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Issue Brief

Aerial Drone Swarms: The Next Generation Military Weapon

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Summary

Affordability, software domination, reduction in mission costs and risk reduction are some of the consummate advantages swarm technology promises in military campaigns. Drone swarms could be engineered out of COTS components and are software dominated. These aspects would probably lead to their quick proliferation even among not-so-affluent militaries. This is a technology that cannot be ignored any longer and work to harness it at the earliest should commence without delay. No other technology is likely to offer as many tactical advantages to the military as drone swarms that too at a rather low cost.

During the opening ceremony of the Winter Olympics at Pyeongchang, a spectacular pre-recorded display by a quadcopter drone swarm comprising of 1218 drones left spectators astounded. Through co-ordinated and pre-programmed flying, the drone swarm made dynamic aerial caricatures depicting a gyrating snowboarder, a flying bird, Olympic insignia, etc. The drones were individually connected via radio frequencies (RF) to a central computer, which controlled the movement and position of each drone to form the dynamic shapes. This display was carried out by Intel using its 'Shooting Star' drones, each of which is about a foot long, weighs approximately 250 grams, and is powered by lithium ion batteries that could keep it in the air for about 20 minutes.

This is, however, not the first time that such a display has occurred. Such swarm displays have been presented on earlier occasions as well, albeit with fewer drones. Not only have artists and aero-modellers been enthused by the immense entertainment possibilities drone swarms present, but their possible use in war has been churning in the minds of military and security strategists. Some concepts are already being tried against adversary forces and installations as well as in counter terror operations.

One significant incident in this regard came to light on January 11, when Russia's Ministry of Defence announced on its Facebook page a swarm drone attack on a Russian military base in Syria. Some media organisations declared this as the first ever drone swarm attack. Excerpts from the Russian Federation's Ministry of Defence Facebook page read as follows:-

> 'Russian Khmeimim air base and Russian Naval CSS point in the city of Tartus successfully warded off a terrorist attack with massed application of unmanned aerial vehicles (UAVs) in the night of 5th – 6th January, 2018. Ten assault drones were seen approaching the Khmeimim air base, and another three – the CSS point in Tartus. Six small-size of these were intercepted and taken under control by the Russian EW units [sic]. Three of them were landed on the controlled area outside the base, and another three UAVs exploded as they touched the ground [sic]. Seven UAVs were eliminated by the Pantsir-S Russian anti-aircraft missiles. The Russian bases did not suffer any casualties or damages.
>
> Having decoded the data recorded on the UAVs, the specialists found out the launch site. It was the first time when terrorists applied a massed drone aircraft attack launched from a range of more than 50 km using modern GPS guidance system. Technical examination of the drones showed that such

> attacks could be undertakens [sic] by terrorists from a distance of about 100 kilometers.'[1]

The Ministry attached photographs of the attacker drones, which were fixed wing aeromodels. Russian experts found on examination of the drones that these were sophisticated and professionally assembled, and could have been received from one of the technologically advanced countries (hinting probably at the US). The drones had satellite navigation electronics and carried professionally assembled improvised explosive devices (IEDs) as weapons which could be dropped at the assigned coordinates. All the drones were fitted with pressure transducers and altitude control servo-actuators, indicating the sophistication of the technology employed.[2] Though this attack appeared to have the numbers of a swarm, whether this was a classical coordinated drone swarm attack is not very clear. Since the last few years, security analysts have been saying that a swarm drone attack by terrorists was no more an 'if' situation, but a 'when' and 'where' situation. This incident probably represents the dawn of drone swarm attacks.

The concept of flying robots and artificially intelligent machines taking on the enemy in groups has always existed in the minds of futurists, and was often seen in science fiction. But, until about a few years ago, technology was lagging to corporealize it. In recent years, with advances in chip technology and software assuming primacy in designing robotics, it has become feasible to design machines exhibiting complex behaviour, achieve mutual coordination and accomplish complex tasks. It is now possible to control, carry out error analysis on and modify the behaviour of robotic machines through algorithms alone without hardware changes. YouTube has a plethora of video footages of drones demonstrating complex behaviours and accomplishing seemingly impossible feats for machines. In one such demonstration, small quadcopter drones, laden with small but potent explosives, were employed as deadly anti-personnel weapons which could be carried hidden in the pocket and launched anywhere to target specific individuals, vital equipment, etc. These drones could even identify the target individuals using facial recognition techniques. Modern drones are getting equipped with artificial intelligence which has made problem solving, target recognition, obstacle negotiation and pathfinding much easier and almost human like.

Big drones like the 'Predator' have been employed in military operations since long, both in unarmed as well as in armed roles. However, they are slow, vulnerable to being targeted, expensive, flown singly, and cannot be of much use against an advanced adversary since their ownership can be easily established. In contrast,

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1 Excerpts taken from the Facebook page of the Ministry of Defence of the Russian Federation, available at https://www.facebook.com/mod.mil.rus/posts/2031218563787556, accessed on February 12, 2018.

2 Ibid

small drones, like the ones captured or shot down by Russia in Syria, could be assembled into non-standard models and used to attack targets clandestinely. Since such models are cheap, they could be made in the hundreds or thousands and used to attack in swarms without much of a cost burden. Electronics like GPS, digital cameras, laser range finders, RF data communication sets, processors, batteries, engines, motors and even pressure transducers and altitude sensors are low-priced enough to be used to produce advanced capability cheap drone models for military missions including armed ones. Modern software technology is reaching a level to enable such drones to function as a swarm relatively easily, digitally communicating with each other, executing tasks while assigning and assuming roles, deciding the positions and roles of each piece in the swarm as per certain algorithms. The swarm of drones behaves and functions somewhat like swarms occurring in nature, e.g., honeybee swarms, flying in coordination, displaying collective intelligence and each executing a small share of the collective task. Defence Analyst Allison Barrie of FoxNews writes,

> 'We are on the cusp of an era when "smart," autonomous, robots fly and travel by ground, communicate with each other and work together as a team to accomplish missions. These robot teams would deploy in teams that could number more than 100 – hence the "swarm" aspect – to overwhelm and defeat the enemy.'[3]

In January 2017, the US Air Force carried out trials with 103 Perdix quadcopter drones functioning as a swarm. The trial included airdropping of these drones in the battlefield from canisters carried by three F/A-18 fighter aircraft, gathering the drones in a swarm and then proceeding to engage targets in the battlefield. William Roper of the US Department of Defense explained in a statement:

> 'Perdix are not pre-programmed synchronized individuals, they are a collective organism, sharing one distributed brain for decision-making and adapting to each other like swarms in nature. Because every Perdix communicates and collaborates with every other Perdix, the swarm has no leader and can gracefully adapt to drones entering or exiting the team.'[4]

The US has been carrying out drone swarming trials since August 2015. In 2016, China demonstrated drone swarming using 67 larger, fixed wing, drones. Russia has reportedly been working on a concept of drone swarming wherein the Scandinavian countries have seen Russian drones flying in formation over their skies. Russia is also probably trying to integrate drones with its 'sixth generation' fighter aircraft.[5] In

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3 Allison Barrie, 'How deadly drone swarms will help US troops on the frontline', *FoxNews*, January 11, 2018, available at http://www.foxnews.com/tech/2018/01/11/how-deadly-drone-swarms-will-help-us-troops-on-frontline.html, accessed on February 12, 2018.

4 Chris Baraniuk, 'US military tests swarm of mini-drones launched from jets', January 10, 2017, available at http://www.bbc.com/news/technology-38569027, accessed on February 12, 2018.

5 United States Army Command, Drone Swarms, *Kindle Edition,* Chapter 2 [Location 229].

parallel to developing drones, the Defense Advanced Research Projects Agency of the US is reportedly working to develop 100-plus combat tactics for employing drones in swarms.[6]

The two instances of different kinds of usage of drone swarms, along with all the developments cited above, show that drone swarms are going to be the choice of the military in the not too distant a future. With the rate at which technology is advancing, the induction of drone swarms may be only half a decade away. They could become the cheapest way to successfully execute many types of military missions. They could not only be used against ground targets but such self-destruct models powered by small jet engines could be pitched against flying aircraft including fighters. While somewhat akin to missiles, these would, however, be much cheaper than missiles. Drone swarms are now being conceptualized as canister launched weapons, especially the quadcopter ones, which would make them easy to pack and carry. Tens of drones could be launched from a single vehicle mounted canister, even while on the move. Launching a swarm of hundreds of drones would probably require only a few vehicles. These could be airdropped through fighter or transport aircraft, or through bigger drones, over or close to target, depending on the danger level in the airspace in the target zone.

Some of the operations where small drone swarms could bring out-of-proportion results could be in army offensives, anti-trench operations, mine laying, helibase or airfield attacks (soft targets like aircraft, fuel vehicles, etc. in airfields), attacks against forward ammunition dumps, radar and communication antennae, command and control nodes, vulnerable points on naval ships, heavily guarded installations, etc. These targets require only a small amount of explosive placed at the vulnerable point to make them dysfunctional or destroy them. Once released, the drones would swarm up, proceed to the target area, attempt target recognition based on the algorithmic logic and then attack the identified targets. The swarms could be varied in size depending on the task to be performed.

Modern day battery powered drones could penetrate the battlefield in depth. Drones swarming the battlefield or an airfield in the thousands would be very difficult to counter. Hundreds of drones over a battlefield or an airfield would saturate the airspace and counter swarm resources invariably would run short. Indiscriminate firing with small arms to shoot down low flying swarms may prove counterproductive and is not likely to be allowed. Electronic Warfare resources would be able to counter a few but only in a large swarm. Since these are small and fast moving, only a few may be shot down and many others would be able to get to their targets. Swarms could also be integrated with fighter aircraft or attack helicopter missions to increase their safety during missions. A drone swarm could be very effective in the anti-

6 Allison Barrie, Note 3.

personnel role by causing substantial casualties in enemy battalions, even when they are concealed in trenches or hideouts. They could prove to be very effective in seeking and taking out enemy armour and guns. Swarms could also be used to counter enemy swarms.

Drone swarms could be particularly useful in urban warfare and counter terrorist operations where they could be launched inside buildings to seek out hidden militants and neutralize them without unduly staking soldiers' lives. Swarms could also find immense use in jungle warfare, particularly in seeking out hidden militants and targeting them without posing risk to own forces. If used in clandestine attack missions against adversaries during peacetime, they would make it difficult to apportion the blame, like Russia is still struggling to do currently. Swarms would also make it easy to execute surgical strikes by replacing personnel with drones. Combat search and rescue is one operation which often requires thorough combing of a large area in difficult and hostile terrain. Swarms could be particularly useful in such missions as well as in HADR missions.

Being cheap and expendable, swarms are likely to reduce the monetary costs of war. Risk management is the cornerstone of military operations. Drone swarms could readily take on tasks in contaminated environments having radiation, chemical or biological hazards or in dangerous situations where the odds are heavily against own forces and likely casualties to own forces could be high. The speed, ubiquity, and prevalence of drone swarms can afford advantages in almost all the 'principles of war' – offensive, concentration, manoeuvre, economy of force, security, shock and surprise. These can paralyse the decision making ability of the enemy.[7]

Drone swarms have some weaknesses and limitations too. First and foremost, their offensive could be blunted through the use of countermeasures like electronic warfare techniques, cyber-attacks, laser and microwave weapon systems, small arms fire, camouflage and concealment or pitching a counter drone swarm. However, none of these is foolproof and each method or weapon has limitations. Even fast switching lasers are subject to weather and counter-counter techniques such as mirrors. Second, for every mission, the drone swarm would require mission specific programming. These programmes could however be made in advance and kept ready for some situations and target scenarios like airfields. An artificial intelligence software base could serve to overcome the deficiencies and inaccuracies in mission specific programmes.

Drone swarm technology promises tremendous advantages in the near future. The Western world already seems to have realized this and is pouring considerable funds into research on this technology. Being showcased at events and used by the military, the technology seems to have already reached a certain credibility mark. Not only

7 United States Army Command, Drone Swarms, Note *5*, Location 518.

aerial drone swarms but marine drone and ground drone swarms are also being worked upon in the US.[8] Even nano drone swarms are being envisaged to become future hacks in the industrial and medicinal fields.

Affordability, software domination, reduction in mission costs and risk reduction are some of the consummate advantages swarm technology promises in military campaigns. Drone swarms could be engineered out of COTS components and are software dominated. These aspects would probably lead to their quick proliferation even among not-so-affluent militaries. This is a technology that cannot be ignored any longer and work to harness it at the earliest should commence without delay. No other technology is likely to offer as many tactical advantages to the military as drone swarms that too at a rather low cost.

8 Ibid, Locations 271, 327.

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