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The Threat of 'Many': A Steadily Growing Threat

Lieutenant General (Dr.) VK Saxena, PVSM, AVSM, VSM (Retd), is a Visiting Fellow at CLAWS. General Saxena was the Former Director General of the Corps of Army Air Defence. He is also a Distinguished Fellow at VIF. He has authored 5 books, publishes regularly across defence media and is also a familiar face on TV, speaking on multiple issues in his core competency domain.

Abstract

This work is configured on a brief analysis of three events—Khmeimim & Tartus (2018), Saudi Aramco plant attack (2019) and Swarm of Drones over the Ukranian sky (2022).This paper intends to highlight how the power of swarm drones has grown disproportionately. It argues that today a stage has come wherein these 'little monsters', organised as deadly swarms, are going to become 'the next big thing' in the air threat matrix of future conflicts.

Key Points

- Making a strong beginning in the first ever recorded attack on 05 January 2018, the drone swarm threat has grown at a steady pace.
- Armed by enabling tools of technology, this threat today poses a new challenge to the defender's air defence systems.
- Difficult to detect and far more difficult to kill, this threat has made the erstwhile conventional air defence weapons ineffective to counter the challenge.
- New means of 'detect-intercept-kill' are emerging in the defenders' domain to deal with the little monsters.
- This work takes the reader through the drone swarm story as it exists today.

Event 1: Khmeimim and Tartus: Where it All Started

The 05 January 2018 drone swarm attack on Russian assets in Syria, will be remembered as a day that marks the first ever recorded drone swarm attack in the history of modern warfare.[1]

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Figure 1: Attack on Russian Assets in Syria

Source:https://www.google.co.in/search?q=swarm+drone+attack+on+khmeimim+russian+base+jan+2018&tbm

A swarm of 13 drones of the so called 'Do It Yourself' (DIY) variety attacked two major Russian assets located in western Syria in the wee hours of January 2018— at the Khmeimim Air Base and the Tartus Naval Facility.

Figure 2: Khmeimim Air Base and the Tartus Naval Facility

Source:https://www.google.co.in/search?q=khmeimim+russian+naval+base&tbm

The air base had a slew of modern Russian air power including strike aircrafts and attack helicopters (SU 34, SU25, SU 24, Mi 24, Mi 28, Mi8, Ka52) besides a host of armoured vehicles (T 90, BTR 82), artillery pieces and BMC2 systems.

- The Tartus Naval Facility comprised berths to house 11 warships. The Base was designed to support Russia's Fifth Operational Squadron (counter balance to US Sixth Fleet in the Cold War era). Besides air defence weapons, Tartus also had a number of Electronic Warfare (EW) units with a soft kill capability to counter the air threat.

- Khmeimim, on the other hand, had a strong air defence deployment, which besides air defence aircrafts, included man-portable SAMs (Strela 2M, Igla, Igla 1S etc.) and Medium range SAMs (Pantsir-S1).

However, it is amazing to note that despite possessing advanced air defence power, all 13 drones could not be destroyed, of which three exploded on landing at the air base causing substantial damage. Why? Here is a brief analysis.

Analysis

Following points could be deducted from the incident:

The swarm attack marked the ineffectiveness of conventional air defence weapons to counter the 'little monsters' in totality.

- Long range radars of Pantsir SAM system (possessing a capability of hitting 20 targets at a time, up to a range of 32-36 km) were unable to detect small drones of sub-metric dimensions due to their 'small footprint' (referred to as radar cross-section or RCS— a measure of the detectability of a target by a radar. Higher the RCS of a target, higher the probability of its detection at a given range).
- Though some detection up to the range of 8-10 km, may still have happened at closer ranges by the fire control and missile guidance radars of Pantsir system, as the missiles did get launched (otherwise not possible to launch these SAMs in the manual mode).
- Some close range detection could have also happened by the Electro-Optical (EO) and Infrared (IR) sensors associated with EW units at Tartus— since there was an attempt to soft kill the drones.

Thus, if just 13 drones (7 at Khmeimim and 6 at Tartus) could not be fully destroyed by a combination of Pantsir and EW systems what would have happened if there were 100 or more drones?

DIY (as suggested by single propeller design and no landing wheels with parts made of metal, wood and plastic), drones showed their power in the first attack itself. Some points about their exhibited capability are as mentioned:

Figure 3: The Swarm that Attacked Khmeimim and Tartus

Source: https://www.google.co.in/search?q=swarm+drone+at+khmeimim&hlen&tbm

- Capability to fly, in an autonomous mode, up to a range of 50-100 km (the assessed launch base was Muwazaara village in Western Syria which was that far). [2]
- Capability to carry precision warhead (one pound of PETN with metal ball bearings to explode as a fragmentation enhancement munitions). Remote munitions drop mechanism that operated precisely at the target end.
- Capability of autonomous navigation and target recognition in darkness.
- Each small drone had sophisticated avionics gear that included pressure transducers for detecting minute differential pressure and altitude control servo-actuators for precise flight control.

That's how the drone swarms first announced their arrival in the combat zone.

Event 2 : Attack on Saudi Oil Facility

In September 2019, the swarm struck again in Saudi Arabia. The targets were two oil processing facilities in Eastern Saudi Arabia located at Abqaiq and Khurais.

Figure 4: Oil Processing Facilities at Abqaiq and Khurais

Source: https://www.google.com/search?q=saudi+oil+facility+abquiak&tbm

The facilities were recognised as vulnerable areas (VAs) and Ground Based Air Defence Weapons (GBADWS) were deployed there.

The GBADWS included state-of-the-art 35 mm Oerlikon guns with Flycatcher Fire Control Radar (detection range 20 Km) and the MIM 104 Patriot mobile air defence system equipped with AN/MPQ 65 passive electronically scanned phased array radar with an instrument surveillance range of 100 km.[3]

- The GBADWS were deployed to protect the oil facilities from a conventional air threat of strike aircrafts, attack helicopters and more. However, the facilities were struck by a swarm of 10-14 small drones in kamikaze mode. The Houthis in Yemen claimed responsibility for the attack.
- The drones used were probably UAV X. The threat vehicles possessed all the swarm capabilities like the Khmeimim drones and more.
- The attack was so deadly that it disrupted about 50% of the country's global supply of crude oil, stalling production of 5.7 million barrels of oil and bringing the Saudi oil output to nearly half its capability.[4]

Figure 5: Drone Attacks in Abqaiq and Khurais

Source:https://www.google.com/search?q=drone+swarm+attack+on+saudi+oil+facilities&&tbm

Analysis

The swarm again played on its intrinsic strength. Because of its small size (RCS) and due to keeping low and flying along the nap of the earth (NOE), the swarm avoided detection by multiple radars of GBADWS (Flycatcher and AN/MPQ65 etc.). The latter were designed to detect small drone targets and, by virtue of their deployment, could only take on a conventional air threat. Thus, the ineffectiveness of conventional GBADWS in countering small drones stood re-validated.

Event 3: Swarm over the Ukranian Skies

As if the catastrophic destruction of human lives and material by tanks, armoured personnel carriers, cruise missiles, guns and howitzers in the ground war and by the aircrafts, attack helicopters and SAMs in the air war, was not enough in the ongoing Russo-Ukraine war, drone swarms again made their ugly appearance.

On 17 October 2022, a swarm of 43 Shahed Kamikaze drones, reportedly acquired by Russia from Iran, attacked Kiev. Over a period of just under two weeks, some 400 of these have reportedly struck Ukraine's power stations destroying some 30% of the country's energy grid.[5]

Shahed 136 or Geran 2 in the Russian inventory, is actually a loitering ammunition. It is small in size (L-3.5m, wingspan 2.5 m, warhead 200kg and operational range of more than 1800 Km).

Figure 6: Russian Drones Destroy Ukraine's Energy Grid

Source:https://www.voanews.com/a/wide-scale-russian-attacks-target-ukraine-s-energy-grid-/6801665.html

As a counter attack, on 29 October, a swarm of unmanned surface vessels (USVs) from Ukraine's so called 'Drone Army' attacked the Russian naval assets at the Sevastopol naval base in the Black Sea.[6]

The drones in Kamikaze mode prosecuted a surprise attack on the unsuspecting naval fleet causing widespread damage on vessels that included an Admiral class frigate and some mine counter measure ships. As per reports, the flagship Russian Frigate, Admiral Makarov, also took a hit. Thus, a new chapter with USV warfare opened up in the expanded warzone.[7]

While both the drone attacks in Ukrainian skies do not qualify for being a drone 'swarm' in their classic sense the end effect of overwhelming enemy's air defences and causing widespread and disproportionate damage was as much as by a classical drone swarm. Thus, highlighting that small drones grouped in some number, produces a swarm kill effect.

Figure 7: Attack by Ukraine on Sevastopol

Source: https://www.google.com/search?q=swarm+drone+attack+on+sevastopol+29+Oct+2022

Emerging Face of the Little Monster

Powered with latest technology the threat now features the amazing intelligence of a 'bird swarm' and a 'human like' dedication and resoluteness to get on with the task, come what may. Today their capability report card runs like this:

- A precise satellite-aided navigation for an unmanned autonomous flight of 50-100 km or more.
- Carriage and precise remote delivery of multiple payloads that may include sophisticated explosives and warheads, improvised devices or simple drop loads.
- Pre-programmed flight (NOE where required), so as to avoid electronic detection from enemy's sensors.
- Acquire the target at the terminal end and home-on to it in the kamikaze mode.

Tremendous amount of AI-based embedded intelligence. A small sample:[8]

- Every machine is aware of its position in the swarm and its *inter se* relationship with the rest of swarm.
- Re-positioning information to keep the swarm grid intact in case any member is shot down.
- Executing a programmed flight path— seamlessly executing battle functions such as map loading, target recognition, weapon release, return to base and self-destruct.
- Adopting electronic attack/evasive measures on command/programme.

The Resolute Warriors

With combat virtues as above, swarms are resolute warriors. Future combat will see more and more of them in multiple roles. These could be:

- Precise autonomous strikes to take the enemy by surprise, avoid radar detection, overwhelm conventional defences and execute kamikaze attacks.
- Navigate quietly and kill precisely by intruding inside restricted spaces.
- Positioned at a critical point to provide situational awareness, over an area of interest by reporting changes to a programmed threshold.
- Lie low and wait for the 'intended' prey. Strike when the target is in kill zone and verified by 'face recognition' software (killing of Qasem Soleimani in 2020).[9]
- Stand-in to fight in 'last man last bullet mode'. Keep re-positioning as swarm gets attrited by enemy fire. Show tolerance for ambiguity to act in a 'no command' scenario.

What Do the Defenders Need To Do

By now, the air defenders are quite clear about the following:

- Drone swarm is the next big thing on the horizon.
- Conventional air defences will be overwhelmed by the sheer quantum of threat.
- An entirely new find-and-kill technique is required to deal with drone swarms.

Air defence is a three pronged battle viz. 'Detect-Intercept-Kill'— 'detect' the threat in time; launch suitable weapons to 'intercept' the threat; kill/negate the threat before it manages to cause catastrophic damage. Each of these function requires a different strategy when dealing with drone swarms.

Drone swarm in large numbers is otherwise a 'big-body' threat. Why they largely remain undetected is because of the following:

- The swarm is programmed to do NOE flying by keeping low and thus avoiding detection by early warning radars (range 80-100+ km) of conventional air defences which are presently not optimised.
- Closer home, the swarm body can be detected by missile guidance radars (range 18-30 km generally) and later gun fire control radars (range 8 -20 km generally) of the conventional air defences.

It then becomes possible to launch guided SAMs or direct gun fire at them, latter largely in the visual domain.

Ever since the small drones have emerged as deadly air threat vehicles, defenders have been searching ways and means to detect them by using Electro Optical (EO) as well as Radio Frequency (RF) detection. Some salient points in this context are:

- EO basically employs a 360^0 detection using a CCD day camera, a thermal night camera along with an eye-safe laser range finder— all coupled to a fire control computing device. These type of sensors paint a 3D picture of the threat on a discernible background to enable detection at fairly adequate ranges (8-12 km).
- RF devices aim to detect the drone threat by operating in RF bands —1.74-150Mhz, 20MHz-6GHz, 400Mhz-6Ghz.
- The coupled fire control devices, in the EO and RF systems, activate a soft or a hard kill, when the drone body enters the kill zone.
- The soft kill involves an electronic attack solution (jamming, phishing, or hacking the threat), alternatively killing the threat by laser beams.
- The hard kill involves destroying the threat by directing the fire of small arms or machine guns or high rate-of-fire air defence guns (3000-8000 rounds per minute).
- Lately, the defenders have realised that backing the EO/RF systems with 3D radars operating in X (8-12 GHZ), Ku(12-18 GHZ) and K (18-27 GHZ) bands, and based on active/passive electronically scanned array (AESA/PESA) radar, could be an effective sensor solution for detecting small drone threat at low altitudes.
- The distinct buzz of the swarm is a sure giveaway if acoustic sensors are programmed for detection and are deployed correctly.

While the above solutions are essentially addressing the challenge of detection and kill of small drones, the drone swarms per se, pose a different challenge. Some points:

- While their detection is not as difficult as a single or a few small drones, the kill is the biggest challenge.
- Even if the swarm body is detected, the conventional air defence systems of SAMs cannot kill all— a few may still land and destroy the assets, albeit partly.

What is required is 'mass kill and area denial systems'.[10] Mass kill implies the capability of spraying the target area by abundant means, like a mass fire using multiple and high rate of fire air defence guns or by sweeping the target with multiple laser kill beams (limited capability in fog, clouds and smoke) or by multiple electronic warfare (EW) systems

propagating RF and jamming energy from multiple sources crisscrossing the swarm flight area.

- Another feasible option is the use of defender drones. This body of drones, controlled by the defender, is directed to achieve a kinetic collision with the swarm, thus achieving a high probability of kinetic kill of large numbers in the threat swarm.
- Microwave based weapons are beginning to provide mass kill solution for swarm based threat. One such weapon which is under development and likely to be operational in US in 2023 is called Mjolnir— it features a huge 20ft satellite dish that spews out high power microwaves capable of materially disintegrating the drone swarm attack.
- Another innovative tool under development is the erection of electronic fence, over a critical area of interest, violation of which by the swarm body will incapacitate its electronics and EM systems on board.
- For launch of swarm kill weaponry, both in soft kill (laser, RF) and hard kill mode, aerial platforms are being tried. On board such platforms are weapons that can spray the swarm body with multiple killer beams, or launch multi-directional RF/EW attacks or can even release hundreds of small drones to cause a catastrophic collision with the threat.

Hence, the cause-effect battle between the attackers and the defenders is in full play.

Where are We on these Aspects

India has a definite and recognisable presence, both in the swarm as well as anti-swarm domain.

In the swarm drone arena, India has nearly developed two products viz. Alfa S swarm drone system and the Robotic Wingman. The Original Equipment Manufacturer (OEMs) is HAL in a joint venture with a company named New Space Research and Technology.

- Air launched Flexible Asset –Swarm (ALFA-S) is a small drone (1-2 m) that can move at a speed of 100 km/h, and carry an explosive warhead of 1.5 Ton which can be launched from an SU 30 MKI or an upgraded Jaguar aircraft.
- ALFA-S remains in the command loop of the mother aircraft by means of EO/IR connectivity. It has limited AI capability and can be directed by the mother aircraft as a swarm to destroy its intended target by a catastrophic ‘collision kill’ in a kamikaze mode.

Figure 8: ALFA-S

Source: https://www.google.com/search?q=ALFA-S+and+Robotic+wingman&tbm

- Robotic Wingman.
    - Realised through a ToT from the US, it is designed to operate in concert with manned missions in the Combat Air Teaming Systems (CATS) mode, more popularly known as the Manned and Unmanned Teaming (MUMT).
    - In an operational configuration, three to four Robotic Wingmen are designed to operate ahead of the manned mission (up to 100 km) in the CATS configuration, thus providing uninterrupted situational awareness to the combat pilot.
    - For the strike, Wingmen can carry a payload that may include Precision-guided-Munitions (PGMs), or laser guided bombs (LGBs), air-to-surface missiles.

It was reported in August 2022 that the "Indian Army has procured swarm drones from two start-up companies in India".[11] In addition, the MoD has initiated a procurement case under the MAKE II category (indigenous design, development, manufacture) for the procurement of swarm drones with a strike capability. It is named as Autonomous Surveillance and Armed Drone (A-SAD). The drones will be capable of both—surveillance as well as strike role. [12]

The above development not only highlights the Indian Army's embrace of new and enabling technologies, but also points to the steadily growing muscle of the domestic drone industry.

As for the counter drone capability, we have come a long way. Some salient points are:

- Any number of EO/IR/RF sensors are now available both in the public as well as in the private defence industry capable of detecting small drone targets.
- Besides just surveillance, ready to use and fully integrated counter drone solutions, involving EO/RF and radar based surveillance and RF based jamming kill of the target drones are now available.

In the above context it is relevant to mention two systems:

- DRDO Anti-Drone System (ADS), which features EO/IR sensors that includes a frequency modulated continuous wave radar for small drone detection up to a range of 4 km. The kill means include an RF/GNSS jamming system with a range up to 3 km and a laser kill system with a range from 150m to 1 km.
- Zen ADS – an anti-drone solution provided by Zen Technologies Ltd.

Figure 9: DRDO and Zen ADS

Source: https://www.google.com/search?q=ZEN++ANTI+DRONE+SYSTEM&tbm

The Zen ADS features a dual-mode surveillance and tracking of the threat. This is provided by active radar as well as a passive solution based on EO suite (day camera, night camera, LRF and processing unit). A combination of both these solutions ensures that a low RCS drone, which would otherwise be invisible to conventional radar, becomes 'detectable' and hence 'defeatable'.

The kill solution is based on a RF (jamming kill) or a kinetic kill through a high rate-of-fire gun. Besides this, there are small arms with special sights or handheld RF guns in the Indian defence industry for adaption to the ADS role.

So, this is the big picture of emerging swarm drone threats to which air defenders must match up to. Thus, India is on the right path to building its capabilities to meet this threat for now and for the foreseeable future.

End Notes

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CENTRE FOR LAND WARFARE STUDIES (CLAWS)

RPSO Complex, Parade Road, Delhi Cantt, New Delhi 110010

Tel.: +91-11-25691308, Fax: +91-11-25692347, CLAWS Army No. 33098; Email: landwarfare@gmail.com

Website: www.claws.in