Centre for Air Power Studies (CAPS)

Forum for National Security Studies (FNSS)

Genesis of SWARM UAVs

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Major highlights of the Fellow's Seminar held on December 19, 2017, are as follows:

- The possibilities of use of swarm UAVs in the combat has fired the imagination of military aviation executives. The miniaturisation of sensors, armament, payloads, advances in robotics, artificial intelligence and advancement of unmanned air vehicles have aided the development of swarm UAVs.
- **Swarming as Military Tactics:** Arquilla and Ronfeldt in their study titled Swarms and Future of Conflict in 2000 presented four models of military engagement during the evolution of military organisation and doctrine, i.e. the melee, massing, manoeuver and swarming. Melee was the primitive form of military engagement in which chaos and disarray predominated during the close combat and the leader exercised insufficient control. In mass attack, vast numbers were used to strike the enemy. The employment of force or firepower in mass was the predominant tactics throughout the World-War-I in which both sides sustained massive attrition. In manoeuver, armed forces divided into smaller units and took on the task of defence and attack as they manoeuvered to destroy the adversary. The employment of manoeuvre during the World-War-II was aided by

industrialisation and mechanisation of the forces. Swarming involved dispersed forces to carry out simultaneous attacks on the enemy from all directions, which created confusion and chaos and disrupted cohesiveness of the adversary's defences.

- **Swarm UAVs:** Artificial swarm involves the simultaneous operation of a considerable number of intelligent robots autonomously as a single cohesive entity to undertake offensive, defensive and HADR operations. Scientists are aiming to develop a capability based on the simple principle “Stay close to the UAV nearest to you, do not bump into it". Miniaturisation of technologies, artificial intelligence and algorithms are crucial to the success of the swarm UAVs. Swarm are likely to have higher survivability due to their smaller size, collaborative operations and redundancy provided by swarm members and they pose a challenge for the defender by striking him from multiple axis, which enhances their chances of success.

- **Swarm Networks**: In a swarm, UAVs need to be networked and connected with other UAVs to employ the collaborative capabilities of the group to carry out assigned tasks. There are five basic kinds of swarm networks. The first network is the line or chain network, in which UAVs are connected to each other in series. However, destruction/ malfunction of members of the chain would divide and influence its cohesiveness. The second network is the ring network. In this network, each entity is attached to another entity on both sides, in a side by side arrangement. The third network is the channel or mesh network, in which every entity is connected to every other entity. It is the most dependable network for the swarm, and in the event of damage or loss of one or more entities, the remaining entities would remain networked with all the other entities and continue to fulfil their operational mission. The fourth network is the star network, in which each entity is connected to the central entity or a Hub or a node. However, this network would become dysfunctional, if the Hub or the central entity is neutralised. The fifth network is the Tree Network, which is nothing but a star network with an additional entity, which acts as standby to the central hub or node. The standby hub would replace the main hub in case of its malfunction or neutralisation. Each type of swarm network has its strengths and shortcomings. The choice of the type of network would be dependent on the

present level of technological developments in artificial intelligence and conceived missions for the swarm.

- **Swarm Employment:** There is an attempt to employ swarms to carry out ISR and strike missions in contested areas by employing the collaborative capabilities of the UAVs to enhance their survivability and increasing the probabilities of the success of the missions. In the cloud or massed swarm, all the UAVs remain grouped as a single close-knit, cohesive entity from the launch till they reach close to the target, where the UAVs divide themselves into smaller formations for their respective missions. The second formation is the 'Vapour Swarm', which consists of several smaller and independent formations or individual entities (UAVs), which are dispersed in space and time and they approach simultaneously over the target from different directions for the final mission. In Vapour swarm, UAVs do not join to form a single cohesive entity.

- **Swarm Development in the USA:** The US has led the evolution of swarm technologies. However, it had kept the exact nature of research on swarm a strictly guarded secret till 2016, which gave an indication of its endeavours and aspirations for the swarm technology. The USAF Research Laboratory (AFRL), Office of Naval Research (ONR), Pentagon's SCO, DARPA and Defence Innovation Unit Experimental (DIUx) of the DoD, think tanks and academia have some role in developing swarm UAVs and enabling technologies.

- There was consistency in R&D efforts of the DARPA, SCO, DIUx, AFRL and ONR for swarm development. DARPA, SCO and DIUx., each of them has a different mandate and approach, but they have a common goal. DARPA explores innovations and new technologies for developing futuristic capabilities. SCO fast tracks prototype development by modifying, upgrading and reengineering innovations and by exploiting existing technologies. DIUX aims at the speedy commercialisation of innovations as well as absorption of new civil technologies in military & vice versa. AFRL & ONR act as collaborators & incubators for development of niche technologies.
- The US has led the swarm development, and it is pursuing various projects related to the development of micro, mini and large swarms with possible applications in offensive, defence and HADR missions.