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Little Monsters With A Mind of Their Own: A Grave Threat

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Key Points

- Drone swarms pose a grave and a lethal air threat today.
- Hundreds of these 'small machines' can be programmed to launch a fully autonomous attack on the targets of choice.
- Powered by AI, swarm drones have a' mind of their own'. They show collective intelligence and possess a high tolerance for ambiguity.
- Front ranking countries of the world are acquiring swarm drone capability. India is also in that list.
- Killing of drone swarms requires low-RCS detection capability at low altitude and low-cost mass kill solution, which could be in the kinetic or soft kill domain.

Building the Perspective

See Where Have They Reached?

Starting from their humble beginnings as machines for looking 'over the hill' and 'round the corner' in their avatar as ISTAR vehicles (Intelligence, Surveillance, Target Acquisition and Reconnaissance), the unmanned phenomenon has exploded into such a revolution that it has 'redefined' aerial combat.

The infamous 'dull, dirty and dangerous' (drones) have manifested as fully capable combat platforms fighting all on their own, or operating shoulder-to-shoulder with the manned platforms. These deadly machines with all weather & all terrain operability, tremendous endurance and comparable lethal loads, are giving a run for their money to their 'manned brethren'.

Make Way: The Little Monsters Arrive

As if all the above and more was not enough, arrive the "little monsters: – the small drones! (remember the attack on Jammu air base on 26/27 Jun 2021?).[1] Powered by the tools of Artificial Intelligence (AI), these "little monsters" now possesses a mind of their own.

Moving many a steps up the 'lethality ladder', the small drones gradually metamorphosed into 'drone swarms', wherein hundreds of these unmanned machines can now be programmed to take on a target much like a deadly swarm of locust that that has the capability to destroy thousands of square yards of standing crop in a matter of minutes! This is where the cumulative lethal power of drone swarms has reached and counting.

Figure 1: Locust Swarm: The Inspiration Behind Drone Swarms

Source:https://www.google.com/search?q=locust+swarm&client=firefox-b-d&sxsrf=APqBsdQiQjmW0ojWjFSw37Z0InpA8jPg:1646215728856&source=lnms&tbm

SWARM: The Myth

It is a common belief that the word 'swarm' relates to a 'locust swarm'. However, that is not completely true— while the drone swarm does replicate much of the characteristics of a locust swarm, it actually is an acronym which stands for Smart Warfighting Array of Reconfigurable Modules.

True to its name, a SWARM refers to a body of unmanned aerial systems (UAS), virtually threaded together to act as one whole, that is capable of executing its assigned mission with a degree of autonomy that may vary from swarm to swarm.[2]

A Possible Swarm Task Sheet

The configuration, as described above, can be put to multiple uses. A possible task sheet may run as under. This is by no way comprehensive.

- ***Gorgon Stare.***[3] Much like the three "Gorgon Sisters" in the ancient Greek mythology, who could turn any person into stone by their 'grim, dreadful and unblinking' stare, the drone swarm could be positioned over an area of interest to provide 'uninterrupted and continuous information' with AI based intelligence interpretation of dynamic movements.
- ***Quiet Killers.*** A 'determined' drone swarm could be programmed to navigate quietly through restricted spaces like doors/windows/bottlenecks/galleries etc. and execute their mission of "peep and tell" or "intrude and kill".
- ***Predators in Wait.*** A 'patient' drone swarm could be placed at a desired location and programmed to wait for their 'intended prey'. In this role, the swarms can act as loiter munitions and attack precise targets on command. AI kicks in with such features as face recognition capabilities, target virtues/behaviour de-coders etc. Remember the killing of Major General Qasem Soleimani, the Commander of the Quds Force of Iran by US on 03 January 2020 at Baghdad International airport using drones as predators -in-wait?[4]
- ***Stand-in-Warriors.*** A 'resolute' drone swarm could be programmed to give a pitched battle in a scene of action. In this role, the swarm warriors will be feeded with such

virtues as “last man last bullet” whereby, even if few/more of its members get knocked down, the rest will stand in to fight. If a member gets shot in a threaded grid, the others will adjust to keep the grid intact. Also, the warriors will show great tolerance to ambiguity. Complex programming algorithms ensures intelligent behaviour resulting in uninterrupted action even with ambiguous/nil orders.

Drone Swarms Get Baptised: A Defining Moment

The date–05 January 2018, will go down in the history as the day that saw the ‘first ever documented drone swarm attack’. The incident is a matter of an important Case Study with relevant deductions. Some salient points are briefly covered.[5]

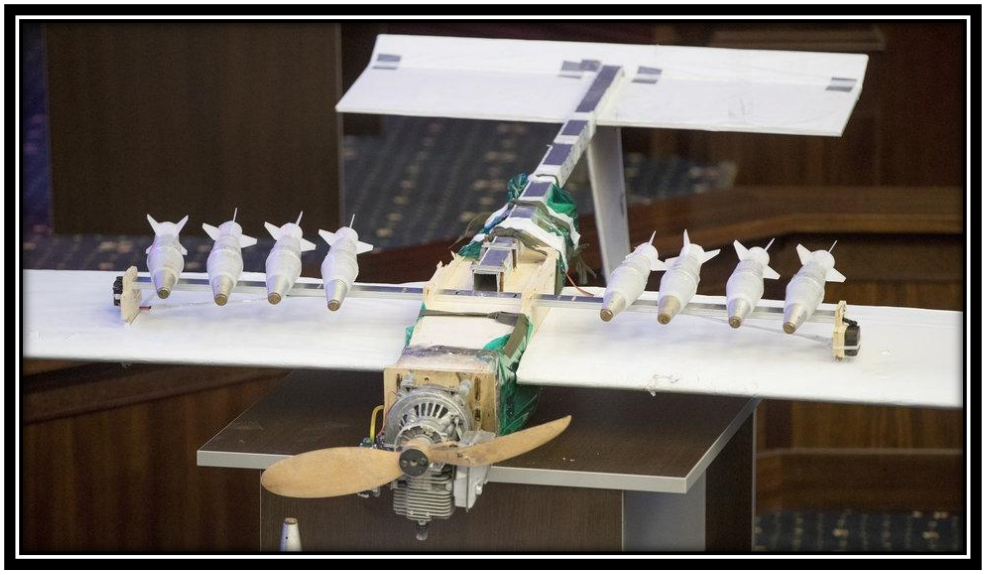
- ***The Event.*** On 05 January, a set of 13 homemade small drones threaded as a swarm, attacked the Russian Air Base at Khmeimim and Russian Naval facility at Tartus—both in Western Syria.

Figure 2: Homemade Drones Bomb Russian Airbase

Source:https://www.google.co.in/search?q=swarm+drone+attack+on+russian+air+base+in+western+syria+05+jan+2018&hl=en&tbm

- ***The Targets.*** Khmeimim was (continues to be) a frontline Russian Air Base in Syria which acted as a focal point for sustaining air operations in the country. It had large number of air assets – Su24, Su25, Su34, Mi24, Mi 28, Mi 8, KA 52. Similarly, the Tartus Naval facility was a major asset berthing some 11 warships and more.
- ***The Threat Vehicles.*** All the threat vehicles were small drones, guided by the GPS. The navigable range was assessed to be in the region of 50-100 km. The said drones, while of DIY (do it yourself) variety, had advanced gear (such as pressure transducers and altitude control servo actuators) for an autonomous flight and precise remote drop operation. Each drone carried few pounds of PETN explosive as warhead.

Figure 3: The Drone (in swarm) that Attacked the Russian Airbase and Naval Facility



Source:https://www.google.co.in/search?q=swarm+drone+attack+on+russian+air+base+in+western+syria+05+jan+2018&hl=en&tbm

- ***Action.*** The vehicles maintained very low altitude (<30 m).This coupled with low Radar Cross Section (RCS) {degree of detectability of an object to a radar} ensured that they could not be picked up by the early warning and missile guidance radars of the Russian Pantsir-S1 Surface-to-Air Missile (SAM) system, till it reaches very close

(range of Pantsir early warning radar is 32-36 Km; probable detection took place at 8-10 km, later by electro-optical (EO) systems at 4-6 km). The Pantsir SAMs launched at the swarm could kill 7 out of 13. The Electronic Warfare (EW) attack from Tartus could kill 3 while the balance three landed and destroyed the air base and the naval facility.

- ***Reflections and Inferences.*** This was a defining incident that brought home the following points:
    - The era of drone swarm had arrived.
    - With it came the autonomous attack capability extending from 50-100 km.
    - The DIY drone had graduated to 'newer avatars' with sophisticated parts for controlled flight and precise remote dropping capability for warhead.
    - Ineffectiveness and huge cost imbalance in launching thousands of dollars of Pantsir SAMs, to kill these "little monsters", each not more than a few hundred dollars, came out clearly.
    - The attack opened up a whole new world of 'Dark Web' wherein big players using non-state actors could hide behind the autonomy of swarm drones and execute 'big attacks' with bigger/sinister aims.

No Looking Back

Expectedly, there was to be no looking back; but soon came 14 September 2019, and there was another devastating attack on the Saudi Oil facilities (Aramco oil facilities) at Abqaiq and Khurais, by a swarm of 10-14 small drones in the Kamikaze mode (probably UAV X).[6]

Some salient details are presented:

- Small RCS coupled with ultra-low flying (very much feasible in the obstacle devoid desert terrain) ensured that radars of such effective air defence weapons like the 35 mm Oerlikon guns and the Patriot SAM system, deployed at the facilities, could not detect the low kamikaze drones.

Figure 4: Drone Swarm Attack on Aramco Oil Facility: September 2019

Source:https://www.google.co.in/search?q=swarm+attack+on+saudi+oil+facility&hl=en&tbm

- Effect of the attack was so devastating that it stalled about 5.7 million barrels of oil—reducing the Saudi oil output to nearly half its capability.

AI Powering Small Drones

The 'sting' in the drone swarm is the 'mind' that powers it to execute assigned missions with precise accuracy. Latest tools of AI are achieving new highs in the drone swarm:

- Navigate quietly and precisely over large distances/restricted spaces.
- Carry out 'peep-in' or 'kill missions' with 'needle-like precision'.
- Provide seamless situational awareness inputs in 'Gorgon Stare' mode.
- Great tolerance for ambiguity.
- Resoluteness to fight with a degree of survivability.

- Collective intelligence of a locust swarm.
- Capability to overwhelm any conventional air defence due to sheer numbers.

Swarm Drones Around the World

Front ranking nations of the world are trying to acquire swarm drone capabilities sooner than later. Some examples are as follows:

- In March 2019, the British Defence Secretary announced that 'Swarm Squadrons' (Sqn) will be a part of Royal Air Force (RAF) in the coming years.

  Following up on this, open sources announced that in January 2020, 216 Sqn RAF will become '216 Sqn Swarm Drone' which will possess the capability of 'confusing the enemy' and 'overwhelming conventional air defences'.

- Choosing an appropriate word 'Gremlin' (meaning an imaginary and a mischievous spirit known for causing unexplained mechanical or electrical problem), the US, in 2019, was developing micro-drones called 'Gremlins' that are droppable from large planes for carrying reconnaissance over wide areas.

  Following up on this, open sources reported in December 2021 that 'Gremlins' were not only dropped by a C- 130 aircraft, but were even recovered back in a neat 'fold in' mission

Figure 5: C-130 Folding in Gremlins by Snatching Them in Mid Air

Source: https://www.google.co.in/search?q=folding+of+gremlins+by+C+130&hl=en&tbm

- Back in February 2020, China reported operationalisation of its 'helicopter drones' and its capability to undertake drone swarm operations in fully autonomous mode. Earlier, many incidents have been reported of achieving controlled behaviour of a large number of drones (1180 drones in a co-ordinated show for Global Fortune Forum in Guangzhou in 2017).
- In May 2021 a drone swarm was successfully tested by China in a guided Beyond Visual Range (BVR) attack.

Figure 6: Chinese New Swarm Drones Being Tested For BVR Attacks

Source: https://www.google.co.in/search?q=China+testing+drone+swarms+&tbm

- In US, trials are underway for a programme called CODE that is Collective Behaviour in Denied Environments. CODE envisages swarm drones powered by AI in carrying out precise missions in opposed scenarios. There is also a talk of OFFSET (Offensive Swarm Enabled Tactics) as an exercise to practice drills and techniques against drone swarm attacks.

- Russia is a strong drone swarm power. Its Flock 93 is projected to be a lethal drone swarm weapon composed of 100s of Kalashnikov ZALAKYB drones each carrying an explosive warhead of 5.5 lbs. Trials on this weapon are in progress since 2019. Swarm drones were reportedly used in a Military Exercise— 'Kavkaz' in 2020. It is understood that, as of now, the capability stands matured and may be used in the ongoing war between Russia and Ukraine.
- Pakistan while sitting confident with its 'Burraq' combat drone, is not reported to be anywhere close to operationalising any drone swarm per se, but with its known closeness with his 'all-weather friend' (China), capabilities actually sits in proxy.

Where Are We?

'Up and about' as a one word answer. Following salient points are stated:

- For the last 3-4 years, the State owned Hindustan Aeronautics Limited (HAL) has shaken hands with a company named NewSpace Research &Technologies. This Company is no small player; it is a reputed company that develops Persistent Drones for Earth Observation and Communication.
- Together they have developed three types of products[7,8] :

Figure 7: ALFA-S Swarm UAV System

Source: https://www.google.co.in/search?q=Alpha+S+drone+swarm+India&tbm

i. The first of these is the air launched small drone called ALFA–S (Air launched Flexible Asset-Swarm).

- It is a small drones of 1-2m diametre.
- It can carry an explosive warhead of 1.5 T.
- It can be launched from Su- 30 MKI and upgraded Jaguar.
- It has some built-in stealth features.
- It has a speed that can go upto 100kmph.
- Once launched, it remains in contact with the mother aircraft through EO and IR connectivity.
- On command, it can destroy the intended target in the Kamikaze mode.
- Limited AI feature are embedded.

ii. The second asset is the 'Robotic Wingman'.

- It is a product being realised through the technology transfer under the Indo-US Defense Trade and Technology Initiative (DTTI).
- Wingman is designed to operate in cooperation with manned missions in what is termed as Combat Air Teaming Systems (CATS) or more popularly, the Manned and Unmanned Teaming (MUMT).
- In operational configuration, three to four Robotic Wingmen are designed to operate ahead of the manned mission (upto 100 km).
- In this role, they are equipped to provide uninterrupted situational awareness (enemy's air defences, information on chosen targets, hostile sensor densities, missile bases etc.).
- Wingmen can carry a variety of arsenal. These could be Precision-Guided Munitions (PGMs), Laser Guided Bombs (LGBs), air-to surface missiles etc. These can be used to strike the targets of desire on command from the combat pilot.

iii. The third product is the Ultra High Altitude Drone that is capable of functioning in altitudes of say 65000-70000 ft and has an endurance that can run into several weeks. Such drones act as the 'stable eyes and ears', much above the gaze of electronic sensors that can provide seamless intelligence, surveillance, target acquisition and reconnaissance (ISTAR) information uninterrupted for a whole operation to go through end-to-end.

All the above three products are now 3+ years into the development. However, open sources have reported that HAL CATS[†] is likely to be battle ready by 2024-25.[9] Suffice to say that we are moving forward 'strongly'.

In addition to the public sector, a large number of private players and startups are getting into the offensive and defensive aspects of drone swarm capabilities. Suffice to say that strong colours of *Atmanirbhar Bharat* can now be seen in the end-to-end capability of drone swarms.

[†] CATS refers to Combined Air Teaming System.

Bracing Up To the Drone Swarm Challenge

True to the dictum vis. “to every sword there is a shield”, the ‘air defenders are up and above in finding a suitable counter to the drone swarm challenge.

The typical air defence problem could be resolved if the twin challenge of ‘detection’ and ‘kill’ are effectively achieved for drone swarms.

Addressing the detection Challenge

Following points are stated:

- Unlike hypersonic weapons, the drone swarms pose no impossibility of detection by electronic sensors.
- Going by its basic signature, a drone swarm is a slow moving body which cumulatively has large collective RCS.
- It can play with the electronic sensors by the following two capabilities:
  - Avoiding radar detection by remaining at ultra-low altitudes, where the reflected signals mainly saturate the radar screens due to ground echo (clutter).
  - By having a degree of stealth muscle to evade radar detection.
  - That said, drone swarms have two big handicaps as well. These are comparatively slow moving objects and have a very distinct acoustic signature.

- Both these are big giveaways if the defender deploys the right type of sensors. Following points are stated:
  - It is noticed that fire control radars of the AESA/PESA variety (Active/passive electronically scanned array radars) operating in the precise X (8-12 GHZ), Ku(12-18 GHZ) and K (18-27 GHZ) bands tend to exhibit high resolution and precise detection capability at low/ultra-low levels. These types of radars are likely to be successful in detecting drone swarms.

- Another sure detectors of drone swarm are EO devices operating in the band of 30-3x10 Hz.[11] Such devices can present a 3D panoramic display of the space under surveillance. A drone swarm body entering this space becomes eminently detectable in contrast.
- Exploiting the swarm buzz, acoustic sensors could be the last line of detection, providing 'detect solution' in the terminal range. These however have their own limitations (degradation due to weather, battle noises etc.)

All the surveillance equipments as described above, are already a reality and in use.

Addressing the kill Challenge

Killing of drone swarms have their own nuances. Some points are stated:

- Drone swarms are low-cost threat vehicles. These demands low-cost kill means. In case there is a cost imbalance between the cost of threat and the cost of kill, the attacker will win the war.
- As stated, launching of thousands of dollars of missiles against low-cost threat vehicles does not make sense on two counts:
  - Grossly skewed cost-balance as explained above.
  - A couple of missiles cannot take out a drone swarm. For instance, even after launching such an advanced SAM as Pantsir Si, Russians could take out only 7 out of 13 drones in the swarm!

What are required for the swarm drone kill are low-cost area kill weapons. Following points are stated as to these weapons:

- A Gatling type of gun spewing out rounds at the rate of 3,000-10,000 rounds per minute (rpm) and saturating the entire drone swarm area with small arm bullets with a hope to catch and kill the swarm, is one possible solution.

Figure 8: Gatling Gun Solution for Drone Swarm Kill

Source:https://www.google.co.in/search?q=killing+drone+swarms+with+gatling+guns&tbm

- Another solution lies in using high rate of fire air defence guns (3,000-6,000 rpm), paring them up with AESA/PESA type of fire control radars and taking on the drone swarms in predicted accurate fire.
- The most potent solution lies in EO based surveillance followed by RF /EW killing of swarm drones. This includes the following:
    - Jamming the communication/ data transmission link between the drones and their Ground Control Station (GCS).
    - Interfering /incapacitating the GPS/INS navigation links between the satellite and the drone swarm which will either make the drones rudderless and incapable of pressing ahead with precise attack or generate a default ‘return-to-base’ command.

- Using laser based weapons to destroy the electronics and electromagnetics on board the drones thus making them incapable.
- The cutting edge technologies are bringing to fore new drone kill weapons. These use high power microwaves instead of laser and create mass kill fields to take out drone swarms. One such weapon is likely to be operational in US in 2023 and is called Mjolnir (It features a huge 20 ft satellite dish that spews out high power microwaves in disintegrating the drone swarm attack).
- Another potent means for drone kill are EW attacks which, besides jamming, involves hacking and phishing attack on drones by either taking control of the drone targets or feeding them with false and misleading signals. While both of these are fine for a single drone attack, taking out a swarm would become difficult as mass hacking/phishing may not be possible/effective. Therefore, multiple layers of EW killers will be required!

So this is the current scene of drone swarms on both sides of the fence. With all that has been said the caption of this work — Little Monsters with a Mind of Their Own: A Grave Threat, finds its relevance.

End Notes

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[9] Ibid.

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