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Air Littoral and Helicopter Operations in Modern Battlefield

Manish Yadav

CENTRE FOR LAND WARFARE STUDIES

Field Marshal Sam Hormusji Framji Jamshedji Manekshaw, better known as Sam "Bahadur", was the 8th Chief of the Army Staff (COAS). It was under his command that the Indian forces achieved a spectacular victory in the Indo-Pakistan War of 1971. Starting from 1932, when he joined the first batch at the Indian Military Academy (IMA), his distinguished military career spanned over four decades and five wars, including World War II. He was the first of only two Field Marshals in the Indian Army. Sam Manekshaw's contributions to the Indian Army are legendary. He was a soldier's soldier and a General's General. He was outspoken and stood by his convictions. He was immensely popular within the Services and among civilians of all ages. Boyish charm, wit and humour were other notable qualities of independent India's best known soldier. Apart from hardcore military affairs, the Field Marshal took immense interest in strategic studies and national security issues. Owing to this unique blend of qualities, a grateful nation honoured him with the Padma Bhushan and Padma Vibhushan in 1968 and 1972 respectively.

Field Marshal SHFJ Manekshaw, MC
1914-2008

CLAWS Occasional Papers are dedicated to the memory of Field Marshal Sam Manekshaw

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Abstract

The strategic environment of warfare is undergoing a fundamental transformation, one that has not been seen before. For decades, military doctrine has been predicated on the principle that air superiority - the degree of control necessary for the successful execution of joint operations - is won in the 'blue skies' at medium to high altitudes. This model assumed that once achieved, such superiority would extend to all altitudes, enabling ground and maritime forces to operate with impunity below this controlled plane. However, recent conflicts and the fast-paced proliferation of low-cost, high-impact technologies have fundamentally altered this calculus, thus creating a strategic 'decoupling' of air control from the upper to the lower tiers of the battlespace. Rotary Wing (RW) aircraft, long established as the dominant platform in this airspace, are now being assumed to have diminished operational relevance. This article argues that the employability of helicopters in modern battlefields is not dead; it is merely in a violent period of tactical transition. By embracing the concept of Air Littoral, leveraging Manned-Unmanned Teaming (MUM-T) and adopting 'stand-in' force tactics, RW aviation will remain a key element of joint operations in Air Littoral.

Introduction

For much of the modern military era, airpower doctrine has been predominantly oriented toward a singular objective: achieving air superiority through the employment of high-performance Fixed Wing (FW) aircraft (fighters & bombers). This strategy assumed that dominance of the high-altitude 'blue skies' would impart control over all lower altitudes and has been the cornerstone of successful joint operations such as the Gulf Wars I and II. The logic was simple: having neutralised an opponent's Air Force as well as advanced Air Defences, the space below would become free from any hindrance to successfully execute strategic strikes, interdiction, or Close Air Support (CAS).

However, the causal factor for the current shift in strategic focus is technological. A new class of threats, driven by breakthroughs in robotics, miniaturisation, and mass production, has introduced a persistent and multifaceted asymmetric challenge. This democratisation of airpower has enabled actors with limited resources, including non-state entities, to exploit the low-altitude air domain with inexpensive Unmanned Aerial Systems (UAS) and Loitering Munitions (LMs). The effectiveness of this approach was demonstrated by ISIS in Mosul, where repurposed commercial drones operated below 2,000 feet, challenging conventional forces operating under a presumed umbrella of air superiority (Srivastava. S). The conflict in Ukraine and other conflicts in the 21st century have brutally demonstrated that the decisive domain of modern warfare is not the stratosphere, but 'Air Littoral' - a contested, cluttered airspace affecting joint operations.

What is Air Littoral?

Air Littoral is a conceptual framework that defines a critical and increasingly contested sub-region of the air domain. Scholars have defined this airspace as 'the area from the Coordinating Altitude to the Earth's surface'. (Grieco, M., & Bremer, K. Air littoral – Another look). Coordinating Altitude is a USAF terminology which is an airspace coordinating measure that procedurally separates users and defines the transition between airspace control elements for safe flight operations in a defined airspace (Joint Chiefs of Staff, JP 3-52). Air Littoral can also be understood as the airspace between ground forces and high-end fighters & bombers. It is the region of airspace where ground fire (small arms, RPGs, MANPADS, AD systems) intersects with air threats (drones, enemy helicopters). Unlike the 'blue skies' where speed and stealth dominate, air littoral is characterised by clutter, obscuration, and hyper-lethality. The concept also emphasises that controlling this airspace is essential for military success in the Tactical Battle Area (TBA).

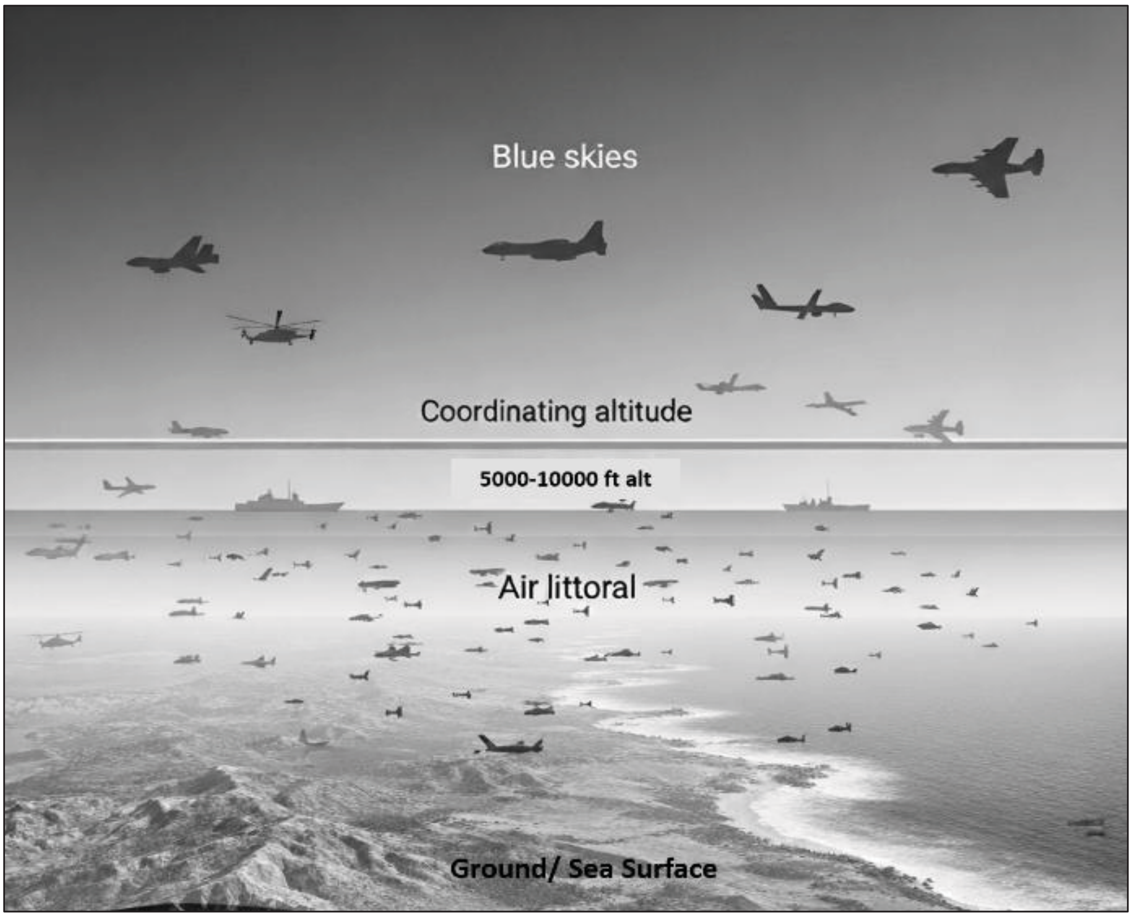

Fig 1: Graphical Depiction of Air Littoral
(Source: Author's Visualisation)

Key characteristics of Air Littoral are: -

- **Low Altitude.** The air littoral, originally defined up to 10,000 feet by Grieco & Bremer, is the airspace closest to the surface (land / maritime) and which has a direct bearing on surface operations.

- **Contested Space.** It is a heavily contested environment due to the proliferation of UAS, AD systems, MANPADS, LMs, and cruise missiles.

- **Support for Land and Sea Operations.** Its primary purpose is to enable and support operations in the land and maritime domain, as well as to deny the same airspace to the adversary.

- **Drones are the Key.** Small, cheap, UAS dominate this domain, performing missions that were once handled by manned aircraft.

- **Convergence of Domains.** In this space, the distinction between 'Land' and 'Air' forces blurs. For example, a quadcopter hovering at 50 feet is technically an air asset, yet it is often controlled by an infantry section commander. Similarly, a helicopter flying Nap-of-the-Earth (NOE) is using terrain masking in a way that mimics ground manoeuvre. The modern battlefield sees these domains converging into a singular 'Air Littoral' manoeuvre space. Therefore, it implies that helicopters, UAS, and ground-based systems must be planned, controlled, and trained as an integrated Op fire and manoeuvre system, not as separate service-owned domains.

The concept, as elaborated by Grieco & Bremer in their work titled 'The Air Littoral: Another Look,' consistently refers to this low-altitude region as a "seam" between the air and ground domains, explicitly drawing parallels to the familiar maritime littoral. Maritime littoral has historically been one of the most challenging environments for joint operations, where the interdependencies between land and sea forces are most pronounced. Militarily, a littoral is a transition zone where different domains meet, creating friction and opportunities for adversaries to exploit vulnerabilities. This pattern extends beyond the air-ground interface, where one scholarly article even speculates on the future emergence of a "space littoral" (Jackson, K., & Arrol, M. 2024).

Effect of Air Littoral on Application of Airpower

The rise of the air littoral fundamentally alters application of airpower by creating a significant 'decoupling' of air control at low altitudes from control of the blue skies. The concept of Air Superiority has been an important part of airpower theory for many years and is often cited as one of the conditions necessary for achieving control of the air during military operations. It is defined as a high degree of control of air over the battlespace, which permits the conduct of land, sea, and air operations at a given time and place with minimal interference from the enemy Air Force (IAP 2022). Typically, achieving air superiority has involved the use of fighter aircraft and Integrated Air and Missile Defence Systems (IADS) to create a 'bubble' of control within the medium to high altitude airspace, supported by the bombing of enemy airfields, C2 centres, and critical infrastructure in depth areas. In the Gulf Wars, USAF was able to gain air superiority, allowing coalition ground forces to move with very little interference from enemy airpower. Conversely, Air Littoral Superiority refers to the level of control over airspace near the surface. Development of Attack Helicopter (AHs), UAS, LMs, Electronic Warfare (EW) platforms, and Short-Range Air Defence Systems (SHORADS) operating in this airspace environment has emerged as a critical factor in shaping how land warfare is fought today. As previously noted, Air Forces may enjoy the tactical advantage over the higher altitudes, but air littoral operations can remain vulnerable to attack from enemy forces. Russia-Ukraine War highlights this disparity, with neither belligerent in control of traditional air superiority but both parties utilising UAVs, AHs and conducting air-to-surface missile attacks over the air littoral environment while simultaneously defending against MANPADS, EW, and counter-UAS systems (Goodwin, 2023). In most cases, air superiority operations are led by the Air Force; however, unlike air superiority, air littoral operations are joint, with surface forces generally taking the lead via land or maritime platforms. Control of this region relies less on fighter aircraft and more on dispersed sensors, mobile AD systems, EW and enhanced coordination between ground commanders and aviation assets (Jackson & Arrol, 2024). Helicopter operations and UAS in the air littoral can directly shape tactical outcomes by providing logistical support, coordination as well as casualty evacuation, and also provide critical Close Air Support to ground troops.

Therefore, an adversary with limited means can operate right overhead and underneath our air superiority, thereby threatening ground forces despite the absence of an enemy Air Force. This new reality means that a conventional military, even one that possesses overwhelming air superiority with high-end fighters and bombers, can find its ground component persistently threatened by low-cost, pervasive aerial systems. Also, open innovation, by accessing off-the-shelf engines, servo actuators, electronics, and 3D printers to create components of drones and missiles, has levelled the playing field, empowering a wide range of actors to contest and exploit the air littoral. A similar incident was observed in March 2021 when Houthi rebels employed a mix of military and commercial-grade drones, laden with explosives for coordinated precision strikes at various Saudi oil infrastructure (Grieco, M., & Bremer, K. Contesting the Air Littoral).

Thus, layered surveillance and temporal awareness are a must as multi-dimensional threats converge in this shared airspace. The speed and dynamism of this environment also render the conventional Air Tasking Order (ATO) model slow and cumbersome to be effective (Grieco, M., & Bremer, K). Another major implication is persistence on the battlefield, which conventionally has been difficult to maintain, largely due to machine and human limitations. This, however, can be achieved by continually rotating drones, as they are cheap and quick to build in large numbers compared to traditional platforms. The differences of air power application as observed from the blue skies domain is tabulated as under: -

S No	Characteristics	Traditional 'Blue Skies' Domain	Air Littoral Domain
1.	**Primary Altitude**	Medium to High	Earth's Surface to Coordinating Altitude (~5,000-10,000 ft)
2.	**Primary Assets**	Fighters, Bombers, MALE/ HALE UAVs, UCAVs and HAPS	Helicopters, UAS (Micro and Mini UAVs), LMs, Cruise Missiles, CUAS, Artillery & SHORADS
3.	**Key Threats**	Peer Adversary Aircraft and Integrated AD Systems	Drones, LMs, MANPADS, Small-Arms Fire, High-Power Lasers, Jammers & Spoofers

S No	Characteristics	Traditional 'Blue Skies' Domain	Air Littoral Domain
4.	**Command and Control**	Centralised, generally at highest authority for quick information dissemination	Decentralised and highly dynamic
5.	**Objective**	Achieving Air Superiority, strategic targeting	Gaining and maintaining Air Littoral dominance for the furtherance of surface operations
6.	**Loss Tolerance**	Low (due to high-end fighters, bombers and High Value Aerial Assets such as AEW&C & Air-to-Air Refueler)	High (Low-cost expendable drones)
7.	**Op Tempo**	Planned and Deliberate	Dynamic and Continuous

Table 1: Airpower Domain Comparison
(Source: Author's Articulation)

This domain, once the uncontested playground of the AH, is now saturated with cheap, lethal and omnipresent UAS. The proliferation of First-Person View (FPV) drones and LMs has led many analysts to prematurely declare the death of the manned helicopter. They argue that large, heat-emitting RW platforms are obsolete flying coffins in an era of transparency and precision fires. The assessment is dangerous and premature. While the character of the threat has changed, the nature of the requirement viz. vertical manoeuvre, rapid logistics transportation, ability to land at difficult places and human tactical judgement in complex terrain/ situations, remains immutable.

Lessons from the Past

Lessons of the air littoral are not merely theoretical but are being written on the modern battlefield and have historical antecedents that can shape future doctrines. Given below are two case studies that bring out the key lessons for 21st century aerial battlefields.

- **2nd Nagorno-Karabakh War 2020.** As one of the critical junctures in 21st century military clashes, the Nagorno-Karabakh war saw extensive employment of Turkish Bayraktar TB2s and other armed UAVs by Azerbaijan, which systematically degraded Armenian SHORADS and heavy armour. It thereby facilitated rapid ground manoeuvre and decisively shifted the war in their favour. Open source data indicates that Armenian RW assets suffered multiple combat losses to these systems, including Mi-8 and Mi-24 platforms, primarily to a combination of MANPADS such as 9K38 Igla, Short Range Surface-to-Air Missiles (SRSAM), and Precision Guided Munitions (PGMs) delivered from TB2s, which exploited sensor-shooter links to engage helicopters either during exposure in the climb phase or while operating at cruising altitudes (approx. 1000-3000 feet agl). These losses, combined with the psychological effect of persistent drone presence, led to the effective grounding of major portion of Armenian helicopter fleet, underscoring that RW platforms lacking integrated CUAS, modern Missile Approach & Warning Systems (MAWS), Directional Infrared Countermeasures

(DIRCM) and robust EW suites become exposed, high-value targets in a drone-saturated air littoral. (Davies, E. 2021, 26 May). Nonetheless, Azerbaijan's subsequent employment of its own helicopters for follow on support and exploitation missions - once unmanned systems and long-range fires had suppressed key radar, SHORAD and MANPAD clusters, demonstrates that a layered employment construct, in which drones lead the penetration and suppression effort and helicopters are committed later for precision strike, Heli-lift and coercive presence, remains operationally viable and tactically effective.

- **War in Ukraine - A Modern Laboratory.** The Russia-Ukraine war serves as a contemporary laboratory that has validated the predictions of the air littoral concept. Both Russian and Ukrainian forces have since vied for control of this battlespace, employing inexpensive UAS and LMs. In July 2025, Russia launched 6,297 drones against Ukraine, representing a 1400% increase from July 2024 (Al Jazeera). The conflict has demonstrated conclusively that "control of the blue skies (operational air) does not extend to the air littoral (tactical air)". Despite the conventional advantages of major powers, the ubiquity and affordability of drones in this space have restored a form of parity, with the salience of controlling this domain for ground operations growing exponentially. As a direct result, both Russia and Ukraine have established a dedicated Unmanned Systems Force (USF) to manage and control this new domain.

As regards the application of helicopters, early stages of the Ukraine war saw Russian Ka-52 fleets suffering attrition rates exceeding 40% as an outcome of conducting traditional CAS tactics - hovering to fire guided missiles, within range of dense MANPAD belts. By 2023, Russians had lost 59 helicopters - 42 of which were shot down in-flight and 17 destroyed on the ground, amounting to almost 30% of its operational fleet. Out of these, nearly 50% were due to MANPADS. The lesson was clear: loitering at these altitudes to conduct strikes is suicidal. Survival requires speed, extreme low-level flight (below 50 feet), and stand-off engagements. Russian pilots changed the doctrinal pivot to long-range stand-off engagements, aided by PGMs & EW support. Modernised Ka-52Ms, equipped with advanced optics and Non-Line of Sight (NLOS) missiles, adopting techniques such as EW helicopters, jamming radar, and Infrared (IR) signature, while drone swarms relaying real-time targeting data, transformed Russian rotary operations into a synchronised, multi-domain kill web. Also, both Ukrainian and Russian pilots quickly adapted to the demanding battlefield conditions and adopted a crude but innovative style of deploying armament called *"toss bombing"* or *"lofting"*. Lofting involved flying at 10 meters altitude, pitch up 30 degrees, fire rockets in a ballistic arc to 6-8 km range, and immediately turn away, deploying flares. While inaccurate, this tactic kept the AHs outside the range of MANPADS and short-range AD weapons, thus turning the helicopter into a highly mobile flying artillery (Gosselin-Malo, E. 2024, July 19).

These case studies highlight that the vulnerabilities of RW assets in a contested low-altitude environment have been compounded exponentially by the advent of modern technology. To keep things in perspective, a summary of helicopter losses in various wars/ conflicts and their attributed threats is as indicated in the graph below.

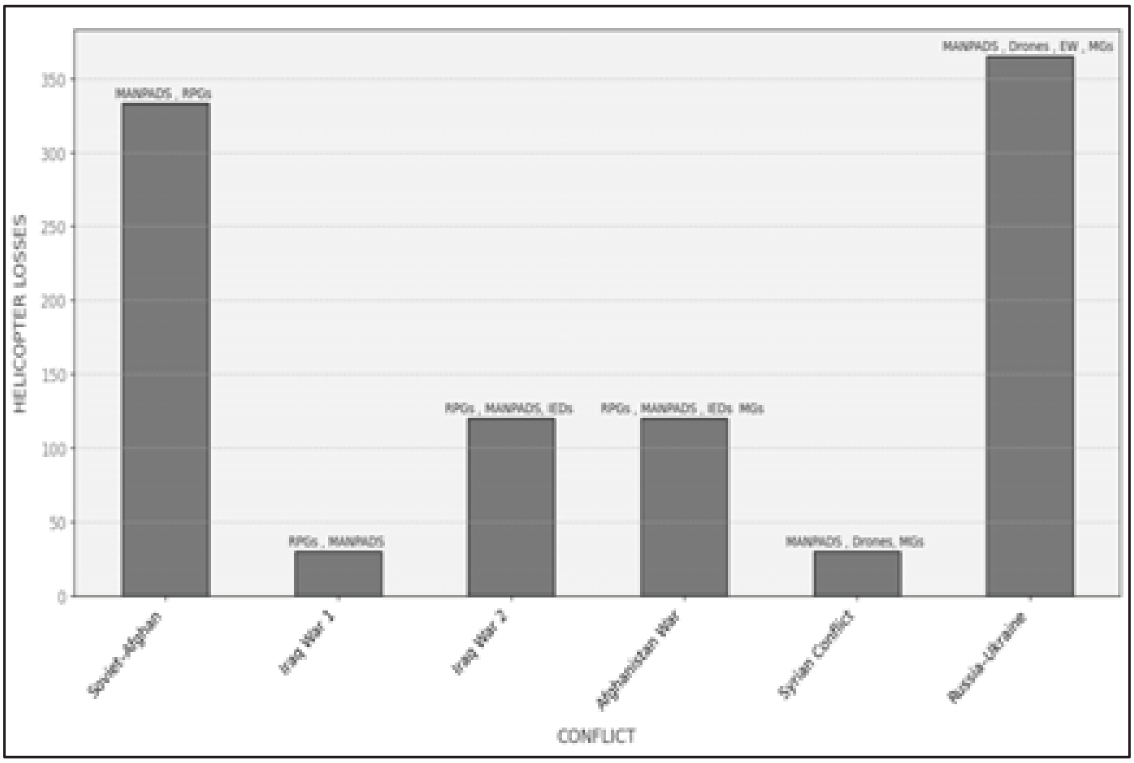

Fig 2: Helicopter Losses and Dominant Asymmetric Threats
(Source: Data from multiple online sources compiled by the author)

Contemporary Threat Landscape

Modern challenges facing RW assets in the air littoral can be conceptualised as a multifaceted dilemma rooted in a triad of evolving threats and inherent vulnerabilities. The **first** and most immediate threat comes from low-cost UAS, FPV drones and LMs. These systems pose a persistent Intelligence, Surveillance & Reconnaissance (ISR) challenge, enhancing the enemy’s kill web and rendering the battlespace targetable to a significant depth. They can also deliver lethal and non-lethal effects at a remarkably low cost, making them highly expendable and difficult to counter at a favourable cost-exchange ratio.

The **second** threat is the proliferation of MANPADS and advanced short-range rockets. As seen in the Vietnam War, the threat of shoulder-fired missiles forced helicopters to fly at very low altitudes and manoeuvre constantly, tactics that are both demanding and dangerous. This threat has only grown more sophisticated and widespread over time, turning the low-altitude airspace into a high-risk operating zone.

The **third** challenge is the inherent paradox of the third dimension. While helicopters are designed to use terrain for cover, their size prevents them from manoeuvring safely and effectively between buildings and large trees in the way that small, nimble drones can (National Defence University Press, 2023).

Another rapidly emerging challenge in the modern battlefield is Electronic Warfare. E.g., studies suggest that Ukraine loses approximately 300 drones daily to Russian EW systems. Also, Russian EW systems reduced HIMARS accuracy from 5 meters to 27 meters, gravely affecting the application of these vectors. Such facts amplify that adversaries will attempt sophisticated electronic attacks to saturate the EM spectrum. Some of them are: -

- **Jamming and Deception.** Beyond simple jamming, the enemy will use networked, adaptive jamming to target specific frequencies and create false signals to deceive onboard systems. This can lead to system degradation, making communication and navigation unreliable.

- **Sensor Fusion Overload.** Helicopter EW systems, such as Radar Warning Receivers (RWR), can be overwhelmed by the sheer number of enemy emitters and multi-spectral threats (e.g., radar, IR, and laser-guided systems). Manual operator response becomes impossible, and automation is required to prioritise and respond to threats.

- **Targeting and Counter-Targeting**. In a heavily contested space, the enemy is not just trying to deny use of the spectrum; they are also using it to locate and target our aircraft. Therefore, there is a need to constantly adapt to new jamming and deception techniques.

In addition, the presence of numerous UAS alongside traditional RW assets turns the air littoral into a chaotic 3-D battlefield, leading to a major challenge of traffic deconfliction, rendering the traditional air traffic control system obsolete. Such a saturation of low-cost, 'non-cooperative' drones that are utilised from recce to direct assault poses a high threat to mid-air collision. For pilots, this presents a significant information overload issue, as they need to rapidly process a cascade of data from onboard sensors, friendly drone swarms, and networked assets. This issue is also compounded by the fact that such drones will have unpredictable flight paths and are dynamic in nature, making conventional deconfliction techniques obsolete in a time-compressed, high-risk environment.

As seen above, these modern threats have compounded the historical vulnerabilities of helicopters, thus creating a powerful incentive to offload risk from high-value manned platforms to low-cost expendable ones. The core issue is that the manned helicopter, with its inherent vulnerability and the high cost of its loss, is increasingly being seen as a liability when directly engaging in the Air Littoral. Thus, the future role of manned helicopters may no longer be to dominate this space directly but rather that of a command node or 'mother ship' supporting autonomous systems. This will redefine the helicopter's role within the combat space from a primary combat platform to that of an orchestrator of combat power, leveraging the expendability of unmanned systems to mitigate its own risk and expand its operational reach.

Helicopter Roles and Relevance in Modern Battlefield

Despite the threats, helicopters provide capabilities that drones cannot yet replicate. RW platforms still provide a unique combination of payload, endurance, human judgement and vertical manoeuvre that unmanned systems have not fully matched. Some of the strengths are: -

- **Payload & Endurance.** Helicopters offer payload and endurance at a scale that current drones cannot match. A heavy-lift platform such as the CH-47 can move several tonnes of cargo or a full infantry section with equipment in a single sortie, while an attack helicopter such as the AH-64 Apache can carry a substantial mix of guided missiles, rockets and cannon ammunition for sustained engagements. By contrast, most tactical UAS/ Rotary UAS deliver grams to tens of kilograms of payload/ ordnance, which is effective for point strikes but inadequate for rapid concentration of combat power or theatre-level logistics.

- **Vertical Manoeuvre.** RW aviation continues to underpin vertical manoeuvre, which remains central to tempo and shock. The ability to insert platoon or company sized forces behind enemy lines, reinforce or extract isolated elements, conduct rapid heli-lift of Artillery or AD systems and casualty evacuation are missions that still rely overwhelmingly on manned helicopters. These vertical manoeuvre capabilities enable commanders to bypass strongpoints and generate operational surprise in the TBA.

- **Human Judgement.** In complex urban regions, the latency and limited situational awareness inherent in remote piloting can be operationally and ethically unacceptable in hostage rescue operations or CAS missions. A crew on the scene can interpret nuance, discriminate between threats and non-combatants, and adapt to rapidly changing ground situations in ways that remain difficult to replicate via a remote operator located many kilometres away. The same applies to human judgements made in marginal weather / intense battlefield conditions where human psychology, skills, and trust play a major and sometimes decisive role in achieving mission objectives.

Crystal Gazing into the Future

To survive in the Air Littoral, modern helicopters must evolve from a standalone operator into a networked 'orchestrator'. This transformation rests on three technological pillars, which are Manned-Unmanned Teaming (providing reach), Modular Open Systems Approach (providing agility) and Integrated Secure Networks (enabling secure communication & networked operations).

- **Manned-Unmanned Teaming (MUM-T).** MUM-T is presented as a decisive strategy for future Army Aviation. The concept involves a manned helicopter, such as an attack or recce aircraft, working in concert with one or more UAS. This collaboration provides significant advantages, including enhanced situational awareness, more accurate hits, and real-time targeting. The UAS can perform dangerous recce and surveillance operations, extend the manned platform's reach, and mitigate risk to aircrew. However, to be successful, MUM-T requires a 'materiel shift' to inexpensive, high-quantity and expendable UAS that can operate effectively in a contested A2AD bubble (Pandey, D. K. Manned-Unmanned Teaming: Enhancing Lethality). Research indicates MUM-T operations can achieve 3-5x force multiplication effects while reducing risk to manned platforms (ibid). In order to understand MUM-

T applicability, it is essential to define the NATO standard Levels of Interoperability (LOI), which measure the depth of integration (STANAG 4586). LOI is defined as the ability of varied systems to communicate, exchange data and use common pool of information and actionable intelligence. Various LOIs are as enunciated in Fig 3 below.

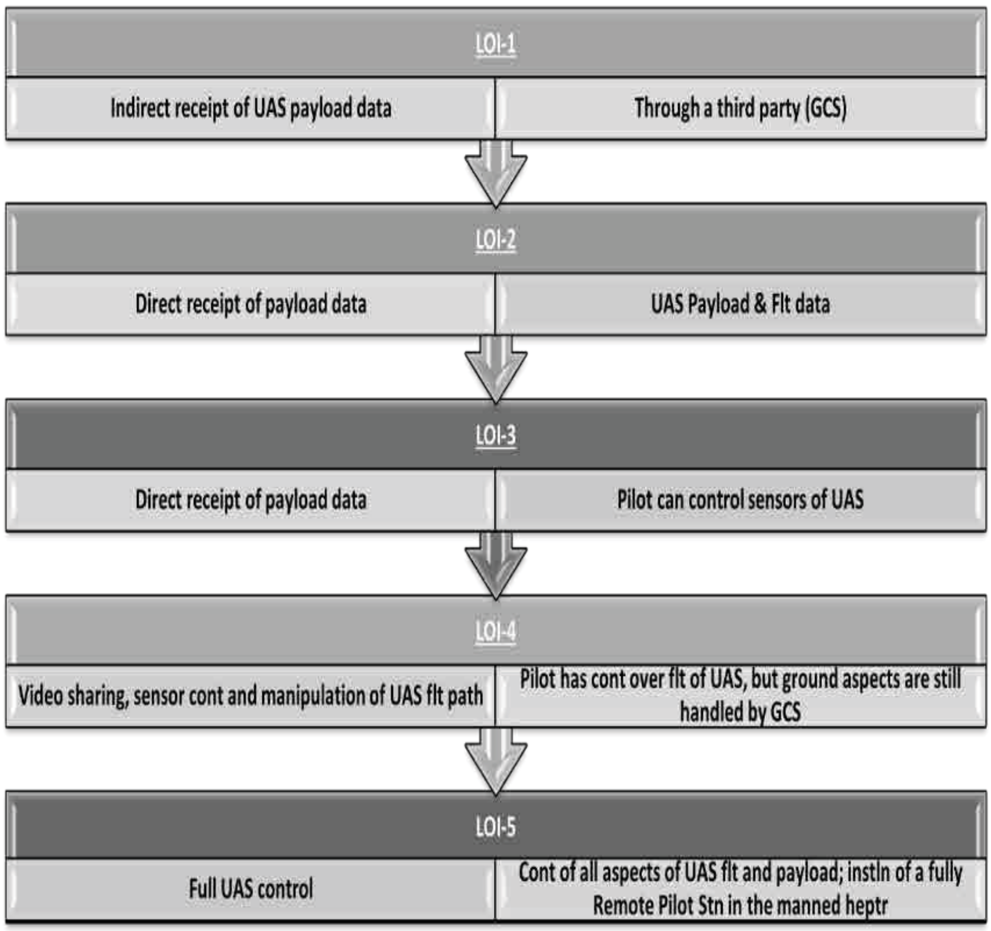

Fig 3: Levels of Interoperability (NATO Standards)

An example of MUM-T in action was demonstrated in 2022 during a simulated combat scenario under the Future Combat Air System (FCAS) project of Airbus. Airbus turned the H 145M Utility Helicopter into a MUM-T powerhouse by installing a specialised 17-inch operator display in the cockpit**.** The H 145M helicopter, operating alongside a jet and several real unmanned systems called “remote carriers”, enabled its crew to assume control of one of these remote carriers and access its live video stream during flight. The system also allowed the crew to hand over control of a drone to a ground soldier after the helicopter left the area, validating cross-domain control (Airbus, 2024, June). This proves that even light/utility helicopters can act as orchestrators for lethal drones, obviating the need for AH in every mission, which are limited in numbers and more suited for high-risk close support missions.

Fig 4: Cockpit view of H145 Utility Helicopter pilot controlling the feed from Remote Carrier (Source: Airbus)

- **Modular Open Systems Approach (MOSA).** If MUM-T is the sword, MOSA is the brain that keeps it sharp. Traditionally, upgrading a military helicopter's avionics takes 3-5 years because of hardware fitment and software proprietary issues. MOSA changes this by mandating open standards - making a helicopter's avionics as easy to upgrade as installing an app on a smartphone. E.g., if a new enemy drone frequency appears, engineers can upload a software application to the helicopter's EW suite to jam it, without waiting 5 years for a hardware refit.

The US Army's UH-60V Black Hawk is the first fully MOSA - compliant Utility Helicopter. In a demonstration by avionics firm *Avilution*, a new specialised radio application was integrated into the UH-60V's flight computer. The initial integration took 27 days to write and certify the code for the Black Hawk, however, when they moved that same code to a CH-47 Chinook (which also used MOSA standards), it took just 3 days to integrate. This 90% reduction in integration time means that if a new threat emerges, the entire fleet can be patched with a software countermeasure in days, not years (Avilution 2023, August 8). This compressed upgrade timeline is operationally decisive in the air littoral, where electromagnetic threats evolve in quick timeframes. Under legacy acquisition models, responding to a newly detected jamming frequency typically requires initiation of a formal Request for Proposal (RFP), contracting the existing proprietary system vendor, engineering the solution, conducting formal testing and finally executing the requisite modification. This arduous cycle consumes 3-5 years and incurs higher costs. In contrast, a Modular Open Systems Approach reconceptualises this response as a competitive software-module integration problem that can be executed within weeks and at a fraction of the cost. This shift is strategically critical for EW survivability in the air littoral, where warfighting relies on rapid frequency-hopping and adaptive electronic countermeasures (Green, A., 2025).

MOSA places a new level of importance on systems change and removes the need for totally replacing a system due to obsolescence. When hardware becomes outdated, MOSA framework allows targeted module replacement - a "LEGO brick" approach without restructuring the entire architecture. Across a 30-40 year helicopter lifecycle, this modularity results in saving large sums of money avoided in replacement costs while maintaining operational relevance. MOSA, thus aims at improving interoperability, reducing costs and rapid integration of new upgrades into operational aircraft.

- **Integrated Networks and Sensor Fusion.** Modern conflicts consistently reinforce a critical truth - *no single sensor or platform, no matter how advanced, can dominate the battlespace in isolation***.** The reality of modern warfare is that terrain obscures line of sight, conurbations clutter and scatter electromagnetic signals, small drones are difficult to detect as they present low Radar Cross Section (RCS) and pervasive EW severely limits standalone situational awareness. If a system relies solely on either a single airborne asset or surface radar, it will create areas of vulnerability and blackout conditions. Integrated networks are necessary to eliminate these vulnerabilities. By taking data from multiple sources (including ground-based surveillance radars, EO/IR sensors on helicopters, passive RF triangulating systems, CUAS Suits, ship-based radars, and AEW&C assets) and fusing all of them into one shared and unified Common Operational Picture, users have a much greater situational awareness than is provided by relying on an individual sensor alone. With this increased situational awareness, the ability to detect threats within that window of time greatly decreases the amount of time it takes for the operator to detect a low altitude threat such as LMs, AHs or low flying cruise missiles, allowing him to respond to such threats much faster and with greater confidence than ever before. The time between detection and response becomes much shorter, thus greatly reducing the length of the sensor-to-shooter loop. Tactical Data Links (TDLs) connect all these various sensors and shooters together to form a cohesive and integrated fighting unit.

Fig 5: Illustration of the networked operations using Link 16 TDL (Source: Viasat)

The Link-16 data system is widely considered a standard for secure, jam-resistant transmission of track data, positional information, commands, and other data-sharing applications between various platforms. The system was originally designed for high altitude air-to-air combat missions but is also increasingly used for surface missions because of its flexible and resilient design that allows real-time, low altitude tracking of helicopters and other ground forces performing missions below the radar horizon. Other tactical links, such as Link-11 and Link-22, link both maritime and coastal forces' ability to communicate air and surface track information across a busy and contested battle space, enhancing situational awareness and improving Battle Damage Assessment (Joint Chiefs of Staff, 2023). Each of these tactical link systems serves to develop a unique thread in the network of tactical data links, filling operational gaps and ensuring the timely delivery of critical information to the appropriate sensor / shooter platform.

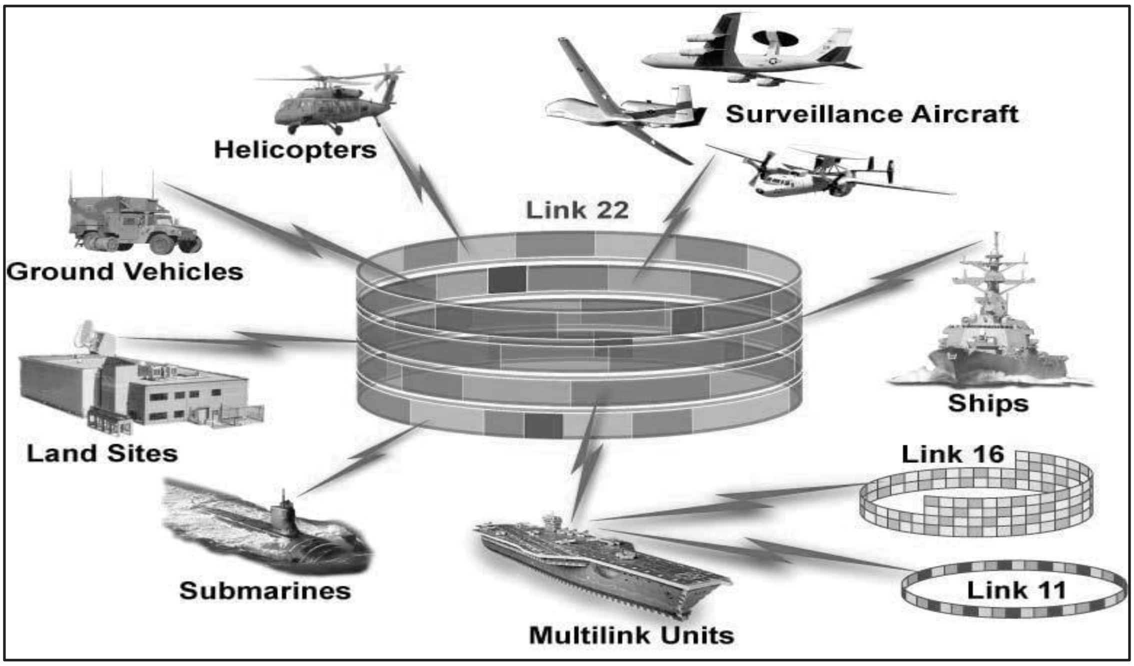

Fig 6: Illustration of the Link-22 TDL (Source: C4ISRNET)

Recent wars demonstrate how significant Integrated Networks are in determining the outcome of battle. In Ukraine, for example, both Ukrainian and Russian forces have used military and civil drones, mobile radar and acoustic array technology to assist in identifying airspace, tracking targets and cueing air defences to respond to low-flying threats. Ukraine, in particular, has shown how effectively a rapid flow of targeting information can enable it to engage Russian forces and deny them tactical freedom of movement (Watling & Reynolds, 2023). Along these lines, NATO has begun to implement lessons learned from these experiences through exercises emphasising the connection of AHs, SHORADs and ISR drones through interoperable Data Links to defeat drone swarms, sudden incursions by helicopters or volleys of cruise missiles. The use of integrated systems was also witnessed during Operation SINDOOR, where the Pakistan Air Force utilised Link-17 to overcome conventional shortcomings and achieve results that would have been impossible in a less connected battlespace (Adel Delves, M, 2025).

Integrated networks can dramatically alter helicopter operations in the air littoral. Attack/ Utility helicopters flying NOE can have the ability to receive threat warnings (incoming missiles) and target cues, both coming from off-board sensor networks, which reduces helicopter exposure to MANPADS and small-arms fire. The combined threat/ target awareness they gain from this type of network enables helicopters to behave more as nodes within a larger air-ground system as opposed to being isolated shooters. Similarly, radars from naval vessels can cue helicopters for intercepts as well as direct land-based AD units toward low-altitude threats.

Looking forward, technologies such as Software Defined Radios (SDR), mesh networks, and AI-based fusion engines are expected to provide additional support and information to platforms operating within the air littoral environment and allow for re-routing of information in real-time when nodes are jammed or destroyed and allow for decentralised decision-making. Also, these technologies will improve the network's ability to operate when individual nodes are being jammed, spoofed or destroyed, thereby providing an ability to maintain its tempo of operation under the stress of electronic attacks. But these advances come with new vulnerabilities - improvements in technology will lead to increased adversary interest in jamming, hacking or spoofing data links to disrupt networks and insert false data into networks. Thus, design resiliency, redundancy and trusting subordinates to act on the best available information even when the network is degraded must be foundational principles from the outset. Dominance in the air littoral will not be by virtue of having the most technologically advanced platform. Rather, it will belong to whoever can ‘sense it first’, ‘share it fastest’, and ‘act decisively’ in a chaotic environment with myriad threats at low altitude.

Recommendations

As seen above, Air Littoral is no longer a peripheral operating area; it is a decisive and contested domain. This new reality will need more than just technological improvements; it mandates a new mindset, a renewed focus on jointness and decentralised execution philosophy. To maintain relevancy in the drone-dominated battlespace, the following measures are recommended:-

- **Embracing the 'Littoral Mindset'.** We must recognise that Air Littoral is a template for future conflict across all domains. This understanding necessitates prioritising a strategic-level, joint force approach towards training, equipping, and organising all services in an integrated manner. Some of the methodologies which may be adopted to optimise operations in Air Littoral are as follows: -

  - **Standardising 'Terrain Flight' in TBA.** Future doctrines on operations in Air Littoral must emphasise aggressive NOE flight - 50 feet and below as an important training measure. The air littoral is only safe in the "clutter," and survival for helicopters depends upon pilots' ability to harness his skills in low-level flying when operating in close proximity to the enemy in TBA.

  - **Decentralised Execution.** While integration of assets is important, the system should also empower ground units with autonomy to act against immediate threats. Therefore, for implementing dynamic Air Space Management (ASM) in the TBA, fundamental doctrinal tenets of centralised command, distributed control and decentralised execution must be adhered.

- **The "Stand-In" Force.** Redefining the helicopter's primary role as the decisive 'finisher' following initial suppression by Drone Swarms executing SEAD/ EW operations & precision strikes, with helicopters conducting the terminal manoeuvre to destroy High Value Targets (HVTs), insert troops or undertake missions in support of ground forces.

➢ **Technology Driven Operations.**

- **Investing in Air Launched Effects (ALEs).** It's important to invest in procuring Air Launched Effects (suicide drones/ sensors) that can be launched from existing hardpoints. Buying dumb rockets can hardly serve any purpose in today's technologically driven battlefield. Every AH must be able to deploy its own sensor screen, thus providing him unmatched tactical ISR and greater reach without being able to expose itself.

- **Cognitive EW Systems.** Future RW platforms should be equipped with cognitive EW systems that use AI and machine learning to analyse the electromagnetic environment in real-time. These systems can autonomously identify new threats and develop counter-strategies, such as frequency-hopping/ deceptive jamming, without human intervention. E.g., Ukraine has deployed a distributed network of small and agile units. It distributes the workload and makes the overall network more resilient. Even if one unit is jammed or destroyed, the rest of the network continues to function. This has allowed them to adapt rapidly to the constantly shifting EW tactics of the adversary.

- **Data Fusion and Dissemination.** Information from all EW sensors should be fed into a central AI-powered fusion system. This system will prioritise threats and display a simplified, actionable picture to the pilot. This fused data should also be disseminated across the network to provide other friendly assets with real-time situational awareness, enabling a collective EW response.

- **Integrated Airspace Management.** A crucial step is to integrate all friendly manned and unmanned assets into a single, cohesive airspace management network. This network would function like a military-specific Unmanned Aircraft System Traffic Management (UTM) system, where all friendly units, from individual helicopters to drone swarms, have their flight data logged and updated in real time.

➢ **Beyond Line of Sight (BLOS) Operations.** At present, AHs can be equipped with Non-Line of Sight (NLOS) missiles such as the Spike NLOS, which provide an effective firing range of 30 km. However, as the standoff engagements rise, targeting from farther ranges needs to be looked into. One such concept is as discussed below: -

- Consider an AH equipped with a loitering munition (such as the CM 501 XA, which is mounted on Z -10, *see fig below*). The LM does not need to lock the target directly and uses external instructions to launch an attack on the target. The AH also does not need to aim directly at the target, which means it does not need to be exposed to the enemy's AD system.

Instead, it can hide at an advantageous position, launch missiles, and attack the target covertly, improving the probability of success and survival of the attack.

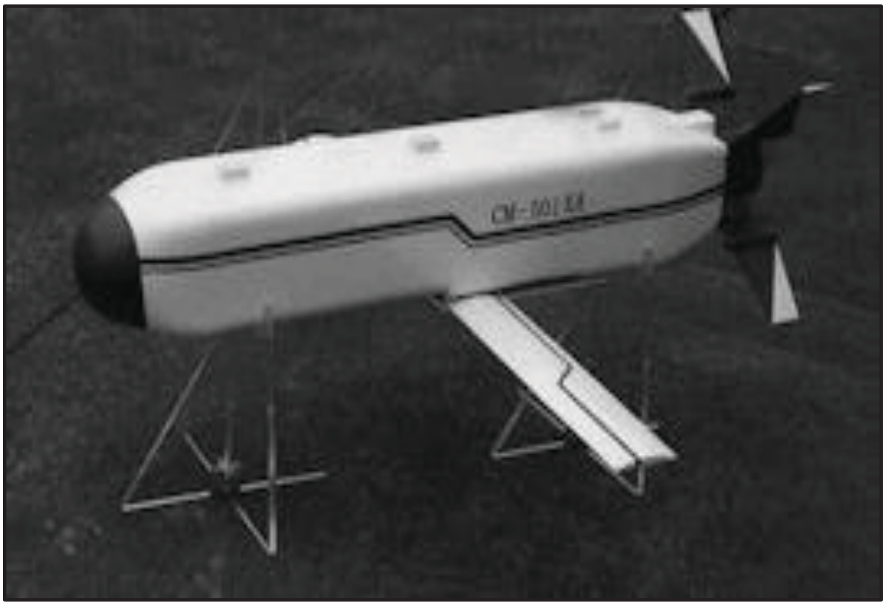

Fig 7: CM 501 XA developed by China Aerospace Science and Industry Corporation, CASIC (Source: Open Source)

- As the LM has its own propulsion system and a limited endurance, it can be used similarly as a fire and forget missile, but also provides ranges much greater than the NLOS missiles (CM 501 XA gives a range greater than 70 km, 8.5 kg warhead, and a loiter time of 30 mins).

- The AH acts as the BLOS launch platform in the TBA outside enemy AD cover, a UAV acts as the relay and Tactical Data Link (TDL) is the critical integrator for networked operation of the LM either by AH or a ground operator once launched from the AH.

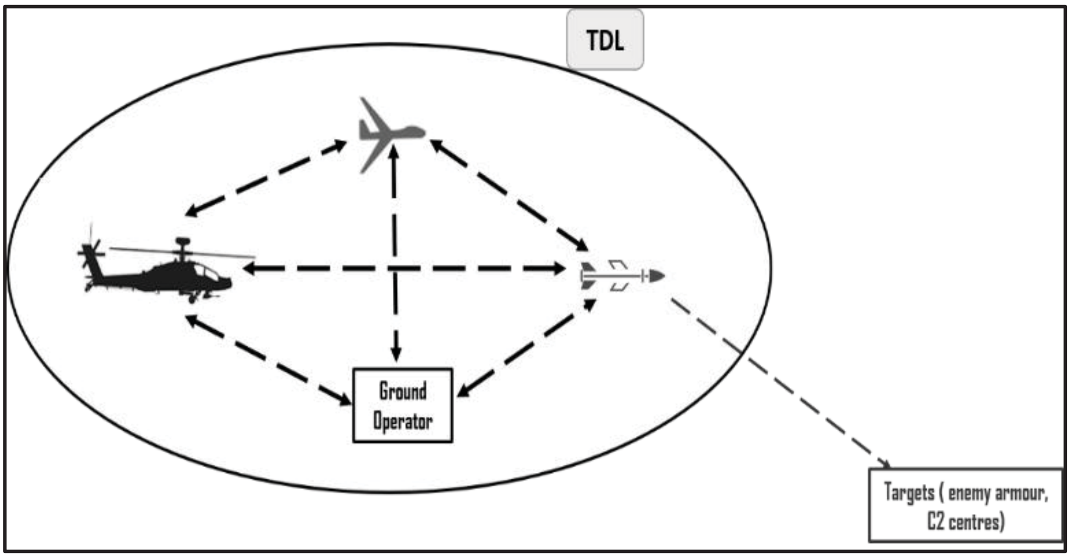

Fig 8: Schematic Representation of BLOS Operation by AH
(Source: Author's Articulation)

- The question now arises, *"Why Helicopters? When the same can be done by ground-based vehicles?"* The answer is simple – it's the inherent operational advantages that helicopters bring to the battlefield viz. their ability to compress time and space, negate tactical & terrain friction, faster mobilisation to an advantageous position and create effects to shape the battlefield, thus bringing the element of surprise and offset force ratios at critical junctures in battle.

Recommendations in the Indian Context

Having seen the recommendations in general, certain recommendations that apply to the Indian context are formulated as under: -

- **Network Integration.** Modern weapon systems need the capability to dynamically interact with other systems to optimise targeting and secure data relay. At present, only the Apache fleet of IA & IAF has this particular feature, that too with the ability to connect within the fleet and not with other class/ type of helicopters. Secure communications and TDLs are a dire need of the future battlefield.

- **MUM-T.** HAL is presently working on a project named 'Combat Air Teaming System (CATS) *Warrior*' which involves integration of MUM-T model on LCA. The time is ripe for a similar MUM-T model for helicopters as well. Apart from enhancing survivability and increasing operational reach, certain other advantages accrued would be lesser pilot fatigue, increased availability of pilots and higher sortie generation rates.

- **Training and Skill Development.** Formulation of a comprehensive training curriculum for military personnel to effectively operate, control, and maintain MUM-T systems.

- **Force Packaging.** Owing to the configuration and weight penalties due to EW suite, future helicopter operations in the TBA will necessitate dynamic force packaging which inherently should include 'dedicated' EW Helicopters apart from helicopters in various other configurations, dictated by the role and mission.

- **Prioritising Survivability Suites.** Retrofitting of legacy fleets such as Mi-17, ALH, ALH-WSI with DIRCM and active EW jammers capable of breaking localised drone control links is an inherent requirement in order to operate effectively in TBA. The system must be able to switch between defensive and offensive EW modes seamlessly.

- **Integration of AD Networks.** Expediting operationalisation of Akashteer at unit level and its integration with IACCS for a common Recognised Air Situation Picture (RASP). In addition, integration of the C-UAS grid with AKASHTEER / IACCS may be looked into.

- **Revision of JSSG-2008.** At present, aerial operations in the TBA are limited to 100 metres with additional 50 metres as a buffer zone for transit purposes. A review to increase this ceiling to 1500 metres (5,000 feet agl) is required for achieving desired degree of freedom of operation by various users. This will facilitate the ground/ maritime force commanders, who have primacy in this battlespace, to effectively employ their assets in a dynamic threat environment.

- **Force Structuring.** As the assets keep increasing, there will be a need to raise more Aviation Brigades to ensure seamless integration of UAS/ UAVs with the helicopter fleet and oversee their training. In addition, Aviation Brigades are also mandated for ASM in the TBA by constituting a Corps Airspace Control Centre (CACC), thus ensuring a centralised command structure of various aerial assets held within a Corps. It will also help in reducing the present time penalty in dedicating aerial assets for immediate response/counter-response missions.

- **Sustained Investment in R&D.** Significant investments in research and development, collaborations between the Armed Forces, DRDO, HAL, public/ private sector companies, startups and academic institutions through joint projects and knowledge exchange programs is required to leverage industry expertise in overcoming defence challenges.

- **Jointness and Integration.** Above all, a mindset which accepts this new reality and is focused on synergising efforts in equipping, organising and training to fight effectively in this sub-domain is the need of the hour.

Conclusion

The future of warfare will see a growing contest to occupy the Air Littoral, where drones and missiles of various types will be employed in massive numbers to saturate the airspace and wreak havoc and confusion on an adversary. Mastering this domain is a prerequisite for a combined arms manoeuvre in the battlefield and avoiding the attritional trap. Helicopter is being refined by the fires of combat. Just as the tank survived the invention of the Anti-Tank Guided Missile (ATGM) by adapting armour and tactics, helicopters too will survive the drone age by adapting in its domain. The future belongs to the connected helicopter - a platform that sits at the centre of a digital web, controlling drones, jamming radars, and delivering heavy firepower with surgical human judgement. Soldiers on the ground, pinned down by enemy fire, do not care about 'blue sky' dominance; they care about the sound of rotor blades bringing fire support and evacuation. That need is eternal.

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Recent conflicts have brought to the fore a new reality for modern armies - a contested low-altitude airspace known as the Air Littoral. This paper is premised on the prevailing assumption that helicopter operations may become obsolete in an era of proliferating drones, loitering munitions, and advanced Air Defence systems. Drawing on combat lessons from Russia-Ukraine and the Nagorno-Karabakh conflict, the paper argues that Rotary Wing aviation remains operationally viable, though its role is undergoing tactical evolution. The paper prescribes a multi-faceted strategic approach encompassing doctrinal innovation, technological advancement, and organisational restructuring to ensure helicopter relevance in future conflicts. By integrating unmanned systems, adopting decentralised execution protocols, and establishing resilient networked command structures, modern helicopters will transition from isolated combat platforms to orchestrators of integrated joint operations in the Air Littoral.

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