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Dragon Smoke
Wales Ex. Enduring Spirit

Man in the loop
Drones in CBRN

Balance of risk
Decon of at-risk population

Zak Kallenborn, independent national security researcher, and Associate Professor Philip Bleek of the Middlebury Institute of International Studies at Monterey on the drone swarm threat and opportunities for homeland defence and security

Fellowship of the Drone

What if drones could talk?

Drones would tell one another what they see and hear. They would work together to solve problems. The drones could search through verdant New Zealand forests for targets, chatter autonomously to avoid an upcoming mountain, or adopt unique roles, coordinating their actions. One drone may fire long range missiles, while others exploit the 'magic' of electronic and cyber warfare. Unthinking masses of drones could throw themselves against a defender's high walls until they crumbled and fell.

Fantasy and reality are merging. The Department of Defense's (DOD) strategic capabilities office (SCO) recently tested a swarm of 103 small, fixed-wing drones launched from three F/A-18 Super Hornets.[1] Other research has developed mixed swarms of ground and aerial drones, while a study in Nature demonstrated a swarm capable of separating and recombining.[2]

As the technology matures, it presents novel threats and opportunities for homeland defence and security, especially regarding chemical, biological, radiological, and nuclear weapons. For additional detail, see our recent article in the *Nonproliferation Review*: Swarming Destruction: Drone Swarms and Chemical, Biological, Radiological, and Nuclear (CBRN) Weapons.[3]

Threats

Adversary states and terrorist organisations can use drone swarms to improve CBRN delivery and pose novel threats to the homeland. Technologically sophisticated states will gain the most benefit. Russia, which is suspected of having chemical and biological weapons programmes, is already pursuing drone swarm technology.[4] North Korea and Syria would also likely benefit, though their ability to develop novel drone platforms is unclear. Acquiring CBRN weapons is already a major challenge for non-state actors, so for the foreseeable future they are unlikely to acquire both sophisticated CBRN agents and such a novel, sophisticated platform as a drone swarm.

The long run is less certain. Basic drone swarm technology need not be complicated. In fact, students at the Massachusetts Institute of Technology developed the Perdix drone that the SCO operationalised. As with non-swarming drones, hobbyist interest may encourage proliferation.

Improving CBRN delivery

"Wind is currently 10mph from the south-east. Temperature is 60oF (15.6oC)," relays a sensor drone to the waiting swarm. As the swarm descends on unaware soldiers, another message: "Wind is currently 14mph from the south-east. Possible defender coming from the north." The attack drones armed with VX payloads adjust their approach to account for the increased wind, while a handful of drones break away to respond to the incoming defenders.

The swarm opens with a VX attack. As the soldiers retreat and remerge in protective gear, other drones equipped with guns and bombs start to fire. The cumbersome protective gear limits the soldiers' ability to move and avoid the bullets, and accurately return fire. In a few minutes, the battle is done and the swarm reforms and moves on. The ability of drones to communicate is a crucial component of this hypothetical scenario.

Drones can collect and share information about environmental conditions that can inform the details of CBRN strikes. Live information offers improved accuracy and decreases the quantity of chemical or biological weapons payload needed. Moreover, the planning burden is likely to decrease because the swarm can respond to changing conditions.

Different types of attack drones can coordinate the timing and targeting of their assaults. Some drones may attack one target, while others attack another. This also allows some drones to focus on possible defenders, using electronic or possibly cyber warfare techniques to mitigate the threat.[5]

Moreover, simple drones without payloads can be used as decoys to draw adversary fire. This can help protect the more valuable drones or other valuable assets. Dummy drones can also just make the swarm look larger. The end result: more survivable, more accurate CBRN weapons capable of complex attacks.

Novel methods of attack

A high pitched buzz interrupts the quiet night as 100 makeshift drones descend on a chemical facility near New York City. Several guards respond to the noise and open fire, 10 drones fall, but the swarm moves past. The drones search the facility for storage tanks, find them and bomb them. Before long, a noxious cloud has risen above the facility, drifting towards the city.

In 1984, a gas leak occurred at Union Carbide India's pesticide plant in Bhopal, India.[6] The release of methyl isocyanate gas injured over 500,000 people and killed between 3,787 and 16,000 people (estimates vary). Drone swarms could enable terrorists to cause similar incidents. Although the US Department of Homeland Security(DHS) mandates that chemical facilities must defend against terrorist attack, defences against aerial threats are minimal.

Nuclear facilities are also potential targets. A release of radioactive material would have significant economic consequences, likely cause some injuries, and certainly cause considerable public fear. Greenpeace recently demonstrated the vulnerability, crashing a Superman-shaped drone into a French nuclear plant.[7] (This should not be interpreted as intending to cause harm. As environmentalists go, Greenpeace is relatively benign. Others, not so much.[8])

Moreover, drone swarms could allow terrorists to mount mass casualty attacks without CBRN weapons, potentially decreasing terrorist demand for them.

Swarms of drones could be flown into crowded areas, dropping bombs on the population below. Areas like stadiums and concert venues make rich targets and terrorists would benefit from having multiple, independently targetable drones.

A single drone can cause significant damage to an airplane wing; a swarm of drones could plausibly bring down a plane.[9] Drone based attacks on airplanes would also allow terrorists to avoid traditional checkpoint security, such as metal detectors, while the terrorists could strike from afar, gaining more time to escape law enforcement. ISIS frequently used non-swarming drones mounted with explosives in its attacks; swarming technology would increase the lethality. But human cognition is critical in limiting how many drones can be deployed. The operator must monitor for collisions, environmental hazards, potential defenders, all while coordinating the attack. Swarming technology - and increased autonomy generally - allows terrorists to employ even more drones.

Given these advantages, why take the risk of developing CBRN weapons? Few terrorist organisations elect to pursue CBRN weapons and even fewer are successful in doing so. Building CBRN weapons is challenging even for well-resourced organisations. Although Aum Shinrikyo allegedly possessed assets of somewhere between $100m and $1bn, and had members with significant relevant technical expertise, many of its CBRN and other weapons efforts ranged from inept to ludicrous. Its bioweapons programme failed to harm anyone, including the cult member who fell into a vat of *Clostridium botulinum*, and its nuclear weapons and earthquake-generating programmes were detached from reality.[10]

Opportunities

Thankfully, drone swarms also offer opportunities for security and law enforcement officials to combat the threat of CBRN weapons. Particularly, drone swarms offer the potential for improved counterproliferation, CBRN detection, and consequence management. Significant improvements in preventing and mitigating CBRN attacks may even decrease adversary interest. If an adversary believes an attack can be easily and quickly interrupted, they will be less inclined to attack in the first place. This is especially true for terrorist organisations where agent acquisition is already a major, uncertain undertaking. Instead of using CBRN agents, they may select other, less harmful attack methods.

Counterproliferation

The year is 2030. After a brutal war with North Korea, the US faces a major challenge: secure North Korea's CBN weapons stockpiles to ensure they do not fall into the wrong hands. Terrorists and other states may try to steal them and use them against the US homeland. For a terrorist, seizing a loose nuclear weapon represents the most reliable - and perhaps the only feasible - method of acquiring such a device. The US military deploys drone swarms to help.

Teams of drones rove across the North Korean countryside in search of unidentified facilities. If a facility is located, soldiers move in to inspect, take samples, and destroy any CBRN material discovered, and should the facility have been destroyed, drones can help too. Ground and aerial drones enter the ruins to collect samples, photographs, and other information.

The same drones could also help ensure security at the facility. Drones could help monitor perimeters for suspicious activity. This may be especially useful as a stopgap at facilities where security measures were weakened or destroyed in the fighting.

Weapons scientists could also supply expertise to help other states and terrorist organisations develop CBRN weapons. If the military suspects a known weapons scientist is an area, they could release a drone swarm to help search. Drones coordinate their searches relying on facial recognition to identify potential suspects. DOD's SCO has already developed a simple swarm to search a village for a known terrorist.[11] This policy challenge is not hypothetical. After the fall of the USSR, the US helped secure the Soviet Union's massive arsenal of weapons and material. The US faced similar challenges after the first Gulf war and the Libyan civil war, and during the Syrian civil war. There is little reason to believe the same challenge will not arise again. In fact, the new 2019 National Intelligence Strategy prioritises efforts to secure CBRN stockpiles.[12]

Drone swarms are likely to be well suited to these tasks. Communication and coordination enables wide-area searches. Drones can spread out broadly, searching for targets, with minimal manpower required. For example, the SCO's Perdix drones are designed primarily for intelligence collection. Drones swarms can also help prevent the smuggling of weapons and material.

They could extend the line of sight for surface vessels involved in interdiction, as swarms could rove out in search of suspicious vessels, returning information to a manned craft. Swarming would enable such drones to coordinate their searches, while underwater drone swarms could be especially valuable in searching for undersea smuggling vehicles. Of course, manned ships will still be needed. Although drones could aid in shipboard searches, humans are likely to still be necessary to open and search containers for example.

Drones can also help monitor land borders. As with interdiction at sea, they could coordinate searches over lengthy borders. They could also be equipped with simple nonlethal weapons to incapacitate would-be smugglers or disable vehicle tyres until personnel can arrive.

CBRN detection

Drones fly through the streets of New York City in search of suspicious gaseous plumes. If one is identified, the drones move in to collect samples. Perhaps the plume is just a cloud of steam, but if the drones identify a cloud of smoke or a hazardous chemical plume, more of them can be called in to collect additional samples. Where there is a major concern, an alert is sent to first responders to investigate and initiate a response.

When the weather turns bad or drones run low on power, they return to the closest maintenance area. Some drones rely on mobile, ground motherships that transport the swarm to new locations. Others return to fixed areas, such as inductive recharging stations on rooftops or designated maintenance facilities.

Early detection of CBRN usage helps to limit harm. The best case is when drones detect signatures of an impending attack. If responders mobilise quickly enough, they may be able to disrupt the attack and prevent harm. If not, early detection still matters. The quicker an attack can be detected, the faster response can begin, quarantines can be established, antidotes deployed. For all CBRN weapons, but especially for biological weapons, early response saves lives.

Of course, the size of drones will probably constrain the types of CBRN detection measures that can be used. Some detectors will still likely need humans to analyse samples, as in lab analysis for possible biological weapons agents. Still, emerging microfluidic - or chip-scale chemistry - is already helping miniaturise chemical and biological detectors, making them more viable for mounting on drones.[13]

Autonomy and communications also allow drones to adopt complex search patterns. Drones concentrate their searches on crowded areas when an attack would inflict the most harm. Drones could emphasise searches around major sport events, popular shopping areas, or highly congested roadways. Drones may also vary their routing to inhibit adversaries from anticipating and account for them.

CBRN detection swarms can also incorporate facial recognition, counterdrone, and other capabilities. Security swarms like this offer flexible, broad protection. Multiple studies have demonstrated simple drone swarms that can modulate their size. That ability would allow a security swarm to change, according to the threat environment, adding or removing capabilities.

Consequence management

An explosion interrupts a peaceful day on San Francisco's Fisherman's Wharf. A letter to the local paper claims the bomb contained radioactive material. First responders deploy a swarm of drones to aid in response. Drones survey the wharf to determine the extent of the damage and how the disaster is evolving. As the drones detect a wind shift, responders expand the quarantine area, and with the increased risk to human life, responders request additional potassium iodide pills and other radiation countermeasures.

The drones communicate to coordinate their searches. Two drones assess one area, while two more assess another. This allows greater efficiency and improves the overall quality of the assessment.

Drones could also help clean up after an attack. Some of the drones could coordinate the spraying or scrubbing of contaminated equipment or areas, while others monitor or even inhibit runoff. Fewer people with specialised CBRN training would be needed. Improved cleanup can help limit the damage and quickly return affected areas and equipment to normal use.

Drone-based response systems lower the risk of harm and offer greater accessibility. Drones can enter contaminated areas in lieu of humans so no one has to risk their life. This is especially significant in highly treacherous environments with a lot of debris or collapsed buildings.

Conclusion

Drone swarms are a rapidly emerging technology that poses novel threats and offers opportunities for homeland defence and security. Governments should consider:

Assessing the threat: Drone swarms present novel threats to homeland security, including by enabling CBRN delivery. Governments should consider the extent of the risk to their countries and the availability of countermeasures. They should also consider the broader impact on CBRN proliferation.

Developing drone swarm platforms: Drone swarms offer novel opportunities for homeland defence that merit exploration. Some of these hinge on more generic efforts to develop underlying technologies related to drone swarm coordination, specifically the ability to deploy heterogeneous drones that can separate and reform as a swarm.

Miniaturising detectors: Drones and drone swarms offer an excellent platform for searching and targeting in a variety of applications, but this requires developing detectors that can be mounted on drones with relatively small payload capacity.

Science fiction is increasingly becoming reality. Drone swarms and other emerging technologies have significant implications for CBRN warfare. Governments across the globe should take action to lower risks and leverage opportunities.

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