration of Ukraine’s intent to execute operations autonomously, leveraging AI-enabled equipment in an asymmetric conflict.⁵²

Faster Kill Chain: Common Operating Picture and Integration with Conventional Weapons

Integration of AI in drones offers multiple advantages on the battlefield. These include automated detection-cum-discernment of targets, confirmation of target coordinates, relaying decisions to engage targets, and on confirmation from commanders, transmitting orders for engagement. In this kill chain of detection-to-engagement, AI

49. Hambling, n. 4.

50. Watts and Bode, n. 37, p. 65.

51. *Ibid.*, p. 8.

52. Bondar, n. 27.

enabled drones ensure greater speed and effectiveness of engagement as well as efficiency of decision-making.⁵³

Ukraine aims at establishing a real-time common operating picture by ensuring that all unmanned as well as reconnaissance systems integrate with situational awareness and fire-correction platforms.⁵⁴ Ukraine's military forces aim to establish a single kill chain by adapting their command and control systems so as to integrate conventional manned weapon systems such as artillery with unmanned systems such as drones.⁵⁵

Ukraine does not aim to replace conventional weapons such as artillery with unmanned systems; instead, Ukraine's armed forces use precise strikes by drones to degrade defences and set the stage for decisive artillery strikes against degraded defences.⁵⁶

CHALLENGES IN USING AUTONOMOUS DRONES

This paper has also identified certain challenges in the use of autonomous drones in Ukraine. These include degradation of sensor capabilities due to adverse weather conditions and challenges in discerning targets which are rapidly moving or in camouflage.⁵⁷

Operation Spider's Web

From the perspective of innovative drone tactics, Ukraine's Operation Spider's Web stands out, and is the last trend identified by this paper. On June 1, a holiday for Russia's armed forces, Ukraine launched strike drones against four different Russian aviation bases, deep inside Russia, using smaller strike drones concealed in compartments of cargo trucks smuggled inside Russia. Ukraine's operation not only imposed significant costs in Russian military equipment but also exposed major vulnerabilities in Russian defences towards the rear.⁵⁸

53. Samus, n. 26.

54. Bondar, n. 27.

55. *Ibid.*, p. 8.

56. *Ibid.*

57. *Ibid.*, p. 29.

58. Kateryna Bondar, "How Ukraine's Operation 'Spider's Web' Redefines Asymmetric Warfare", June 2, 2025, <https://www.csis.org/analysis/how-ukraines-spider-web-operation-redefines-asymmetric-warfare>. Accessed on September 14, 2025.

The operation reportedly required almost 18 months of planning, 150 small strike drones, modifications in standard cargo trucks, covert operatives and drones with “remote human control with elements of autonomy and potentially AI-assisted functionality.”⁵⁹ Ukrainian FPV drone pilots who operated from Ukraine utilised Russian telecommunication networks for controlling the drones, open-source autopilot software for stable unmanned control and “AI-assisted targeting” for striking the right Russian aircraft.⁶⁰

AUTONOMOUS DRONES: POLICY OPTIONS FOR INDIA

In the light of the emerging trends in the usage of autonomous drones from Ukraine, certain policy options which are relevant from an Indian perspective include incentivisation of modular drone production, production of drones with autonomous technology, shortening of the drone kill chain, creation of drone strike companies and offsetting attempts at replicating Operation Spider’s Web.

A White Paper published by the Drone Federation of India states that India’s drone industry is envisioned to grow to a Rs 15,000 crore industry, with 90 per cent indigenisation in “drone component manufacturing”.⁶¹ The paper highlights that India’s Drone Rules 2021 “eased operational approvals and opened more than 90 per cent of Indian airspace to drone operations”⁶²

News reports indicate that there are almost 600 drone manufacturing and associated companies in India’s drone manufacturing ecosystem. In 2021, in order to incentivise local assembly of drones, apart from government incentives to indigenous drone manufacturers, a ban on the import of fully built drones and semi-knocked down drones was introduced.⁶³

Drone Rules 2021 permit certification of complete drone systems through the “Indigenously Designed, Developed and Manufactured

59. Ibid.

60. Ibid.

61. Bobby Yadav, “Building Bharat Drone Stack”, Drone Federation of India, June 2025, <https://www.bharatdronestack.org/building-bharat-drone-stack-whitepaper.pdf>. Accessed on September 14, 2025.

62. Ibid.

63. Ankit Saxena, “Inside India’s Quiet Drone Revolution: The Fight For Self-Reliant Subsystems”, *Swarajyamag*, <https://swarajyamag.com/reports/inside-indias-quiet-drone-revolution-the-fight-for-self-reliant-subsystems>. Accessed on July 5, 2025.

(IDDM) pathway”; however, a similar mechanism for “certifying individual subsystems or modules” requires policy support, as per a report in *Swarajya* magazine.⁶⁴ Consequently, critical drone components such as core electronics, batteries, sensors and motors are primarily sourced from other countries, including China, thereby creating a national security challenge.⁶⁵ This challenge is being offset with the aid of over 100 Indian companies, including start-ups, which are working towards building indigenous drone components, thereby leading to resilient supply chains.⁶⁶ Policy support based on an inclusive dialogue with smaller start-ups shall certainly go a long way in enhancing indigenous component production.

As far as autonomous drones are concerned, Indian start-ups as well as joint ventures are championing this cause. Start-ups in India, such as Vecros have benefited from the Indian Army’s Innovations for Defence Excellence (IDEX) programme and are spearheading the construction of drones with autonomous navigation, which can function in a GPS-denied environment.⁶⁷ BonV Aero, an Odisha based start-up specialising in autonomous drones for logistical solutions, demonstrated lifting 30 kg of load at an altitude of 19,024 ft in Ladakh.⁶⁸ A report in *The Times of India* highlighted the role in Operation Sindoor played by Bengaluru headquartered Alpha Design which manufactures drones possessing autonomous strike capabilities, in collaboration with Elbit systems of Israel.⁶⁹

Post-Operation Sindoor, the Government of India may plan further investments in India’s drone industry worth Rs 2,000 crore (US\$ 234 million) over a three-year period in “manufacture of drones,

64. Ibid.

65. Ibid.

66. Ibid.

67. Rebalance, “VECROS, India’s First Autonomous, Spatial AI-Powered Drone Company, Raises \$250K Led by Rebalance”, *Medium* (blog), February 8, 2024, <https://therebalance.medium.com/vecros-indias-first-autonomous-spatial-ai-powered-drone-company-raises-250k-led-by-rebalance-ac4fd3d0baa7>. Accessed on July 2, 2025.

68. “Odisha Startup Bon V Aero Launches Fully Autonomous Drone Logistics Service”, *Business Standard*, November 10, 2024, https://www.business-standard.com/companies/start-ups/odisha-startup-bon-v-aero-launches-fully-autonomous-drone-logistics-service-124111000291_1.html. Accessed on July 2, 2025.

69. “Bengaluru-Made ‘Suicide Drones’ Make Debut with Operation Sindoor”, *The Times of India*, May 8, 2025, <https://timesofindia.indiatimes.com/india/bengaluru-made-suicide-drones-make-debut-with-operation-sindoor/articleshow/120976015.cms>. Accessed on July 2, 2025.

components, software, counter-drone systems, and services”.⁷⁰ Apart from drone production, policy incentivisation of Indian industry’s focus on software solutions like Ukraine’s Delta system for providing a common operating picture, decision support and means to shorten the drone kill chain, shall be pivotal for future conflicts.

Ukraine’s drone strike companies and brigades may offer policy options for force restructuring in an Indian context. The same offers scope for further research and a cost-benefit analysis.

Operation Spider’s Web provides a national security challenge, wherein such an operation may be explored by inimical state or non-state actors against India. Such a challenge shall require in-depth wargaming and complete synergy among all the stakeholders of India’s national security. From a technological standpoint, an autonomous air defence shield for critical installations serves as a problem statement for innovative, emergent and cost-effective solutions by India’s defence ecosystem.

CONCLUSION

Ukraine’s drone strategy centres around the end objective of removing soldiers from direct combat. In doing so, Ukraine leverages a large inventory of FPV drones, autonomous drones, the innovative Delta communication backbone, Brave1 drone ecosystem and various ministries within the Government of Ukraine. In employing drones as a centrepiece of Ukraine’s military strategy, the country has demonstrated multiple instances of autonomous strikes using drones while incentivising innovation in domestic production of drones.

Emerging trends of autonomous drones usage by Ukraine indicate the necessity of resilient supply chains, modular drone production, opportunities for creating drone strike companies as well as brigades, and software for generating a common operating picture to shorten the kill chain. Operation Spider’s Web is a demonstration of Ukraine’s innovative drone tactics in keeping drone pilots out of

70. Sarita Chaganti Singh and Shivam Patel, “India Plans \$230 Million Drone Incentive after Pakistan Conflict, Sources Say”, *Reuters*, July 4, 2025, sec. India, <https://www.reuters.com/world/india/india-plans-230-million-drone-incentive-after-pakistan-conflict-sources-say-2025-07-04/>. Accessed on July 2, 2025.

Russia while retaining the ability to strike four Russian air bases, deep inside Russian territory.

Autonomous drones offer a significant advantage over the skill or battle stress limitations of human operators, ability to function in a dense EW environment and reach of operations vis-à-vis non-autonomous drones. At the same time, autonomous drones face limitations of discerning camouflaged as well as fast moving targets, and ruggedness of sensors under harsh battlefield conditions.

From an Indian perspective, the government has incentivised drone production through policy linked initiatives, banning the import of drones, and a supporting framework through Drones Rules 2021. Indian start-ups as well as larger ventures are engaged in the production and testing of autonomous drones as well as modular components; however, further policy support in indigenous production of drone components may be required. Post the success of Operation Sindoor, the government is reportedly planning an incentivisation boost for India's drone ecosystem.

Ukraine's success in executing Operation Spider's Web presents a national security challenge for India, wherein inimical states or non-state actors may be encouraged to execute such designs against India. However, such a challenge can be offset by the timely identification of solutions and synergy among the stakeholders of national security.

