

Biological and Chemical Threats and UAV Delivery Systems A Lethal Combination

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The Chemical or Biological Weapons (CBW) of mass destruction and Unmanned Aerial Vehicle (UAV) technology both have dual-use potential, and can be manufactured cost-effectively, covertly utilising the same set of equipment, manufacturing unit and manpower, which makes it a deadly combination. The proliferation of CBW technology has always been a global threat. The threat of CBW-weaponised drones from non-state actors has been escalating with increasing covert support to terrorism by state actors. The UAV technology is a truly disruptive technology having facilitated covert and asymmetric warfare and blurring the conventional concepts of combats, conflicts and sovereignty. The entry of sophisticated UAV technology, weaponised with emerging highly potent synthetic biological agents or nerve agents have brought in tectonic shifts in biological and chemical warfare of the future. Throughout history, chemical and biological weapons have evoked fear. The marriage between modern CBW and UAV technologies is a lethal combination; an attractive proposition for state- or non-state-sponsored warfare or terrorism respectively, and another potent challenge for global security agencies.

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During an outdoor rally of German Chancellor Angela Merkel in 2013, a small quadcopter crash landed on the podium near Merkel and her

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colleagues. Another incident of a Caesium-laced radioactive drone that landed on the rooftop of Japanese Prime Minister's office 'carrying a camera and a bottle of unidentified liquid that bore a sticker with the universal symbol of radioactivity',¹ sent alarm bells ringing for all the global security agencies. Though it was a harmless prank to send a political message, the potential of Unmanned Aerial Vehicles (UAVs)/drones weaponised with CBRNE (Chemical, Biological, Radiological, Nuclear and high-yield Explosives) agents was pointed out by experts. It was no surprise for the US security agencies though as the Federal Bureau of Investigation (FBI) had successfully averted an attack on Pentagon and Capital Buildings using three remotely controlled aircraft containing C-4 explosives in 2011 and another attack in 2015 using remote-controlled aircraft fitted with improvised explosive devices (IEDs) to attack a school and a Federal building by Islamist terrorists.²

The potential threat of utilising cybernetics as a biochemical warfare amplifier is not science fiction. Albeit at a different scale, a 1944 German design³ of a UAV intended to disperse air-borne potent biological agents has been the inspiration for modern Bioactive-UAVs, truly a disruptive technology. The *computers-as-weapons paradigm* is bound to keep evolving as tele-guided miniature crawling/flying robots are being developed with capabilities to efficiently disperse modern genetically modified almost-invincible bioweapons.

UAVs/UAS more commonly described as drones, have proven to be a disruptive technology in aerial systems for military applications in recent years. One of the concerns is a potential utilisation of UAVs for carrying Chemical or Biological Weapons (CBW) load across the strategic Western, Northern and North-Eastern border locations in India. Amongst the NBC (Nuclear, Biological, Chemical) weapons, biological weapons are more likely to be delivered via UAS or UAVs.

Due to the geo-political challenges created by the Wuhan virus, followed by the Russia–Ukraine conflict, probability of UAV-weaponised with chemical, biological and nuclear escalation has raised many security related concerns globally and in India. From India's national security perspective, the close China–Pakistan defense collaboration has always been a concern. Reports regarding cooperation between Wuhan Institute of Virology and the Defense Science and Technology Association (DESTO) to develop biological weapons are not a secret. China has been expanding its UAV network and its increased utilisation in close proximity of the Line of Actual Control (LAC) is raising many eyebrows in India.⁴

The cooperation between China, Pakistan, Iran and North Korea for completing existing Weapons of Mass Destruction (WMD) arsenals, perfecting the range, deployability and effectiveness of their weapon systems and delivery mechanisms. An extremely ambitious leader of this quadruple arc and leading global drone producer, China has the most developed BW arsenals in the world.⁵ Field-tested for effectiveness on Ukrainian battlegrounds recently, and having effective CBW weaponisation capability, Turkish combat drones (Baykar Technologies) have gained popularity for autonomous performances and precision strike. By declining to supply combat drones to India over Pakistan, Turkey has highlighted its intentions. Prohibition of import of Chinese drones and drone components in India has addressed a major cybersecurity concern and data theft. These autonomous or miniaturised UAV-enabled CBW threats in the form of terrorism or warfare by state-sponsored terrorist networks or adversary states themselves has multiplied for India, thereby beckoning a robust policy framework.

The purpose of this article is to bring out the tectonic shifts in the CBW threat landscape due to emerging technologies and interdisciplinary convergence with other technologies such as Artificial Intelligence (AI) and cybernetics thereby reducing the barriers and increasing deployability of novel CBW agents. The purpose of this article is also to put forth the national security perspective for India for such threats with non-kinetic warfare potential, in reference to weak international regulatory frameworks and to suggest broad policy initiatives for the same.

HISTORICAL BACKGROUND

There is a long history of chemical and bio-weapon (CBW) programmes of many nations,⁶ CBW terrorism attacks and assassinations involving CBW-agents, frequent accidental leakages of bio-agents from research labs and a variety of biosecurity threats in different forms. The widespread and uninhibited deployment of chemical weapons during World War I, triggered the arms race to develop deadlier chemical weapons. The Germans were technologically far ahead in developing nerve agents but they were relatively years behind as far as biological weapons development was concerned.⁷ The mysterious decision of Hitler of not deploying the huge stockpiles of chemical nerve agents, is still an enigma to the analysts. World history would have taken a very different turn at Normandy had the Germans decided otherwise. During World War II, there were many such potential triggers like the chemical disaster involving 10,000-ton

mustard gas on USS John Harvey, which could have led to chemical Armageddon but was successfully hidden from the world.⁸

Modern bacteriology research, which identified either specific bacteria or virus as a causative agent of a particular infectious disease started 50 years before World War I. Earlier the use of biological weapons was limited to poisoning wells and catapulting diseased human and animal dead bodies into enemy camps. These new scientific tools of modern bacteriology gave military scientists an edge to develop biological weapons for inflicting mass casualties in enemy camps. Bacteriological agents and toxins were developed, tested and weaponised during World Wars I and II and the Cold War. Though the global nuclear arms race attracted most of the limelight due to the immediate and very visual impact, the global arms race for the other two categories of weapons of mass destruction (WMDs) namely, chemical and biological weapons was progressing just as robustly, but covertly. This unabated arms race is on, in spite of tremendous efforts to curb the proliferation and arms race of chemical and bio-weapons through various multilateral international treaties and agreements, such as Biological and (Toxin) Weapons Convention (BWC), Chemical Weapons Convention (CWC), UNSCR 1540, Missile Technology Control Regime (MTCR), Australia Group (AG) and Wassenaar Arrangement (WA).

Conventional weapons, along with chemical and nuclear weapons are relatively difficult to acquire, hide, and are expensive, whereas bio-weapons have relatively easy accessibility and delivery, are low-cost, predictable with short incubation period and non-detectable by traditional security screening methods. These distinct properties make bio-weapons an attractive proposition for covert, asymmetric and non-kinetic warfare. Similarly, the plausible deniability of biological threats is a unique feature, which has kept this threat relatively more discrete. The events like nerve agent assassination attempts,⁹ Syrian war, Covid-19 pandemic, and the controversies surrounding the Gain of Function Research however, have unceremoniously brought into the open the ugly underbelly of the global CBW arms race.¹⁰

BIOLOGICAL AGENTS AND DELIVERY MECHANISMS

Biological Weapons are usually composed of biological agents such as lethal or de-capacitating infectious pathogens (bacteria, viruses, fungi, prions, peptides, etc.), toxins or insect-vectors like mosquitoes, fleas, ticks infected with pathogens, along with delivery mechanisms like liquid/

powder sprays, bomblets to infect humans, crops, poultry, cattle directly or through air and water resources.

The biological agents are broadly divided into two groups: infectious agents and non-infectious agents. The infectious agents include bacteria, viruses, fungi and prions. These agents infect, multiply, cause diseases and get transmitted with their host community such as human, plant and animals. Sometimes, these infectious biological agents, especially the viruses and prions can cause disease across the species barrier, for example, Mad cow disease (Bovine Spongiform Encephalopathy), a neurodegenerative disease. However, as part of Gain of Function Research (GOFR) in a lab, zoonotic infectious agents are also 'humanised' by genetic modification. This GOFR is a hotly debated issue for its ethical basis and probable pandemic potential.

Non-infectious agents are typically toxins derived from biological sources such as plant, bacteria, fungi, etc. As the name suggests, these agents do not cause infectious disease but have localised toxic effects. So, their behaviour is more like toxic chemicals than the infectious agents, even though the manufacturing facility and process is similar to the biological agents. Hence, the toxins are mentioned under both the international conventions, BWC and CWC.

The same technological advancements meant to provide better healthcare to the mankind has been utilised covertly to sharpen the bio-weapons' edge. Re-emergence and enhancement of Pathogens with Pandemic Potential (PPPs),¹¹ manipulation using plasmids to develop antibiotic resistant strains of pathogens such as Anthrax, Plague and Tularemia, various genetically modified cloned bacterial and viral agents,¹² made-to-order designer pathogens as offspring of Synthetic Biology, genetically modified ticks, mosquitoes, fleas as crawling carriers of PPPs—the list of modern biological agents is endless.

HISTORICAL PERSPECTIVE OF AERIAL DELIVERY OF BIOLOGICAL WEAPONS

There are numerous examples of aerial dispersal of CBWs in actual warfare or for the experimentation purpose. Historically, biological weapons have been deployed in the form of gas or liquid composed of bacterial spores or growth medium for the biological agents to survive and multiply till they are aurally released in the form of bomblets or sprayers. Another six-legged crawling medium that has been widely utilised is arthropods carrying infectious diseases such as plague-infested fleas, malaria and

yellow-fever-carrier mosquitoes, haemorrhagic fever carrying ticks to target humans, potato beetles, honey bee pathogens, plant hoppers, grass hoppers and anti-crop agents to target agriculture.¹³

- The very first nations to utilise infectious biological agents and toxins for the modern biological warfare were the United Kingdom and Canada. They have experimented many biological agents across the world for the purpose of assessing feasibility and efficacy of the aerial delivery of BWs. One of the prominent examples is Gruinard Island in Scotland. In 1942, the aerial bombing of Gruinard Island conducted by bio-weaponeers of Porton Down with anthrax bombs, was so successful for the purpose of 'territory denial', that the island remained inhabitable till 1990. Operation Dark Harvest utilized 280 tonnes of formaldehyde to decontaminate the persistent anthrax from the island of 196 hectares.
- Another example of aerial delivery of BWs is from Unit 731 where the Japanese scientists experimented with aerial delivery of many BWs called 'defoliation bacilli bomb' filled with plague-infected fleas, anthrax, cholera, smallpox, botulism, utilising porcelain shells.¹⁴
- Soviet Union's bio-weapons programme called Biopreparat involved research, development and experimentation with a wide variety of aerial delivery mechanism from small planes to ICBMs filled with highly infectious and antibiotic-resistant strains of pathogens including anthrax, tularaemia, typhoid, botulism, various viruses such as Marburg virus, haemorrhagic viruses, anti-crop agents.¹⁵
- The expansive BW programme of the US also involved research, development, weaponisation and extensive aerial experimentation of BWs across the world and even their own populations. Alleged role of American germ warfare in China during Korean war involved aerial delivery of beetles laden with anthrax, canisters filled with insect vectors, small mammals infected with plague, cholera, encephalitis, etc.¹⁶

Another example as described in a 1996 document is of a hypothetical scenario regarding intricate strategic planning of an aerial attack of an invisible non-contagious incapacitating agent with predictable incubation period of three days in a specified enemy area; wherein own troops are

provided with protective gear, vaccines or medical counter measures move in the enemy territory on the fourth day without any difficulty or resistance as 90–100 per cent of those infected enemy troops would have died or too sick to fight. This almost 30-year old example elaborates how tactical use of bio-weapons coupled with conventional kinetic methods of warfare can win difficult territories.¹⁷ Such examples help the readers to appreciate the fact that the entry of sophisticated UAV technology weaponised with emerging highly potent synthetic biological agents have brought in tectonic shifts in biological warfare of the future. Tools utilised for ‘precision agriculture’ have dual-use potential for ‘precision CBW warfare’.

Throughout the history of biological warfare, the aerial delivery of BWs has been successfully experimented and utilised. In modern times, the scientific developments are happening at a break-neck speed involving modern designer virus BWs created utilising CRISPR, ‘Gain of Function’ research, race-targeted BWs, genetically modified insect vectors. The modern bio-weaponeers are far more creative in designing ultra-modern BWs designed with fusion of interdisciplinary technologies such as AI, cyber and UAVs to have an edge over the others.

UAVs were originally developed for military applications considered too risky for the pilots. With improvements in control technologies, the UAVs have become essential assets for most militaries across the world as well as for many civilian applications too. The most prominent innovation in drone technology is neither the large-scale systems nor military technology. This technology has truly disrupted the way in which aerial environment operates in 21st century. This technology has overcome the earlier size and cost constraints of aerial environment. This easily available, accessible and cost-effective technology is routinely deployed for domestic purposes like ‘precision agriculture’ and medicines delivery.

The UAVs/drones are usually classified based on the size/weight, degree of autonomy, altitude, payloads or communication types (drone-to-drone, drone-to-ground station, drone-to-network or drone-to-satellite). Though the UAVs have offered distinct advantages on so many levels, they suffer from various security, safety and privacy issues.¹⁸

UAVS AS DELIVERY SYSTEMS FOR BIOLOGICAL WEAPONS

Dispersal of biological agents is ideally suited for a UAV-based delivery vehicle, as its flight stability fulfils the need of spreading the biological

agent evenly along the intended line of contamination. Since 1944, UAVs have been explored, designed, experimented and utilised for covert and not-so-covert biological warfare. One such example is of the Iraqi conversion of L-29 trainer aircraft into a UAV as a CBW platform for delivering weapons in early 1990s. Another smaller Iraqi UAV called Al Musayara-20; capable of but not yet equipped with biological agents, had the range (> 500 km), payload (20 kg), guidance (GPS-enabled) autonomy required to an effective BWs delivery system.

A 2015 US Patent (8,967,029 B1) gives an insight into developments happening in this domain of utilising UAVs for biological warfare. This patent illustrates how toxic mosquitoes producing toxins can be effectively dispersed utilising suitable UAV for offensive military purposes (Figure 1). The term ‘toxin’ is used here to mean ‘any chemical, biological component, bacterium, virus, immunological agent’, or other material having an influence on humans and being capable of delivery and transmission to humans via mosquito bite. The toxin is expected to be suitable to be transmitted by mosquito bite after the mosquito consumes the mosquito food containing a toxin. An example is ‘genetically modified

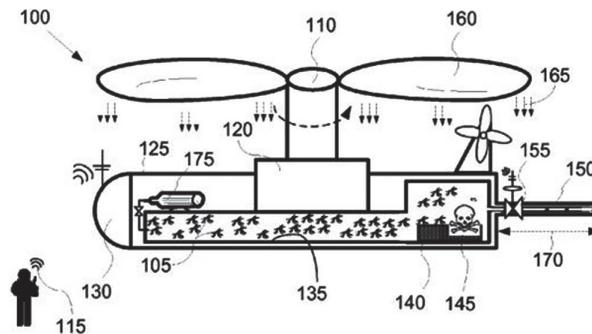


Figure 1 Toxic Mosquito Aerial Release System – Patent US-8967029-B1

Note: A preferred embodiment of a UAV device (100) for the aerial release of mosquitoes (105). It includes: an UAV; a container (125); a central processing unit (130); a mosquito breeding bin (135); a mosquito food (140); a valve (155); and optionally a compressed gas source (175). The UAV includes a motor (120) that, for example, powers a lifting blade (160), that is, it powers one or more lift rotors, operable by remote control (115), by a pilot on the ground or in another vehicle. The UAV may also be autonomously controlled by the central processing unit (130). The container (125) is the housing that serves as a means for attaching to it or to contain or within it, the central processing unit (130), the mosquito breeding bin (135), the mosquito food (140), any compressed gas source (175), the toxin (145), the release tube (150) and the valve (155).

or weakened malaria parasite altered or combined with hepatitis B virus' to trigger an immune response in a human population to protect that population from contracting malaria. Another example is the 'malaria parasite itself to cause malaria'.¹⁹

This patent also gives an insight into the way international non-proliferation treaties are interpreted conveniently by some inventors.

The Chemical Weapons Convention treaty has been interpreted to allow the development of non-lethal chemicals, such as calmiative and gastrointestinal convulsives, when classified as riot control agents. Additionally, non-lethal weapons involving calmiative agents have been studied for use by the U.S. armed forces.

This treaty (Biological Weapons Convention) has been interpreted not to apply to the biological agents or toxins themselves, but rather certain purposes for which they may be employed which are prohibited. Thus, there are permitted purposes defined to include prophylactic, protective and other peaceful purposes. The biological agents or toxins may not be retained in quantities that have no justification or which are inconsistent with the permitted purposes.'

Some inventors find ways through the cracks in the BWC and it further fuels the biological arms race.

Literature search of global patent databases throws up many such overt or dual-use covert patents related to innovations utilising drone technology for releasing vectors for biological warfare purpose.²⁰

CHEMICAL AGENTS AND DELIVERY MECHANISMS

Modern chemical warfare began during World War I in 1915 between German and French troops ending with 1,00,000 casualties and one million injured. Though chemical weapons were not used during World War II, only because of fear of chemical retaliation, the arms race to develop deadlier chemicals continued during and after the World War II.

Chemical agents are broadly classified into two groups: lethal and non-lethal agents. Lethal agents are further classified according to their effect on the human body as choking agents, blood agents, blister agents, and nerve agents. Non-lethal agents include incapacitating agents (riot control agents) and psychochemicals.²¹ Beyond the traditional chemical agents and nerve agents, the emerging technology of AI-powered drug discovery divulged its darker side recently. This drug discovery model generated 40,000 molecules in less than six hours, which included some

known nerve agents like VX and many novel and much more toxic chemical weapon agents.²²

One significant historical incident involving aerial dispersal of a nerve agent, suspected to be VX in Dugway Proving Ground in Utah, US, had tremendous impact on the CBW disarmament and non-proliferation history. This experimental testing gone awry, resulted in the death of more than 6,000 sheep. With no conclusive evidence of VX poisoning; treatment against VX proving ineffective; sheep in neighbouring areas, the shepherders and veterinarians showing similar symptoms as the sheep roused the suspicions of other biological and/or chemical agents being experimented with. Had the released cloud of the agents travelled in a slightly different direction, instead of sheep, the victims would have been a large number of residents of the Salt Lake City. The reputational damage and its domino effect led to a series of events and increasing tremendous domestic pressure on the US government. As a result, the Nixon government was forced to end the US offensive biological programme.

Chemical munitions are composed of bursting elements surrounded by chemical agents. Bursting elements rupturing the munitions result in dissemination of chemical agents in the form of a cloud of small droplets, aerosol generators or crop dusters to spread chemical agent aerosol over a large area in a controlled manner. UAVs with chemical agent dispersal mechanism profess precision delivery due to their capability to hover and accurately place the agent in the target zone.²³

SURVEILLANCE AND DETECTION

Since a few decades, UAVs technology has been increasingly developed with the integration of various detectors, sensors and sampling systems for both civil and military application requirements to facilitate early detection of CBW threats without putting a first responder's life in danger.²⁴

The UAVs equipped with inexpensive detectors with low complexity sensors and ability to detect wide variety of substances have the potential to be utilised for early detection of CBRN threats²⁵ Similarly, armed UAV/ drone swarms—multiple UAVs capable of coordinating their actions to achieve shared targets—have the potential to achieve more effective CBRN attacks, surveillance or early detection.

Drones fitted with chemical or biological sensors, detection pod, a gyroscope, a wireless data transmitter have been designed, patented and

deployed for the investigation, monitoring, detecting, recording, analysis of diffusion or leakage of dangerous chemical gases²⁶ or CBW attack.²⁷ Another creative innovation describes an aerodynamic automated biological assay device (AABAD) microfluidic cassettes to analyse and transmit the air sampling data for biological threats and designed to auto-rotate via centrifugal force, once deployed in large numbers by a UAV.²⁸ While biological samples in a threat environment are to be analysed, it is hazardous to carry the sample to the base for analysis. The surface of the drone too carries the hazard with it. Instead, such automated samplers transmitting the data would have a distinct advantage for biological threat detection. Effective simulation of UAV swarm algorithms for multi-agent detection have been utilised for patrolling.²⁹

For domestic surveillance and monitoring of industrial zones of hazardous chemicals, in situ methods of detection with drones fitted with a variety of detectors remotely detecting, analysing and transmitting the data may be used. Depending on the type of chemical analyser, capillary tube detector, multi-sensor portable gas detector, IR absorption analyser or optical devices Light Detection and Ranging (LIDAR) and Sound Detection and Ranging (SODAR) may be used. Many parameters such as monitoring need, limitations of the UAV and the sensor, weather conditions, presence of temporary and permanent chemical substances in the zone, etc., need to be considered before pairing the UAV and specific chemical sensor.³⁰

Whole-cell bio-sensor has been designed to respond to various environmental pollutants like chemicals, bio-chemical toxins, water pollutants and radiation leakages. A UAV/quadcopter-mounted bio-sensor system has been developed for domestic application of environmental pollutants, chemicals and radiation in remote location. The system is designed to include a Polydimethylsiloxane (PDMS) microfluidic channel for bacterial inoculation and to facilitate bacterial growth.³¹

Instead of detection instruments, a six-legged biological detective can be utilised for the detection of explosives, mines or chemicals.³² Trained and marked honeybees with their excellent sense of smell congregate on the mine locations and are monitored by UAV mounted cameras and video analysis using computer vision techniques. Another such project, Hybrid Insect Micro-Electro-Mechanical System (HI-MEMS) was an attempt to develop cybernetic organisms and cyborgs from honeybees and other insects with remotely controlled flight and motion controls. These cyborg swarms could be potentially utilised to conduct reconnaissance

missions such as collecting intelligence, delivering toxins or retrieving samples, etc. Multiple cyborg swarms could be deployed with specific targets to simultaneously spread infectious diseases to human beings, plant or animals, attack crops, infect food supplies.³³

CBW DECONTAMINATION DRONES

In case of a terrorist attack or an accidental diffusion of chemical and/or biological agents, the affected area needs to be cordoned off and decontaminated with neutralising agents such as oxidizers, silica gelling agents, bleach activator compounds. However, to avoid the hazards to the first responders, robotic drones have been developed for decontaminating large areas. If left without decontamination, these chemical agents or toxins may cause casualties, incapacitation or permanent disabilities in human beings or animals.³⁴

The probability of a terrorist attack by CB-weaponised drones is usually undermined citing access to CBW agents and related technology, challenges in weaponisation and handling. The 9/11 attack too would have been described as 'science fiction' till it actually happened. However, plausible deniability and covert support from states, makes CBW-UAV a medium- to high-level threat, not just from non-state actors but also from adversary nations.

AUTONOMOUS DRONES

Drone Swarm technology has the ability of drones to autonomously take decisions based on shared knowledge.³⁵ DARPA's 2016 project called OFFSET-programme (Offensive Swarm-Enabled Tactics) envisions future small-unit infantry forces drone swarms comprising of >250 small UAVs and small unmanned group systems (UGSs) along with autonomous swarms or human-swarm teams.³⁶ Such emerging technologies armed with cutting-edge modern BWs present the face of new-age warfare.

A report³⁷ highlights the escalating asymmetric warfare potential of CB-weaponised UAVs/UAS with both the technologies modernising, and dropping costs of technology acquisition every day. The report cites an example of agricultural drone Agras MG-1S agriculture UAS model from Dà-Jiáng Innovations (DJI), China, a leader in commercial agricultural drones for efficiently spraying chemicals, liquid pesticides and insecticides. The dual-use potential of such UAS is evident from the design, wherein the UAS carries a 10 kg fluid container and has

a capacity of covering 10 acres of land in a single flight. This report discusses various recommendations to counter CBW-UAV threats.

- Develop a National Counter UAS Strategy
- Explore Layered Defence Technological Solutions
- Update CWMD Exercise and Training Concepts to Incorporate UAS CBW Delivery ('Commanders need to ensure that their formations understand how UAS-delivered CBW effects can affect personnel, equipment and the dynamics of combat power; they should train for and implement CBW survivability measures and techniques.')
- Ensure a Sufficient Stockpile of Necessary CBRN Protective Equipment
- Account for CBW-Capable UAS and Swarming Technology in the Missile Technology Control Regime (MTCR)
- Fully Leverage World Customs Organization (WCO) Operations, Actions and Activities.

CBW EXPORT CONTROL MEASURES

Five major international accords Australia Group, CWC, BWC, Wassenaar Arrangement and UNSCR 1540 govern the international export controls for CBW threats.

Australia Group was constituted as a consequence of Chemical weapons deployment during Iran–Iraq war (1980–1988), with an objective of standardisation of export control legislations and regulations for CBW agents, equipment, related know-how, technology and software. Five Common Control Lists agreed upon by AG members are as follows³⁸:

- Precursor chemicals to chemical warfare agents;
- Dual-use chemical manufacturing facilities and equipment, and related technology and software;
- Dual-use biological equipment and related technology and software;
- Human and animal pathogens and toxins;
- Plant pathogens.

Chemical Weapons Convention has three schedules of chemicals as control measures. Schedule 1 chemicals are the ones with high potential for use as CW agents and have little or no use for purposes not prohibited by the CWC. Schedule 2 chemicals pose dual-use potential with

significant risk of misuse, and known to have some civilian use as well. Schedule 3 chemicals are those that pose a risk of misuse, but are used in large quantities in civilian activities too. The Organization of Prohibition of Chemical Weapons (OPCW) implements the CWC's compliance and verification protocol including declarations by state parties regarding export and import of chemicals in the Schedules.³⁹

The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies governs the export controls on a wide range of military and dual-use equipment. The two control lists of restricted technologies under WA are the Munitions List and List of Dual-Use Goods and Technologies. Among many other categories of items UAVs too are listed along with certain military vehicles, smoke canisters, etc. Items listed in the Munitions List relevant for CBW are:⁴⁰

- CW chemicals and key precursors, as well as certain chemical defoliants;
- Equipment specially designed or modified for military use to disseminate CW agents;
- Protective, detection, and decontamination equipment and related supplies (such as biopolymers for detection purposes and biocatalysts for decontamination purposes);
- Software designed to operate or maintain equipment controlled under the Munitions List; and
- Software for determining the effects of conventional, nuclear, chemical or biological weapons.

The list of Dual-Use Technologies also lists dual-use protective and detection equipment and components with potential for CW misuse.

Missile Technology Control Regime (MTCR) is not a legally binding treaty but an informal political understanding among 35 countries and seeks to limit proliferation of missiles and missile technologies including UAVs capable of delivering CBRN payloads, related technologies, equipment and parts needed for manufacturing the same.⁴¹

Biological Weapons Convention is an international disarmament treaty, which bans BWs by prohibiting their development, production, acquisition, transfer stockpiling and use of biological and toxin weapons. BWC has its own sets of limitations in absence of scientific institutional back-up and an executing authority like OPCW and effective verification regime.⁴²

The United Nations Security Council Resolution 1540 was adopted unanimously as a response to the 9/11 terrorist attacks and anthrax letter attack in the US with an objective to rein the proliferation of WMDs among non-state actors. The Resolution requires all the UN state parties to criminalise activities by non-state actors related to WMD and related activities through national legislations and effective enforcement. The Article 8(a) of the Resolution⁴³ requires the state parties 'to promote the universal adoption and full implementation and where necessary, strengthening of multilateral treaties to which they are parties, whose aim is to prevent the proliferation of nuclear, biological and chemical weapons'.

DISCUSSION

In modern times, scientific developments are happening at a break-neck speed involving modern designer CBWs created utilising Synthetic Biology, Gene Drive technologies Computer-Aided Drug Design technology. Modern CBW-weaponeers are far more creative in designing ultra-modern CBWs designed with fusion of interdisciplinary technologies such as AI, cyber and UAVs to acquire the cutting-edge. It is the failure of modern society to call out the Elephant-in-The-Room, by denying the probability of misuse of modern biotechnological methods and convergence of other streams such as cybernetics and AI, which has allowed the explosive proliferation of modern CBW weapons.

The barriers and weaponisation challenges of the BWs of the yore have been answered by the modern technology and made them more potent and deployable. Analysts advocating non-proliferation and disarmament of bio-weapons believe that the GOFR has fuelled the bio-weapons arms race dangerously and under the garb of authentic research, more potent infectious biological agents are being developed.

All state parties to current non-proliferation regimes and treaties need to form an effective integrated WMD non-proliferation mechanism to create a web of prevention and non-proliferation. This web of prevention needs to be woven in such a way that these international treaties act in a synergistic manner to increase their effectiveness. Increased global capability and cooperation in gathering and sharing intelligence will be effective in identifying misuse of UAVs and WMDs by non-state actors. Collective efforts need to be taken to energise and strengthen multilateral non-proliferation organisations and regulations like the Wassenaar

Arrangement (WA), MTCR and Australia Group (AG), and effective National Implementation of UNSCR 1540, CWC and BWC.

Despite all the international efforts, the future of international regulation of Drone/UAV and Artificial Intelligence-enabled autonomous UAS appears bleak. Since 2017, the United Nations has been negotiating a ban on these autonomous weapons systems with little success. Technologically advanced nations in robotic and artificial intelligence, with their commercial interests in mind, object to any such bans citing the restrictions on further research. Another contentious issue is the veracity of the purpose, civilian or military.

Considering the tectonic shifts happening in the CBW threat landscape, weak international regulatory frameworks fraught with global polarisation and increasingly aggressive neighbours acquiring and coalescing emerging weapon technologies, Indian security authorities need to formulate some concrete measures such as constitution of an interdisciplinary Task Force for drafting a National CBW Defense Policy, international collaborations for CBW surveillance network, threat awareness and training for stakeholders. Similarly, as evidenced during the Covid-19 pandemic, cooperative knowledge-sharing and problem-solving for the sake of national security needs a permanent, credible and formal platform for the stakeholders to effectively counter the security challenges of the tech-savvy new world.

The same emerging technologies, which are responsible for the disruptions in the CBW threat landscape need to be utilised for creating credible defense infrastructure. India being a technology hub for chemical, pharmaceutical, biotechnological and UAV domains has tremendous potential to build value and become 'Aatmanirbhar Bharat'. Thrust on industrial innovations in this emerging market has tremendous potential for building India's defense exports further.

WHAT THE FUTURE HOLDS

The proliferation of CBW technology has always been a global threat. The threat of CBW-weaponised drones from non-state actors has been escalating with increasing covert support to terrorism by state actors. UAV technology is truly disruptive technology as it has facilitated covert and asymmetric warfare, blurring the conventional concepts of combats, conflicts and sovereignty. Cyber-hacking civilian or military drones and utilising for CBW attacks is not impossible feat for the terrorist organisations.

The growing threat of misuse of drones can be effectively countered with various strategies of defence against drone attacks, such as electronic jamming, deeper perimeter defence of airports, fibre optic laser guns, etc.

The web of prevention created by current non-proliferation regimes and treaties needs to be woven into integrated international treaties that act in a synergistic manner to increase their effectiveness. Collective efforts need to be taken to energise and strengthen multilateral non-proliferation organisations and regulations like the Wassenaar Arrangement (WA), MTCR and Australia Group (AG), and effective National Implementation of UNSCR 1540, CWC and BWC.

For concrete and effective non-proliferation of the WMDs, delivery mechanisms and related technologies, the developed nations need to be more proactive in handholding the developing world for technology sharing and national implementation measures instead of arm-twisting methods of non-proliferation. Such overall positive synergistic approach in future will be more effective in addressing and containing emerging threats.

To counter these emerging CBW threats, India needs to take concrete steps for National CBW Defense Policy formulation, preparedness and response mechanisms. India being a technology hub for chemical, bio-pharmaceutical and drone technologies can capitalise on these assets by building a robust chemical and bio-defence industry. These challenges arising out of technological advancements may be turned into a blessing in disguise to mobilise effective measures for strengthening integrated national legislative, enforcement, surveillance, regulatory and security frameworks to counter any future challenges to the national security by utilising the same technology.

NOTES

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