Nuclear Mission of Drones

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Drones are increasingly proving their relevance in a number of areas, including military. These unmanned systems could also have utility for different missions relating to nuclear science and technology. Although drones have demonstrated their usefulness in radiation monitoring in 1940s, yet their role as delivery vehicles is being debated. The weight, range, speed and endurance factors make a nuclear weapon country to prefer missiles and bombers. Technology is progressing very fast, and drones are taking advantage of the rapid developments in new technologies. Tomorrow, drones may be considered relevant for delivering at least some categories of nuclear weapons if these technological advancements result in enhancing the required capabilities of drones. However, even with the existing technological level, these unmanned systems are useful not merely for surveillance of adversary's nuclear facilities and assets but also for nuclear safety and security.

Keywords: *Drones, Nuclear Safety, Nuclear Security, WMD, Nuclear Weapons*

Introduction

Can a drone drop nuclear weapons and can it be useful for a country's overall nuclear strategy? Till a couple of decades back, these questions were by and large unheard or at best possibly being figured out in closed decision-making circles. However, technological advancements have led to a meaningful debate on drones, particularly regarding their military and commercial usage. With a new set of actors exploiting the latest

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technologies, usefulness of drones is being reported on a daily basis in different fields, ranging from agriculture to health care and environment.

Currently, security missions are increasingly being accomplished by drones. The military drones can be classified according to their performance, such as target drones, reconnaissance drones, surveillance drones, cargo drones, bombers, offensive drones, transport drones, multi-role drones and so on.[1] Indeed, drones have been used for engaging disposable targets since the 1960s. Though old drones have not completely disappeared, new drones are fast joining the fleet of nations. Kamikaze or suicide drones are still in operation, and so are the drones performing intelligence, surveillance and reconnaissance roles.

Interestingly, a number of writings compare drones with nuclear weapons or other weapons of mass destruction (WMDs), basically to underline their capabilities for devastation or causing damage to an adversary.[2] At the same time, other writings differentiate drones from WMDs on the basis of precision technology which helps drones to discriminate their targets. Drones, according to this school, can or should differentiate between a combatant and a non-combatant target. This school of thought also lays emphasis on several conditions for the success of the operation. However, the success of this model needs professional management of the institution that operates drones. Quite evidently, in the absence of focused intelligence and a good sensor system, drones cannot be a weapon of discrimination or useful for targeted killings.

While some scholars believe that it is possible for the armed forces, which have the resources and technology, to use swarm drones to match the destruction of small nuclear weapons and other WMDs,[3] others dispute it. As a weapon in itself, a drone may act like a conventional weapon, but as a carrier of WMD, it immediately falls into the category of WMD system. Notwithstanding the divergence and convergence between WMD and drone as an independent weapon, it is pertinent to probe the nuclear tasks of drones, such as what kind of a nuclear role have drones been performing and may perform in the future? The article discovers that drones have been accomplishing different nuclear missions ever since the advent of nuclear weapons age. With further evolution of technology, drones may acquire some unthinkable roles.

Drones as Delivery Vehicles

Soon after the emergence of nuclear weapons, the United States (US) started exploring the possibility of using drones for delivering it. The idea

gathered momentum when the country was in the process of acquiring a more powerful thermonuclear device, namely, hydrogen bomb. Apparently, the US Air Force felt that it would not be able to develop a missile to drop the hydrogen bomb before the deadline. Also, the security community was apprehensive about the use of manned aircrafts for dropping a 10,000 pound hydrogen bomb 4,000 nautical miles away. Thus, the relatively 'low cost, durability and availability'[4] of a drone made it the new weapon of choice. In addition, it was assumed that the expanse of blast and heat generated by a hydrogen bomb would be better carried out by an unmanned system, though this too had its share of challenges.

In the early 1950s, under Project Brass Ring, the US Air Force modified B-47 Stratojet manned aircraft to make it a remotely piloted vehicle to drop a hydrogen bomb.[5] The plan was for the nuclear-capable drone to fly as a manned aircraft first, with the crew setting the course and then bailing out after a distance. Another plan was to keep it completely automated. However, several factors forced the authorities to abandon the project in March 1953. It could not generate the kind of support it needed inside the American security establishment. It also confronted navigational challenges because of the holding of information by companies involved in the navigation project. Jamming of the drone was another issue. Finally, scientists convinced the government that dropping a hydrogen bomb with changed size could be accomplished by a manned aircraft. They also discounted the risk quotient of carrying a hydrogen bomb in a manned aircraft.[6]

With technological progress, a thinking emerged: '…that the Predator would be able to slam into targets at ranges of three hundred miles while carrying three hundred pounds of explosives or a small nuclear warhead, yet each plane would cost just thirty thousand dollars.'[7] Another study found: 'Autonomous unmanned systems such as aerial drones or unmanned underwater vehicles could also be seen by nuclear weapon states as an alternative to Inter-Continental Ballistic Missiles (ICBMs) as well as manned bomber and submarines for nuclear weapon delivery.'[8] One of the earlier reports of the US Air Force saw the potential of drone for nuclear strike.[9] It stated that ethical and political/policy issues need to be resolved so that 'lethal combat decisions' involving machine may be taken. The report questioned factors, such as: 'the appropriateness of machines having this ability, under what circumstances it should be employed, where responsibility for mistakes lies and what limitations should be placed upon the autonomy of such systems.'[10]

Presently, some scholars view that swarm drones[11] can be highly useful for nuclear mission and deterrence[12] in multiple ways. First, drone swarming may do the job of ballistic missile defence and provide a shield against incoming missiles carrying nuclear weapons. Second, by gathering information of the adversary, swarm drones can point out vulnerability of the adversary and makes any nuclear targeting quite effective. Third, as demonstrated by Israel, these drones can be used as decoys to shield aircraft from missiles. Besides, in combination with cruise missiles, they can make the nuclear structure quite diverse and formidable.[13] Drone swarming, even without carrying nuclear weapons, may provide great supporting role to the nuclear force structure.

David Hambling paints a very interesting scenario, although the strategic community, predominantly, is sceptical of it. He visualises:

> … the nuclear balance is maintained because neither side can disable the other's strategic weapons with a first strike. Swarms might change this balance and make first strikes possible—or strikes by non-nuclear powers seeking to disarm nuclear ones. The swarm club is far easier to join than the nuclear club or the ballistic missile club. A swarm might be deliberately engineered as a weapon of mass destruction, with no mechanism to recall or halt it. While few dictators are able to get their hands on atomic warheads and ballistic missiles, swarms are more easily accessible, and the threat of a 'doomsday swarm' designed to kill as many people as possible might be a counter to nuclear-armed opponents. Such possibilities indicate that swarms could be highly destabilizing. That might encourage the international community to start discussions on arms control and whether swarms should be classed as weapons of mass destruction.[14]

However, considering the present technological status of swarm drones, it appears difficult for them to strategically match nuclear weapons. Tomorrow, the changed technological level of swarm drones may add strategic complexity and uncertainty.

Another article has argued that a nuclear-dedicated unmanned combat aerial vehicle (ND-UCAV) could be a very good replacement for nuclear-capable bombers.[15] It has listed several advantages of ND-UCAV, such as cost effectiveness, functioning like a stealth aircraft, a much shorter runway for takeoff and landing, allowing for greater dispersal and force realignment, recallable even before the release of the nuclear weapons and so on. However, the same report has also listed

some problems, like designing new warheads which could be adapted to the drone.

On 1 March 2018, the Russian government announced in the Federal Assembly that of the many advanced technology weapons, it is developing a nuclear-armed underwater drone. This news was confirmed by the Russian authorities.[16] Apparently, it got leaked. The American media reported that Russia had built a nuclear submarine drone capable of delivering nuclear weapons.[17] The US military establishment calls the drone submarine 'Kanyon';[18] and the Russian media calls it 'Ocean Multipurpose System "Status-6"'.[19] Based on leaked news in the Russian media, a description of the drone has been prepared:[20]

1. A self-propelled underwater craft.
2. Movement at a depth of 3,280 feet.
3. Speed of more than 56 knots.
4. Range: 6,200 miles.
5. Accompanied with command and control ship.
6. Support ships, a non-nuclear submarine, *Sarov*, and a surface ship to salvage.
7. Delivery by two classes of submarines: Project 09852 (a nuclear-propelled submarine or the Oscar II-class submarine) or Project 09851.

Seemingly, the Russian 'Ocean Multipurpose System' will consist of four submarines, one of which will be the special-purpose nuclear-powered submarine, *Khabarovsk*, and 32 Poseidon underwater drones.[21] The drones will be launched from the submarines, with each submarine carrying a maximum of eight drones. These drones will be capable of carrying both conventional and nuclear warheads. An American report of 2019 states that each of the drones is capable of carrying a nuclear warhead of 2 megaton.[22] The nuclear activity may generate radioactive tsunami[23] because of the drone's capability to detonate very deep under the surface. The drone's speed of 200 kilometre per hour is also considered a great military advantage. It is further argued that this does not give any strategic advantage to Russia, which already has ICBMs and hypersonic weapons.[24] Yet, it may make Russia's first strike quite flexible. The country can inflict massive damage to its adversaries' ports and other naval infrastructure.

The American establishment earlier projected this underwater vehicle as 'an autonomous submarine strike vehicle armed with a nuclear

warhead ranging in size to "tens" of megatons in yield.'[25] The drone submarine's megaton-class warheads may destroy the ports used for submarines. Apparently, the US does not have a nuclear drone like this. More so, the US does not even have a system to intercept this drone inside the water. Although the US government has officially stated that it is exercising restraint regarding developing a matching weapon system, yet it may be exploring the costs and benefits of matching the Russian system. The Americans also fear that the development of such a weapon will lead to Russian doctrinal changes; according to a section of the American security community, Russia may lower the threshold of using the weapon as it is facing the problem of aging conventional weapons. The US government in the United Nations (UN) has maintained that these Russian drones are 'designed to destroy adversary coastal cities and ports in a radioactive tidal wave'.[26]

China is also into the nuclear drone business. The US has been officially alerting the world about Chinese aerial and underwater drone capabilities, and surmising disruption of the global strategic stability.[27] China is developing nuclear-powered underwater drones, perhaps as force multipliers to its nuclear firepower, for targeting variegated installations or places. The global strategic community maintains that it may disturb 'the offense–defense balance in underwater warfare'. The statement of a US official in 2021, though not confirming that China had already developed drones in the autonomous mode, asserts that China has done adequate preparations towards it.[28] China is expected to accomplish its multidimensional nuclear mission in the future. This may increase nuclear competition between the US and China in particular, and China and its rivals in general. The strategic community has already started discussing this situation.[29]

A stealth aircraft may escape the radar of a country but a fighter aircraft, in general, leaves signature, and therefore the chances of its interception are quite high. Can drones armed with conventional explosives be used for counter-proliferation? Many view its role positively for a pre-emptive strike. Indeed, a Kamikazi drone could be useful for such stealth military operations. One of the purposes could be targeting such a facility. In 1981, Israel had attacked Iraqi Osirak nuclear facility with aircraft. Although Israel endorsed the attack in the name of self-defence. Quite significantly, the Israeli nuclear facility at Dimona had also faced the problem from drone in 2013 quite frequently.

Radiation Monitoring After Nuclear Weapons Tests

As discussed earlier, the nuclear role of drones was visualised with the advent of nuclear age. In the beginning, its role was mainly for measurement of radiation level in the environment after nuclear weapons tests.[30] After using the nuclear bombs on Hiroshima and Nagasaki in 1945, the US conducted a number of nuclear weapons tests at Bikini Atoll, in the Pacific Ocean, in July 1946, known as Operation Crossroads.[31] The US deployed the B-17s, also called babes, to measure the radiation level[32] of the hovering cloud after conducting nuclear weapons tests. The aim was to investigate the effect of nuclear weapons on warships.

The B-17 was modified to perform the role of a drone or an unmanned aerial vehicle (UAV). Ironically, the B-17 was a fighter aircraft which was used in battles till World War II. Developed as Model 299 by Boeing, named as Flying Fortress by Richard Smith (a *Seattle Times* journalist) and later even by Boeing, but officially labelled as B-17 by the US Army Air Corps,[33] the aircraft was considered most trustworthy in the battle against Germany during World War II. It apparently dropped more bombs that any other US aircraft in the war.[34] The discarded plane was used for radiation monitoring purpose by remotely piloting it.[35] Described as 'a four-engine plane…a low-wing monoplane that combined aerodynamic features',[36] the 1948 US nuclear weapons tests (Operation Sandstone) also used the drone version of B-17 to collect radioactive data from the cloud.[37]

There was yet another fighter aircraft which, after suitable modifications, was reportedly used as a drone for measuring the radiation level in 1946 nuclear weapons tests. This aircraft was F6F Hellcat Fighter, produced by Grumman. Known as 'Zero Killer', it too was a popular US aircraft during World War II and was dreaded by the Japanese aircraft. As underlined in a report, the aircraft became 'unmanned, soon after the first bomb test'.[38] Further:

> Instrumentation on board and photographic plates taped to the control stick obtained data on radioactivity. Three more manned flights preceded the final unmanned flight on July 25, 1946, which evaluated the first underwater explosion. Records indicate that exposure of this aircraft to the radioactive cloud was minimal and residual radiation is negligible.[39]

There are at least two versions regarding the distance of the motherships from where the radiation level was monitored and studied.

The New York Times reported that the motherships were stationed merely 8 miles away from the explosion site.[40] However, a study conducted much later found the distance to be 25 miles away from the site.[41] According to this study, the monitoring site did not face the danger of radiation. Two of the drones were badly damaged because of the blasts, but continued to fly to reach the destination, California, after procuring data.

The US had constituted a new drone unit in 1946. The air force and other departments kept evolving the drone units to match developments in technology as well as the country's requirements. Thus, the US kept changing drones it used for radiation monitoring: for example, later on, it used QF-80 and other drones.

Over a period of time, the drones have been equipped with adequate technology to trace the site of nuclear blasts. In fact, not only various instruments but also animals have been mounted on drones to study the impact of radiation. For example, the harvester system mounted on a drone can take it to the blast site and collect the radiation level and other data. The unmanned feature of drones can save human lives. Drones, to a great extent, may still be relevant for studying the radiation level of a possible nuclear test and the nature of possible nuclear test of other countries, especially adversaries. However, the radiation monitoring task needs radiation-hardened chips.

Reconnaissance of Nuclear Installations

The spy drones are known for collecting an adversary's vital data, including that of nuclear or other sensitive installations. This system of collection and transmission of data, which otherwise is considered a negative phenomenon, may at times produce positive results. It can be a good tool for building confidence and allaying misgivings by giving a clear-cut picture of the perceived enemy's preparedness and intention. Historically, most of the reconnaissance drones have been used for the purpose of defence preparedness. Earlier, during the Cuban missile crisis, the US planned to collect the data on Soviet nuclear weapons preparedness through drones. However, because of resistance by the armed forces that such a venture may reveal the top-secret military drone programme, the US government was forced to abandon the idea; but the development of the project continued.

The US, as the most technologically developed country, also toyed with the idea of undertaking risky ventures in certain tense geopolitical situations. It kept sending drones to know the level of nuclear activities

in many other countries, including Iran and North Korea. Further, as pointed out by some studies, after China's nuclear tests, the US stepped up its surveillance on Chinese nuclear activities. According to a report, the US sent 160 Lightning Bug excursions to collect data on some select Chinese targets. Other writings also record that the jet-powered Firebee target drone breached the security systems of protected targets and installation, and performed its reconnaissance missions to gather information about the Chinese nuclear programme.

More recently, it has been acknowledged that an American research vessel, *Yantar*, undertakes underwater reconnaissance for supporting the underwater nuclear drone with data.[42] Further, in the past few months, the American DroneRAD system has hogged the limelight in the Ukraine–Russia conflict. The US apparently wanted to use the system for surveillance of Russian nuclear activities in or near the war zone. As per the US Nuclear Corporation:

> The Model DroneRAD comes equipped with two radiation sensors: a gamma-ray search tool to locate gamma-emitting hotspots and a beta-gamma air monitor to measure the air for dangerous radioactive airborne particulates. The gamma search tool can find dangerous radioactive hotspots, either from released radioactive materials or from solid sources such as exploded or unexploded nuclear weapons and shrapnel. The air monitor can be used to monitor any radioactive airborne particulates that can be easily inhaled or that can enter into the food chain when it settles as nuclear fallout on farms, plants, or food stock. The data is displayed on the DroneRAD's ground station, in real time and overlaid on an aerial map, showing the flight route and a color-coded scale of the recorded radioactivity at each point.[43]

China is another country that has emerged as an important actor in the drone business, especially surveillance, with its signature generally found in most of the illegal or illicit drone transactions. China has also sent surveillance drones to monitor nuclear capabilities and activities of its rivals. A recent report divulges that the Chinese intelligence agencies, through their agents, sent drones to collect information of British nuclear installations and bases.[44] Since 2019, the report informs, at least 18 drones were spotted over British military sites and nuclear power stations. The nuclear submarine base in Faslane, Scotland, where Trident submarines and nuclear weapons are housed, was the special target of the Chinese spying drones. Another significant nuclear installation was the Atomic

Weapons Establishment in Aldermaston, Berks, the place of designing and manufacturing of nuclear warheads.

Nuclear Security

Drones can be used for both nuclear terrorism and prevention of nuclear terrorism. Theoretically, a terrorist may acquire a drone from the highly proliferated market and use it for malicious intention. In general, it may be easier for a terrorist or a terror group to acquire explosives, or even rather easily available chemical agents, but it would be difficult to acquire nuclear weapons/warheads or even nuclear materials. Acquiring radiological materials for a dirty bomb is considered a somewhat more realistic scenario. However, how a terrorist mounts these materials on a drone is another question. Admittedly, some malicious acts cannot be bracketed as acts of terror but may appear as terror-like activity because of use of nuclear or radioactive materials For example, on 25 April 2005, a drone with radioactive material was discovered on the rooftop of Japanese prime minister's office. A Japanese protester had carried out the act to protest against nuclear power. This act was certainly malicious.

When mysterious drone formations appeared in a few American cities in 2019–20, the strategic community expressed concern.[45] A special team was formed to unravel the mystery. After observing the sky for a couple of weeks and studying the sightings in January 2020, it reported that the sightings were 'planets, stars, "small hobbyist drones"…commercial aircraft and environmental conditions.'[46] Still, the team could not resolve the mystery of the four earlier sightings. The strategic community senses several dangers, including an attack on nuclear power plants, if these drones kept escaping the radar of the security agencies.

One of the reports of the US government does not find drones to be a cause for alarm for the security of nuclear installations.[47] It notes:

> …nuclear power plants and Category I fuel cycle facilities do not have any risk-significant vulnerabilities that could be exploited using UAVs and result in radiological sabotage, theft of special nuclear material (SNM), or substantial diversion of SNM. Similarly, [it] determined that information gained from UAV video surveillance of an NRC [Nuclear Regulatory Commission]-licensed facility is bounded by the type of information that could be provided by the knowledgeable insider currently permitted in the DBTs.[48]

However, several other reports, even those originating in the US, do not share this optimism. A report from one of the US laboratories

maintains that attacks are possible with a drone hitting a target directly.[49] Obviously, this could be mobile or immobile sites of the nuclear energy complex. This study, however, underlines some limitations relating to weight, capacity and accuracy. Of course, this may change if the drone drops a nuclear warhead, creating a completely different scenario.

Drones, if used prudently, may have a positive impact for nuclear security. Indeed, the role of a drone as an instrument of surveillance for critical infrastructure, like nuclear power plants, has been well recognised in literature on drones. Its surveillance usefulness is recognised not only in a conflict or war situation to assess an enemy's capability, but also for the security of nuclear power plants and other installations where sensitive nuclear materials are stored. Further, drones could be useful in providing physical protection to a nuclear power plant or other sensitive nuclear installations. A camera-equipped drone can capture data and relay it to the relevant pilots or operators. With increasing quality of cameras, the drone's ability to undertake better surveillance is enhanced. It helps authorities to take preventive measures. If critical infrastructure is damaged, cameras of drone may assist in assessing the damage without risking human lives. Drones may also support nuclear security by helping or complementing patrolling and providing extra data to respond to nuclear security incidents. Thus, the task of tracking and monitoring is properly accomplished.

Likewise, by locating radioactive materials before they are used for a malicious objective, drones may prevent nuclear terrorism. As flying or aerial robots, drones are expected to help in the prevention planning of radiological materials. It is opined that when nuclear materials are on ground, they are difficult to detect; and only airborne radiation can be detected and provide the required information.[50] A study finds three important aspects for drone measurement: the altitude; pitch angle; and distance.[51]

With new developments in drone technology and the entry of many start-ups, smaller and more effective drones are coming into the market to counter the challenge of nuclear terrorism. One of the articles gives an indication about a new system mounted on a smaller drone:

> The centerpiece of the system is a fusion device that paints a target area with neutrons. Then sensors look for gamma rays or other particles with the signatures of specific materials such as explosives or a nuclear device. It's the same technology used at security checkpoints to scan luggage and shipping containers in airports…[52]

However, this system uses 'the radiation source small enough to mount on a drone'.[53]

Nuclear Safety

As discussed, drones equipped with modern gadgets and technology may be operated for radiation measurement. The radiation measurement drone, whether unmanned or remotely piloted or controlled, helps agencies in evading the possibility of radiation risks to human beings while monitoring radiation in the environment. One of the studies has forecast: 'UAVs may also be used to inspect contaminated areas, such as in fission reactors for leakage detection, in storage areas of nuclear sources, or even in hazardous scenarios of nuclear disasters.'[54] The general understanding is that in high-risk activities or zones, robots are very much in application. The task of 'remotely operated robots' can be transferred to drones for monitoring high-risk radiation activities.[55] Some of Industry 4.0[56] tools may further equip drones to perform high-risk activities through autonomous fly, whether predefined or exploratory.

A visuo-haptic augmented reality interface is used to overcome some of the challenges posed to remotely monitored operators.[57] The visuo-haptic technology or equipment gives not only the view of the radiation source or the radiation risk area, but also a sense of touch and motion to a remote pilot or operator. It simulates or generates a sensation to the pilot on computer as if he or she is interacting directly with the physical activities without taking any radiation risk. It is considered highly relevant for the most intense detected radiation source. Based on impedance control—a handling system for studying a dynamic interaction between a manipulator and its environment—an assessment is made when drone is near the detected radioactive source and when it goes away from the source. A 3D histogram of the assessed radiation intensity is exhibited, and assessments made at different distances through new tools embedded with the drone system help the operator, who in turn sends the report to the concerned agency or department for taking suitable action.

Depending upon the situation, several drones may be employed at such a site. However, the concerned authority may have to do geofencing or virtual perimeter so that the drones do not knock or hit each other. In a few cases, high spatial resolution charts of radiologically contaminated places or sites have been procured through small multi-rotor vehicles. The biosensor system, which is mounted on drones or UAVs for general environmental observations, notifies detection of radiation leakage as

well. Also, a gamma ray detector camera is considered highly effective for risk characterisation.[58]

At a number of places, drones may serve the mission of nuclear safety. For instance, radiological characterisation through drones is considered highly helpful for managing uranium mines. Similarly, for tall buildings or edifices and areas with high-voltage lines, drones could be useful in radiation monitoring and assessment work. An unmanned vehicle was used to monitor radiation at the Fukushima site, and its measurement of radioactive cesium deposition on ground was found extremely accurate. It also assisted the authorities in guiding robots in the damaged Fukushima power plants. Overall, it was assessed that radiation distribution maps with a resolution of more than 1 m obtained through drones could be very precise.

In 2021, the International Atomic Energy Agency (IAEA) informed that it had developed a new low-cost drone technology to monitor radiation levels in an emergency situation.[59] The Fukushima incident made the agency realise the requirement for developing a drone-based system. The IAEA-developed instrumentation with data processing and storage capability, along with the methodology to collect data with radiation-hardened sensors, cameras and Global Positioning System, has been verified in the environment of Fukushima. As improved technology is leading to an increased capacity to carry bigger loads, swarming and improved sensors, the IAEA is aiming to have long-duration drones measuring radiation more precisely and effectively.

Conclusion

Although in several economic, social and security sectors drones are demonstrating impressive performance, their nuclear mission is either downplayed or not fully explored. Drones play multiple roles in the nuclear domain and are active in both defensive and offensive functions. In fact, many of these activities started long ago with the advent of the nuclear weapons age. At the time, some of the existing systems like manned aircraft were modified to undertake activities of a drone. Gradually, independent design and development of drones started taking shape. The drone as a tool of radiation measurement was almost simultaneously accompanied with the drone as a potential carrier of nuclear warheads.

As the US was the first nuclear weapons country, naturally it explored most of the nuclear-related activities with drones in the initial years. As the technologies and the systems relating to drones kept evolving, many

other nuclear weapons countries also realised its usefulness. Considering the sensitivity and dangers of nuclear materials and technology, these countries may be moving prudently. A drone's role in providing physical protection and radiation monitoring has received international legitimacy. The idea of the drone as a carrier of nuclear weapons has certainly generated excitement across the world. Experts have, in fact, started discussing it as a carrier of at least smaller nuclear warheads.

As of now, drones are not considered equivalent to missiles in terms of weight, range, speed and endurance. As a result, there is no earnest indication of nuclear weapons countries reposing faith in drones as critical delivery vehicles to deliver nuclear weapons. For this to happen, technology needs to mature further. Currently, the underwater unmanned vehicle for delivering nuclear weapons appears to be quite popular in the decision-making systems of the nuclear weapons countries. It is evident that drones may acquire more and more roles in nuclear missions in the future.

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