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ISSUE BRIEF
IB/22/24

EMERGENCE OF DRONES AS EFFECTIVE AIR THREAT VEHICLES – A CASE STUDY APPROACH

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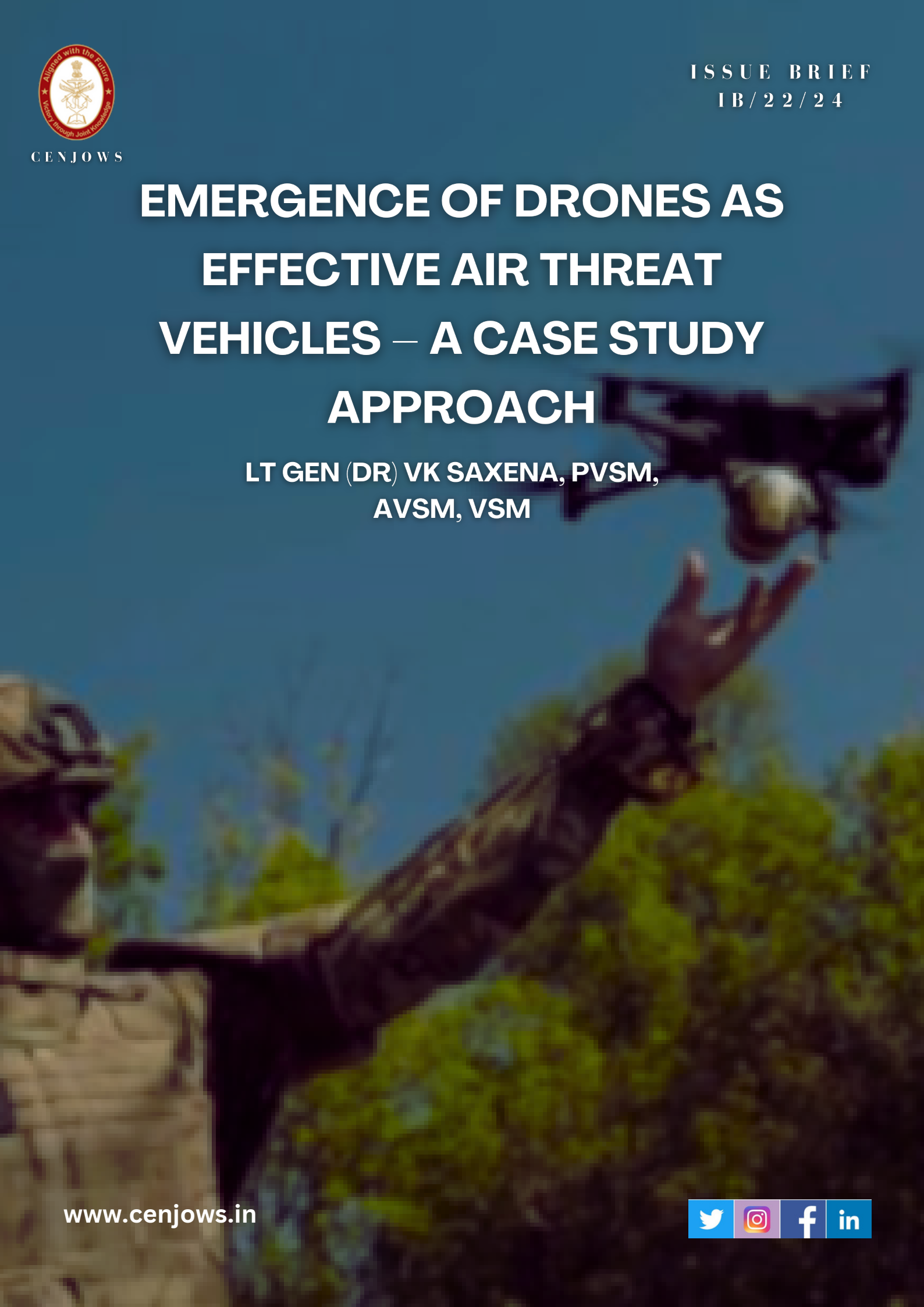

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EMERGENCE OF DRONES AS EFFECTIVE AIR THREAT VEHICLES – A CASE STUDY APPROACH

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Abstract

Drones have arrived; and arrived in a big way to emerge as effective air threat vehicles with many combat virtues. This work examines the journey of ascendency of drones to the prominence these 'little monsters' have come to acquire today. For this exercise, a Case Study approach has been followed where suitable deductions have been drawn from three events; 1. First ever documented swarm drone attack on the Russian air base at Khmeimim and Naval facility at Tartus, both in western Syria on 05 Jan 2018 with a brief mention on the swarm drone attack on Saudi oil fields on 14 Sep 2019. 2. Armenia-Azerbaijan Conflict where the dominant use of drones by Azerbaijan turned the tide of war in their favour and 3. The Russo-Ukraine war where the drone power assumed a totally new meaning and dimension. The final reflection at the end of the work highlight how in the absence of specific counter drone arsenal, small drones can strike big and can cause disproportionate casualties and what it requires to deal with the drone-based threat both in the field of detection and kill. It finally emerges that while the drones have come a long way, the threat is very much addressable given the right arsenal.

Genesis

Drones have made substantial changes in the current threat spectrum which is transforming to new levels with the passage of time. It is essential that a holistic look be given to this important issue.

This work analyses the emergence of drones as effective air threat vehicles in a Case Study Approach and draws some deductions therefrom. Following Case Studies have been covered

- Case Study 1 – Attack on the Russian Air Base at Khmeimim and Naval Facility at Tartus both in Western Syria that took place on 05 Jan 2018 (along with a mention on attacks on Saudi oil fields on 14 Sep 2019).

- Case Study 2 - Armenia - Azerbaijan Conflict

- Case Study 3 - Russo- Ukraine War

Case Study 1

Historic Significance

The event under consideration in this case study has a unique historic significance. It marks the first ever documented swarm drone attack on a military facility. It therefore serves as a good start point for the captioned analysis.[1]

What assets got attacked?

1. **The Khmeimim Air Base**

   This base was (and still is) being operated by the Russian defence forces as a permanent military contingent.[2]
   The base had strategic air assets - (SU 24, SU25, SU 34, Mi24, Mi 28, Mi8, Ka52) besides a contingent of land forces operating artillery guns, armoured vehicles (T 90, BTR 82) and support systems.

In Ground Based Air Defences (GBAD) it had man-portable air defence systems (MANPADS) like Igla 1M and Strela 2m as also a Short Range SAM system, Pantsir-S1.

2. **Tartus Naval Facility**

A major Russian Naval facility capable of housing up to 11 warships (could also include nuclear-capable vessels). The base supports 5th Operational Squadron (perceived as a counterbalance to US 6th Fleet in cold war era). By way of air defences, the base had an Electronic Warfare (EW) unit.

Action

The attack vehicles were just 13 small-sized drones. On first look these appeared to be of primitive design (fibre body, single propeller, no landing gear). In the wee hours of 05 Jan 2018, this swarm of 13, was directed precisely in the kamikaze mode on to the two facilities. Russians claimed that 7 out of 13 drones were destroyed by the Pantsir System while six were subjected to EW attacks ex Tartus.

Russian claims notwithstanding, the fact was that three drones still landed and exploded at Khmiemim causing severe damage to air assets while three were captured intact (EW?).

Drones cause severe damage to air assets at Khmeimim 05 Jan 2018

https://www.google.com/attack+on+Khmeimim+air+base+05+Jan+2018

Analysis and Deductions

Following points are made

- How come the front ranking air defence systems could not effectively kill the drones? Here is why?

    - Pantsir SAM is meant to deal with conventional air threat like the ones posed by strike aircraft, attack helicopters, cruise missiles, SSMs and more. In all these cases its surveillance and target tracking radars can detect targets with Radar Cross Section (RCS) of 1-5 m^2. RCS is a measure of detectability of an object to a radar. Larger RCS would mean that the target would be more easily detectable by radar (typical RCS values- 4GF16 – 5m^2, F18-1m^2 , J 20 – 1m^2, SU 35 1-3m^2, F35 stealth aircraft -.0015m^2).

    - Compare these with the typical RCS of a small drone -0.01-0.4m2 (single rotor – 0.01-0.03m2, quad-copter 0.01-0.10, hexa-copter -0.04-0.32m2).[3]

    - In all probability therefore the target acquisition radar (range 32-36 Km) or missile guidance radar (range 18-20km) of Pantsir would not have detected the drones until these came real close that would have led to last minute missile launch; since some missiles did get launched.

    - What about the MANPADS? Russians had Igla MANPADS. These fair-weather heat-seeking fire-n-forget weapons require a minimum threshold of heat signature for its infra-red seeker to home on to the target. Small drones didn't provide that. Also, since the attacks took place in pre-dawn hours these precluded fair weather Igla MANPADS to be effective.

- We are talking of Jan 2018. Even at that time the retro examination of intact drones revealed sophisticated avionics gear including pressure transducers and altitude control servo-actuators capable of precise navigation over 100-150 km. Sophisticated design of warheads and mechanisms for precise drop. Where these would have reached in 2024, one can extrapolate.

This Case Study brings out the following:-

- Conventional air defence weapons are not optimised to counter the small drone threat.

- The cost of kill is highly skewed in favour of attacker (Unit cost of Pantsir S1 is quoted as 13-15-14-67million USD!).[4]

- Small drones in swarm will in all probability will beat the target handling capability of a terminal air defence system. A few threat vehicles will still reach the target, evading the GBAD.

A Brief Mention on the Attack on Saudi Oil Fields

On 14 Sep 2019, two major oil facilities in Eastern Saudi Arabia located at Abqaiq and Khurais respectively came under attack by a swarm 14 drones. These were of similar make and capabilities as at Khmeimim.[5]

The facilities were operated by State-owned oil company Aramco. The devastation caused by the attack impacted some 5 million barrels a day of crude that was roughly equivalent to half of the country's output or nearly 5% of the global oil supply![6]

https://www.google.com/search?q=14+sep+2019+drone+attack+on+saudi+oil+field

Analysis and Deductions

Following points are made

- Just 14 Kamikaze drones and this level of destruction shows what drone can do if not countered in totality.

- Again, how come the GBAD systems could not counter the drones? Here is why?

    - The Abqaiq base had at least one MIM 104 Patriot Missile Systems. The radar systems of this SAM system are designed to handle the RCS of conventional threat at medium and high altitudes[7]. It is not optimised for detecting small RCS drones flying in at low altitude. It was also reported that the SAM's 120^0 fixed view was trained on Gulf and Yemen side while attack sneaked in from west. No detection – no missile launch.

    - There were also three Skyguard short range air defence systems deployed at Abqaiq oil field. This SAM system has missiles (Aspide missiles) of range 10 km. The radar associated with the system needs to track and illuminate the target, the seeker in the missile rides the reflected energy from the radar and home on to the target.

    - Though the system literature claims that it can destroy strike aircrafts, cruise missiles and remotely piloted vehicles[8], surely its search and target acquisition radar could not detect the low RCS drones executing a low altitude flight. Some sources say that the system was deployed on the other side of the facility looking south and east.

Case Study 2

A Brief Backgrounder

The war between Armenia and Azerbaijan; the two countries which became independent post the fall of erstwhile USSR is not new. It started way back in Feb

1980[9]. The main reason for repeated conflicts has been the disputed autonomous region of Nagorno-Karabakh which is claimed by both nations.

The two nations have fought several wars over it (First war 1980-1994, Second War 2020. Major/minor border clashes have laced the intervening period and continue till date).The focus here is on Armenia-Azerbaijan Conflict of 2020 where the drone power used by Azerbaijan in preponderance turned the tide in the war.[10]

What drones were used?

In this war, Azerbaijan employed drones in large numbers. Their drone arsenal was mainly composed of two types of machines, namely the Bayraktar TB2 and Harop.
The TB2 can operate up to an altitude of 27000 ft. and it has an endurance of 27 hrs. Two capabilities about this machine stand out; 1. Its surveillance and target acquisition capability and 2. It weapon pack.

For the first, besides the Infra-red (IR), electro-optical surveillance capability the drone has on board an X band Radar. This radar is an Active Electronic Scan Array radar capable of dynamic electronic beam switching. This radar is capable of detecting small RCS targets besides being resistant to enemy jamming efforts.

TB2 has an impressive weapon load. The same includes anti-tank missiles (L-UMTAS, range 500m to 8 km), precision guided munitions with ranges from 8-14 km, laser-guided rockets and anti-armour and anti-personal missiles (range1.5-8 km).
Harop drone is made by Israel Aerospace Industries. It is is actually a loitering munition that can lay in wait for its prey up to 6 h. It has a small RCS of 0.5m2 and a unitary warhead of 23 kg.

Analysis on Outcomes

Why these machines proved to be a great success is actually owed to the deficiencies and deficits in the tactical deployment drills by the Armenian forces. Here is how?

- The Armenians had a solid GBAD inventory with ranges from terminal end to hundreds of km. These included Strela 10M SAMs (range 5km),OSA -AK SAMs

(range 10 km), SAM 6 (and 2K12Kub) Kvadrat medium range SAMs (MRSAM range 24 km, Buk M2 MRSAM (range 30 Km),Upgraded Pechora SAMs (range 35 km), Ganef SAMs (range 55 km). In addition their arsenal included a long range air defence and anti-missile system (S-300 PMU, range 40-350 Km).

- Again all the above GBAD systems are optimised to tackle the conventional air threat. The sensors associated with these systems are not designed to track small RCS drones in the region on 0.3-0.5m2. Bayracter and Horop thus mostly avoided radar detection.

- Since small RCS drones largely remained undetected by conventional radar sensors, the SAMs controlled by these sensors could not be launched effectively. On the flip side the old vintage radars of SAMs like Buk M2, SAM6, PMU etc. emit so much of RF energy as to be easy targets for homing on by drone sensors.

- Open sources have also commented negatively on the Air Defence Battle Management and Control System of Armenia. Very simply, this system is responsible for the end-to-end control of air defence battle. This deficit also added to the sub-optimal performance of its GBAD inventory.

Case Study 3

And now to the drone-warfare aspect of the war with no end in sight; 940 days and counting. Here is how the drone story unfolded:-

- The strong pre-emptive strike launched by Russia on night 23/24 Feb 2024, failed to achieve its twin aims, i.e. 1. To destroy Ukrainian air assets on ground to the maximum extent possible and 2. To kill the enemy air defences by silencing their sensors, taking out their air defence control nodes and destroying the communications and connectivity that connect the eyes and ears with control nodes and weapon systems. It is not in the purview of this work to go into the reasons for the same.[11]

- The results of the above were two; 1.The skies over the Ukrainian battlefield remained contested and 2. The air defences survived to fight another day.

- Against the backdrop of this reality the Russian offensive comprising of hundreds of main battle tanks, infantry fighting vehicles armoured personnel carriers and multiple rocket launchers rolled out in a blitzkrieg manner.[12]

- The Ukrainian drones played a prominent role here and caused disproportionate casualties on the Russian armoured and mechanised columns.

Analysis and Deductions

The analysis attempts to check why the drones made a big kill?

- It actually started with the defenders getting to realise a significant deficit in the Russian fire arm. This deficit was exploited fully by the Ukrainians to their advantage. What was this deficit? The same is briefly highlighted below.

- Russia is a very strong air defence power. Its ground offensive was backed by a wide array of weapon systems. These included the terminal weapon pack to include towed and self-propelled guns systems and MANPADs. The SAMs covered the entire range bracket from very short range (5-10 km) to medium ranges (42-100+ km). Their arsenal also included long range air defence and anti-missile system PMU 300.[13]

- Much like Armenia, it would be seen that the air defence weapons pack detailed above is optimised to address the conventional air threat. The sensors associated with the radar controlled missiles are not suited to detect small RCS drones. Ukraine deployed them in plenty.

- In addition to the weapon-fit deficit, there were many a tactical follies as well. The air defence weapons were not seen to be deployed tactically and moving in a leapfrog manner covering the head and tail of the fire arm. Many a videos showed them moving ‘packed up’ as ‘convoy serials’ (sic) or at best firing on wheels. The open sources also reported deficiencies in communications,

connectivity, air space control procedures and more. All these added to sub-optimal performance of the Russian GBAD.[14]

- The Ukrainian drone inventory besides its indigenous machines like Aerorovidka R18, A1-CM Furia, Leleka 100, Raybird 3, Shark and many more, had many others from the supporting countries, for instance, the Bayractar TB2, Switchblade kamikaze machines from US and Germanium -2 optical drones etc.[15]

- As this goes to print, Ukrainian side has shared videos of their so called dragon drones (some units have called it - wings of vengeance) These look like small yellow balls of fire that fly low and ubiquitously (thus avoiding sensor detection). Some reports have claimed dragon drones pouring molten-metal over the targets thus burning everything that exists on the target. [16,17]

https://www.google.com/dragon+drones+of+ukraine

- Actually to counter the initial onslaught of the Russian armour thrust, the Ukrainians deployed a trio of weapons, namely, the anti-tank missiles, drones and MANPADs. This combination claimed disproportionate casualties. As per an open source assessment of Jul 2022 some 1700 tank casualties were suffered by Russians.

- The drone story took off from here. Ukrainians realised that given the chink in the Russian GBAD arsenal, drones could cause big kill. There was no looking back. In Dec 2022, Ukraine started to build what came to be called, the ‘Army of

Drones' under the leadership of its Deputy PM.[18] This effort grew with time as Ukrainians put the drones to multiple uses – surveillance of front lines, guiding artillery fires and destroying mechanised columns, ammunition depots, logistic hubs and more.[19]

- On 06 Feb 2024 something very significant happened. President Zelenskyy, ordered the formation of an entirely new branch in the Ukrainian Armed Forces dedicated to drones. Ukraine is the only country in the world with such a dedicated organisation. It was claimed that Ukraine will acquire the capability of making one million drones in 2024. This number could go on to 2 million with necessary western support.[20]

- Ukraine took the drone strikes inside Russia from early 2023 and the same has grown in intensity ever since. As latest as on 10 Sep 2024 Ukraine has launched a drone attack in Russia with 144 Drones, This marks the largest drone attack by Ukraine in the war till date.[21]

- Another success story of drone strikes (duly backed with anti-ship cruise missiles) has been in the Black sea. As per one assessment in Jul 2024, Ukrainians have been able to destroy a whopping 26 Russian vessels in the Black Sea.[22]

- The kill potential of the aerial drones and SAMs has been enhanced significantly by injection of Uncrewed Surface Vehicles (USV or sea-drones as these sometimes called). A USV is essentially a remote- controlled boat capable of being guided precisely to make a catastrophic collision with a vessel and exploding its warhead (850-1000 kg) in a kamikaze mode.

- As regards RCS, USVs possess small signatures. All of 5-6 meters. This enables it to slip through under the radar shadow of sensors deployed on ships. Ukrainians has put out two models of USVs; 1.The Sea Baby and 2. Magura V5.[23,24]

The drone kill game continues unabated on both sides as these little monsters (or small wonders?) continue to grow in their lethality and accuracy to land deadly attacks on the targets of choice.

Some Final Reflections

This portion of the work briefly does a ‘balancing act’. All that is said till now, may give a feel to the reader that ‘small drones are kind of ‘do it all machines’ (deadly?). Is it true? Yes and No.

Yes

- Yes, in scenarios where counter-drone specific weaponry is not there. In these situation the small drones ditch radar detection by those sensors that are incapable of detecting small RCS targets. Not that the sensors are sub-optimal, these are simply not designed for the threat hand. Once drones cannot be detected by conventional electronic sensors, radar-controlled SAMs normally remain ineffective. Otherwise also millions of dollars SAMs for a small drone kill is bad and unsustainable in the long run.

- Beyond the RCS, many times small drones (and USVs on water) fly so low as to remain ubiquitous and slip under the radar shadow, thus avoid detection.

- At other times, the quantum of small drones simply overwhelms the finite target handling capability of the air defence system (as in the case of a swarm of drones). AI driven drones/swarms may actually ‘avoid’ radar illuminating zones.

No

‘No’, in all other scenarios where specific counter drone capability exists. What capability? Basically the capability to ‘detect’ and the capability to ‘kill’.

Detection

- Taking the typical small RCS to be in the range of 0.3-0.5m2, the ideal sensor resources for drone detection are the RF, Electro-Optical (EO)/IR based surveillance devices.

- Since most small drones operate in the visual domain, EO devices are able to record the 3D dynamic image of the drone(s) in flight which can be recognised against a threshold background clutter/noise.

- As to radar–based detection, the Active Electronically Scanned Array Radars, as also, some other precise radars with operating frequencies in the range of 6-15 GHz are known to detect small RCS targets.

- Experience has it that the most ideal solutions of detection feature an dual band RF and EO/IR pack coupled with a precise radar normally operating in C, X, and Ku bands. (radar bands are the frequency range in which the radar operates).

The Kill

There are several kill options post detection. A word about these is briefly stated

- The most prevalent of the kill means is through the use of Radio-Frequency (RF). The RF jammers aim to jam /disrupting the communication and connectivity signals which either control the drone for its navigation or forge the connectivity between the drone and the ground station.

- Several type of drone guns (like the small arms) are available to do RF jamming of drones and affect a soft-kill. The drone guns used by Russian forces in the later months of war (Ukrainian counteroffensive and beyond) were used LPD 820 and LPD 801 drone guns.[25]

- Another option is the Electronic warfare (EW) kill. EW kill means either aim to attack and disable the critical electronics, electromagnetics on board the drones or disrupt/disable/cripple and the commination/navigation connectivity between

the drone and ground control station thus affecting a soft kill. EW means could also include various types of spoofing devices which generate and send spurious signals with an aim to misguide the drone and disorientate/corrupt its navigation signals[26] or the hacking devices that actually hijack and take control of the drone guidance and navigation steering it to a chosen safe point for destruction.[27]

- Drones electronics is also very vulnerable to directed-energy kill options based on firing laser shots to burn/cripple the sensitive electronic components of the drones. Lasers have long been a reality. In future one will see the employment of high power microwave or charged particle beams taking on the drone swarms.

- Emerging drone kill solutions are coupling the soft kill with hard kill options. Several means are available to affect the hard kill, these include air defence guns with high rate of fire, MMGs or even small arms.

Nothing stated above is fancy. Our own country has readymade drone kill solutions already deployed in the Services.

- In the public sector DRDO has successfully demonstrated its integrated counter drone solution. This solution called D4S (Drone Detect, Deter and Destroy System). The same is produced by Bharat electronics Limited (BEL). For target detection the system utilises EO/IR and radar sensors. D4S has a detection range of 4 km. Its kill means is an RF/GNSS jamming system which has an effective range up to 3 km. It also features a laser kill beam with a range of 150m to 1 km.

- In the private sector, the Company in the forefront of producing the Counter Drone Solution is Zen Technologies Limited. This company has emerged as a leading anti-drone technology player. Zen Anti Drone System/CUAS, designed and developed indigenously is based on a dual mode of detection based on RF, as well as, video based detection made possible through day and night cameras mounted on automatic servo based positioning system (range 3 km).

- For detection of autonomous drones it has X Band 3 D radar which provides precise data about the target co-ordinates. The kill solution is an RF jammer that disables the drone and its control station by simultaneously jamming ISM bands, GNSS signals mobile signals and any other frequencies intercepted by the system.
- The company is also in the process integrating hard kill options along with its current soft-kill based ADS. It is also integrating AI powered products in its anti-drone solutions. (The Company has recently launched its AI powered anti-drone system camera, named Hawkeye. This device has multiple sensor detection modules which are capable of detecting drones to a range of 15 km in all –weather conditions.

Many of the orders for Counter drone systems for the three Services are mainly being bagged by BEL, Zen Technologies Limited, and some other MSMEs.[28]

So what could be the sign off line?

- Small drones have clearly emerged as effective air threat vehicles of today.

- In the absence of specific anti-drone weapons in the defender's arsenal, these little monsters can cause disproportionate casualties.

- However when faced with modern age counter drone systems, the drone threat is very much addressable.

DISCLAIMER

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