HOW SINGAPORE AND THE SAF CAN GET READY FOR THE ERA OF SWARM UAVS

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ABSTRACT

The author believes that Swarm Unmanned Aerial Vehicles (UAVs) have the potential to pose a real threat when used for malicious purposes, citing examples to prove the capabilities of such technology. The author feels that Singapore may be susceptible to attacks from Swarm UAVs due to its small geographical size. He also highlights that swarm UAVs can continue with the mission even with the loss of a sizeable portion of members as a it is possible for a large enough swarm to overwhelm a small country's air defence system. In this essay, the author proceeds to discuss Current Counter Swarm UAV Technologies as well as Current Measures in the Singapore Armed Forces. He also briefly discusses possible solutions to Swarm UAVs, namely, Deterring Rogue Drone Operators and Disrupting Swarm UAVs. The author concludes that there is no one size fit all solution to the threat of swarm UAVs and highlights that continuous efforts and resources have to be committed in order to deal with such a threat.

Keywords: *Autonomously, Synergistic, Overwhelm, Disruption, Deterrence*

INTRODUCTION

In January 2018, a group of 13 drones attacked Russia's main outposts in Syria, the Khmeimim air base and the naval base in Tartus.[1] In August that same year, 'two drones detonated explosives near Avenida Bolivar, Caracas, where Nicolas Maduro, the President of Venezuela, was addressing the Bolivarian National Guard.'[2] Though the amount of drones was not massive in both incidents, these events demonstrated the potential for more mass attacks on key installations and key personnel. Swarm capabilities were also demonstrated in 2017 when 300 drones assembled into an American Flag in Lady Gaga's Super Bowl halftime show, while Chinese company eHang claimed the record for the biggest swarm in a New Year show where 1,000 drones formed a map of China and the Chinese character '福' in Guangzhou.[3]

Due to the ability to share information and make autonomous decisions, swarm UAVs have the potential to revolutionalise conflicts and the way threats are perceived in the future. This technology, coupled with their ability to overwhelm a target in large numbers and the ease of access due to a low cost of production, presents a very real danger to key installations if used in the wrong hands. Swarm UAVs can fly around to gather intelligence, overrun tank battalions and might even sweep in to attack a warship.[4] Hence, it is critical that a study be conducted to determine the current and future capabilities of swarm UAVs, as well as the measures that Singapore and the SAF can take to mitigate this potential threat in both peacetime and in war.

CHARACTERISTICS OF SWARM UAVs

Swarm UAVs come in various shapes and sizes and they mainly involve mini or micro class UAVs.[5] Mini UAVs have wingspans up to 3m and weigh up to 20kg, while micro UAVs are shorter than 15cm in any dimensions and weigh less than 500g.[6] Current examples of smaller UAVs include the Gremlins, micro drones designed to drop from planes to perform reconnaissance, currently being developed by the United States(US) Defence Advanced Research Projects Agency (DARPA).[7] Meanwhile, bigger UAVs such as the XQ-58 Valkyrie drone, measuring almost 9m in length, are able to carry precision-guided bombs and surveillance equipment.[8]

Swarm UAVs pose a serious threat due to their ability to co-ordinate autonomously, thereby increasing the possible range and complexities of mission. These missions can include swarming enemy sensors and spreading out over large areas for reconnaissance missions.[9] As swarm UAVs can communicate with one another and adjust to real time information, their decision-making process is significantly quicker than a group of individually controlled drones.[10] An example will be how camera and sensor equipped UAVs can share such information within the swarm, allowing the swarm to manoeuvre around obstacles and to strike targets effectively.[11] This presents a step up in capability as compared to traditional UAV operations, which require a pilot and conventional communication procedures. A test conducted by DARPA in 2018 showed how six live and 24 virtual drones were able to 'autonomously locate and engage both pre-planned and pop-up targets', even under enemy jamming conditions.[12] Furthermore, by utilising Artificial Intelligence (AI) technology, swarm UAVs will be able to self-organise and can potentially have a synergistic effect, allowing them to act as an integrated unit to strike as one.[13] This technology will enable the use of combined arms tactics. Some UAVs in the swarm can be armed with chemical or biological payloads while others carry conventional weapons, allowing much closer integration between these weapons than would be currently possible.[14]

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Swarm UAVs are also dangerous due to their ability to overwhelm an enemy in large numbers. The sheer numbers in a swarm provide a greater chance of mission success as the rest of the swarm can complete the mission even if one or a few members of the swarm is destroyed in an operation. The fact that three out of the 13 drones that attacked Russian bases in 2018 managed to breach the base perimeter showed how swarm UAVs could overwhelm an adversary's defences and the potential damage that a co-ordinated swarm UAV attack could cause.[15]

As swarm UAVs tend to be low in cost, they are expendable and can be easily purchased by groups with malicious intent. Due to the low cost, adversaries may choose to use them for suicide missions to overwhelm a target. Defending against such threats will significantly be more difficult due to the high cost of kinetic weapons, as compared to the low cost incurred and the zero risk of fatality to the adversary. While the drones used by eHang in the New Year Show cost USD$1,500, current surface to air missiles, such as the FIM-92 Stinger, cost USD$38,000.[16] Furthermore, though the drones used in the attack on Russian bases were primitive and homemade, they required both kinetic and non-kinetic means in the form of electronic warfare units and Pantsir-S anti-aircraft missiles to take them down.[17] This cost disparity between kinetic measures and current swarm UAV technologies calls for greater research to be done in more cost-effective measures to deal with swarm UAVs.

A RSAF soldier holding a Jammer Gun, which uses signals to jam the control signals of a drone.

DANGERS OF SWARM UAVs TO SINGAPORE

Swarm UAVs can pose a dangerous threat to Singapore. Considering how swarm UAVs can lose dozens of members and still continue with the mission, a large enough swarm could possibly overwhelm the conventional air defence system. Singapore is also particularly susceptible to swarm UAV attacks due to the ease of deployment in the country. Singapore is a

congested city with many high rise buildings, providing potential launching and hiding spots for malicious actors. As swarm UAVs can be deployed with a range of 50km, malicious actors can hide within built up areas, therefore posing a challenge for authorities to apprehend them.[18] Furthermore, as Singapore's critical infrastructure and airfields are located close to the populace, Singapore presents itself as an attractive target to potential adversaries.[19]

The interest of regional terrorist groups in swarm UAV technologies also poses a potential threat to Singapore. Southeast Asia has been dubbed as the second front for the Islamic State (ISIS). With ISIS using off-the-shelf drones since 2014, it is only a matter of time before swarm UAVs become part of their arsenal in the region.

It is hence clear that swarm UAVs have the potential to cause damage to Singapore's key installations. The threat of a small number of UAVs was already made clear when several drones intruded into restricted airspace around Singapore's Changi Airport and disrupted its operation for about 10 hours from 18th – 19th June, 2019.[20] Hence, the potential damage that a swarm of UAVs can cause to Changi Airport or any key installation would definitely be on a much larger scale. As Singapore's economy is heavily dependent on important infrastructure such as Changi Airport, Jurong Industrial Estate and the Central Business District, any mass attack on such key installations would have drastic impact on Singapore and affect confidence in Singapore's defence capabilities.

CURRENT COUNTER SWARM UAV TECHNOLOGIES

In June 2019, the US revealed a 'high powered microwave (HPM) system, the Tactical High Power Microwave Operational Responder (THOR)' to protect its key installations against swarm UAVs.[21] As it is stored in a shipping container, it can be deployed almost anywhere and set up in a few hours, using 'short bursts of high-powered microwaves' to disable swarm UAVs.[22] While the US utilises THOR against short-range targets, it uses the 'Counter-Electric High-Power Microwave Extended-Range Air Base Air Defence (CHIMERA)' for swarm UAVs at medium to long ranges.[23] Both systems utilise a microwave system, whose broad firing arc are able to take down multiple UAVs at once.[24] Furthermore, as these waves have no negative effect on humans or wildfire, these systems would be able to sweep the sky with microwave radiation, affecting everything in its path.[25]

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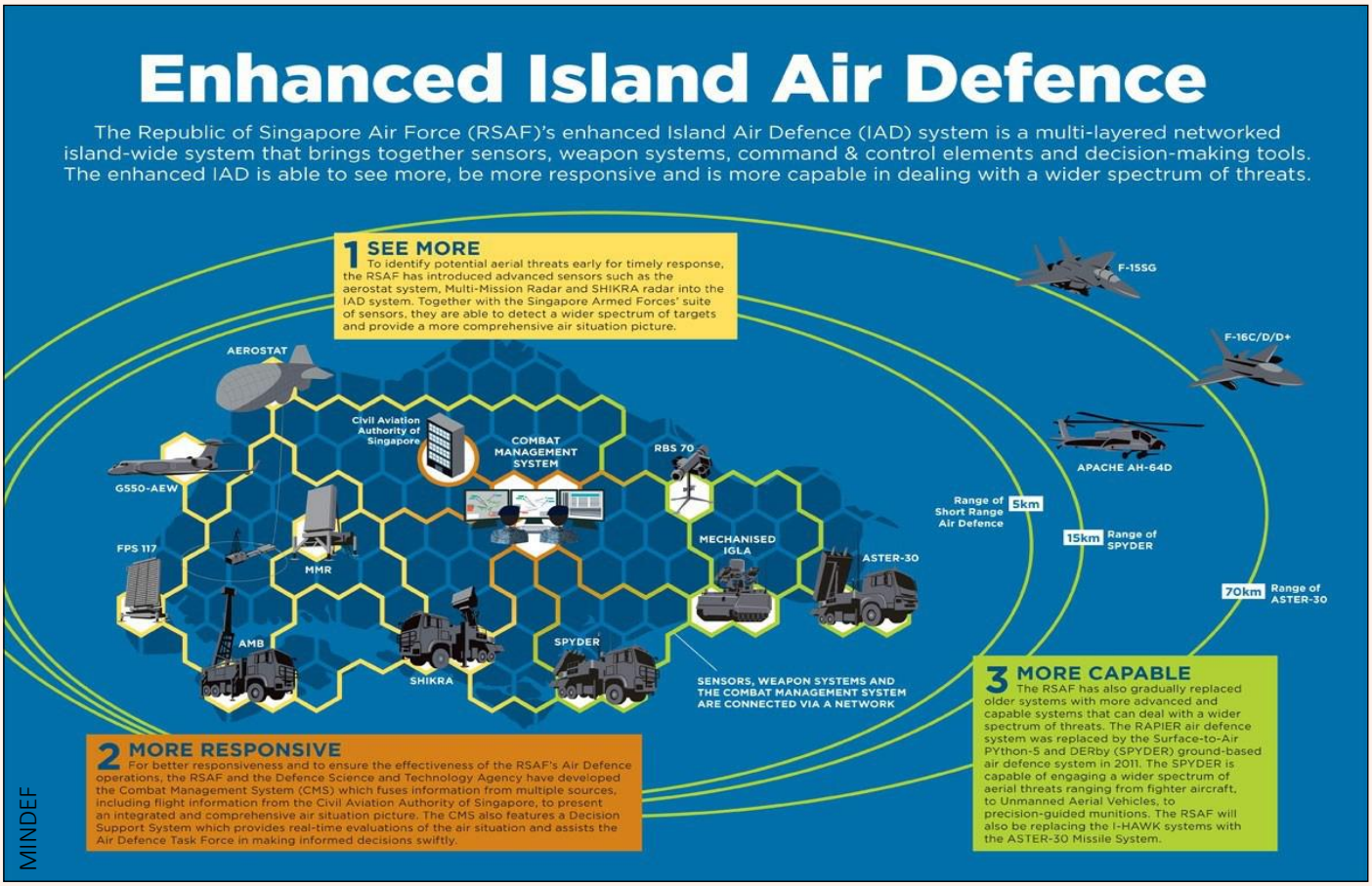
Russia has recognised the threat posed by advancements into swarm technology, triggering them to invest in counter swarm UAV technologies. One concept undergoing testing is the 'Repellent' system, designed to 'detect and disrupt enemy Intelligence, Surveillance & Reconnaissance (ISR) UAVs and to suppress their communications by powerful obstruction or directional interference, as well as disabling their controls.'[26] The system comprises 'two surveillance systems and two jamming systems with sensors and emitters mounted on elevator masts to enable simultaneous engagements of multiple targets.'[27] This technology is envisioned to protect not only military installations, but also troops on the ground.[28] Additionally, Russia has other counter UAV assets, such as the LEER-2 system, an electronic warfare (EW) system mounted on Tiger Light armoured vehicles, which uses dedicated jamming systems to disable UAVs.[29]

The growing threat of Iranian interest in armed UAVs has also pushed Israel to develop swarm UAV countermeasures.[30] Israel Aerospace Industries (IAI) has developed a '3D radar and Electro-Optical sensors and Electronic Attack jamming system' to combat this



The RSAF Enhanced Island Air Defence Model.

threat.[31] These 3D radars can visually identify UAVs at a maximum range of 20km while the jamming system can cause the UAV to return to its point of origin or to shut down and make a crash landing.[32]

POSSIBLE SOLUTIONS TO SWARM UAVs

Due to the versatility of swarm UAVs and its potential impact to multiple industries, it poses a problem from peace to war. Threats could range from a nuisance caused by hobbyists to targeted attacks by state actors or terrorist groups. Hence, mitigating measures should start from peace and involve a Whole of Government (WoG) approach. However, while the rule of law would act as an effective deterrence against hobbyists, stronger measures such as the use of both kinetic and non-kinetic means would be needed against organised attacks by terrorists and state actors.

In this essay, the author proposes a two prong approach, deterrence and disruption, to effectively deal with the threat of swarm UAVs. The use of deterrence will be aimed towards hobbyists and prevent would-be malicious drone operators from carrying out any disruptive activity using swarm UAV technologies. A WoG approach will be required for deterrence measures to be more effective. This concerted government effort will show a united front against the misuse of swarm UAV technologies and send a strong deterrent message towards potential malicious actors. These measures, including the rule of law and education, will aim to dissuade hobbyists and the common man from utilising swarm UAVs. However, in the event of organised attacks or the failure of deterrence, disruption measures may be used to take down swarm UAVs to protect Singapore's key installation and personnel.

Deter Rogue Drone Operators

The rule of law is an essential deterrence measure to prevent the possibility of a swarm UAV attack. The government, including the Ministry of Law and Ministry of Trade and Industry, could consider setting legislature on the import and sale of swarm UAV related technologies in Singapore. This will act as a first road block and prevent such technologies from reaching the hands of local actors and malicious groups within Singapore. Furthermore, stronger deterrents could be implemented for rogue drone users. The current sentence for first-time errant drone operators is a fine of up to $20,000. Repeat offenders can be jailed for up to 15 months and fined up to $40,000. In comparison,

the penalties are unlimited fines and a five-year sentence in the United Kingdom and a US$250,000 fine and a three-year sentence in the US.[33]

Regional treaties and agreements controlling the import, trade and sale of swarm UAV related technologies in the region would also act as an additional layer of deterrence. This can be done through official forums such as the Association of Southeast Asia Nations (ASEAN) or by pursuing bilateral understanding and partnerships with regional countries. Having such agreements would show a strong regional resolve against swarm UAVs, thereby dissuading potential malicious actors from utilising such technologies. On the international front, Singapore can also work with other international organisations and key states at the forefront of counter swarm UAV technologies, such as the US, to establish international norms on the use of swarm UAVs.

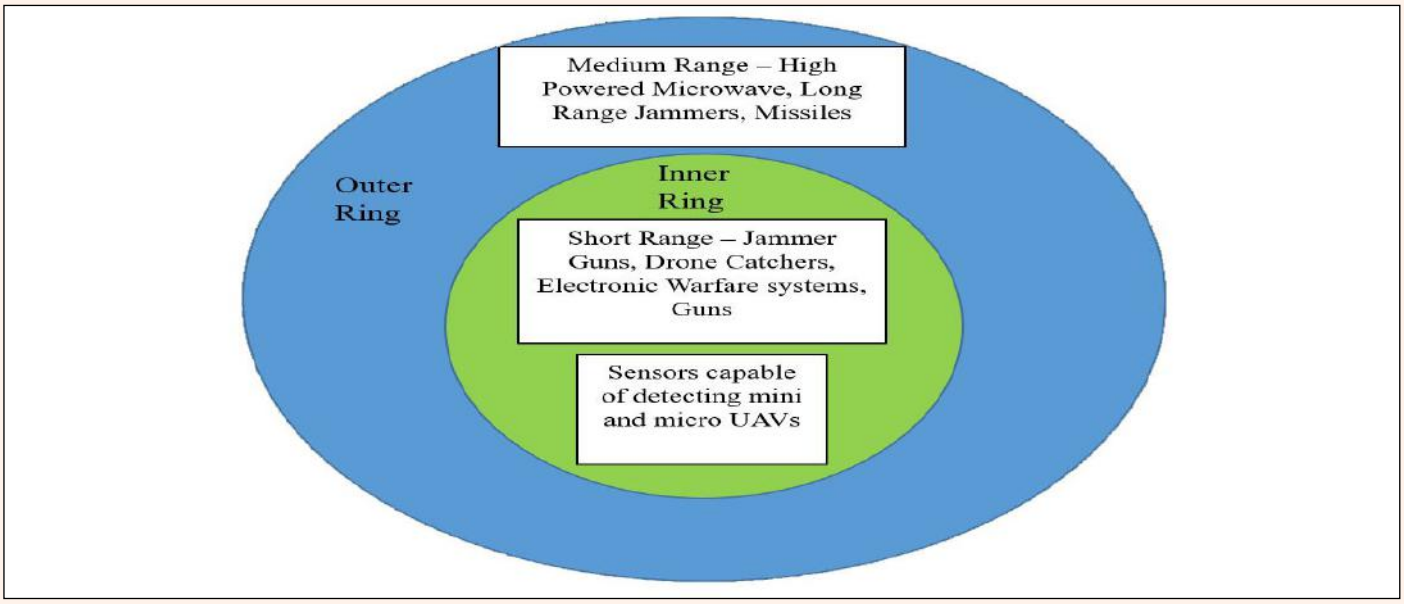
Should deterrence fail, detection and disruption measures utilising both kinetic and non-kinetic measures would have to be used against swarm UAVs to prevent them from affecting key installations and to protect Singapore.

Other than implementing the rule of law, education can also be employed as a form of deterrence. The Singapore government could hold workshops for drone enthusiasts, such as the Multirotor Association of Singapore, to educate them on the proper usage of drones in Singapore and the consequences for the misuse of such technologies. Pamphlets detailing drone regulations and offences in Singapore can also be placed in drone retail shops to ensure that relevant information is relayed to potential drone users.

Disrupting Swarm UAVs

Should deterrence fail, detection and disruption measures utilising both kinetic and non-kinetic measures would have to be used against swarm UAVs to prevent them from affecting key installations and to protect Singapore. As there are different considerations under peacetime and wartime, these measures would differ in both scenarios.

Peacetime. There are a few challenges in taking down swarm UAVs in peace-time. Firstly, as swarm UAVs are versatile in their missions, they might affect multiple industries and thereby require effective intra-government co-ordination to detect and disrupt malicious swarm UAV operations. The Singapore government, like most, is mostly structured into 'vertical silos', with information not easily shared.[34] Hence, a change may be required for the government and institutions to be more networked, allowing a more



Proposed Counter Swarm UAV multi layered defence.

'spontaneous horizontal flow of information.'[35] A suggestion would be for the National Security Co-ordination Centre (NSCC) to be the co-ordinating agency for relevant ministries, such as the Ministry of Home Affairs and the Ministry of Defence, to facilitate detection and disruption of swarm UAV attacks during peacetime. To better prepare for a potential attack, the NSCC could ensure proper delegation of tasks in the event of a swarm UAV attack and set up regular Tabletop Exercises (TTX) to run through potential situations.

Secondly, it may be difficult to have an immediate assessment of the operator's intent upon the detection of swarm UAV operations. To prevent a potential mistake, shooting down swarm UAVs with kinetic projectiles would not be ideal and non-kinetic means would be the preferred measure against such threats in peacetime. While it is important to apprehend swarm UAV operators with malicious intent, the primary objective during peacetime would be the immediate disruption of swarm UAV activities near key installations. Investigations should be carried out after the threat is neutralised to apprehend rogue operators and to serve as a deterrence against future threats.

Thirdly, counter swarm UAV operations in peacetime should take populace and key installations into account. Kinetic means would hence not be ideal due to the possible collateral damage. A suggestion would be for Singapore to adapt Israel's 'detect and disrupt' model, using 3D sensors and Electric Jamming equipment primarily to deal with swarm UAVs. While high-powered microwaves (HPM) are effective, their wide range could cause damage to essential industries, such as telecommunications. They should therefore only be used against autonomous swarm UAVs if jamming equipment fails against them.

As most of the counter swarm UAV technologies available are more suited for wartime purposes, the Singapore government could consider working with private companies to produce innovative solutions to the threat of swarm UAVs in peacetime.

Wartime The SAF would be the main co-ordinating agency in the event of war or organised swarm UAV attacks by terrorists and state actors. In order to do this, the SAF may have to revise and improve its internal concepts of dealing with UAVs. Having a multi-layered defence system, like the current Enhanced Island Air Defence, would enable the SAF to effectively deal with swarm UAVs. Due to their numbers, swarm UAVs require multiple rings of defences and both kinetic and non-kinetic means to combat them. A high-powered microwave (HPM) system and missiles could be forward-deployed as the first line of defence (outer ring) while state of the art jammers, drone catchers and guns could be placed behind to deal with any surviving UAVs (inner ring).[36] These devices would have to be supported by sensors and radars tuned to detect small UAVs, akin to the 'Repellent' system in Russia and 3D radar and EO Sensors in Israel. A similar concept proved effective in the January 2018 mass UAV attack on Russian bases when electronic means were able to defeat six of the drones, while the remaining seven which broke through the perimeter were shot down by Pantsir-S1 Short Range Gun/Missile air defence systems.[37]

Setting-Up of an entity

As swarm UAV technologies are evolving at a rapid rate, the SAF may have to modify its concept of operations to better deal with such a threat. While the SAF leadership has to study and research continuously on swarm UAV technologies before operationalising any platform or equipment to deal with swarm UAVs, a faster process could be implemented to deal with the rapidly evolving threat. Due to the array of complex operations autonomous swarm UAVs can undertake, the current method of simply arming existing units with new equipment may not be enough. Similar to how MINDEF set up a cyber-command to deal with upcoming cyber threats, a new entity could be set up to combat swarm UAVs and AI-related threats.[38] Instead of developing the associated counter swarm UAV Concept of Operations (CONOPS) and measures only after a thorough understanding of swarm UAV technologies, this entity could adopt an incremental model approach to tackle the threat progressively and continuously. Using this approach, this entity could swiftly determine and experiment with an initial CONOPS and continue to

evaluate, adapt or redevelop it as new threats appear. This entity could also be empowered with the latitude to experiment with technologies and force structure, thereby increasing the SAF's pace of innovation in counter swarm UAV technologies. Additionally, this entity could be empowered to bypass any bureaucratic red tape, allowing for a quicker response cycle and thereby enabling SAF to keep up with the rapidly evolving swarm UAV threat. A suggestion would be for this new entity to work with the Defence Science and Technology Agency (DSTA) and DSO National Laboratories to research and experiment on emerging technologies, such as the HPM utilised in the US.

Though restructuring communication processes and researching on counter swarm UAV technologies is a good start, these solutions just scratch the surface and more efforts may have to be dedicated in order to keep up with the rapidly evolving swarm UAV technologies.

CONCLUSION

The Japanese success at Pearl Harbour was contingent on catching the Americans totally off guard.[39] If Singapore wishes to prevent a similar situation from happening with regards to the potential threat from swarm UAVs, it may have to devote considerable resources to better warning systems, better fighting concepts, and producing both kinetic and non-kinetic means to deal with such threats. As there is no one size fit all solution to the threat of swarm UAVs, continuous efforts and resources may have to be committed in order to have a fighting chance against such a threat.

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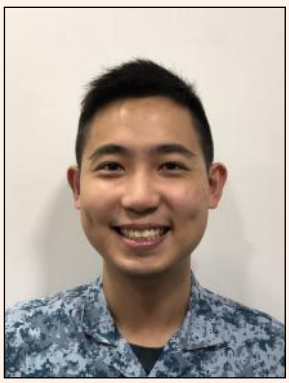

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