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MULTI-DOMAIN UNMANNED TEAMING: LESSONS FROM UKRAINE'S RECENT INTEGRATION OF AERIAL SWARMS WITH USV AND UGV FOR INDIA'S EVOLVING JOINT OPERATIONAL FRAMEWORK

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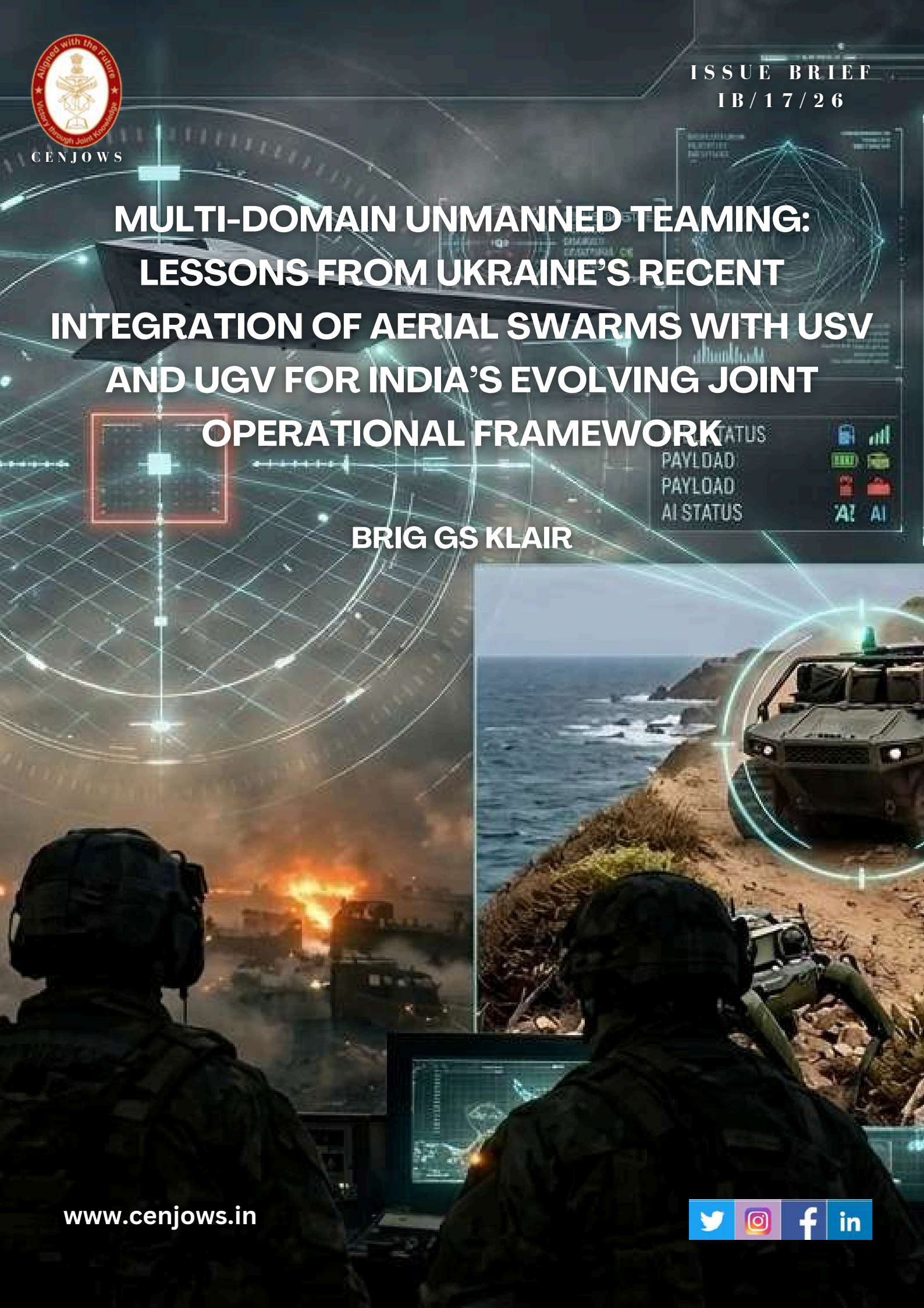

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Multi-Domain Unmanned Teaming: Lessons from Ukraine's Recent Integration of Aerial Swarms with USVs and UGVs for India's Evolving Joint Operational Framework

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Abstract

The conflict in Ukraine has redefined modern warfare by integrating unmanned systems across air, sea, and land to create powerful multi-domain effects. Recent operations have shown that coordinating aerial drone swarms with unmanned surface vessels and ground vehicles allows forces to overwhelm traditional defences. It aids in maintaining pressure even under severe electronic jamming. For our tri-services, these developments provide a critical roadmap aligned with the Joint Doctrine for Multi-Domain Operations. This analysis explores how India can leverage artificial intelligence and decentralised mesh networks in order to manage the high cognitive load of contemporary battlefields while reducing human risk. It emphasises the need for a "Whole-of-Nation" strategy that integrates India's private tech sector into the military-industrial complex. By adopting these lessons, India can build a resilient, self-reliant, and technologically advanced joint operational framework capable of deterring evolving multi-domain threats.

Keywords: Multi-domain Operations, Unmanned Teaming, Artificial Intelligence, Mesh Networks, Communications Resilience, and Self-Reliance.

Introduction

The conflict in Ukraine has become a pivotal example of how unmanned systems are reshaping modern warfare. Initially, soldiers relied on inexpensive commercial drones primarily for reconnaissance. Over time, this has evolved into sophisticated, coordinated, and complex operations. These now involve aerial drone swarms, Unmanned Surface Vessels (USVs) on sea, and Unmanned Ground Vehicles (UGVs) on land. These systems operate in an interconnected manner through networks, artificial intelligence (AI), and advanced communication frameworks, enabling them to support one another and deliver combined effects across air, sea, and land domains simultaneously.

This progression holds significant implications for India, where the Armed Forces are rapidly moving toward a more integrated approach to warfare. It is noteworthy to mention that the Joint Doctrine for Multi-Domain Operations was published in August 2025. To achieve operational superiority, the doctrine emphasises the need to synchronise efforts across land, sea, air, space, cyber, and cognitive domains.[1] Concurrently, India is working to set up Integrated Theatre Commands (ITCs). These ITCs will facilitate joint operations under unified command structures. Most importantly, these will replace the traditional service-specific silos.[2] Nevertheless, key enabling technologies are still under development. These include resilient networks, AI-driven advanced decision-making, and affordable, large-scale unmanned platforms.

China's People's Liberation Army (PLA) has closely analysed Ukraine's experience. It is actively incorporating these lessons into its modernisation efforts. PLA strategies focus heavily on drone swarms and manned-unmanned teaming. As per open-source information, the PLA is actively deploying these low-cost, expendable systems in challenging environments such as high-altitude and maritime zones.[3] This is particularly relevant for India. In a future conflict along the Line of Actual Control (LAC) or in the Indian Ocean Region (IOR), these multi-domain unmanned threats are likely to play a dominant role.

This study reviews Ukraine's advancements since 2024 in integrating aerial swarms with USVs and UGVs, providing battlefield case studies. It also compares PLA

adaptations, discusses the consequences for India’s joint operational framework, and proposes practical recommendations for the tri-services. It provides actionable insights to enhance India's unmanned warfare capabilities, making them more effective, self-reliant, and integrated.

Despite Ukraine’s progress, India must overcome its unique tech hurdles. Boosting indigenous AI for autonomous task distribution and adaptive decisions is still in early stages and holds the key to self-reliance. Without AI systems that can dynamically reassign roles within drone swarms or coordinate unmanned platforms across domains in contested situations, operational efficiency risks being compromised. Communication infrastructure also requires enhancement. India’s current networks need upgrades in fibre optics or advanced frequency-hopping technologies to counter sophisticated Electronic Warfare (EW) threats, as seen in Ukraine. Additionally, ramping up production to supply a large number of attritable platforms presents industrial and logistical challenges. To match Ukraine’s rapid-iteration, low-cost drone production, India must invest in targeted R&D, resilient supply chains, and strong EW countermeasures.

Moreover, unmanned teaming poses risks requiring careful management. Networked systems are vulnerable to cyberattacks that can disrupt operations or lead to a breach of sensitive data. Clear standard operating procedures and thorough operator training are essential to ensure accountability. India’s joint framework must tackle these challenges with layered defences, strong cyber-hardening, and doctrinal changes. These steps will enable unmanned systems to improve operational effectiveness without jeopardizing it.

Ukraine's Unmanned Systems Evolution

Ukraine’s unmanned systems have undergone rapid transformation since the war’s onset. In 2022 and 2023, drones were mostly simple first-person-view (FPV) quadcopters used for reconnaissance or, at times, for isolated kamikaze strikes. By 2025–2026, the focus has shifted to coordinated swarms capable of multitasking. Now Ukraine is working with groups of 8 to 25 aerial drones flying together as coordinated swarms. These drones use AI to share information with each other, reassign tasks if one gets shot down, and pull off precision strikes even when communications are

jammed.[4] Fiber-optic-enabled drones have aided long-distance jamming-resilient operations.[5]

Figure 1*: Fiber-Optic Drones Weave Spiderweb Barriers in Ukraine War* ***Source****: The Choshun Daily*

At sea, USVs have flipped the situation in the Black Sea completely. Ukraine's been using a series of USVs, called the Magura. The Magura series, especially the V5 and newer V7 models, has evolved from basic explosive boats to versatile platforms. Some Magura V7 vessels are armed with modified air-defence missiles such as AIM-9 Sidewinders. Notably, these platforms have successfully engaged Russian fighter aircraft.[6] These vessels often operate in small groups. Typically, one acts as a “mothership” vessel deploying smaller FPV drones or carrying additional fuel and sensors to extend operational range.

On land, UGVs have become increasingly omnipresent, particularly around Kharkiv. They serve diverse roles including transporting logistics, evacuating casualties, clearing mines, and conducting assaults in hazardous zones. By early 2026, Ukraine aims to deploy over 20,000 UGVs. Pertinently, many of these UGVs are equipped with basic AI, thereby enabling autonomous navigation and obstacle avoidance with minimal human intervention.[7]

A standout feature of Ukraine’s success is the dramatic scale-up in production. In 2025, Ukraine produced over 4 million drones of various types. The target for 2026 is

7 million.[8] A decentralised manufacturing approach has enabled this outcome. The government sets goals and funds projects, while hundreds of SMEs handle design and production. Private investment reached nearly $105 million in 2025, with an ecosystem of over 500 manufacturers.[9] This model enables rapid innovation, battlefield testing in weeks, and low-cost replacements.

System Type	Main Roles	Typical Range / Endurance	Autonomy Level	Production Estimate (2025–2026)
Aerial Swarms (FPV/OWA)	Reconnaissance, precision strikes, jamming	20–50 km	Semi-autonomous (AI task sharing)	4–7 million
USVs (Magura V5 / V7)	Naval attack, air defence, mothership	Up to 800 km	Remote + AI guidance	Several hundred
UGVs	Logistics, casualty evacuation, assault	20 km +	Basic to medium autonomy	20,000+ targeted

Table 1: *This table illustrates how Ukraine balances low cost, flexibility, and scale to maintain a constant pressure on the battlefield*.

Multi-Domain Integration in Ukraine: Case Studies and Key Lessons

The real strength of Ukraine's unmanned systems is not the individual platforms but how they are combined across domains to support one another.

Case Study 1: Black Sea Naval Operations In 2025, Ukraine regularly used aerial drone swarms to locate Russian ships and then directed USVs to attack them. One well-known example was the strike on the corvette Ivanovets in Lake Donuzlav. The aerial drones provided continuous video and targeting data, allowing a group of USVs to approach undetected and overwhelm the ship with explosives.[10] In another development, Magura V7 USVs were fitted with air-defence missiles and successfully

shot down Russian Su-30 fighters. This manoeuvre showcases that sea-based platforms can also contribute to air defence.[11] Some USVs acted as motherships, carrying and launching smaller FPV drones to extend their reach and saturate targets. As a result of these actions, Russia had to move its Black Sea Fleet further east. This allowed Ukraine to reopen important grain export routes. The main lesson here is that when aerial reconnaissance feeds real-time information to naval platforms, the combined effect is much greater than what either domain could achieve in a stand-alone manner.

Case Study 2: Kharkiv Ground Operations In the fighting around Kharkiv in late 2025, UGVs and aerial swarms were used together in several assaults. Aerial drones first scouted Russian positions, identified vulnerable positions, and guided UGVs carrying weapons directly into the battle. In some cases, the entire operations were conducted without any soldiers on foot. The drones scouted, UGVs delivered ammunition or attacked, and the cycle was repeated.[12] Fiber-optic communication links were critical because they allowed the systems to operate under intense jamming. These operations reduced casualties significantly and, in a graduated manner, turned previously static front lines into more fluid engagements. The key takeaway is that seamlessly integrating ground and air unmanned systems can drastically enhance safety and operational success. In addition, unmanned platforms aid in handling up to nearly 80% of high-risk tasks.

***Figure 2**: Ukraine's Expanding Robot Army **Source**: Atlantic Council*

Key Lessons

- Combining domains creates a multiplier effect. Lethality increases by 50–80% when aerial platforms cue sea or ground systems.
- Electronic warfare is the biggest threat. Fiber-optic cables and adaptive AI are currently the most effective countermeasures.
- High attrition rates mean that the mass production of cheap, replaceable platforms is essential.
- The Ukrainian military has to a great extent shifted its doctrine towards “drone-centric” operations. It has created a dedicated branch for unmanned systems and actively trains every soldier to operate drones.[13]

Lesson Category	Example of Domain Synergy	Main Vulnerability	Observed Outcome on Battlefield
Aerial-USV naval synergy	Drones guide USV strikes	Jamming	Russian fleet forced to retreat, shipping lanes reopened
UGV-aerial ground teaming	Drones scout, UGVs attack or supply	Terrain & high losses	Lower human casualties, more dynamic front lines
AI coordination & autonomy	Drones reassign tasks automatically	Cyber attacks	Faster decision-making, fewer operators needed

***Table 2**: These examples show how teaming across domains can make affordable systems into force multipliers.*

The war in Ukraine has shown that "off-the-shelf" commercial technology can be a game changer. By using commercial satellite imagery and AI software from private companies, Ukraine has been able to track enemy movements with incredible precision.[14] India must adapt to a "whole-of-nation" approach. The private sector must be harnessed to develop and deliver AI tools capable of analysing the battlefield data in real-time, leading to actionable intelligence.

Comparative Insights: PLA Adaptations from Ukraine

The PLA has incorporated key lessons from the war in Ukraine into its own planning and equipment. PLA analysts have written extensively about Ukraine's use of low-cost attritable drone swarms and how they can saturate defences. They have conducted exercises with groups of 200 or more drones launched from motherships. This is similar to Ukraine's aerial tactics.[15] In the Western Theatre Command (facing India), the PLA is testing high-altitude UGVs for logistics and reconnaissance. Similarly, the PLA Navy utilises USVs for operations in the South China Sea.[16]

China is also developing "loyal wingman" drones that fly alongside J-20 fighters and GJ-11 stealth UCAVs that can operate autonomously. The PLA emphasises the mass deployment of cheap systems that can absorb losses, exactly replicating Ukraine's approach.[17] They have scaled up the production of fibre-optic FPVs and are experimenting with them in exercises to overcome electronic warfare—again, a direct lesson from Ukraine.[18] The PLA may use similar multi-domain unmanned teams along the LAC. This could create overwhelming pressure through saturation attacks and persistent ISR. India must quickly match this capability.

Implications and Suggested Adaptations for India's Joint Framework

Ukraine's experience directly supports the direction India is already taking with the multi-domain Operations doctrine. The doctrine emphasises coordination across various domains and the deployment of unmanned systems to achieve an advantage in information and decision-making.[19] In scenarios involving high-altitude terrain in the LAC, aerial swarms can offer continuous surveillance and targeting capabilities. Moreover, UGVs can transport supplies and execute limited strikes in regions where movement is challenging. This integration of reconnaissance and strike capabilities would deny freedom of movement to the adversary by shortening the sensor-to-shooter loop to seconds,[20] while posing minimal risk to personnel. Similarly, in the IOR, the collaboration between USVs and aerial drones can monitor critical maritime chokepoints. This would, in turn, improve the early detection of submarines and coordinate response with manned platforms. Ultimately, this will contribute to expanding India's maritime domain awareness and influence.

Perhaps the greatest opportunity lies in self-reliance. Ukraine achieved success through a dynamic collaboration between the public and private sectors, which facilitated rapid innovation. India can replicate this through the iDEX scheme, DRDO projects, and partnerships with private companies. India has already made progress in this regard.

- NewSpace Research & Technologies has developed high-density swarming UAVs.[20]
- BotLab Dynamics has demonstrated coordinated swarm shows that can be adapted for military use.[21]
- DRDO is working on the D4 counter-drone system and directed-energy weapons to defeat incoming swarms.[22]

However, gaps remain. India still needs better EW-resistant communications (fibre optics or advanced frequency hopping), large-scale production of attritable platforms, and focused realistic joint training that includes unmanned teaming. Standard radio links are often the first to fail during jamming. To fix this, we need to move towards "mesh networks". Under this model every drone, boat, and ground robot act as a signal relay for the others.[23] This establishes a resilient "self-healing" network free of single points of failure. In the event of a drone being taken down, the signal effortlessly reroutes through the surviving swarm, guaranteeing unbreakable connectivity. Leveraging these autonomous networks guarantees that our mission-oriented teams remain combat-ready and resilient, even in the harshest EW environments.

Suggested adaptations:

- Integrate multi-domain unmanned teaming into tri-service training and exercises, such as Cold Start, Trishul, etc.
- Accelerating the development of AI for autonomous task-sharing and mothership concepts in indigenous UAVs and USVs.
- Build layered counter-unmanned autonomous systems (C-UAS) combining interceptors, lasers, and high-power microwaves.
- Create incentives for private companies to scale production to over 1 million units annually, similar to Ukraine’s model.

Ukraine's Model	Relevant Indian Context	Suggested Action / Adaptation
Aerial-USV naval synergy	Maritime security in IOR	Joint trials with Industry, DRDO USV prototypes & Navy
UGV-aerial ground teaming	High-altitude logistics & ISR on LAC	Test high-altitude UGVs with aerial cueing
Rapid production & iteration	Transformative Atmanirbhar Bharat approach	iDEX partnerships to reach 1 million+ drones/year
EW countermeasures (fiber-optics)	EW challenges on borders	Develop fiber-optic & advanced adaptive frequency hopping systems
Mass attritable systems	Defeating adversaries through Asymmetric Advantage	Prioritize low-cost, replaceable platforms in R&D

***Table 3**: These adaptations would make the tri-services more agile and better prepared for the kind of multi-domain threats as seen in Ukraine.*

The effective integration of unmanned teaming into complex operational environments demands significant evolution in training, doctrine, and adaptability. There is a need to develop a comprehensive training curriculum that familiarises troops with multi-domain unmanned systems. The emphasis should not only be on technical proficiency but also cognitive skills to manage autonomous platforms alongside manned units. Doctrine evolution is equally critical. Guidelines on command-and-control structures, rules of engagement, and the ethical use of autonomous systems need to be clearly defined. This will ensure accountability and operational coherence. The troops would need to adapt to new roles as controllers and coordinators of unmanned assets. This will require a shift of mindset from traditional combat to collaborative human-machine teaming. Continuous joint exercises incorporating unmanned systems are essential. These would assist in building trust, interoperability, and decision-making agility under contested conditions. The end goal will be to ultimately enable the armed forces to exploit the full potential of unmanned teaming while mitigating the risks associated with complexity and autonomy.

Figure 3*: Tri-Services Exercise (TSE-2025) 'Trishul' held in Nov 2025.* ***Source****: The Press Information Bureau.*

Recommendations

Looking ahead, multi-domain unmanned teaming will be pivotal in shaping India's future conflict landscape. It is therefore appreciated that proactive action will allow India to transform lessons from Ukraine into a sustainable strategic advantage against evolving multi-domain threats. To prepare well, India needs to:

- Invest heavily in cutting-edge AI software that allows drones, USVs, and UGVs to share tasks and adapt automatically in a denial-of-command signal environment.
- Doctrine and training frameworks should be updated to embed multi-domain unmanned teaming into tri-service exercises. This will foster interoperability and operational agility under contested conditions.
- Strengthen partnerships through suitable alliances with like-minded nations to access advanced C-UAS technologies and share best practices.
- A phased roadmap is essential. Pilot projects and joint trials could be considered for implementation between 2026 and 2028. These projects would need to validate concepts and capabilities. This will aid in eventually setting the stage for full operational deployment between 2030 and 2035.

Conclusion

Modern warfare is moving beyond just physical destruction. It is now a race to see who can think and decide faster. In the cognitive domain, commanders endure intense psychological strain alongside the imperative for rapid and high-stakes decision-making. Pertinently, all these factors are at play under extreme operational fatigue. In high-tempo drone encounters, the sheer amount of data from the sensors can cause information overload. By using AI to filter this data, we can shorten the "Observe-Orient-Decide-Act" cycle, thereby preventing being overwhelmed by digital noise.

India has made great strides through the proactive schemes of GoI and the various DRDO projects such as the Multi-Agent Robotics Framework. However, these efforts are often scattered.[24] To truly succeed, India must have a clear future-proof strategy. This needs to encompass both short-term achievable goals and a long-term vision. This strategy would assist in fostering an ecosystem where advancements in unmanned systems, AI, and robotics can seamlessly transition from civilian innovation to military application. With the shared thread of integration, this policy should focus on creating common standards. This will ensure that a drone from a small startup can "talk" to a ship or tank without any compatibility issues. This integration would also guarantee that technological progress is not just theoretical but is practically implemented and improved through repeated feedback cycles. This approach necessitates substantial government investment and a streamlined acquisition process. It will aid in transitioning beyond sporadic efforts to establish a robust, continuous cycle of innovation and deployment.[25]

Ukraine’s integration of aerial swarms with USVs and UGVs demonstrates how multi-domain unmanned teaming can deliver asymmetric advantages over adversaries. For the tri-services, these developments offer tangible, actionable insights that can strengthen the joint operational framework, enhance self-reliance, and improve readiness against emerging threats, particularly from the PLA that is already adapting the same ideas. The time to act decisively is upon us.

DISCLAIMER

The paper is the author's individual scholastic articulation and does not necessarily reflect the views of CENJOWS, the Defence forces, or the Government of India. The author certifies that the article is original in content, unpublished, and it has not been submitted for publication/ web upload elsewhere and that the facts and figures quoted are duly referenced, as needed and are believed to be correct.

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