1-32

DRONES: CHALLENGING AIR AND LAND WARFIGHTING PRECEPTS

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Abstract

Recent conflicts have generated heated debates on prosecution of conventional wars. Unprecedented exploitation of drones at scale, despite their vulnerabilities in a contested environment, potentially segmenting the air domain in the air littoral and blue skies, is challenging long held precepts on air superiority, air denial, control of the air littoral and massed use of drones. This article analyses the implications of the evolving paradigms for the aerial and surface domains, in context of the trajectory of the unmanned capabilities, and draws relevant lessons for the Indian Armed Forces, suggesting measures for leveraging drones for air superiority, air denial, responsive control frameworks for control of the air littoral and close air support.

GROWING DEBATES ON TRADITIONAL PRECEPTS

Future Conflicts-Contested Control of Air. The contrast between the ongoing Ukraine war, and the Gulf War-1 (1991), the last *major land and air war*, could not be more striking, despite the asymmetrical technological and numerical superiority of the attacking major power in both wars. The ineffective *destruction and suppression of enemy air defence (DEAD/ SEAD) operations by the Russian Air and Space Force (VKS),* despite engaging 75% of Ukraine's known air defence (AD) sites during the first 48 hours, could

not cripple the forewarned and agile, though smaller, *Ukraine's Air Force (UkAF) and AD*. Eighteen months into the war, despite a 6:1 advantage,[1] *the VKS lacks air superiority, and is constrained to operate from friendly territory, exploiting its standoff advantage to support*[2] *its land forces. The UkAF, denied control of air on the battlefront, cannot support*[3] *Ukraine's floundering counter-offensive*.[4] *With both sides seeking mutual air denial and contesting local air superiority at the battlefront*,[5] *the attritional slugfest is getting prolonged*.[6] *Besides* the underwhelming performance of the vaunted VKS,[7] *agile air denial by Ukraine has kept the VKS at bay*.[8] While it will be naive to sketch the contours of the future air wars in the Indian context in absence of granular details of the conduct of war, *it will be fair to assume that, given the air power balance between the adversaries, control of air will be heavily contested, and windows of air superiority will be fleeting, at best*. Analysts argue that the time needed to achieve meaningful SEAD may be unacceptably long, jeopardising joint surface operations, and the only alternatives are to either have stealthy penetrating offensive counter air (OCA) capabilities, including large amounts of stand-off, stand-in and loitering munitions, or make the surface forces stronger, less reliant on air support.[9] *Implications of such assumptions for air and surface operations need to be examined*.

Drones and the Air Littoral-Is Ukraine a Precursor? *Unmanned platforms (drones), hitherto typically exploited asymmetrically by one side*, are being *used at scale by both sides in a major conventional conflict, ushering a drone war as a first, both close and deep. Attritable military and re-purposed commercial, including First Person View (FPV) racing drones,* are *being used at scale*,[10] *crippling traditional platforms* like tanks, guns, ships and parked aircraft. It is reported that Ukraine's crowd sourced '*Army of Drones*' now has 200 drone manufacturers, *including famed Antonov*, with 30 new indigenous models recently ordered.[11] The *impact of drone warfare is significant in the air littoral* (airspace contiguous to the surface, but below the operations of combat aircraft*), a new mini-domain*,[12] *which is critical for surface operations.* Russia, too, aims to manufacture 6000 drones by 2025.[13] The *'replicator' program* of US envisages several thousands of small and cheap unmanned systems

(land, air, sea, below the sea) by 2025, leveraging attritable autonomy and *creating mass to fight China's might*.[14] The US Navy wants thousands of drones under the Super Swarm project.[15] Experts opine that in the next *10 to 15 years, about one-third of the world's most advanced militaries could be robotic*.[16] Employing UAS for a wider set of missions is one of the five priorities recommended for the USAF.[17] *In the Indian context*, the *northern adversary is a military and commercial drone leader*, with a few systems combat proven across the globe. India's *western adversary has an inventory of proven Chinese, Turkish and indigenous drones, having exploited them in combat since 2015*. It uses repurposed commercial drones for border violations. *While India presently has an inventory of unarmed MALE drones and few Harop anti-radiation munitions (ARM)*, induction of small/tactical drones (surveillance/kinetic) and loitering munitions (LM) has commenced at a frenetic pace. It will be *reasonable to surmise that any future war in the Indian context will witness exploitation of drones in the air littoral at a scale comparable to the Ukraine conflict*. *Operational and technological implications of exploitation of drones for the surface and aerial domains, specifically the air littoral, need an incisive examination*.

FUNDAMENTAL DOCTRINAL PRECEPTS

• **Air Supremacy/Superiority**. As per the Indian Air Force (IAF) doctrine, the degree of control of air varies from *Air Supremacy* (nil enemy air interference), *Air Superiority* (minimal enemy air interference) to Favourable Air Situation (FAS- limited in time and space, with greater enemy air interference).[18] The *western doctrinal equivalents are air supremacy, superiority and parity, respectively*. While mentioning command/control of air, the Chinese doctrines stipulate no such gradation, but some analysts argue that instead of seeking prolonged control of air over all areas, PLA might pursue air superiority *for key tasks at key times and over key areas*,[19] *especially prioritising counter air and missile defence and EW capabilities*.[20] *IAF doctrine accords* priority to *control of the air* through *Offensive Counter Air (OCA) and AD Operations*.[21] The networked, layered and agile AD capabilities of India's adversaries, buttressed by drones, electronic warfare (EW) and cyber-

attacks, will likely present a challenge, *and* proponents hold varying views on control of air.[22] *With each side securing FAS at best, we need to debate its implications for air and surface operations.*

• **Air Denial**. *Air Denial* does not figure in air force doctrines. However, its equivalent in maritime warfare, *Sea Denial (disputing command of the sea)*, conceptualised by Sir Julian Corbett,[23] is one of the missions for the Indian Navy.[24] Successful air denial has kept the VKF outside the Ukraine controlled airspace,[25] by remaining a *force in being*, like sea denial *with a fleet in being*.[26] *Counter arguments hold that only weaker states may prefer air denial strategy*[27] *to fend off a stronger air force, till favourable air control is gained.*[28] Cheaper, distributed mass and agility help survive attrition to keep the airspace continuously contested. The *Anti-Access Area Denial (A2AD)* capabilities of near-peer adversaries *make the quest for air superiority costly, and air denial a pragmatic option, especially where the overall strategic intent is to deter and defend. Mutual air denial, right to the edge of the battlefront, helps hold deterrence.*[29] *Air superiority and air denial are not binary options, and could be pursued sequentially or in parallel, along different fronts, based on situational priorities.*

• **Control of the Air Littoral**. *Though Ukraine initially led the exploitation of the air littoral*, the Russia followed suit,[30] restoring parity. *Given the affordability and proliferation of drones in the air littoral, the salience of controlling this space will grow exponentially for the ground forces. Command and control (C2) and integration of air littoral assets, counter-UAS (C-UAS) capabilities and* Air-Space Management (ASM) *need a holistic examination*.

• **Tactical Surface Operations and Drones**. The IAF doctrine holds that *once some degree of control of air is achieved, subsequent air and surface operations can be coordinated* to maximise application of combat power.[31] Conducted in parallel with Strategic Air Operations, Counter Surface Force Operations (CSFO), *are coordinated air operations carried out for* surface forces *either to further their objectives or an integrated military objective*, to deter, *contain or defeat the enemy's surface forces*.[32] Under situations of fleeting FAS or air

denial, *CSFO, which includes Battlefield Air Strikes (BAS),*[33] *the doctrinal equivalent of western Close Air Support (CAS), may be constrained, as in the Ukraine conflict, where drones and artillery have supplanted this mission. This calls for an examination of measures to enhance the efficacy of BAS by manned aircraft, armed/attack helicopters with drones and organic surface forces fire power (rockets, missiles, artillery).*

• **Drones, Deniability and Escalatory Dynamics**. *Drones provoke with deniability*, complicating response options, thus, potentially engendering *miscalculations*. *Escalation dynamics* are more complicated *where the sovereignty over disputed borders is contested*. In 2001, China released the *manned EP-3* only after a *formal apology from US, but* in 2013, it used a drone to violate the Japanese sovereignty over Senkaku.[34] Clearly, with lower political costs, drones are ideally suited for challenging *sovereignty*.[35] The US chose not to retaliate when Iran shot a MQ-4C in 2019. In grey situations, therefore, drones would be preferred to push the boundaries.

COMBAT MASS- DRONES ENABLING AIR SUPERIORITY

The Debates. Traditional *belief holds that some planes will always get through*,[36] since defence, spread thin, invites defeat.[37] In practice, Ukraine has denied air superiority to VKS,[38] *localising it in time and space*,[39] leading analysts to advocate *air denial over air superiority*.[40] Analysts have countered the view that airpower is inherently offensive,[41] averring that *defence scores over offence, since ground based AD (GBAD) can exploit mobility, density and expendability to deny air superiority* with a *volumetric and layered defence (lateral & vertical)*,[42] *advocating a more balanced mix of high (crewed) and low (un-crewed) capabilities*.[43] The argument holds that *OCA operations* are costlier than *Defensive Counter-Air (DCA) operations which create a threat in being*, with open skies and technology *favouring cost effective air denial*,[44] *e.g. despite NATO's air superiority in Kosovo (1991), Yugoslavia's agile AD remained a credible threat*.

LEVERAGING DRONES TO CONTEST THE CONTROL OF AIR

That *control of the blue skies (operational air) does not extend to the air littoral (tactical air), was demonstrated by ISIS against the* US in Mosul,[45] operating repurposed commercial drones *below 2000 feet*.[46] Azerbaijan executed effective SEAD by exploiting relatively cheaper unmanned assets in its conflict with Armenia in 2020.[47] The increasing cost of multi-role manned aircraft *demands better options to generate the mass needed to gain control of air in contested environments*. *There is a need to leverage autonomous/loyal wingmen (LW), swarms and cheap LM, which* could also become aerial mines.[48] Dispersed warfighting in Ukraine has led analysts to argue for air denial with drones and mobile short range air defence (SHORAD) and man portable AD (MANPAD) in asymmetric situations like Taiwan,[49] *exploiting the enemy's lack of air-land integration*.[50] Low signature cheap drones *have the virtue of mass without the vulnerabilities of concentration,* with interoperable C2 networks.[51] However, drones which can make a winning difference will need better survivability, autonomy, sensors and payloads,[52] than the ones used in Ukraine. The USAF has *argued that cheap unmanned aircraft could potentially help mitigate aircraft inventory shortfalls*.[53] *The IAF doctrine holds that drones, unmanned combat aerial vehicles (UCAV) and counter-UAS have made the battle-spaces a dense environment* and their usage needs nuanced assessment, considering their capabilities, benefits and vulnerabilities in a contested battle-space.[54]

- **AI driven Autonomy in Air Combat**. Human judgment, though superior, is slower than machines, and *is a limiting factor* when the battle rhythm goes high, as in air combat. Underscoring the salience of AI, Chinese military scholars anticipate *battlefield singularity*, when combat gets faster than human cognition, ushering hyper-war, with unintended escalations spiralling out of control.[55] In DARPA's Alpha Dog Fight, AI pilots are repeatedly beating human pilots in manoeuvres and targeting.[56] However, all human functions cannot be automated.
- **Autonomy and Drones**. Autonomy in kill chains has three different *dimensions*- the *human control* (in the loop, on the loop and out of the

loop); *complexity* (automated, autonomous and intelligent); and *the function automated* (tracking, identifying, selecting, prioritising, timing, striking).[57] Guided munitions, even with *in-flight re-targeting*, are not autonomous, since humans select the targets. Even LM, *which selects and hits targets*, is limited in time (endurance), space (footprint); is designed for a specific target type and the target area is human controlled.[58] *Drone swarms can be potentially truly autonomous*.

• **AI Driven MUM-T - Generating Mass to Gain Air Control**. AI driven Man-Unmanned Teaming (MUM-T) enhances situational awareness, lethality and survivability. *The supporting role of a LW has been transformed with* AI and data-links, *operating beyond visual range (BVR)*, collaboratively penetrating the enemy's A2AD bubble with *mass and precision, absorbing attrition*.

• **Global Trends in MUM-T**. The US *third offset strategy is leveraging narrow AI driven MUM-T,* bolstering the capabilities of human warfighters,[59] fusing human creativity with technological precision,[60] under the System of Systems (SoS) approach of Next Generation Air Dominance (NGAD) program. The US plans at least 1000 highly autonomous, swarm capable and mission tailored *Collaborative Combat Aircraft (CCA), with the first batch entering service in the late 2020s, teaming two CCAs each with 200 NGAD platforms and 300 F-35s.*[61] CCA project will leverage the ongoing MUM-T projects like Air Combat Evolution (ACE) for collaborative AI powered dog fighting and the Skyborg project, which tested UCAV prototypes MQ-20 Avenger, XQ-58 Valkyrie and MQ-28A Ghost Bat (Australia). The US has successfully AI piloted X-62A, a modified F-16, in within-visual-range (WVR) and BVR fights with a simulated opponent.[62] The US proposes to equip six F-16 fighter jets with AI-enabled self-flying capability, to refine CCA autonomy.[63] *The NGAD SoS*[64] *approach facilitates* spiral development.[65] The US Navy jets have demonstrated refuelling and ISR with unmanned MQ-25, besides collaborative MUM-T between ships and unmanned surface vehicles (USVs). The UK, drawing lessons from her closed LW Mosquitoes and swarming Alvina drone projects,[66] has launched the

Lightweight *Affordable Novel Combat Aircraft (LANCA) - Follow on project*, and envisages a future fleet having 80% un-crewed assets.[67] *The VKS, which has been experimenting with an unmanned S-70 Stealth UCAV Hunter* as a LW paired with Su-57 since 2019, *reportedly used the prototype in Ukraine in a standalone mode*.[68] The second pilot of the Chinese J-20[69] would operate LW AVIC-601-S[70] and FH-97A,[71] the latter with radius of action of 1000 km. A US Army study had established that *the maximum number of UAS that could be controlled was two as managing three created extremely high workload for the pilot*.[72]

• **The Indian MUM-T Trajectory**. *India's Combat Air Teaming System (CATS),*[73] featuring CATS Warrior, Hunter, Infinity (HAPS) and Aerially Launched Flexible Assets (ALFA), with the US Air Force Research Lab collaborating on ALFA-S (Swarm)[74] could be flight tested in 2024.[75] Typically five LW, a recoverable version with a combat radius of 350 km and a kamikaze version with 800 km, may be controlled by a manned fighter aircraft, with the LCA as a demonstrator and later the SU 30 MKI and Jaguar as mother aircraft.[76] Equipped with AESA radar, the Warrior could launch up to 24 ALFA-S swarm drones, carry two short-range or BVR air-to-air (A2A) missiles externally, and two Smart Anti-Airfield Weapon (SAAW) in its internal weapon bay.[77] The project may later include a HALE class UAS.[78] Experiments to convert legacy manned platforms for uncrewed flying are underway.[79] Prototypes of the Naval LCA are reportedly becoming testbed for the aircraft carriers as part of the *CATS-OMCA (Optionally Manned Combat Aircraft)* project.[80] An 'Integrated Unmanned Road Map for Indian Navy' was released in October 2021.[81]

• **Global Trends in Drone Swarms**. Drone swarms are collaborative, self-organising and self-healing small UAVs (sUAV) that execute missions as a coherent whole, *with limited human control,*[82] *imposing unfavourable costs on the defender, retaining distributed combat power, even after absorbing attrition*.[83] Massed drone attacks, like on Saudi oil facilities in 2019 and Russian air base in Syria in 2018, *were not swarm attacks. Swarms are ideally suited for OCA, decoys, SEAD, LM (against air or surface targets), ISR, Air Interdiction,*

defend bases and counter-swarm missions.[84] The US Navy's Low-Cost UAV Swarming Technology (LOCUST) program, with low endurance and slow Coyote drones, has been subsumed in the more ambitious Super Swarm project.[85] While the US OFFSET (Offensive Swarm Enabled Tactics Program) final experiment in 2021 demonstrated a single operator controlling a heterogeneous swarm of drones and UGVs in an urban setting, challenges of spatial congestion were instructive.[86] China has demonstrated a swarm of 200 drones from a 48-tube launcher from a helicopter,[87] besides larger pre-programmed demonstrations. *Israel was the first to use swarming drones in operations in 2021 to attack Hamas militants*, and is equipping infantry with swarming drones to search and attack buildings, with Legion-X, an autonomous solution that works in close collaboration with soldiers.[88] Besides these, Russia, France, Turkey, Spain, UK, UAE, South Africa and Armenia have swarm drone programs. Pakistan is seeking Chinese help to fine-tune drone swarm technology.[89]

• **India's Drone Swarming**. Following public demonstrations starting in 2021, the Indian Army has reportedly operationalised[90] swarm drones with a 50 km reach in 2022, initiated procurement of improved autonomous surveillance/strike drone swarm, including for higher altitudes,[91] and IAF has ordered a 200 drone swarm with 150 km range.[92] IAF has sought industry response for 1000+ km range collaborative swarm for long range saturation/destruction counter air missions, in dense EW environment.[93]

LEVERAGING MUM-T: LESSONS FOR THE INDIAN ARMED FORCES

• **LW.** *LW can be* a communication gateway between manned aircraft[94] and *launch smaller UAS*[95] for EW, ISR and kinetic effects.[96] The mother aircraft modification, wingman drones, the two-way data-link, radar and EO systems would need expeditious indigenous development,[97] besides rigorous development of AI algorithms.

• **Autonomous Dog Fighting- Building Trust.** Autonomous dog fighting where the *human pilot retains higher-level functions* (strategy and target priority),[98] with AI enabled UAS undertaking risky manoeuvres,[99] *would*

take long to develop, must necessarily be indigenous, must be pursued in mission mode.

• **SEAD**. The absence of UAVs for SEAD cost the Russians dear.[100] Anti-gravity manoeuvres by agile UAVs, anti-radiation LM, and decoys, would confound AD. *Experimentation for integration of* DRDO developed *Rudram series ARM* with UAS must begin post haste.

• **Electronic Warfare** (**EW) & Decoys**. Electronic signatures create vulnerabilities and attritable *UAS are ideally suited*, e.g. the Miniature Air Launched Decoy (MALD) and MALD-J (Jammer)[101] of the US.

• **HAPS.** Recoverable High Altitude Pseudo Satellites (*HAPS) operating from the stratosphere can* provide prolonged ISR, satellite relay/hub, EW support for MUM-T/ surface nodes, disaster management, especially in communication denied environments. Since performance challenges need to be overcome,[102] the CATS (Infinity) program of HAL (prototype in 2025) or recent initiatives with the private sector,[103] need to be expedited.

• **Swarms**. Swarms are multi-domain (land, sea and air) and demand inter-service coordination, a review of ASM, especially in the tactical battle area (TBA), and counter-measures,[104] to include EW, directed energy weapons (DEW) and lasers.

• **Drones to Substitute Critical Platforms and Provide Responsive Logistics**. *Special drones could replace* manned AWACS/AEW&C aircraft and refuellers,[105] reducing costs and vulnerability.[106] Unmanned helicopters can deliver up to 2700 kg and an unmanned glider, released from a C-130 at 25000 feet can deliver up to 750 kg of cargo across 75 km.[107] Chinese UAV AT200, operating from unpaved and uneven surfaces, can deliver 1.5 tons.[108] In contested environments, VTOL drones with ability to evacuate one or two soldiers would be critical.[109] However, physical infrastructure and ground crew of unmanned systems need reduction.[110] While logistics drones have been inducted in the Indian Armed Forces recently, the ability to operate in contested environments must be ensured.

The Future Trajectory. Future UCAVs will *be stealthier,* with advanced communication gateway nodes[111], and certified to operate in controlled

space, with collision avoidance capabilities, hardened for EW. Interoperable autonomous unmanned entities would have *satellite independent data links to facilitate collaborative targeting.*[112] Unmanned transport aircraft[113] *or* HALE UAS like Grey Eagle may launch drone Eaglets.[114] Vignettes envision UAS pilots and ground forces cooperatively controlling munitions launched by each other.[115] A *multi-domain MUM-T architecture* may have *manned and unmanned multi-domain assets*, *operating as a SoS*, leveraging trusted autonomy.[116] However, the challenges of assured PNT, communication/EW hardening, interoperability, linking *varied C4I systems*, doctrines, and experimentation in AI and autonomy need to be overcome.[117] Data, pace of combat and *denied communication environment* are spurring the *development of fully autonomous systems*. Ethical concerns have been raised about Lethal *Autonomous Weapon Systems (LAWS),* which have the human out of the loop,[118] due to *non-compliance with the proportionality and distinction clauses of the law of armed conflict, and* risks arising from *hacking or software errors.*[119] LAWS must follow algorithms that obey laws of armed conflict.

TACTICAL OPERATIONS, THE AIR LITTORAL & DRONES

Salience of Drones in the Air Littoral for Tactical Operations

Territorial conflicts are won through tactical engagements in the surface domains. Operations in the *air littoral* enable an overmatch, leveraging *speed, concentration, dispersal, persistence and mass*. Though the VKS accords priority to *support to land forces,*[120] *such support has remained sub-optimal.* In contrast, *Ukraine* exploited the air littoral,[121] with reportedly 6000 drones when the conflict began. Presently, while the VKS has an upper hand in the high (operational) airspace, attrition of nearly 80% of Russian drones,[122] and similar attrition[123] of Ukrainian drones, *shows that air littoral (tactical air space), deemed salient by both sides, is highly contested*. The *air littoral* is *mostly exploited by tactical and sUAS which are organic to the surface forces, and significantly impact tactical outcomes* by leveraging agile strikes, and *most importantly by cueing surface fires. China's drone capabilities in the war zone*[124]

have been explained at length in another article in this volume. Exploitation of the air littoral at the tactical level at scale, with a mix of drones, missiles, rocket, artillery and mortars (RAM), C-UAS and EW, and *critical issues related to this realm, need examination by air and surface forces*.

• **Deterrence through Manoeuvre in the Air Littoral**. *Conceptualisation of overt deterrence by detection for the Western Pacific is an idea with merit.*[125] Besides surveillance, imposing costs and uncertainties on the adversary with cheap and attritable drones would ensure deterrence. Notably, *mass in the air littoral enables manoeuvre, while denying it to the adversary, which in turn enables ground manoeuvre. This cross-domain deterrent manoeuvre is enabled by helicopters, massed drones, RAM, mobile SHORADS and C-UAS capabilities.*

• **Integrated Command and Control (C2) and Airspace Surveillance and Control (ASC) Frameworks in the Air Littoral**. *Generating a layered and massed* attritable force necessitates a seamless integration. Moreover, *in the air littoral,* time and space are compressed, shortening the OODA cycle. Innovative solutions like integration of the network of drones with the coalition's air space network in Iraq[126] present a model for integration *of operations in the Air Littoral.*

• ***Vertically Segmented Air Control***. *Analysts suggest* infusion of *a vertical dimension while defining air control in the trans-domain air littoral.*[127] The *drones have virtually segmented the control of air into two parallel contests-operational air control (OAC) at the higher levels,* and more localised *tactical air control* (TAC) *near the surface, impacting tactical outcomes.*[128] *In the Ukraine war, this segmentation has occurred by default, since air forces of both sides are not carrying out penetration attacks below 3000 metres in day time since a month after the war began.*[129] C2 *is progressively getting pushed to tactical levels*. Growing autonomy, AI driven target recognition, micro-munitions and shrinking costs will accelerate exploitation of drones for missions at the tactical level, *necessitating C2 and ASM at lower levels. Analysing Israel's wars since 1967, analysts have argued that air superiority does not necessarily confer decisive advantage for the ground combat*, contending that *conferring*

exclusive control of the air dimension to a single service is unsound, and tactical ground forces must be capable of independently influencing all domains that are relevant to their mission, with three *critical organic unmanned capabilities*- networked sUAS for ISR; mobile and networked SHORAD, counter-RAM and C-UAS; and UAS for critical kinetic and logistics support.[130] At the brigade level a tactical reconnaissance strike complex, a 'tactical internet of things' is visualised.[131]

• **C2 and ASC- The Indian Framework**. AD of the nation and ASC at the apex level is the IAF responsibility, excluding the AD of integral assets of the Army and the Navy.[132] The *Integrated Air Combat and Control System (IACCS) of the IAF implements ASC*, as well as *Air Battle Management*, orchestrating air operations in close coordination with other services, which requires integration with the Navy's Trigun and Army's AkashTeer.[133] AD clearance for all air movement, including in the ADIZ, is accorded by the IAF, except for very low flying army air assets within a small bubble of air space, for which flight information has to be intimated.[134] In the tactical battle area (TBA), the permission or denial of the use of air space to a user is managed through standing instructions (height bands, time slots, areas, no fly zones), and dynamic instructions to a user.[135] *What needs to be examined is whether this centralised framework facilitates decisive operations in the air littoral*? Any C2/ ASM frame work for the air littoral should *enable dynamic surface operations, service-agnostic responsive exploitation of all resources, dynamic reallocation of resources and leverage interoperability*.

• **A Drone ASM Integration Model- UTM and ATM**. The National *Unmanned Aircraft System Traffic Management (UTM) policy of 2021*[136] *addresses traffic management of drones in airspace up to 1000 feet. It advocates a seamless interoperable interface between UTM (Digital Sky) and Air Traffic Management (ATM) at the systems level, especially in the trans-boundary zone, with little human intervention, through Real-time Identification & Tracking (RIT)*. The IAF is mandated to accord AD clearance for drones through the Digital Skye interface. The Collaborative Low Altitude UAS Integration

Effort (CLUE), under validation by USAF, aims to have UAS integration upto 12000 ft MSL.

• **Integrated/Networked C-UAS**. Though navigation and communication links make drones extremely vulnerable, the adversaries will leverage *standoff, mass and attritability to enhance survivability. Detection holds the key and* integrated hybrid *systems* with EW, DEW, high-power microwave (HPM) and laser to counter cruise missiles, RAM, UAS and swarms, with a networked, multi-layered and SoS approach, *are necessary*. High-resolution AESA radars to detect and track thousands of small air and surface targets are needed at the tactical level. As part of a *warfighting concept* up to 2040,[137] the US Army is prioritising potent *C-UAS systems*.[138] *Militaries are adopting a joint approach, like the* US Army's Joint C-UAS Office and a Joint C-UAS academy.[139] The USAF *is making its Multi-Domain Control Station for Unmanned Systems interoperable with* the US Army's Forward Area AD C2 system.[140] Commercial drones *and sheer numbers will complicate identification of friend and foe (IFF),* necessitating integration of GBAD and C-UAS *capabilities at the systems level. The Indian Armed Forces and CAPFs are inducting varied standalone C-UAS systems* and there is a need to *synergise the C-UAS capability development and operational integration*.

• **Drone-Array Manoeuvre in the Air Littoral**. Organic unmanned capabilities must include relevant payloads, resilient communications, desirable autonomy and swarming. The concept of a *human controlled drone array, which can survive attrition without losing mission effectiveness, as the basic unit for air littoral operations, merits early experimentation and wargaming*.[141] *Mission tailored tactics of swarms for offensive and defensive operations at the unit/sub-unit level* can be evolved, with *the decision to use lethal force remaining under human control*. Robust datalinks, autonomous combat logistics, and other AI driven *functions will need to be developed through rigorous experimentation. Manoeuvre in the air littoral will enable manoeuvre on the surface, defying* Fukuyama's prediction[142] that drones have undermined land force structures.

BAS: OPTIONS UNDER CONTESTED AIR CONTROL

Doctrinal Precepts and Practice

The *1,000-foot air battle is an existential fight for the ground forces.*[143] CSFO include *Air Interdiction*, where enemy is *not in vicinity* of own forces, *maybe be executed independently by IAF*, and *BAS, which* engages *targets in the close vicinity of own ground forces, necessitating joint planning and close coordination with the fire and manoeuvre of own forces and integrated AD operations.*[144] *Western doctrines have similar precepts for CAS.*[145] BAS entails challenges of target acquisition, identification, enemy AD, EW, and the possibility of fratricide,[146] underscoring the role of ground and airborne forward air controllers (FAC) to enhance the mission success. Doctrinally, the *air commander must decide on the employment of air assets for BAS*, keeping in mind the overall air situation.[147] Contextually, Western CAS doctrines have provisions for *missions being placed on ground/airborne alert for 'on call AI or CAS'*, and persistent ISR,[148] *likely assuming air superiority*. The IAF doctrine holds that remotely piloted aircraft (RPA) can designate targets for BAS.[149] *Western doctrines advocate employment of combat UAS for CAS*, with a high degree of procedural coordination between air and ground forces, considering risks from friendly fires, GBAD and drones.[150] *Risk avoidance in contested environments renders BAS/CAS procedures inflexible.*[151] *There is a need to examine viable capability enhancements, leveraging unmanned systems.*

BOLSTERING BAS/CAS BY FW AIRCRAFT- SUGGESTED ENABLERS

With unmatched effectiveness against hardened targets, *combat aircraft are indispensable for BAS/CAS. However, Russia's Su-25 Frogfoot, designed for CAS, has fared poorly,*[152] *and in one year of fighting Russia has lost 50 ground attack aircraft and 44 attack helicopters in CAS.*[153] In the Indian context, *BAS has played a critical role recently during the Kargil conflict (1999)*, where laser-guided bombs were procured, to ensure responsive BAS.[154] Despite having a land-centric role, CAS by VKS has been sub-optimal,[155] due largely, to the inability to find, fix and accurately strike dynamic targets,[156] and Ukraine's

contested lower airspace.[157] *Measures summarised below could improve BAS by aircraft in contested/ denied environments*.

• **Procedural Enablers**. Airborne FAC must be leveraged,[158] besides using devices that help share real time geo-tagged imagery between the pilot and ground elements.[159] Trusted relationships, a modifiable Air Tasking Order (ATO), improved shared air-ground situation, and risk-tolerant delegated C2[160] improve CAS. Providing real time airborne ISR, *bypassing higher control centers, improved CAS in Afghanistan.*[161] Adoption of *delegated C2 and flexible TTPs for CAS*, based on risks in specific tactical situations, will empower pilots and improve CAS.[162]

• **Multi-Domain Joint Fires, DEAD/SEAD**. BAS must be complemented by coordinated DEAD/SEAD, multi-domain fires, cyber and EW, and space operations.

• **Standardised Joint Training.** Certification of pilots (including UAS) is a must. Standardised joint training of FACs, Ground Liaison Officers (GLOs), staff, EW and AD/Arty officers must include ASM and coordination of joint fires.

• **Optionally Manned & Unmanned Platforms as Enablers**. Development of Optionally Manned Combat Aircraft (OMCA), such as the Jaguar Max[163] project, need to be expedited. *AEW&C sensors integrated on* an unmanned platform *could feed a manned platform at a safer distance or a ground station,*[164] *reducing the* numbers and costs.[165]

• **Stealth Aircraft and CAS**. Citing evidence that *more aircraft were hit during CAS sorties than AI sorties and improvements in modern radars, analysts argue that even stealth aircraft will be detected and their munitions countered at close ranges.*[166] *The costs and benefits thus weigh against their use for CAS.*

BAS/CAS BY ARMED/ATTACK HELICOPTERS

Doctrinal Precepts and Practice

The US doctrines uphold CAS by RW aircraft/UAS,[167] and planned upgradation of US Army *helicopters with radio links* and *Cognitive Decision-*

Aiding System will enhance interoperability during CAS.[168] In the ongoing Ukraine war, the Russian armed/attack helicopters are reportedly *exploiting darkness, attacking armour from 5-6 miles stand-off,*[169] having suffered day-time attrition. The Chinese Z-10 is night capable, with multi-purpose air-to-ground strike munitions reportedly having a range of 20 km, and drawing lessons from Ukraine, China is contemplating use drones as screens/LW.[170] The *IAF doctrine stipulates BAS missions for armed/attack helicopters.*[171] *The Indian forces operate AH-64, indigenous Light Combat Helicopter (LCH), and weapon system integrated* Advanced Light Helicopters (ALH) and it has been argued that more attack helicopters are needed, and are being procured.[172]

MUM-T Trends for BAS/CAS by Helicopters. The AH-64E Apache has fielded MUM-T,[173] the UH-60 Black Hawk can fire ALTIUS-600 family of drones[174] and unmanned recoverable/expendable swarm drones[175] are under procurement for MUM-T with future RW platforms.[176] These drones, launched from unmanned/manned rotorcraft and ground/shoulder fired systems, will detect, identify and *deliver lethal and non-lethal effects* against *enemy A2AD, C2 and logistics systems.*[177]

Lessons for India. *India is reportedly developing an unmanned Rotary UAV, based on ALH as part of the CATS program, capable of firing swarmed ALFA-S.*[178] Conceptual and technological experimentation is needed for evolving MUM-T, to ascertain attritability, autonomy and a balanced mix. The existing helicopter fleet should be made interoperable for MUM-T with UAVs in service and under procurement. *The best option is to maximise combat power in the air littoral through integrated helicopter and drone MUM-T, controlled by the surface forces.*

BAS/CAS BY UAS

Doctrinal Precepts and Practice

Western doctrines hold that combat UAS can undertake CAS and related missions in the kill-chain, Battle Damage Assessment (BDA) and counter-UAS,[179] with *control and de-confliction being akin to manned aircraft.*[180]

Western combat UAS have provided effective CAS,[181] albeit in uncontested environments. Views advocating preference of manned aircraft for CAS,[182] are equally contested.[183] *In the Indian context,* doctrines hold that remotely piloted aircraft (RPA) can designate targets for BAS.[184] It has been opined that drone swarms have a great role in *Air Interdiction or Deep Air Support, including* interdiction of targets such as command posts, communications, radars, aircraft on a ship.[185] Dynamism in C2 and ASM has been infused by the US, by creating a *Joint Air Ground Integration Centre (JAGIC) at the division level,* permitting low cost sUAS to be deemed attritable, *obviating restrictions on fires; and by adopting permissive procedural air control measures.*[186] For critical battle-spaces, JAGIC equivalents, or scalable enabled joint cross-functional teams at the brigade level, and permissive procedural controls must be examined in the Indian context.

Need for Organic Tactical/sUAS and BAS/CAS. In prolonged attritional conflicts, over time, the advantage will shift to side with more numbers. The delayed and ineffective response of grouped theatre aircraft in the 2017 US and Nigerian soldiers ambush, which underscores the *salience of more responsive organic tactical combat UAS for ground forces,*[187] *is just one of the many instances*. *In 2016,* the USAF had listed *potential benefits from 11 missions by air launched sUAS, ranging from CAS and AI, to strike coordination and force protection.*[188] Smaller, cheap LM, kamikaze and repurposed commercial grenade-carrying drones are ideal joint weapon systems.[189] *Mass and disaggregation with organic sUAS would enable more* BAS missions.

India's Growing Capability. Weaponised sUAS, LM and swarms have been recently introduced to support the surface forces. Heron (Mk2) can employ air-to-ground missiles, anti-tank weapons, bombs, and upgradation of 70 Herons with SATCOM and weapons is planned.[190] 97 Indigenous armed MALE UAVs *and 31 MQ-9B are planned to be inducted.*[191] DRDO has successfully demonstrated Stealth Wing Flying Testbed (SWiFT), a scaled down UCAV.[192]

ENABLING DRONES FOR BAS- TAKEAWAYS FOR INDIAN ARMED FORCES

• **Capability Suite**. Weapons (kinetic and non-kinetic) and sensor capabilities must enable *BAS in the Indian context, since the targets in the frontiers are underground and hardened*. SAR, laser and dual-seeker enabled weapons would be necessary. SEAD, C-UAS, EW and decoy drones would enhance BAS mission success. *High bandwidth interoperable connectivity must enable MUM-T with aircraft, to create a kill-web, enhancing BAS options manifold*. Runway independence, minimal electronic signatures, hardening, autonomous navigation and resilient beyond line of sight (BLOS) communications would be essential capabilities. Stealthy combat-UAVs would be the way forward.[193] By themselves, drones are no game changers, and *AD, EW, C-UAS systems and skilled personnel must complement drones.*[194]

• **BAS/CAS-Mission Planning and Execution**. BAS *mission planning with UAS would entail consideration of several factors like the GBAD/*C-UAS threat, weather, interoperability, communications, payloads, launch/recovery, range, altitude and endurance. ASM and integrated battle management for AD and fires are most important.[195] Extant coordination of MALE/HALE drones, helicopters, fires, EW and ASM at the Corps Air Control Centre (CACC) and the Joint Operations Centre (JOC) needs to infuse delegation and dynamism to deliver BAS in contested environments. *BAS decisions with tactical drones should be made at the tactical level, ensuring responsiveness by shortening the joint C2 chains*.

• **Kill Webs of Organic Drones and Organic Firepower of Surface Forces**. *Potent organic* precision surface fire-power is cheaper, massed and difficult to counter, well suited for responsive BAS. *The Indian land forces have lethal and precise long range rockets, guns and missiles*. Both IAF and Indian Army are acquiring surface launched Pralay missiles having 150-500 km range, with a 350-700 kg warhead.[196] Development of Guided Pinaka rockets (130-150 km) and cheaper 250 km Brahmos like cruise BAS capability is underway. *Organic and attritable runway independent drones at the tactical level are needed*

to build a kill-web to unleash the power of the organic weapons, since resources grouped or controlled at operational or higher levels are less responsive for dynamic tactical operations.

IN SUMMATION

Driven by autonomy, AI and MUM-T, drones have demonstrably accelerated the tempo of warfighting by shrinking the observe, orient, decide, act (OODA) cycle, *bolstering several critical multi-domain capability areas- situational awareness, defeating enemy A2AD, deep strikes, DEAD/SEAD, manoeuvre in the air littoral, dynamic kill webs for the surface forces and* responsive logistics, *in contested environments,* despite their *vulnerabilities and limitations.*

21st century conflicts are witnessing a watershed moment when the exquisite platforms driven traditional doctrinal paradigm of air superiority is being debated, cheaper mass and agility driven air denial is finding wider acceptance as an operationally viable choice, the drone dominated air littoral has virtually segmented the air space into operational and tactical air control, and the surface forces are increasingly leveraging organic drones to optimally exploit organic fire and manoeuvre assets to shape the outcomes of tactical battles.

It is axiomatic that air and surface forces must examine and explore new joint solutions to the warfighting challenges at the doctrinal and conceptual level. This paper has presented arguments for leveraging drones to generate mass with MUM-T to gain air superiority; achieving air denial with LM, EW and swarms for DEAD/SEAD; and drones as enablers. Measures have also been suggested for leveraging drones in the air littoral to further surface operations with manoeuvre in the air littoral, suggested segmented C2/ASM models, C-UAS frameworks; and finally the paper has suggested ways to strengthen BAS by leveraging drones: with manned aircraft, helicopters and organic drones, arguing for control of organic tactical drones and helicopters in this bubble to be vested with the surface forces, to maximise combat power in the air littoral.

Drones have cross-domain attributes *which necessitate real time sharing of critical information and data. Moving beyond interdependence, what is needed*

is integration, with *flexible C2, interoperable and resilient communications, and integrated* sensor-to-shooter webs. Decentralised exploitation of drones as a MUM-T driven SoS at scale presupposes *C2 and ASM frameworks for the air littoral that optimise application of combat power and joint mission accomplishment. Evolution of concomitant air and surface warfare TTPs is equally critical*. However, it will be prudent to surmise that *the tactical, operational and strategic effects that drones deliver are necessary, but, by themselves, not sufficient conditions for victorious outcomes*.

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