

Drones and Air Power Strategy

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Introduction

It is almost a century since air power came to be considered to be important under defense strategy.¹ In the meantime, mainstream concepts have changed and theories have continued to be developed with regard to air power.²

Generally speaking, air power refers to a force projected by assets with physical flight ability. However, it is not because of this physical property that air power came to be regarded as an important strategic element. Air power has continued to be a focus of attention from the 20th century until now as a force which, with its breakthrough ability and mobility, can exercise the function of rapidly sweeping through battlelines and combat areas—that is, as a decisive force because of which battles could be won or lost.³ In short, it is not immediately clear whether some specific airborne assets are components of air power. In that sense, it is necessary to question whether so-called drones, which are also known as unmanned aerial vehicles (UAVs) or unmanned combat aerial vehicles (UCAVs), constitute air power in terms of functions.⁴

In this respect, while the visual image of drones has become widely known, there are many unclear points concerning how drones are actually operated. Even drone-related books and papers regarded as authoritative ones do not provide sufficient empirical explanations as to what strategic functions drones may perform.⁵ Most discussions so far held on drones merely mention the military results and the extent of damage caused by drone attacks, while individual drones' respective performance features or their strategic functions have rarely been discussed.⁶

As a general rule, drones are expected to be equipped with the 3Ds or 4Ds⁷, which are properties lacking in manned aircraft. This means that in the conflict between creative ideas and constraints that occurs during the process of developing a military, conventional constraints can be removed or mitigated, increasing the room for more creativity to be exercised.⁸ In the case of manned aircraft, consideration must be given to physical safety and fatigue risks for pilots, whereas the use of drones makes it unnecessary to give consideration to those matters.⁹ However, constraints may change because of factors other than science and technology. It is necessary to look at things from multiple angles, such as government policy, economic rationality, various rules, customs, and reliability.¹⁰

The presence of drones is growing in the security environment across the world.¹¹ Col. Matthew Tedesco of the U.S. Air Forces, in a paper titled "Countering the Unmanned Aircraft System Threat," stated that militaries who fail to examine "ways to defend against the use of UA Systems are not preparing adequately for the next war."¹² Meanwhile, regarding the fact that the threat from drones has become an urgent challenge even in the U.S.

mainland, which tends to be regarded as a safe place, the FBI Director made testimony before the Senate Homeland Security and Government Affairs Committee. Referring to the possibility of a drone attack on the U.S. mainland (while mentioning terrorists as possible perpetrators but theoretically not limiting the risk to the context of terrorism), he stated: "I think the expectation is that it's coming here imminently." This statement came as a shock at that time.¹³ At around the same time, toward the end of 2016, the U.S. Senate adopted the National Defense Authorization Act of 2017 and decided to introduce a provision concerning drones into Title 10 of the United States Code. The Senate also asked the Secretary of Defense to look into the possibility of countering the threat from drones to the U.S. forces and report the findings to Congress.¹⁴

As epitomized in the U.S. case described above, the threat from drones has now become so serious that countermeasures must be systematically taken in various quarters. The situation is set to become increasingly serious.

1. Position of Drones in Air Power

(1) Framework of Air Power and Development of Strategic Visions

I will clarify the definition of air power in this paper before examining the strategic significance of the functions of various types of drones while taking account of the usefulness of drones as air power. It goes without saying that putting emphasis on the distinction between air power and other military services, i.e., sea power and land power, is not only meaningless but also even harmful in that such distinction could undermine the flexibility of strategic thinking. The purpose of clarifying the definition of air

power here is to clarify the functions that constitute elements of strategy.¹⁵

In this respect, Michael Clarke's classification is useful as a conceptual framework for identifying the functions of air power.¹⁶ According to his classification, broadly speaking, air power played the following five roles in various actual battles that occurred in the past: (1) preparation of the battlefield, (2) close air support / air interdiction to ongoing operations,¹⁷ (3) primary strategic effect,¹⁸ (4) political coercion, and (5) other operations, in which air power played no significant combat role, or a humanitarian role.¹⁹

If those who are well-versed in the history of air power look at this framework, it will probably occur to them that it represents an image of airpower conceived in retrospect, not the image that existed from the beginning.²⁰ Historically, whenever some new technology, regardless of whether or not it was related to air power, came within the reach of practical use, the nature of future combat was imagined and strategic concepts were developed. Each time that occurred, several different approaches were proposed contemporaneously and went through the process of refining through actual combat experiences. Examining the usage of individual new technologies is in itself important research work. On the other hand, as drones and all other new technologies become obsolete in due course, it is important to consider a general approach to new technology—that is, we should not only pursue individual new technologies but also consider how new technologies should be accepted.

From a broader perspective, it is important to have a tolerant attitude, i.e., willingness to respect and accept other people's ideas

after critically examining them. In this respect, Lt. Gen. Jay Silveria, Superintendent of the U.S. Air Force Academy, attracted attention for vigorously advocating his own beliefs as a commander and as a human being in an address to academy cadets. When confronted with an incident of discriminatory graffiti within the academy, he explicitly pointed out the presence of diversity of personnel as an underlying factor in the strength of the U.S. Air Force and made it clear that he would never tolerate language and behavior that might undermine that value, that is, language and behavior that did not respect other people.²¹ While his address attracted interest from various quarters, the thrust of the address was that diversity should be regarded as a core of strength. Rather than playing down the significance of diversity as an issue particular to the United States, a country of immigrants, we should bear it in mind as an important factor for developing future strategies.

In that sense, as to the question of how drones may affect air power strategy, it is necessary to closely examine each of the various theories out there in terms of how they treat the functions of air power, instead of discriminating between the mainstream and other theories. Generally speaking, it should be kept in mind that air power refers to the capability to gain and maintain combat superiority through usage of airspace and that it is a concept that encompasses abilities to conceive and execute ways of flexibly using airspace, including outer space and cyberspace, in accordance with the level of technology at the time.

(2) Technology Transfer and Threat Awareness Regarding Drones

The number of countries that possess armed drones has exceeded 30.²² Although the number of countries capable of

developing drones on their own as opposed to importing is smaller, drones are gradually proliferating across the world. Moreover, it is relatively easy even for non-state agents, such as terrorist organizations, to possess drones.²³

At present, Turkey's case is notable in terms of technology transfer and proliferation. In the second half of the 2010s, Turkey leapt to the cutting edge of drone technology. One factor is said to be a technology transfer from the United Kingdom. When proceeding with military intervention in the neighboring Syria, Turkey achieved significant results by making effective use of an armed drone called the Bayraktar TB2. According to media report, Bayraktar TB2s operated by the Turkish military within Turkey and in Syria and Iraq, were used in a wide range of operations, from targeted killing to close air support (CAS).²⁴ In February 2020, after 33 Turkish soldiers were killed in an air raid by the Russian military in the Idlib province in Syria, the Turkish military launched Operation Spring Shield (OSS) against the Assad government and pro-Iranian militias. At that time, as Russia held air superiority in the airspace over the Idlib province, the Turkish military could not deploy F-16 fighters in OSS but it defeated Assad's forces there within days by making effective use of drones. Specifically, of Assad's forces there, 3,000 troops, 151 combat vehicles, eight helicopters, three drones, three fighter jets, including two Sukhoi fighters (Su-24s), 100 military vehicles, eight air defense batteries, 86 cannons, and one command center building suffered damage, resulting in the retreat of the forces from the province.²⁵

According to media reports, the young chief technology officer (CTO) of Bykar, the company which developed the Bayraktar, is a

graduate of the Massachusetts Institute of Technology (MIT). The company reportedly overcame the development of a missile rack, which posed the greatest challenge for the development of the armed drone, thanks to a technology transfer from a U.K. company that had developed the missile rack used in the Boeing F-18 Hornet fighter aircraft.²⁶

Medium-size drones (10 to 20 meters long in wingspan) like the Bayraktar that are operated at medium and high altitudes for a relatively long duration of time, 24 to 36 hours, are called MALEs. MALEs are used as the main drones in various operations. As indicated by this case, the leap from the development of a drone to its practical use in various operations may take only a few years (Bykar started the development of the TB1, the TB2's predecessor, in 2007, followed by the first flight in 2009. The TB2 made the first flight in 2014, followed by the first successful missile test-firing in late 2015).

On the other hand, small drones (ranging from ones launched from missile pods to palm-size ones) operated at low altitudes and at low speeds are distinctive in that they are difficult to detect by radar. Such drones are known as LSS (low, slow and small²⁷).²⁸ Drones of this type can be developed and manufactured more easily than MALEs. Generally speaking, MALEs and LSSs, unlike manned fighter aircraft, do not necessarily require cutting-edge technology.

2. Eastern Ukraine Conflict as a Test Ground for Drone Operation in Actual Combat

It is presumed that until now, the operation of drones in actual combat has been associated with the images of remotely controlled

unmanned attack aircraft (unmanned bombers),²⁹ such as the Predator (MQ-1) and Reaper (MQ-9), killing individual persons and destroying facilities.³⁰ Reconnaissance drones, such as the Global Hawk (RQ4), are also well-known.

However, even in the case of relatively prominent drones like these, it is still not well understood how and under what strategies they were (are) operated, that is, what functions they provide from the perspective of strategy. That may be because of the need to maintain the confidentiality of military tactics and operations,³¹ and also because the advance of science and technology is so rapid that our understanding cannot keep pace. On the other hand, the fact should not be disregarded that drones for practical use are not necessarily provided to users in the form of finished products but that drones assembled by users themselves from off-the-shelf components (which may be called "generic" drones, which do not necessarily require advanced technology) are widely in use.

The eastern Ukraine conflict, which broke out in 2014, is attracting attention as a typical example of this situation.³² It is said that in this conflict, drones played a strategically important role amid the intensifying confrontation between the Ukrainian government and the anti-government forces supported by Russia.

(1) From the Onset of War to the Introduction of Drones

The Ukrainian regular forces, which include the second largest army in Europe, did not possess any drone at the beginning of the armed conflict in 2014. According to media reports, the Ukrainian forces were considering restoring the Soviet-era Tu-141 drone as a realistic option, and this reflected the desperate situation of military technology in Ukraine.³³ It is said that over the quarter century since the collapse of the Soviet Union, the Ukrainian

forces had been chronically vexed with corruption and shortages of financial resources.³³ In the meantime, the anti-government forces had received strong support from the Russian military,³⁴ which had been promoting modernization, and as a result, there was a stark contrast between the two sides in terms of deployment of advanced weapons.³⁵

As the battles intensified, the battlefields expanded, entrapping citizens in war. For example, the number of deaths due to anti-vehicle landmines in Ukraine in 2016 was the highest in the world. Around four years into the military conflict, still with no prospects for a truce, an extraordinary trend emerged. A group of people within the regular Ukrainian forces started to develop drones under their own initiative. The group not only developed drones but also proposed drone-based tactics. Lt. Colonel Toby Shepard of the U.S. Army, who concurrently served as a military attaché at the U.S. embassy in Kiev and as a military adviser to the Delta Center, which oversaw the command function of the regular Ukrainian forces, commented that after starting from scratch in developing and operating drones, Ukraine advanced to the stage of developing its own drone system.³⁶

The Delta Center is comprised of around 40 personnel, including graduates of the Ukrainian Military Academy. Its main mission was to reduce the time necessary for information gathering by drones so that information on the situation in the frontlines could be grasped in real time. Information collected by drones was shared immediately with U.S. military attachés and was used to identify the capabilities of the Russian forces that were supporting the anti-government forces. According to Lt. Colonel Shepard, eventually, it came about that Ukraine developed some small

drones that were superior in performance to their U.S. equivalents. The Delta Center's achievements were so successful that Colonel Shepard gave the sobriquet "the ultimate geek squad" to the Delta Center's staff.

Dennis Gurak, deputy head of the foreign investment division of UkroboronProm, a Ukrainian state-run military supplier, who prides himself as being an expert on international business administration and marketing, pointed out that the Delta Center's strength rests in its success in recruiting competent university graduates³⁷ in the so-called STEM fields, including mathematics, physics and engineering. In the Soviet era, the Ukrainian military industry supported the Russian economy for many years. Many Russian military assets, including tanks, rockets, missiles and helicopters, were manufactured in Ukraine. Therefore, it is conceivable that in Ukraine, there was an atmosphere and infrastructure that attracted competent workers who had the ambition and ability to create something new by applying science and technology. You may understand that situation if you think of Japan's case. Japan used to be called a "country built on technology" where there was an atmosphere that prized manufacturing skills and practical education and respected knowledge and cultured learning. Gurak predicted that apart from the United States and China, Ukraine would become the only country to have created a well-established drone industry in just two years.

Regardless of whether or not Gurak's assessment is accurate, the country leaped to the stage of putting drones into practical use in a short period of time as described above. Also behind Gurak's confidence in Ukraine's success is awareness of the fact that flight

training for the Raven (RQ-11B), a small drone, was provided to the regular Ukrainian forces by the Joint Multinational Training Group Ukraine (JMTG U), a U.S.-led group of around 250 military personnel, at the Yavoriv Combat Training Center in western Ukraine.

The Raven belongs to the abovementioned LSS category of drones. It weighs about 4 pounds (slightly less than 2 kilograms), is capable of staying airborne for 1 to 1.5 hours and can be launched by hand.³⁸ AeroVironment, a U.S. drone maker, has shipped around 1,000 units of the "generic" drone since 2001. In July 2016, 72 units were provided to the regular Ukrainian forces as part of official U.S. assistance. However, it has repeatedly been pointed out that the U.S. assistance was not effective in directly supporting the regular Ukrainian forces because of their lack of ability to attack the anti-government forces' missile batteries due mainly to the Raven's limited flying range and the vulnerability of camera image data to hacking. Rather, that situation is considered to have suited the Obama administration's intention to limit the U.S. intervention in Ukraine to a moderate one not involving direct attacks on the anti-government forces.³⁹

In any case, the regular Ukrainian forces made rapid progress in drone technology development and operating skills while receiving drones and training from the outside. Drone manufacturing skills in the private sector also continued to develop. Matrix UAV, which is based in Kiev, is playing the central role in the manufacture of drones in Ukraine.⁴⁰ In addition, Meridian Corporation⁴¹ succeeded in developing drones that can be manufactured using a 3D printer. As indicated by those cases, while a certain level of technological expertise is required for

creating drones, ease of introduction and use (the presence of a certain level of aeronautical engineering and programming skills is sufficient while heavy industries or large-scale factories are not necessary) is a distinctive feature of drone production.⁴² As an example of a more modern trend, some Ukrainian drones have been manufactured with funds collected through an internet-based crowdfunding initiative (People's Project.com),⁴³ that is, with support from the general people.⁴⁴

(2) Competition between Countries at the Technological Cutting Edge and Latecomers

On March 23, 2017, the anti-government forces succeeded in exploding the regular Ukrainian Forces' munitions depot (where around 140,000 tons of munitions were stored) that was said to be the largest in the world at the time by dropping incendiary grenades from just one small drone.⁴⁵ As symbolized by that incident, from the outbreak of war, the anti-government forces, with support from Russia, maintained superiority over the regular Ukrainian forces in terms of drone technology and ability to identify attack targets. To overcome this situation, the regular forces requested Steven Pifer, the U.S. ambassador to Ukraine, to provide equipment to obstruct Russian drones' radar and U.S.-made drones, such as the Reaper,⁴⁶ albeit ones stripped of attack capabilities.⁴⁷

As the United States did not immediately provide assistance in response to this request, Ukraine decided to develop drones on its own. One major development challenge was how to maximize the airborne time. The anti-government forces were making full use of radio jamming and GPS neutralizing technologies, vehicle-mounted anti-drone systems, including Krishna II, and other

advanced electronic warfare technologies possessed by companies such as Radio-Electronic Technologies Corporation in Moscow. The regular forces needed technologies of their own to counter those Russian technologies.

Even manually assembled drones based on widely available civilian technologies can not only perform reconnaissance operations but also attack important facilities located deep in enemy territory without securing air superiority. In such operations, drones provide an outstanding cost⁴⁸ advantage. As the attacking side faces no risk of losing human lives, it is difficult to develop deterrence against drone attacks.⁴⁹

On the other hand, while drones may be regarded as low-cost, low-risk assets, remotely controlled drones are vulnerable to the risk of snooping of communication radio signals, which could lead to the identification of the location of a base station. Indeed, according to informed sources, there was a case in which the location of a Ukrainian base station was identified because of the anti-government forces' electronic warfare capabilities supported by Russia, resulting in the killing of the person who was operating the drone.⁵⁰ In short, while it can be said that small-scale outside support is sufficient for a latecomer to bridge the technology gap with the frontrunner because the difference in the level of drone technology itself is small, the fact remains that in actual combat, the country with a technological edge in electronic warfare, which is closely related to drone operations, has an advantage. Therefore, preparing countermeasures against jamming⁵¹ and developing autonomous drones that do not require communication with base stations is important.⁵²

3. Drone Attacks on Important Facilities and Countermeasures

(1) Cross-Border Attacks

In the attack on Saudi Aramco's oil facilities in Abqaiq and Khurais in Saudi Arabia in September 2019, drones were used as is widely known.⁵³ A total of 18 drones were deployed in the attack, accompanied by seven Iranian-made cruise missiles (Cuads-1).⁵⁴

What was notable about this attack, which affected prices of crude oil and related financial products is that the defense system at the Saudi Aramco oil facilities did not function at all. This was an operation that effectively took advantage of the weaknesses of the defense capability and was very effective in terms of the cost-benefit balance given that the attack cost was 1,500 dollars per drone.⁵⁴

The Saudi Aramco oil facilities were under the protective cover of defense by the Patriot air-to-surface missile system (PAC-3) and Oerlikon 35 mm anti-aircraft gun. The anti-aircraft gun was equipped with the Skyguard radar system, but the drones and cruise missiles, which flew at low altitudes, could not be detected and intercepted. As can be easily imagined, the flaws in the Saudi oil facilities' defense system immediately cast doubt on the effectiveness of Japan's air defense as well. Referring to the threat from drones, Kono Taro, who was Japan's Defense Minister at the time, said that drones have a game-changing element.⁵⁵

The Acquisition, Technology & Logistics Agency is preparing three major countermeasures. They are (1) kinetic destruction by a high-power energy weapon (laser weapon), (2) neutralization through electronic jamming, and (3) development of an automated warning system that enables early response by detecting radio

waves issued by drones.⁵⁶

I cited the attack on the Saudi Aramco oil facilities as a case that attracted wide attention, but there are various other facilities that could become targets of drone attacks. Generally speaking, operators of infrastructure facilities that support the political and economic activities of countries and regions and, in some cases, influential private-sector companies, such as multinationals, must have risk awareness given the possibility that if drone attacks have incapacitated their facilities, social turmoil could be triggered, leading to the disruption of social functions. What first comes to mind is the Israeli operation that is said to have prevented the construction of an Iraqi nuclear facility in Osirak with a drone attack.⁵⁷ In Saudi Arabia, for many years, there have been concerns over the safety of not only oil facilities but also of other facilities that have been pointed out as possible attack targets, including the desalination plant in Jubail.⁵⁸

In Japan's case, almost all sorts of infrastructure, including dams, trunk roads, railways, and airports—not to mention nuclear power plants—could become targets at any time and be attacked in any way. Not only must we consider that risk in the context of terrorism, but also it is necessary to look at the risk in the context of national security—in this case, a hypothetical enemy may be assumed—and have strong awareness about specifically what actions to take, particularly about what kind of system should be established to counter the risk in the event of war.

The reason why it is necessary to keep vigilance against such risk is that drones may intrude into enemy airspace without detection because they are so small as to be misidentified as birds

or other benign flying objects and also because they can continue to fly at ultra-low altitudes that are out of radar range.⁵⁹ (©It is difficult to detect drones of the LSS type without a specialized radar system [Figure 4 at the end of the text]. Even if a specialized radar system is used, it would be inefficient to constantly watch out for such drones.)

(2) Terrorism and Disturbances

In the United Kingdom, for three days from December 19, 2018, Gatwick Airport,⁶⁰ the second-largest airport in the country, after Heathrow Airport, was shut down with arrivals and departures suspended.⁶¹ The cause was presumed to be an intrusion of two drones into an area near the runway,⁶² but the investigation was terminated without any culprit behind the incident being identified.⁶³

In response to the incident, the U.K. government vowed to develop a system to prevent the occurrence of similar incidents. In the year before the incident, a drone had nearly collided with aircraft in the sky over the airport. If we are to put the safety of passengers and other civilians before other considerations as the basic principle of safety precaution, there is no perfectly ideal solution, as it is inevitable to impose some inconveniences in terms of economic efficiency (tradeoff between the safety of the people and the freedom of economic activity).⁶⁴

4. Review

The sight of drones delivering successful results in actual combat would make any military force around the world feel that they cannot afford to do without drones. In light of the U.S. military's use of drones in Iraq and Afghanistan, experts have the

highest regard for the usefulness of drones.⁶⁵ China has also made significant progress in putting drones into service since the beginning of the 2010s. In recent years, the progress has been particularly remarkable. After the entry-into-service of the GJ-11 (an improved version of the Sharp Sword, a stealth attacker drone that made the first flight in 2013), which is a stealth attacker drone that was displayed in a military parade in October, the People's Liberation Army conducted a demonstration test of a launcher capable of launching small drones (said to be around 1.2 meters long and similar in shape to the CH-901) used for the purpose of swarm tactics—48 drones can be launched simultaneously, for a total of up to 200 drones—and a helicopter capable of launching such drones while being airborne in an exercise simulating amphibious landing operations in October 2020, according to Chinese media reports.⁶⁶ It is also said that in addition to the helicopter used in the demonstration test, there are other platforms capable of launching drones for swarm operations, including vehicles, landing ships, and fighter aircraft.⁶⁷ It is easily conceivable that such drones could become a concrete threat in emergencies in such regions as Taiwan, the Senkaku islands, the Paracel Islands and the Spratly Islands. Therefore, we should assume that China is developing drones and putting them into service in order to intimidate other countries.

According to the Russian state-run TASS news agency, Russia has also put into service drones intended for swarm tactics operations. In September 2020, in Kavkaz 2020, a large-scale international military exercise conducted with the participation of a total of 80,000 personnel, Russia executed a swarm operation⁶⁸ using drones deployed by a unit in the Southern Military District,

including the Forpost, Orlan-10 and Eleron-3 drones, at altitudes of 100 to 5,000 meters. In the operation, the drones performed the enemy search function, which had previously been performed by manned aircraft, thereby making it possible to find and identify targets quickly and accurately without exposing the lives of any crew to risks.⁶⁹

(1) Drones and Political Coercion

As is clear from the abovementioned case, air power strategy, including the deployment of drones, has the potential to exercise an overwhelming combat power—the power to defeat the enemy without significant damage to one's own forces.

If drones are to be classified according to Clarke's abovementioned classification of air power components, they can be classified as assets that contribute to "political coercion."⁷⁰ When one's own forces are expected to suffer damage associated with attacks, a combat force higher than a certain level cannot be easily used. In that sense, deployment of drones can be expected to serve as a traditional sort of deterrence (using conventional weapons), i.e., denial deterrence.

In this respect, following the technological advances of drones in recent years, there have recently been some studies that discussed the revision of the traditional theory of deterrence and the possibilities of a new deterrence function. There is also the argument that as a precondition for discussing drones' possibilities in terms of deterrence, we must even change our perception of drones' role in air combat with manned fighters, which was previously dismissed as an unrealistic prospect. Regarding drones' role, it is known that they have been widely used in target killing operations as well since the war in

Afghanistan while being used mainly for reconnaissance. Moreover, in recent years, drones' bombing capability, as shown by the abovementioned drone attack on Saudi Aramco's oil facilities, has attracted attention. In addition, Dr. John Stillion of the Center for Strategic and Budgetary Assessments (CSBA), discussed the vision of air superiority in the near future in a paper published in 2015.⁷¹ Before discussing the vision, he conducted an empirical analysis of changes in weapons with decisive power in aerial combat between fighter aircraft and reached the conclusion as stated below.

Dr. Stillion pointed out that while gun attacks from behind were the mainstream mode of attack in fighter-to-fighter combat in the 1960s, missile attacks from behind took over as the mainstream in the 1970s, followed by the shifts to missile attacks from every direction in the 1980s and to missile attacks from beyond visual range (BVR) in the 1990s and later.⁷² Based on these findings, Dr. Stillion concluded that the presence of humans in the cockpit during aerial combat is now quickly losing its significance.⁷³

Before the publication of Dr. Stillion's paper, Ray Mabus, Secretary of the Navy, provided an interesting point of debate related to the U.S. military's weapon systems. He commented that the F-35 is all but sure to be the last manned strike fighter aircraft to be deployed by the U.S. Navy. Following this comment, debate on the vision of next-generation or near-future air power has heated up. The debate has extended beyond the issue of to what extent unmanned fighter aircraft can replace their manned equivalents. In relation to the question of what an emerging air power will look like, expectations for unmanned fighter aircraft have continued to grow.

Some studies have found that even in aerial combat, manned fighter jets, which tend to be considered to maintain superiority, are already no match for unmanned ones. In June 2016, ALPHA, a fighter-controlling AI system developed by Psibernetix of the United States, achieved overwhelming wins in all of the several rounds of simulated aerial combat that it fought with an elite pilot of the U.S. Air Force. What is noteworthy is that Col. (retired) Gene Lee, the pilot who operated the fighter aircraft in the simulated combat and who had continuously participated in aerial combat simulations since the 1980s, mentioned his impressions of the combat with the AI system based on comparison with his past experiences. According to Lt. Gene Lee, ALPHA has now reached the level where it can detect the opponent's intentions, predict changes in the position of the opponent's aircraft and the timing of missile launches, and respond instantly, and as a result, it is all but impossible for humans to defeat ALPHA.⁷⁴

Going beyond the debate that focused on drones' role as a force, Amy Zegart of the Hoover Institution at Stanford University asserted that attention should be paid to the fact that drones have arrived at a stage of technological innovation where they can be used to exercise political coercion.⁷⁵ Even though Zegart's assertion may be crude, the point that she made is important. The traditional theory of deterrence (which is based on rationalism) maintains, based on the knowledge of evolutionary biology, that costly threats are highly credible. This is known as costly signaling theory. A typical example is deployment of a tripwire force. While it is possible to take the position that the U.S. Forces in Japan can be expected to play their role as tripwire forces,⁷⁶ Zegart argued that it should not be taken for granted that high-

cost signals are highly credible. On the other hand, he asserted that deploying drones, despite being a low-cost signal, is effective as a highly credible threat and cited three functions of drones as evidence. The three functions are: (1) sustainability in long-duration conflicts, (2) certainty of precision, and (3) changes in the relative costs of war. As drones can be expected to perform those functions, they may be used to exercise political coercion, including the deterrence effect, particularly when the enemy does not have a similar level of drone technology.

As is typified by the mutual assured destruction (MAD) theory, all nuclear deterrence theories have some problems,⁷⁷ whether in terms of effectiveness or ethics.⁷⁸ When a new theory pointing to the possibility that deploying drones may exercise strong deterrence conveniently emerges, it inevitably raises suspicions. However, whether we can seriously consider such new ideas, rather than dismissing them out of hand, is a challenge when we develop a new security theory. Mabus' abovementioned argument should be understood not as propagating the idea that an era of drones is arriving but as expressing the fundamental perception that it is impossible for military forces to maintain their strength unless they identify what kind of combat forces they own by classifying the forces by function with a flexible mind, i.e., without being bound by fixed ideas or prejudices.

In any case, it goes without saying that the argument that deploying drones may exercise deterrence should not be confused with the convenient idea that deterrence exercised by deployment of drones can replace nuclear deterrence. The main thrust of the argument is that conceiving multiple layers of threats may contribute to deterrence strategy. In this respect, in April 2020,

the U.S. CSBA published a report titled "Deterrence by Detection." That the director of the CSBA himself advocated the new strategic concept of "deterrence by detection" in the report and called for early implementation of the concept is an indication of the strength of emphasis placed on the new idea.⁷⁹ This report explicitly cited China and Russia as forces attempting to change the status quo and argued for the importance of deploying drones and promoting international cooperation in preparation for the two countries' territorial expansion efforts. The report proposed that the United States and its allies should have strong awareness about the need to deter Chinese and Russian attempts to turn the seizure of foreign territories into a *fait accompli* and realize real time situational awareness without a new military buildup through resourceful allocation and operation of existing military assets. The strategy proposed by the report aims to put pressure on China and Russia by making them constantly aware of being monitored by using 46 non-stealth drones—from among the existing fleets of drones operated by the United States and its allies—in each of the Western Pacific and Europe (for a total of 92 drones)⁸⁰ for the surveillance operation.⁸¹ This strategy takes advantage of the unique characteristics of drones in order to mitigate the heavy burden, including fatigue and mental concentration on the part of pilots—that will be inevitable if manned aircraft are used to counter possible surprise attempts to seize (uninhabited) territories.

(2) Swarm Tactic's Advantage in Advancing Deep through Enemy Defense and Refining of the Tactic

Drones are being very effectively used as decoys in actual combat to help the attacking side identify the positions of surface-

to-missile batteries. Since Israel demonstrated the outstanding effectiveness of this tactic in the Battle of the Bekaa Valley, the U.S. military has resorted to the use of drones as decoys as the basic form of drone-based operation in various battles. When the opposing side is unprepared, this tactic is very effective (e.g., the opening battle of Operation Desert Storm in 1991⁸²). This tactic not only makes it very difficult for the opposing side to intercept enemy aircraft but also significantly undermines the opposing side's defense capabilities by facilitating attacks on its bases.⁸³ Unless effective countermeasures against those risks are prepared, it is difficult to exercise deterrence, as defense capabilities are expected to be neutralized.

One possible countermeasure is to avoid misrecognizing drones as manned aircraft and launching surface-to-air attacks against them by enhancing recognition capability. However, this countermeasure has a tactical vulnerability—recognition capability may become meaningless if drones themselves are equipped with attacking capability. Now that drones' stability and reliability in terms of flight range and duration have improved, it is gradually becoming popular to develop drones equipped with attacking capability (lethal drones).⁸⁴

Moreover, it is necessary to consider how to respond when a large number of drones, including ones equipped with attacking capability, are used to launch a swarm attack. In this respect, the decision on whether to take the offensive or defensive may change depending on how drones may be operated.⁸⁵ This is a point of discussion that becomes clearer when we consider the concept of defense in depth. With regard to the effectiveness of air power, the idea that in air warfare, the offensive side has an advantage over

the defensive side—as opposed to the view that in traditional land warfare the defensive side has an advantage over the offensive side—was popular at one time. In short, air power was considered to be particularly useful for attacks. It is impossible to adequately discuss strategy without understanding that point.⁸⁶

However, if modern air power, including aircraft other than drones, is to be exercised, it is insufficient to look only at airspace. In particular, support from land, sea surface and satellites (mainly in terms of information and communication) is essential nowadays.⁸⁷ Therefore, it is impossible to consider which of the offensive and defensive sides has an advantage without paying attention to that point. In short, this is an era in which thinking about air space alone is not sufficient when considering the issue of air superiority. In that sense, the development and deployment of satellites is attracting attention. That is why there are high expectations for the swarm tactic, under which autonomous drones within the swarm complement each other's insufficiency in terms of information collected—that is, support from the outside is unnecessary. Conversely, if the enemy has the capability to launch a swarm attack, that will pose a serious threat.

The question of whether to take the offensive or defensive still depends significantly on the situation and circumstances of the time, that is, on the context of war. For example, many strategists advocated the idea that strategic bombing in regions that directly support civilians' lives, such as urban areas, has the effect of considerably undermining democratic countries' willingness to continue the war (in other words, the offensive side has an advantage). However, in reality, that scenario did not necessarily come true. Conversely, in many cases, such strategic bombing may

end up rallying the morale of the enemy state's population, rather than causing a loss of willingness to continue the war. In addition, as strategic bombing is hugely costly, the defensive side may have an advantage over the offensive side in some cases if the efficiency of the bombing in terms of the cost-benefit balance is taken into consideration.

One of the major determinant factors of the question of whether the offensive or defensive side has an advantage is the degree of depth of defense. It goes without saying that there has been awareness that the depth of defense depends on geographical features and the location of strategic bases, but ultimately, physical factors such as geographical features and distance are not necessarily the decisive ones. The deeper the offensive side intrudes into enemy territory, the greater the degree of resistance by the defensive side becomes, causing larger damage to the offensive side and increasing the total amount of time and cost spent on attacks. That is the essence of the defense in depth concept. From the offensive side's viewpoint, receiving 10 counterattacks each time an advance of 100 km deeper into enemy territory is made naturally means facing a greater degree of defense in depth than receiving three counterattacks during an advance of 300 kilometers.

From the above, it can be concluded that drones are an asset that involves no human casualties and very low financial cost, and on top of that, when drones are used in a swarm operation, the opposing side has no effective countermeasure. In short, drones do not cause attrition on the user's side. In contrast, it is clear from the case of the drone attack on the oil facilities in Abqaiq that it is difficult for conventional radar systems and missiles to detect and

intercept drones. Conventional defense systems are all but useless against drones operated in a huge swarm.⁸⁸

As I already mentioned, the Acquisition, Technology & Logistics Agency is conducting studies with a view to developing and operating high-power energy weapons and jamming weapons. However, it is necessary to assume the possibility that if a drone swarm is deployed to strike a base better defended with a laser weapon, the enhanced defense capability could be easily neutralized due to the swarm's numerical superiority given that shooting at incoming drones reveals the weapon's position.

The operation of drone swarms is moving toward the stage of full-blown development. As an outstanding example, in April last year, the Royal Air Force (RAF) newly established the No. 216 squadron, which is responsible for conducting demonstration tests of drone swarms.⁸⁹ As part of this squadron's operation, a drone swarm acts as a wingman for a formation of F35 and Typhoon fighter aircraft and is expected to contribute to the exercise of breakthrough power by mainly performing the decoy function against the enemy's A2/AD operations.⁹⁰ This project has been assessed as having the potential to "exceed expectations."⁹¹ As was mentioned earlier, the effectiveness of the principle of this operation has been demonstrated in various actual battles. In that sense, the project is presumed to have been inspired by the past examples mentioned earlier.⁹²

So far, no significant countermeasure against this kind of drone operation has been developed.⁹³ Moreover, the larger the swarm is, the more difficult it is to counter the operation. The size of swarms being planned is amazing. In 2018, it was reported that each of the United States and China conducted a successful flight

test of a swarm of around 200 drones and that both countries intended to move on to flight testing of a swarm of around 1,000 drones within several years. Indeed, they have succeeded in controlling a swarm of that size.⁹⁴

One key to the successful formation of such large swarms is technology for local communication between drones, including technology to counter attempts to interfere with local communication.⁹⁵ Even if communication with base stations become unnecessary, the principle will remain unchanged, regardless of swarm size or generation, that drone-to-drone electronic communication technology underpins the swarm tactic.⁹⁶

(3) No Need for Air Supremacy, and Need for Command and Control Assets

Among the strategists who made distinctive arguments regarding air power strategy is Giulio Douhet. *The Command of the Air*, Douhet's most well-known book, was conceived in the early days of air power, when at least some experts saw limitless possibilities in air forces. After World War II, it became commonplace for military forces to downgrade the role of air power from gaining air supremacy (the situation where the enemy has been deprived of airborne capabilities and space for flights by aircraft of one's own side has been secured) to pursuing air superiority (the situation where one's own side can execute various operations, including, land and naval operations, without significant interference from the enemy by taking advantage of the superiority of its air power over that of the enemy) in view of the limits of feasibility of air supremacy.⁹⁷

One major feature of strategies using drones is that they do not

require even air superiority, not to mention air supremacy. As a general rule, it is naturally difficult to execute operations in airspace controlled by the enemy, but in the case of operations using drones, conventional principles like that are unlikely to apply, particularly when drones are operated as a swarm. The key to swarm operations is the ability to minimize the impact of loss of some drones on the whole of the swarm and maintain the swarm as a robust system. For example, when a huge herd of gnus (wildebeests) is crossing an African river, the movement of the whole herd is not affected by the loss of some gnus that have fallen victim to crocodiles. A swarm as a system is incomparably robust compared with a single high-performance aircraft, which is highly vulnerable in that the flying function itself may be lost due to the loss of a single component, such as a tailfin. That is the main reason why the Defense Advanced Research Projects Agency (DARPA) is paying particular attention to the swarm tactic. The swarm tactic is highly likely to change the nature of air combat.⁹⁸

However, even if aerial operations are not affected by the presence or absence of air superiority, it is difficult for drones, not to mention manned aircraft, to exercise their functions unless they receive support from other domains, particularly support in terms of information and communication, as was mentioned earlier. In that sense, electronic warfare capability continues to be important, and therefore, there are expectations for the development of autonomous drones that do not require long-distance communication with base stations or satellites.

Of course, there are vulnerabilities in the flying capabilities of drones themselves. There are much greater limitations for drones than for manned aircraft in terms of flight range and speed. Even

so, technology is developing day by day.⁹⁹

(4) Attention Focusing on Drones as Advanced Autonomous Weapons, and Application to Civilian Use

It is said that although the United Kingdom was unenthusiastic about drones until 2015, its stance has since changed drastically as the country has become aware of their strategic importance. As was mentioned earlier, RUSI's awareness of the threat of drones is growing, as indicated by its objective analysis in 2018 of the current situation of drones in China. In April 2020, the RAF created the No. 216 Squadron as a unit responsible for conducting demonstration tests of drone swarm technology. As part of the squadron's operations, a drone swarm acts as a "wingman" for a formation of F35 and Typhoon fighter aircraft. It is expected to contribute to the exercise of breakthrough power by mainly performing the decoy function against the enemy's A2/AD operations.

Under this project, dubbed Mosquito, a single person remotely operates a swarm of up to 20 drones (more specifically, the project tests a technology for providing self-sufficiency within the swarm by sending operational signals to it from the outside). This technology is not only expected to contribute to the reduction of direct personnel cost but is also suited to the RAF's current policy of pursuing the reduction of the time and cost necessary for fostering drone operators.¹⁰⁰ In other words, the technology contributes to reducing the cost of combat as well as enhancing combat capability, which is a strategic goal that is higher in priority than operational objectives.

In the case of the United Kingdom, its interest in drones is simple. That is, for the United Kingdom, what is important about

drones is their ability to operate autonomously, rather than being remotely operated. Similarly, DARPA of the United States has launched a research project on the swarm tactic as a method of operation whereby the drones' nature as an autonomous weapon becomes particularly clear.¹⁰¹ This project is focusing on the point that a drone swarm is robust compared with remotely controlled individual drones in that drones within the swarm can share information among themselves without constantly receiving information and instructions from remote places.

The most promising countermeasure against drones so far taken is conducting electronic interference against locational information signals and instruction signals sent to drones.¹⁰² Although other countermeasures, such as physical destruction using a directional energy weapon,¹⁰³ also have been conceived, it is uncertain whether anti-drone weapons that have entered service¹⁰⁴ can deal with swarms of 500 or 1,000 drones. It must be pointed out that the swarm tactic has been conceived with a view to gaining an overwhelming numerical superiority in the first place.

As a result, some experts advocate the idea of responding to a swarm with a swarm. The United States and China are the outstanding leaders in that respect. In particular, China has already succeeded in controlling a swarm of around 2,000 drones in swarm demonstrations at various non-military attraction events.¹⁰⁵ Japan should acknowledge that it is lagging far behind in this field and devote efforts to enhancing technological development and operational proficiency in terms of practical use of drones with a view to promoting use of drones for a broad range of civilian purposes, rather than relying only on military

applications.¹⁰⁶

In that sense, it is essential to make active use of drones for delivery of goods and at various attraction events. The government will probably be able to give a strong push to the practical use of drones by actively introducing some form of tax break for businesses using drones, just as it did in order to promote the development of car engines with ultra-high fuel efficiency as part of the policy to encourage the use of eco-friendly cars, to cite a recent example.¹⁰⁷

We must not forget that drones are predicted to replace manned fighter aircraft as future generations of attack aircraft essentially because there is an abundance of seeds for technological innovation due to their small size, low cost, and "generic" nature, which means that they are based on familiar technology. Large, complex, costly military assets can be developed and operated only by regular military forces. However, at a time when technologies focusing on providing new functions without being bound by precedents are attracting increasing attention, emphasis should be placed on joint technological development by the military and civilian sectors.¹⁰⁸ In that case, it is important to consider how to encourage further development of drone technology in the civilian sector, rather than focusing on drones' military contributions.¹⁰⁹ If drones are not applied to military purposes, that would be the best scenario.

From the perspective of strategy, it is presumed that leaving it ambiguous whether a particular asset is intended for military or civilian applications will help to enhance the deterrence effect. What is important is what the asset can perform, not to whom it belongs or by whom it is managed. Naturally, the distinction

between civilian and military applications should be made where necessary. However, as indicated by the car rental and sharing businesses' encroachment on the car market, the necessary approach is to focus attention on assets' functions and distinguish between those that can be performed and those that cannot.

Conclusion

In preparation for the introduction of the Global Hawk by the ASDF, a provisional reconnaissance squadron was organized in March 2021, with full-fledged operation of drones set to start soon.¹¹⁰ After the deployment of the Global Hawk, it will be important to consider and continue reviewing its position under air power strategy while accumulating operational experiences.¹¹¹

As my analysis in this paper showed, air power strategy, which assumes the exercise mainly of an outstanding breakthrough capability through air power, will be enhanced as a result of the introduction of drones as an additional strategic element. Moreover, it has become clear that if drones are to be operated in a swarm, it will be necessary to consider countermeasures against possible threats to swarm operations.

In addition, regarding the role that may be performed by drones in exercising the function of political coercion under air power strategy, the question is not whether or not the level of drones' deterrence function can match the level of the deterrence function of nuclear weapons or other weapons of mass destruction. The development of drones has reached the stage where a certain level of deterrence can be expected.

Regarding air power, including not only drones but also other assets, and other combat forces that are expected to have the

power to determine the course of war, emphasis should be placed on what functions can be performed. Therefore, it is necessary to have a strong consciousness about the need to develop an organizational environment that enables creative execution of strategy without stifling new ideas and operational visions by imposing fixed ideas and prejudices. As was shown in the case of the arguments over the possibility of drones replacing manned aircraft in the United States, it is essential to develop an environment that encourages flexible thinking in addition to promoting technological innovation if new technologies are to lead to rethinking of strategy.

Roughly speaking, the above is an overview of drones as a game-changer. Drones have the potential to dramatically change traditional air power strategy, and the potential is about to go beyond the realm of theoretical possibility and turn into reality. In that regard, Japan's air power must not lag farther behind other countries' air power.¹¹²

Table 1 Major modern air battles classified into five categories

I. Preparation of the battlefield	II. Close air support (CAS) / air interdiction to ongoing operations	III. Primary strategic effect	IV. Political coercion	V. Other operations (in which air power played no significant combat role, or a humanitarian role)
First Gulf War 1990-1991	Somalia Intervention by US 1992-1995	Afghanistan War (Phase 1) 2001-2002	US-led no-fly zones campaign in Iraq 1991-2003	Rwanda civil war 1994
Second Gulf War 2003	Bosnia campaign (end of UN Protection Force (UNPROFOR phase) 1995	Libya operation 2011	Bosnia campaign (end of UNPROFOR phase) 1995	US intervention in Haiti 1994
	Sierra Leone operation 2000	Israeli air strikes inside Syria 2013-ongoing	Russian anti-separatist campaigns in Chechnya 1994-1996, 1999-2000	Italian-led intervention in Albania 1997
	Second Gulf War 2003	Anti-Islamic State coalition in Iraq and Syria 2014-2018	Kosovo campaign 1999	Australian-led intervention in East Timor 1999-2000
	Afghanistan War (Phase 2) 2006-2014	Saudi-led air operations in Yemen 2015-ongoing	Russian war against Georgia 2008	NATO intervention in Macedonia 2001
	French-led intervention in Mali 2012-2014	US-led counter terrorist drone operations in South Asia, Somalia, Levant, Yemen and Libya 2010-ongoing	Russian operations in eastern Ukraine 2014-ongoing	French intervention in Côte d'Ivoire 2004
	Anti-Islamic State coalition in Iraq and Syria 2014-2018	Russian operations to support Syrian government 2015-ongoing		

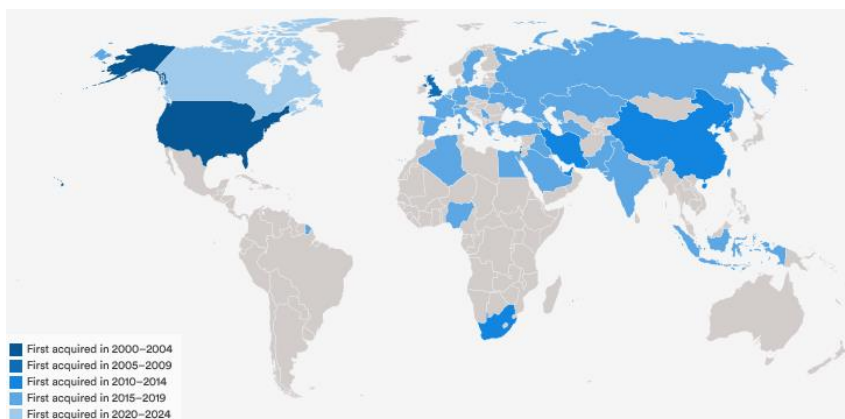
Source: Michael Clarke, "Combat Air Power and Political Effect," John Andreas Olsen ed. Routledge Handbook of Air Power, Routledge, 2018, p. 231: Table 19.1 "Modern air warfare five categories."

Table 2 Major self-assembled drones in Ukraine and their specifications (as of 2015)

PD-1: People's Drone 1	<p>Wingspan: 3 meters</p> <p>Flight range: 30 kilometers</p> <p>Camera angle stabilizing gimbal</p> <p>Encoded video signals</p> <p>Remote distance measurement</p> <p>Function of making an autonomous return in the event of loss of GPS signal</p>
RVJET	<p>Wingspan: 1.95 meters</p> <p>Flight range: 30 kilometers</p> <p>Flight altitude 50 to 2,000 meters</p> <p>High-quality camera</p> <p>Long-distance transmission of video signals</p> <p>Remote distance measurement</p>
Octocopter	<p>Flight range: 10 kilometers</p> <p>Flight altitude: 50 to 2,000 meters</p> <p>An optical lens with a magnification power of 30x and an infrared camera</p> <p>3D gimbal</p>
Phantom	<p>Flight altitude: 5 to 300 meters</p> <p>Flight range: 4 kilometers</p> <p>Signal amplifier</p>

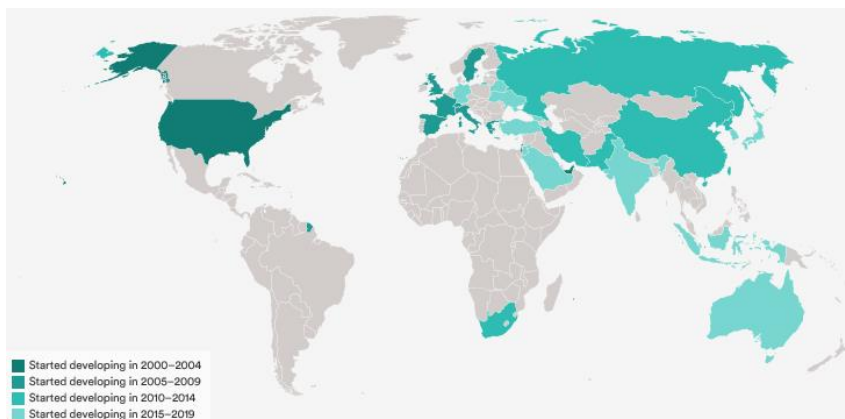
Source:<https://www.defenseone.com/technology/2015/03/ukraine-tomorrows-drone-war-alive-today/107085/>.

Figure 1 Countries owning drones with attack capability



Source:<https://www.newamerica.org/international-security/reports/world-drones/who-has-what-countries-with-armed-drones/>.

Figure 2 Countries that have developed drones with attack capability



Source:<https://www.newamerica.org/international-security/reports/world-drones/who-has-what-countries-developing-armed-drones>.

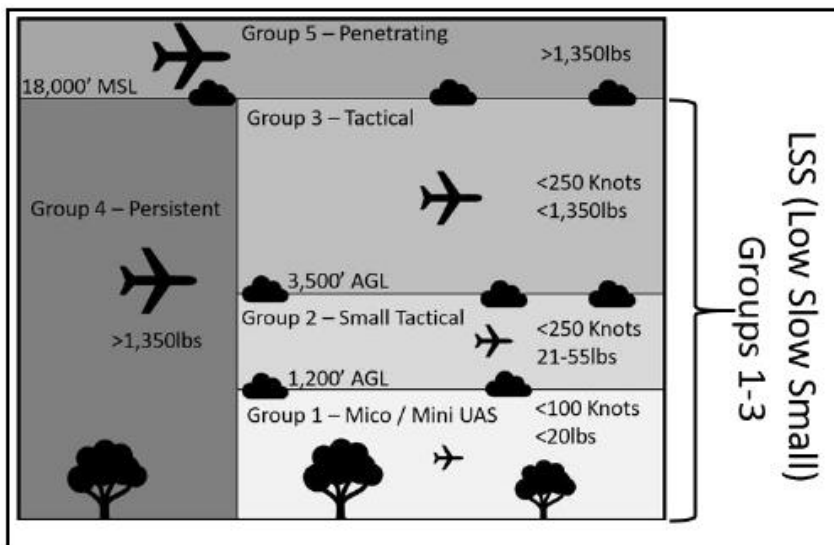
Figure 3 A video of a swarm operation demonstration test conducted by the People's Liberation Army

(The video shows the fixed wings opening while the drone was flying after being launched.)



Source: "Swarm," China Electronics Technology, September 2020,
https://www.youtube.com/watch?v=JUG5GZqtkA&feature=emb_logo.

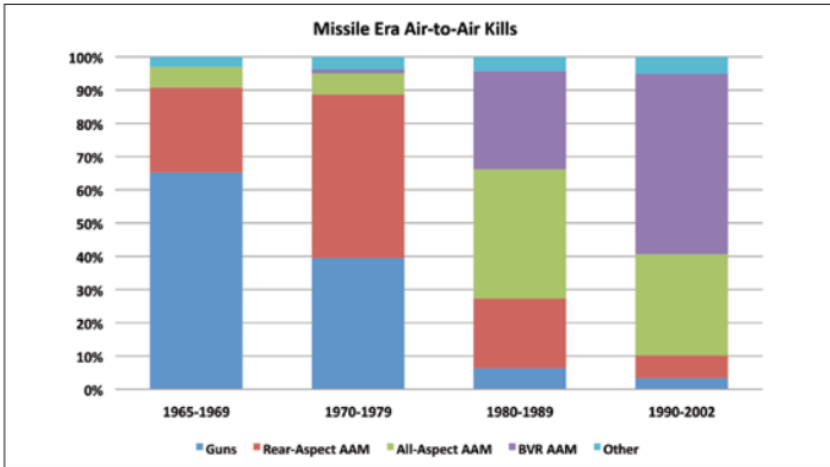
Figure 4 Classification of drones



Source: US Army MAJ Jason M. Kowrach, US Army Counter Unmanned Aerial Systems: More Doctrine Needed, School of Advanced Military Studies, US Army Command and General Staff College Fort Leavenworth, KS, 2018, p. 5, <https://apps.dtic.mil/sti/pdfs/AD1071111.pdf>.

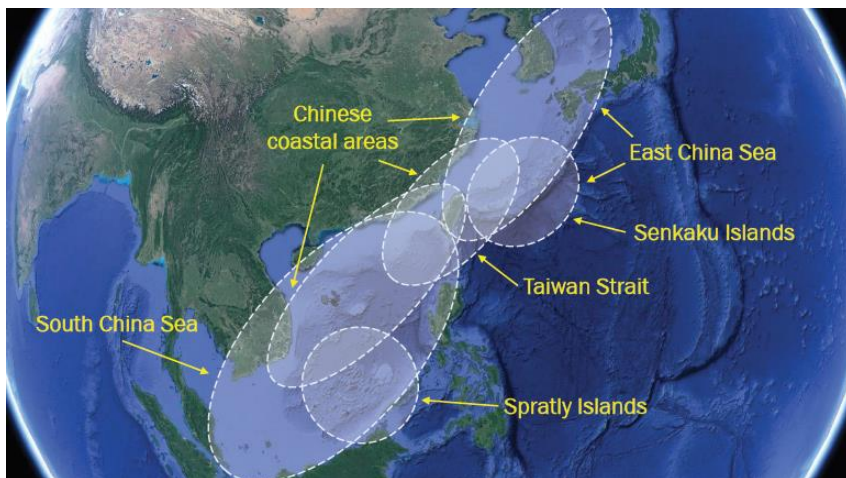
Figure 5 Changes in weapons with decisive power in fighter-to-fighter aerial combat

FIGURE 1. MISSILE-ERA AIR-TO-AIR KILLS



Source: John Stillion, *Trends in Air to Air Combat: Implications for Future Air Superiority*, CSBA, 2015, p. ii.

Figure 6 Proposed West Pacific areas to be covered by drone surveillance



Source: Thomas G. Mahnken et.al, Deterrence by Detection: A Key Role for Unmanned Aircraft Systems in Great Power Competition, CSBA, 2020, p. 30.

Figure 7 A demonstration of a swarm of 2,000 drones in Shanghai



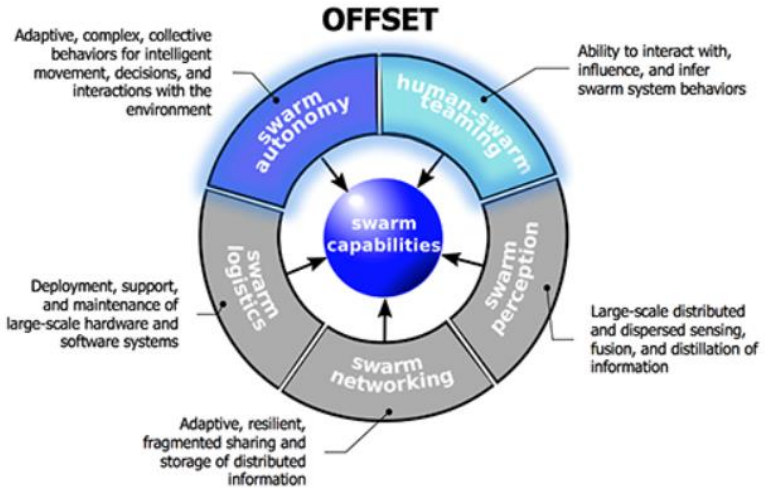
Source: <https://www.youtube.com/watch?v=Zh3-Mvrp1Lc>.

Figure 8 Assessment of autonomy by asset (spectrum)

Decreasing human control				
Inert system	Remotely controlled system	Automated system	Autonomous system	Highly intelligent autonomous system
SABO assault rifle	Hellfire missile	Phalanx close-in weapon system	Taranis drone?	Yet to be designed

Source: Peter Burt, Off the Leash: The Development of autonomous Military Drones in the UK, Drone Wars UK, November 2018, p. 12, <https://dronewarsuk.files.wordpress.com/2018/11/dw-leash-web.pdf>.

Figure 9 Concept of DARPA's OFFSET (OFFensive Swarm-Enabled Tactics) research program Towards Autonomous Swarm Capabilities



Discover and Develop Novel Swarm Tactics

Goal: *Design a tactics-focused game to rapidly explore, evolve, and evaluate swarm tactics*

Source:<https://www.darpa.mil/work-with-us/offensive-swarm-enabled-tactics>.

Figure 10 Image of autonomous drones acting as wingmen(Royal Air Force)



Source: https://defense-update.com/20201008_ew-swarm.html.

Figure 11 Appearance of an anti-drone directional energy weapon



Source:

https://www.defenseworld.net/news/27051/Laser_Weapon_Fired_from_US_Warship_Destroyes_Target_Drone.

¹ According to Akiyama Masayuki's argument, (defense) strategy represents the sum of tactics to defeat the enemy. Akiyama also distinguishes strategies involving multiple service branches from ones undertaken individually by different branches, calling them "grand strategies." However, this classification is merely a conceptual one, and in actual military campaigns, particularly in modern war, it is impossible to make a clear distinction between those two sorts of strategies. See Akiyama, Masayuki (ed. Todaka Kazushige), *Kaigun Ouyo Senjyutsu/Kaigun Senmu*, Chuokoron-Shinsha, 1903, (published in 2019), pp.14-15; Yamamoto, Satoshi, "Sheringu No Yokushi Riron," *Air Power Studies*, No. 6, 2019, Note 33 (p.104); Among prominent strategists, there is no authoritative consensus on the classification of grand strategy, strategy, campaign, and tactics. However, roughly speaking, However, efforts have been made by those who have experienced (aerial) combat to make use of their knowledge (e.g., knowledge of "air campaigns" as referred to by Warden) to work out and consider broader national strategies. It has been expected that through those efforts, refined discussions on classification will be held. Regarding major changes in and stratified understanding of strategic thinking, see Komori Atsushi, "Duue to Waaden no Riron," and Ishizu Tomoyuki, and Yamashita Aihito (eds.), *Ea Powaa—Sora to Uchuu no Senryaku Genron*, Nikkei Business Publication, 2019, p. 240.

² It was in 1911 that aircraft were used as a means of war for the first time ever. The view that air power has a history of around 100 years is based on ideas advocated since the interwar years by W. Mitchell, G. Douhet, and other visionaries who had particularly pioneering ideas among those who witnessed the performance of aircraft in actual combat following the first deployment of aircraft in war. The term "air power" was used by Mitchell in 1925. See William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power-Economic and Military*, G.P. Putnam's Sons, 1925; on the other hand, some experts argue that clear awareness about air power in the modern sense—i.e., a force seen in the context of strategy—first arose within the U.S. military, which developed the lessons of the Vietnam War into an air power concept by the Gulf War in 1991. Benjamin Lambeth (trans. Sakata Yasuhiro) "Dai Issho Ea Pawaa no Bunseki," and Ishizu and Yamashita (eds.), *Ea Powaa—Sora to Uchuu no Senryaku Genron* (Note 1), pp.1-22.

³ Regarding the classification of the functions of air power, the point of

emphasis varies across experts. However, that the breakthrough function (and the maneuverability, which is the prerequisite for breakthrough) is the most important has been regarded as a given. It is also popular to regard functions used in joint operations with other service branches, such as close air support (CAS), as being among the air power's most important functions together with the breakthrough function. Takahashi Hideyuki, "Duue to Mitcheru—Senkanki ni Okeru Ea Powaa Riron no Soushisha," Ishizu and Yamashita (eds.), *Ea Powaa—Sora to Uchuu no Senryaku Genron* (Note 1) pp.52-56; As will be mentioned later, Clarke also classified close air support as a function of air power in the modern sense (a function which has continued to be significant until now).

⁴ Also referred to as UAS (unmanned aerial system), with drones regarded as part of a system. UAS is the whole of a system, such as an information network necessary for UAVs to exercise their functions. It is said that in the U.S. military, the term UAS is used in order to emphasize the component aspect of UAVs—that UAVs are merely part of a remotely controlled system—as opposed to the concept of UAVs as independent aircraft.

⁵ In a report published at the end of 2018, RUSI of the United Kingdom pointed out that while the United States had imposed various restrictions on exports of drones, China had exported drones to Middle East countries (Jordan, Iraq, Saudi Arabia, and the UAE). This point is important in that it means Chinese-made drones have gained broad opportunities for practical use (demonstration tests conducted through deployment for actual combat). See Aniseh Bassiri Tabrizi and Justin Bronk, *Occasional Paper: Armed Drones in the Middle East –Proliferation and Norms in the Region*, RUSI, 2018, p.39.

⁶ For example, Iwamoto (2019) provided an overview of the characteristics and properties of drones before discussing arms control regarding drones, but his study did not make clear how drones are used for strategic purposes. See Iwamoto Seigo, "Gunyou Doroon wo Meguru Gunbi Kanri no Genjo to Kadai," Japan Association of Disarmament Studies (ed.), *Gunshuku Fukakusan no Shosou*, Shinzansha Publisher, 2019, pp.373-375.

⁷ ""4Ds" stand for "dangerous," "dirty," "dull," and "deep." These are all properties which are considered to be absent in manned aircraft and which are unique to drones. However, of the "4Ds," "deep" is a property that may be present in aircraft in general. Therefore, in the case of drones in

particular, "difficult" (resistance against difficulty = appropriate implementation of complex processes), or "dear" (usefulness = reduction of expenses and delays) should be considered to be the fourth "D." As "deep" is a property that may be present in aircraft in general, including both manned and unmanned aircraft, it refers to the function of easily crossing defense lines or frontlines with a superior breakthrough capability and striking the heart of the enemy. Moreover, in the case of drones, the important point is that they can intrude deeper into enemy territory than manned aircraft, as there is no need to give consideration to pilot safety. As will be mentioned later, this is a function on which particular attention is focused in this paper.

⁸ According to Dr. Harry Yarger, "the role of the strategist is to exercise influence over the volatility, manage the uncertainty, simplify the complexity, and resolve the ambiguity, all in terms favorable to the interests of the state and in compliance with policy guidance." This idea was cited as the basic concept in the defining and clarification of the term "strategy" in the U.S. military's "Joint Doctrine." Joint Chiefs of Staff, JDN 2-19, Strategy, December 2019, p.II-1.

⁹ At the time of the accident at the Fukushima Daiichi Nuclear Power Station on March 11, 2011, the U.S. military flew a Northrop Grumman Global Hawk (RQ4) in the sky over the nuclear facilities in order to identify the damage status. As the altitude at which the Global Hawk flew was not revealed, it is uncertain whether or not the unmanned aircraft flew right over the facilities. However, this was a typical case of operating an unmanned aircraft drone without the need to give consideration to possible radiation damage to pilot health unlike if manned aircraft were used for such missions. The 1st Helicopter Brigade under the Ground Self-Defense Force's Central Readiness Force flew two helicopters (CH-47Js) over the nuclear facilities and carried out an operation to dump sea water.

"Kimeru"—7,500 Rittoru Ikki Genshiro Housui Saku," web version of Nihon Keizai Shimbun, March 11, 2016, <https://www.nikkei.com/article/DGXMZO98208240Z00C16A3970M00/>.

¹⁰ In this respect, for example, Mark Moyar—who pointed out that the drastic reduction of defense spending started by the administration of Barack Obama, who achieved a change of government after criticizing the Bush administration's various policies, immediately after his inauguration in January 2009, was the main cause of the political retreat of the second

Obama administration—emphasized the limitations of the strategy of making overly frequent use of target killing using drones in the context of the war on terrorism. This was a rebuke against the Obama administration for having adopted lopsided strategies as it was ultimately constrained by its eagerness to replace the Bush administration's initiatives with his own. See Mark Moyar, *Strategic Failure: How President Obama's Drone Warfare, Defense Cuts, and Military Amateurism Have Imperiled America*, Threshold Editions, 2015.

¹¹ Michael Boyle comprehensively discussed the possibilities and limitations of drones, including the current situation and forecasting of the future. See Michael J. Boyle, *The Drone Age: How Drone Technology Will Change War and Peace*, Oxford University Press, 2020.

¹² Matthew T. Tedesco, "Countering the Unmanned Aircraft System Threat," *Military Review*, November-December 2015, p. 64.

¹³ This was part of FBI Director Christopher Wray's reply to a question from Senator John Verhoeven from North Dakota. The assessment was given at the same time as his opinion that while drones could be easily used for attacks, it was difficult to intercept them or crack down on their use. See Haye Kesteloo, "Terrorists drone attacks are coming to the US 'imminently', warns FBI director," DroneDJ, October 11, 2017.

¹⁴ *National Defense Authorization Act of 2017*, Senate –Armed Services, 114th Cong., Senate Bill 2943, <https://www.congress.gov/bill/114th-congress/senate-bill/2943/text>.

¹⁵ It goes without saying that air power is not possessed only by air forces. In Japan's case, for example, the Atsugi and Iwakuni air bases are under the jurisdiction of the Maritime Self-Defense Force, while the 1st Airborne Brigade belongs to the Ground Self-Defense Force. In the early years of air power, while Douhet and Mitchell conceived the creation of an independent air force, air power extending across service branches was developed and maintained in accordance with the expansion of the scope of functions required by the existing service branches. When conceiving the vision of air power, it is necessary to exercise creative thinking and have a comprehensive perspective, bearing in mind the possibility of deploying assets across multiple services or making flexible use of civilian technologies and assets.

¹⁶ Michael Clarke, "Combat Air Power and Political Effect," John Andreas Olsen ed. *Routledge Handbook of Air Power*, Routledge, 2018, p.231:

Table 19.1 "Modern air warfare – five categories."

¹⁷ The operations explicitly referred to here are close air support (CAS) and interdiction (INT). Although it has been pointed out that it is becoming difficult to distinguish between these two operations because of the blurring of battlelines, they are distinguished under this classification. Battlefield air interdiction, which is planned mainly from the perspective of ground combat, may be treated as the same category of operation as CAS.

¹⁸ The primary strategic effect refers to the effects of functions that may affect the course of the entire war, such as strategic bombing and gaining air superiority, rather than the effects of functions that may affect the course of local battles.

¹⁹ See Table 1 at the end of the text.

²⁰ For example, the following document pointed out that although the importance of gaining air superiority has been generally accepted under operational plans of air forces around the world, in the early years of air power, battles were fought with only a vague awareness about that. Benjamin Franklin Cooling, *Case Studies in the Achievement of Air Superiority*, Air Force History and Museums Program, 1994.

²¹ Jay Silveria, "Air Force Academy leader: Why diversity?," *CNN Opinion*, February 14, 2018; Ken Chamberlain, "Lt. Gen. Jay Silveria: Diversity is a 'force multiplier'," *AirForceTimes*, February 14, 2018.

²² The present number of countries owning military drones equipped at least with reconnaissance capability, regardless of the presence or absence of attack capability, is said to be higher than 100. *Nihon Keizai Shimbun*, August 27, 2020, morning edition, 2nd page.

²³ See Figures 1 and 2 at the end of the text.

²⁴ Dan Sabbagh and Bethan McKernan, "Revealed: how UK technology fueled Turkey's rise to global drone power – UK-based manufacturer supplied crucial missile component to Turkish drone-maker during development stage," *The Guardian*, November 27, 2019, <https://www.theguardian.com/news/2019/nov/27/revealed-uk-technology-turkey-rise-global-drone-power>.

²⁵ Ali Bakeer, "The fight for Syria's skies: Turkey challenges Russia with new drone doctrine," MEI, March 26, 2020, <https://www.mei.edu/publications/fight-syrias-skies-turkey-challenges-russia-new-drone-doctrine>.

²⁶ Sabbagh and McKernan, *supra* note 24. At that time, the Turkish Ministry of National Defense published a video of a drone hitting a target after penetrating the protective shield of the Pantsir Air Defense System, a short-range anti-missile defense system developed by Russia to guard against precision attacks by missiles flying at low altitudes. *ibid.*; Also See "Countries pay top dollar for Russian-made short/medium range air defense systems. Are they really effective?" @clashreport, March 10, 2020, <https://twitter.com/clashreport/status/1237100080773169159?s=20>.

²⁷ See Figure 4 at the end of the text. Typical examples of MALE (medium altitude long endurance) drones are the Reaper of the United States and the Orion of Russia. Orion is said to have been used for both reconnaissance and attack missions. Igor Rozin "Russian Military Introduces a New Attack Drone," *Russia Beyond*, November 15, 2019.

²⁸ US Army MAJ Jason M. Kowrach, *US Army Counter-Unmanned Aerial Systems: More Doctrine Needed*, School of Advanced Military Studies, US Army Command and General Staff College Fort Leavenworth, KS, 2018, pp. 11-12, <https://apps.dtic.mil/sti/pdfs/AD1071111.pdf>.

²⁹ Drones larger than the MALE class have a sufficient payload to carry weapons in many cases. In the case of the Predator and its high-performance successor, the Reaper, there are both RQ and MQ types. Under the U.S. classification, RQ refers to drones for reconnaissance missions and MQ refers to those for attack missions.

³⁰ It is said that the first time that a powered attack drone, as opposed to a glider drone, was deployed in actual combat was in the Yugoslav conflict in 1995. See Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 2005, p. 479; Some war historians argue that the first unmanned aircraft used for a military attack is the balloon deployed by Austria in 1847 in order to strike Venetia. Although that argument may be valid depending on the definition of unmanned aircraft, the balloon does not meet the modern definition of the term, i.e., aircraft based on robotics technology. Among early examples that may meet the modern definition is a little-known unmanned aircraft called Scout (also known as Oriole), which was made by IAI, an Israeli state-run company, and which was deployed by the South African military in 1981 in the war with Angola. One well-known recent case of a drone strike is the attack by MQ-9 of the United States on January 3, 2020, that killed Qasem Soleimani, the commander of the Iranian Islamic Revolutionary Guard. See Zachary

Cohen et.al., "US drone strike ordered by Trump kills top Iranian commander in Baghdad." CNN, January 3, 2020, <https://edition.cnn.com/2020/01/02/middleeast/baghdad-airport-rockets/index.html>.

³¹ For example, the U.S. Army published a document that provides an overview of its drone strategy (including procedures that usually come to mind in relation to aerial operations, such as detection, identification, mission command and defeat). See United States Army, *Counter-Unmanned Aerial System (C-UAS) Strategy Extract*, 2016, <http://www.ssri-.com/MediaReport/DocumentUS/ArmyCUASStrategy.pdf>.

³² See "Ukraine and Russia agree to implement ceasefire," *BBC News*, December 10, 2019.

³³ It is said that the prototype Tu-141 was manufactured in 1974 and that mass production started in 1979. Robert Beckhusen, "Ukraine Resurrects Soviet-Era Super Drones: Kiev's Tu-141 unmanned vehicles," *War is Boring*, June 5 2014, <https://medium.com/war-is-boring/ukraine-resurrects-soviet-era-super-drones-3403f80c51ba>.

³⁴ According to TASS, the Russian state-run news agency, Russia has already put drones intended for the swarm tactic into service. In September 2020, Russia executed a simulated swarm tactic, operating a swarm of drones deployed by the Southern Military District, including Forpost, Orlan-10, and Eleron-3 at altitudes of 100 to 5,000 meters during Kavkaz2020, a large-scale international military exercise in which a total of 80,000 personnel participated. The drones were tasked with enemy search, a function previously performed by manned aircraft. The swarm tactic makes it possible to quickly and accurately detect and identify targets without exposing crews to risks. See "Russia trials swarming reconnaissance drones during Kavkaz-2020 military exercise," *UNMANNED AIRSPACE*, September 24, 2020, <https://www.unmannedairspace.info/counter-uas-systems-and-policies/russia-trials-swarming-reconnaissance-drones-during-kavkaz-2020-military-exercise/>; See also, Xavier Vavasseur, "Russia's Forpost UAV Designates Naval Targets During Black Sea Fleet Maneuvers," *NavalNews*, August 2020, <https://www.navalnews.com/naval-news/2020/08/russias-forpost-uav-designates-naval-targets-during-black-sea-fleet-maneuvers/>; Forpost is said to be an improved version of the Israeli-developed IAI Sercher II, for which Russia acquired a license in

2010. It is a large drone weighing 450 kilograms which has a flight duration of more than 18 hours. Equipped with high-performance optical sensor and communication functions, Forpost played a significant role in identifying targets of cruise missiles and confirming the results of the missile strikes when the Russian Navy launched attacks on terrorist forces during the civil war in Syria. In the abovementioned military exercise, conducted in the Black Sea, it is said that the enemy search operation conducted by Forposts belonging to the Russian Navy enabled accurate missile launches from Su-24 M bombers and Su-30SM fighters.

³⁵ John Wendle, "The Fighting Drones of Ukraine: In garages and warehouses around Kiev, an army of gadgeteers, takes on Russian war machine," *Air & Space Magazine*, February 2018, <https://www.airspacemag.com/flight-today/ukraines-drones-180967708/>.

³⁶ Ibid.

³⁷ In Japan, the waning popularity of STEM majors and subjects has long been pointed out not only as a problem in the narrow context of development of advanced technology or industrial competitiveness but also as a matter of concern for wider society. That is because of the underlying public perception that gaining national strength as a technology-oriented country, a path consistently pursued by Japan since the Meiji Period (1868-77), still remains a desirable policy direction. As an indication of that perception, the Cabinet Office, for example, has continuously conducted statistical surveys such as the Social Survey on Science and Technology, and many experts discuss the appropriateness of Japan's science and technology policy in reference to the survey results, particularly changes in the perceptions of young people.

³⁸ Joseph Trevithick, "America is Still Training Ukrainian Troops to Fly a Drone They Hate," *The War Zone*, April 4, 2017, <https://www.thedrive.com/the-war-zone/8921/america-is-still-training-ukrainian-troops-to-fly-a-drone-they-hate>.

³⁹ Ibid. It has also been pointed out that Chinese drones have come to be used because not only the United States but also Germany and France have refrained from engaging in drone-related trade with Ukraine due to concerns over a possible deterioration of relations with Russia.

⁴⁰ One major drone made by Matrix UAV is Katana, which has been deployed for the purpose of frontline surveillance. The quality level of Matrix UAV's drones has continued to improve. For example, the company

has also developed a drone capable of launching an attack on a target 90 kilometers away. See "Grenade Launching Drone from Ukraine," *Liteye*, August 20, 2018, <https://liteye.com/grenade-launching-drone-from-ukraine/>.

⁴¹ An article dated January 31, 2021. The company succeeded in developing a small drone called Берегиня, which has a flight range of 12 kilometers and which is capable of reaching an altitude of 100 meters in three seconds and withstanding winds of up to 20 meters per second. See [Ukroboronprom.com.ua](https://ukroboronprom.com.ua), January 2020, <https://ukroboronprom.com.ua/uk/media/ukrayinskym-vijskovym-prezentuvaly-rozrobku-pershogo-rozviduvalnogo-ukrayinskogo-kvadrokoptera-beregynya.html>.

⁴² As for major self-assembled drones in Ukraine, see Table 2 at the end of the text.

⁴³ The crowdfunding initiative achieved its fund-raising target of 27,600 US dollars (approx. 3 million yen), leading to the manufacturing and deployment in actual combat of a drone called PD-1. "People's Project: Ukraine's Military and Civil Crowdfunding," last updated on October 31, 2016, <https://www.peoplesproject.com/en/first-peoples-uav-complex/>. Information on the initiative can be obtained from a video interview with the group of people involved in the manufacturing of the drone. See "Ukraine's Crowdfunded Military Drone," June 18, 2015, <https://www.youtube.com/watch?v=CK4myw8PQKk>.

⁴⁴ PD-1 is said to be a reconnaissance drone which has a wingspan of approx. 3 meters and a flight range of approx. 35 kilometers and which is equipped with electronic components such as an infrared camera and an encoded video link. Dan Peleschuk, "Ukraine is fighting a drone war, too," *The World*, <https://www.pri.org/stories/ukraine-fighting-drone-war-too>.

⁴⁵ Pavel Polityuk, "Ukraine sees Russian hand in ammo warehouse blasts," *Reuters*, March 23, 2017, <https://www.reuters.com/article/us-ukraine-crisis-blast/ukraine-sees-russian-hand-in-ammo-warehouse-blasts-idUSKBN16U0N8>.

⁴⁶ The Reaper is an improved version of the Predator (MQ-1). It was in October 2007 that the Reaper, armed with Hellfire missiles, launched its first attack in actual combat in Afghanistan. See the following, which pointed out that the Obama administration was taking care to conceal or refrain from commenting on facts of drone attacks at that time, including

the abovementioned one: Tim Ripley, *Air War Afghanistan: US and NATO Air Operations from 2001*, Pen & Sword Books, 2011, pp. 10, 187.

⁴⁷ Patrick Tucker, "In Ukraine, Tomorrow's Drone War is Alive Today," *Defense One*, March 9, 2015, <https://www.defenseone.com/technology/2015/03/ukraine-tomorrows-drone-war-alive-today/107085/>.

⁴⁸ The "cost" as referred to here represents a comprehensive concept of various items. It may be divided into the following three items: (1) blood (human lives), (2) treasure, or financial cost, and (3) reputation. See Amy Zegart, "Cheap fights, credible threats: The future of armed drones and coercion," *Journal of Strategic Studies*, Vol. 43, No. 1, 2020, p. 15.

⁴⁹ However, apart from safety issues, ethical problems related to the absence of the pilot from the battlefield, including a phenomenon known as the "PlayStation effect," are often pointed out. Moreover, it is often pointed out that the absence of involvement of any crew member whose life may be exposed to risks is encouraging early use of force. See Eduardo Sepulveda and Howard Smith, "Technology Challenges of Stealth Unmanned Combat Aerial Vehicles," *Aeronautical Journal*, June 2017, <https://www.researchgate.net/publication/317835667>.

⁵⁰ Tucker, supra note 47.

⁵¹ Some papers pointed out the possibility of introducing blockchain technology into communication. Richard Uber, "Penetrating Artificial Intelligence-enhanced Anti-access/Area Denial: A Challenge for Tomorrow's Pacific Air Forces," *Journal of Indo-Pacific Affairs*, Winter 2020, pp. 54-65.

⁵² Some countries, such as the United Kingdom, have taken the position that the use of autonomous weapons that do not involve any human control should be prohibited while pointing out the risks that are involved not only in drones but in autonomous weapons in general. Peter Burt, *Off the Leash: The Development of Autonomous Military Drones in the UK*, *Drone Wars UK*, November 2018, p.57,

<https://dronewarsuk.files.wordpress.com/2018/11/dw-leash-web.pdf>.

Although countries taking that position aim for or forecast further sophistication of the intelligence of autonomous weapons in the future, they have not made any predictive reference to fully autonomous weapons. See Figure 8 at the end of the text.

⁵³ It is said that this was the largest-scale attack on oil facilities since the

Iraqi forces under Saddam Hussein struck oil facilities in Kuwait during the 1990-1991 Gulf War. See Stephen Kalin and Sylvia Westall, "Costly Saudi defenses prove no match for drones, cruise missiles," *Reuters*, September 18, 2019.

⁵⁴ According to one estimate, the amount of financial damage caused to Saudi Aramco came to 31 billion dollars. Moreover, the scale of damage due to factors such as the waning of investment appetite following the postponement of Saudi Aramco's planned initial public offering (IPO) cannot be easily calculated. Hara Kazuhiko, *Sauji Kokuei Sekiyu Shisetsu Doroon Kogeki de Jindai na Higai—Genyu Yunyu Izon Suru Nippon Sekiyu Kikimo*," Research Institute of Economy, Trade and Industry, September 27, 2019, <https://www.rieti.go.jp/jp/papers/contribution/fuji-kazuhiko/125.html>.

⁵⁵ "Mujinki Taisaku, Kenkyu Isogu Boeisho, *Sauji Kogeki de Hakusha*," *Nihon Keizai Shimbun*, October 1, 2019.

⁵⁶ Ibid.

⁵⁷ Roger Claire, "Iraku Genshiro Kogeki!," Takasawa Ichiro (trans.), Namiki Shobo, 2007. The Iraqi government under Saddam Hussein asserted that the construction of nuclear facilities was intended for electric power development, but Israel suspected the possibility of the facilities being converted to military use and launched an attack on them in the name of "preemptive self-defense." The U.N. Security Council condemned the Israeli attack under UN Security Council Resolution 487.

⁵⁸ See Kalin and Westall, *supra* note 53.

⁵⁹ Several companies claim to have developed radar systems capable of dealing with drones of the LSS type (Figure 4 at the end of the text). For example, the ELVIRA radar system, developed by Robin Radar Systems of the Netherlands, is said to have a full 360-degree coverage and be capable of detecting drones of the LSS type. See Robin Radar, *The making of our new drone radar: IRIS*, <https://www.robinradar.com/drone-detection-radar>.

⁶⁰ Located approx. 50 kilometers South of London.

⁶¹ This was the first such large-scale shutdown since the one at the time of a huge volcanic eruption in Iceland in 2010, and it is said to have affected 1,000 flights and 140,000 passengers.

⁶² According to the authorities, two drones intruded into an area within a 5-mile radius of the runway but any act of terrorism was not recognized. In response to a request from the Sussex police, under whose jurisdiction the

airport was, military personnel were mobilized on the second day of the shutdown, December 20, but the intrusion by the drones continued into late night the same day. As a result, the airport remained completely shut down until some functions were restarted at 6 a.m. the following day, December 21 (it took one more day before full reopening of the airport). See Sheena McKenzie and Gianluca Mezzofiore, "Police hunt drone pilots in unprecedented Gatwick Airport disruption," *CNN*, December 20, 2018, <https://edition.cnn.com/2018/12/20/uk/gatwick-airport-drones-gbr-intl/index.html>.

⁶³ The investigation was muddled from the beginning to the end. For example, although two residents in the neighborhood of the airport were arrested and detained, their arrests were later found to be wrongful. A large amount of compensation was paid to the exonerated suspects.

⁶⁴ Ulrich Beck, *Risikogesellschaft: Auf dem Weg in eine andere Moderne*, Frankfurt am Main: Suhrkamp, 1986 and Ito Midori (trans.), *Risuku Shakai—Atarashii Kindai Heno Michi*, Hosei University Press, 1998). According to the concept of "risk society" proposed by Beck in the 1980s, modern society took risks in its pursuit of affluence, and as a result of the distribution of the risks throughout society, human lives and society itself have come under threat. It so happened that immediately after the publication of the book, the Chernobyl nuclear power station accident occurred, raising the questions of what should be done about modern society as it precariously navigates through risks and how the responsibility for the damage done should be distributed.

⁶⁵ "Once they realize they can have this guardian angel above them, they want it all the time." David A. Fulghum, "UAV Boom Continues," *Aviation Week*, February 4, 2008, p. 51.

⁶⁶ It is not only drones that are operated as a swarm. The U.S. Air Force Research Laboratory has conceived a plan to use subsonic cruise missiles as a swarm, and Lockheed Martin is developing a missile for that purpose, called the Gray Wolf. It is assumed that while individual cruise missiles cannot break through the enemy's air defense, the evasion rate of a swarm of Gray Wolf missiles is expected to be improved as the missiles immediately share among them the information collected on the enemy's radar.

⁶⁷ See Figure 3 at the end of the text. Liu Xuanzun, "China unveils first

practical drone swarm tech 'to be used in amphibious landing missions'," *Global Times*, October 18, 2020, <https://www.globaltimes.cn/content/1203857.shtml>.

⁶⁸ See, supra note 34.

⁶⁹ Ibid.

⁷⁰ See Table 1 at the end of the text.

⁷¹ John Stillion, *Trends in Air-to-Air Combat: Implications for Future Air Superiority*, CSBA, 2015.

⁷² See Table 5 at the end of the text.

⁷³ A CSBA report written in a later year (2018) pointed out that as the U.S. Navy and Air Force had their own institutional cultures and customs, there would be resistance to a shift to drones in some quarters of those forces even if manned aircraft's advantages were lost.

⁷⁴ Nicholas Ernest and Gene Lee et al. "Genetic Fuzzy based Artificial Intelligence for Unmanned Combat Aerial Vehicle Control in Simulated Air Combat Missions," *Journal of Defense Management*, Vol. 6, Issue 1, 2016; However, it is said that even in the case of high-performance drones, there are some problems, such as a lack of clarity as to where the responsibility for a failed drone operation lies. As a result, there has never been a case in which a drone was deployed to respond to an airspace incursion, for example. The downing of a drone by the General Atomics MQ-9 (Reaper) in November 2017 was cited as an example of a drone shooting down another drone in air combat by *Sekai Kokuki Nenkan 2018-2019*, an extra issue, Koku Joho, March 2019 issue, Haruhara Kenichi (ed.), Sekireisha, 2019, p.405. According to the magazine, the U.S. military was operating 190 units of MQ-9 across the world as of March 2019.

⁷⁵ Zegart, supra note 48, pp. 6-46.

⁷⁶ For example, the following comment represents the typical understanding: "The U.S. government will find it impossible to flee a crisis in Japan if casualties occur among U.S. servicemen. That will be a tripwire for triggering automatic entry into war by the U.S. Forces" (Watanabe Yoshikazu, Commanding General of the Ground SDF Eastern Army). In many cases, arguments like this offer definitive judgments without presenting scientific supporting evidence. (Okinawa's Choice (2nd in a series) Sankei Shimbun, web version, February 22, 2019; As to the concept of "tripwire," see the following: Thomas Schelling, *The Strategy of Conflict*, Harvard University Press, 1960, p.47; Some people criticized the

fact that even prominent experts (Okamoto Yukio, Yamaguchi Noboru, Morimoto Satoshi, and Kawakami Takashi) have left unclear the significance of U.S. Marine troops being stationed in Okinawa from the perspective of nuclear deterrence. See Mike Mochizuki, "Yokushiryoku to Zai Okinawa Bei Kaiheitai—Hihannteki Kensho," *New Diplomacy Initiative* (ed.), *Kyozo no Yokushiryoku: Okinawa Tokyo Washinton Hatsu Anzen Hosho Seisaku no Shin Kijiku*, Junposha, pp.106-116. Some people astutely pointed to the possibility of adopting a rationalist line of argument so that, depending on the circumstances, activities presumed to be credible threats could easily provoke use of force. If we are to approach this issue scientifically, we must take into consideration the idea that threats may be more effective if they remain ambiguous. See James Fearon, "Selection Effects and Deterrence," *International Interactions: Empirical and Theoretical Research in International Relations*, 2002, pp. 5-29.

⁷⁷ Regarding MAD, in addition to the "nuclear winter" argument, there is also a critical opinion that was expressed by a group of Catholic archbishops. See Tsuchiyama Jitsuo, "Yokushi Shippai no Gaikou Seisaku Riron," *Kokusai Seiji*, No. 90, March 1989, p. 34.

⁷⁸ In particular, concerns have persisted about the absence of a framework between the United States and China that is based on some kind of deterrence theory like the one that existed between the United States and the Soviet Union. For example, Takahashi Sugio, a Japanese expert on nuclear deterrence, argues that Japan should use various occasions to continue calling for the inclusion of China in some framework or other. See Wada Hiroaki, "INF Zenpai Jouyaku Shikkou Chugoku wo Gunbi Kanri no Wakugumi ni —Kaku Yokushi Senmonka," *Mainichi Shimbun*, web version, August 3, 2019.

⁷⁹ Thomas G. Mahnken et al., *Deterrence by Detection: A Key Role for Unmanned Aircraft Systems in Great Power Competition*, CSBA, 2020, p. 43.

⁸⁰ Figure 6 at the end of the text shows the proposed areas of drone surveillance in the Western Pacific.

⁸¹ Under the strategic vision, there are some important points of discussion that have yet to be theoretically sorted out. Mahnken et al proposed using non-stealth drones for surveillance but did not present principles or empirical knowledge as to why awareness of being kept under surveillance

exercises a deterrence effect. Although they pointed out Admiral Williams Owens' mention of the importance of the ISR function in the 1990s, they did not explicitly explain what kind of deterrence effect demonstrating the surveillance capability to the opponent will generate or the reason why doing so may generate a deterrence effect. Naturally, capabilities and intentions constitute the foundation of deterrence, and it may be almost common sense that conveying capabilities and intentions to the opponent generates some deterrence effect. However, it is inconceivable that demonstrating not merely the surveillance capability but all capabilities increases the deterrence effect. Depending on the circumstances, doing so could even provoke action if the capabilities are discounted. See Mahnken et al., *supra* note 80, pp. 7-9.

⁸² At the beginning of Operation Desert Storm in 1991, a squadron led by Col. Jeff Greer launched a total of more than 100 TALD missiles in nighttime hours and destroyed the Iraqi radar system with anti-radiation missiles after the system responded to the decoy missiles, thereby demonstrated the effectiveness of the method of using decoys to locate the target. At present, the TALD missile is carried mainly by the F/A-18 Hornet, which can be equipped with up to six TALDs (ADM-141).

⁸³ The U.S. DARPA started research and development on a miniature air-launched decoy (MALD) in 1995 and achieved some results, as the (overwhelming) effectiveness of such a decoy was proved in actual combat. Although the U.S. Air Force at one time planned to deploy 1,000 such decoys, it decided in 2002 to abandon the deployment plan due to an insufficient flight range in particular, following changes in the strategic environment and other factors. On the other hand, the development of various types of MALD has continued. Among major aircraft capable of carrying MALDs are the F-16 fighter and the B-52 strategic bomber, as well as drones, such as MQ-1 (Predator), MQ-1C (Gray Eagle), and MQ-9 (Reaper).

⁸⁴ The XQ-58A (Valkyrie) of the United States and the S-70 of Russia are typical examples. These two types, both of which are under development (it is said that the first delivery of the S-70 drones will be brought forward to 2024), are assumed to take on a wide range of reconnaissance and attack missions as individual aircraft or as wingmen for manned aircraft. Each of them has a flight range of more than 2,000 miles, and in the case of XQ-58A, surprisingly, the per-unit development cost is estimated at around 200

million yen, approximately one-fiftieth of the cost of the F-35 or other advanced manned aircraft. This cost performance is considered to be a sufficient level to enable the use of XQ-58A as a consumable asset.

⁸⁵ When it comes to the question of whether the offensive side or the defensive side is at an advantage, one of the most obvious cases of the defensive side being at an advantage is landing operation. Many attempts have been made to use drones as a way of reducing the huge risks to which the landing side (attacking side) may be exposed. The South Korean Marine Corps' efforts to use drones for that purpose was cited in the following: "Combat Drones to Conduct Amphibious Operations for South Korean Marine Corps," *DefenseWorld.net*, November 23, 2018, https://www.defenseworld.net/news/23733/Combat_Drones_to_Conduct_Amphibious_Operations_for_South_Korean_Marine_Corps.

⁸⁶ Vigorous efforts have been dedicated to studies on the question of whether the offensive side or the defensive side is at an advantage in ground battles, including classic studies by Clausewitz and others. See *Kuwata Etsu, Koubou no Ronri—Sonshi kara Gendai ni Itaru Senryaku Shisou no Kaimei*, Hara Shobo, 1991. As to the question of whether it is possible to have discretion in choosing whether to take the offensive or defensive, although there is no room for choice at some stages, the possibility of making the choice should be pursued if choosing the offensive or the defensive is decisive for gaining an advantage. See the following as an example of a document that argues that "*Shiki Unyou Koyo*" indicates the possibility that even if the offensive side is generally at an advantage in air defense combat, there are countermeasures that may be taken by the defensive side, including a surprise attack. See Sugimura Takashi, "CSC Daiichiji Shiken Oyobi Dainiji Shiken no Gaiyou Oyobi Shoken Tou ni Tsuite," *Houyu*, Vol. 46, No. 3, 2020, p.102.

⁸⁷ Assumed here is the operation of a drone swarm using a command and control system comprised of nodes linking an earth station—a ground or sea-surface station (fixed or mobile)—and space satellites, similar to the U.S. forces' Global Command and Control System. As system stability is naturally the key factor in actual combat, the development of technology to ensure system stability is attracting attention. In cases where cloud technology is used for intra-swarm communication (short-distance communication) and where signal transmissions from the earth station and satellites to the cloud (long-distance communication) are centralized,

interference with the long-distance communication may render the swarm useless. Therefore, it is essential to work out the optimal mix of centralized and decentralized systems from the perspective of risk management. In that sense, in activities to develop a command and control system in the United Kingdom and elsewhere, there is awareness about the possibility of reducing risks posed to long-distance communication used for command and control of swarms if a drone swarm is organized as a wingman for manned aircraft. In any case, if a drone swarm is to exercise its capabilities over a large sea area, such as coastal seas around Japan, it is currently essential to ensure appropriate deployment of satellites as relay points. In that sense, we should have strong awareness about the fact that outer space constitutes an important strategic environment. See Xi Chen, Jun Tang and Songyang Lao, "Review of Unmanned Aerial Vehicle Swarm Communication Architectures and Routing Protocols," *Applied Sciences*, Vol. 10, Issue 10, May 25, 2020.

⁸⁸ It should also be noted that Saudi Arabia could not prevent this attack despite its huge military budget, which, at 70 billion dollars, is the third largest in the world, after the U.S. and Chinese military budgets.

⁸⁹ Harry Lye, "RAF experimental drone squadron stalled by coronavirus," *Airforce.com*, April 2020, <https://www.airforce-technology.com/news/raf-experimental-drone-squadron-stalled-by-coronavirus/>.

⁹⁰ See Figure 10 at the end of the text. Tamir Eshel, "RAF Tests an Innovative Anti A2D2 Concept – Pitting Drone Swarms Against Air Defenses," *Defense Update*, October 2020, https://defense-update.com/20201008_ew-swarm.html.

⁹¹ George Allison, "Royal Air Force Swarming Drone Project 'Exceeding Expectation'," UKDJ: *Impartial Current*, June 22, 2020, <https://ukdefencejournal.org.uk/royal-air-force-swarming-drone-project-exceeding-expectations/>.

⁹² The Royal Australian Air Force has also made remarkable progress with respect to drones used as wingmen for manned aircraft. In May 2020, the Royal Australian Air Force announced that in collaboration with Boeing of the United States, it would operate three prototypes of an AI-based attack drone for one year on a trial basis before the mass production planned over the following five years. This drone has a flight range of 3,700 kilometers and is assumed to fly to battlefields as wingmen for manned aircraft and engage in combat in the same capacity. Andrew Greene, "Australian-

designed AI attack drone prototype unveiled by Boeing ahead of mass production," *ABC.net.au*, <https://www.abc.net.au/news/2020-05-05/ai-attack-drone-australian-designed-prototype/12215612>. In August 2020, it was reported that Australia will start the development of a new type of drone for maritime surveillance with an investment of 1.3 billion dollars (approx. 135 billion yen). See Sandy Milne, "Australia Invests \$1.3 Billion in New Drone Defense Program," *Australian Aviation*, August 6, 2020, <https://australianaviation.com.au/2020/08/australia-invests-1-3bn-in-new-drone-defence-program/>.

⁹³ When asked to comment on the attacks in Abqaiq and elsewhere, Jorg Lamprecht, founder and CEO of Dedrone, a U.S. company providing anti-drone solutions, said that it is necessary to explore a more efficient way of intercepting drones, which may be worth as little as hundreds of dollars each—particularly when they are operated as a swarm—than countering with missiles, which could cost as much as 3 million dollars each. Specifically, he proposed using a combination of radio frequency detectors and radar to detect drones and high-powered cameras to verify payloads, and jamming and other technologies to demobilize them.

⁹⁴ At a 2020 New Year celebration event held in Shanghai, 2,000 drones were operated to project images of fireworks and create illumination displays in the night skies. See Figure 7 at the end of the text. A video of the event is available online. See "2,000 drones light up night sky in Shanghai to welcome new year," *CGTN*, January 1, 2020, <https://www.youtube.com/watch?v=Zh3-Mvrp1Lc>.

⁹⁵ Heiko Hamann, *Swarm Robotics: A Formal Approach*, Springer, 2018; See the following as an example of document that discusses technology to address security vulnerabilities that may arise when individual drones that constitute a swarm engage in communication with each other in order to complement each other's sensor functions: Liang Zhao, "A Multi-UAV Clustering Strategy for Reducing Insecure Communication Range," *Computer Networks*, April 24, 2019, pp. 1-25.

⁹⁶ The 2020 edition of the Japanese annual white paper on defense also referred to possible military attacks using swarms in the context of near-future threats and stated that it will be difficult to guard against swarms with a traditional air defense system. The Ministry of Defense (ed.), *Defense of Japan 2020 (Annual White Paper)*, August 7, 2020, p.164.

⁹⁷ See Takahashi, Duue to Mitcheru—Senkanki ni Okeru Ea Powaa Riron

no Soushisha," Note 3, p. 210.

⁹⁸ In January 1958, the United States established the Advanced Research Projects Agency (ARPA) as an organization specialized in converting advanced science and technology to military applications in order to counter the threat from the Soviet Union's remarkable rise as a military superpower (following the Sputnik Shock, which came in 1957). In 1996, ARPA was renamed DARPA (Defense Advanced Research Projects Agency). DARPA has conceived and realized advanced technologies that have surprised the world, including ARPANET (1969), which was the forerunner of the internet, stealth aircraft (1977), and GPS (1983). At present, DARPA is implementing the OFFSET (OFFensive Swarm-Enabled Tactics) program (intended to devise tactics using a swarm of up to 250 drones in urban warfare and for other purposes), which concerns drone swarm tactics. This program is now in the fifth sprint (research competition) (see Figure 9 at the end of the text). As a result of the first to fourth sprints, DARPA has already concluded contracts with multiple sprinters (entities to which research is commissioned). The name of the project is presumed to imply rethinking and renewal of existing standards, indicating that the operation of drone swarms is attracting attention as a potential game-changer. See DARPA, "DARPA Seeks Novel Urban Swarm Capabilities, Enhancements to Physical Testbeds: OFFSET program solicits proposals for fifth swarm sprint and awards contracts for fourth swarm sprint," *OUTREACH@DARPA.MIL*, September 27, 2019, <https://www.darpa.mil/news-events/2019-09-27>; Swarm tactics is attracting attention not only from DARPA but also from various other quarters. Regarding information on the U.S. Army's swarm-related initiative, see the following: Patrick Tucker, "US Army Seeks Internet-of-Battlefield-Things, Distributed Bot Swarms: After nearly two decades of war against technologically unsophisticated foes, the Army Research Lab is reorienting to counter China and Russia," *DefenseOne*, July 18, 2017, <https://www.defenseone.com/technology/2017/07/us-army-seeks-internet-battlefield-things-distributed-bot-swarms/139533/>.

⁹⁹ Drones with aerial refueling capability are starting to appear. In September 2019, the U.S. Navy published a video of the MQ-25, the development of which has been commissioned to Lockheed Martin. The MQ-25 has been conceived as a carrier-based drone which can take off and land on the USS George Washington and other carriers. It is remote-

controlled by a pilot, and its main mission is refueling the F-35C and other fuel-efficient fighter aircraft. Refueling provided by the MQ-25 is supposed to extend the operational radius by 52% for the F-35C and by 45% for the F/A-18E/F. See Lockheed Martin, "MQ-25 Concept," September 2019, <https://youtu.be/T1F8GoVnonU>.

¹⁰⁰ Ibid.

¹⁰¹ According to the program manager at DARPA, swarm technology is applicable to not only military but also civilian purposes, including disaster recovery, search and rescue, and wildfire monitoring and mitigation. See "DARPA's OFFSET Swarm Sprints Take to the Skies," *Inside Unmanned Systems*, October 29, 2019, <https://insideunmannedsystems.com/darpas-offset-swarm-sprints-take-to-the-skies/>; On the other hand, in the United Kingdom, drones are considered to deserve attention exactly because they are at the cutting edge of autonomous weapons. It is said that until 2015, the U.K. Ministry of Defense was unenthusiastic about developing drones despite being aware of the need for autonomous weapons. See Burt, *supra* note 52.

¹⁰² There is a well-known incident in which Iran captured an RQ-170 (Sentinel) without causing significant damage to it in 2011 when the drone was (alleged to be) intruding into Iranian airspace. It is said that the Iranian Islamic Revolutionary Guard forced the Sentinel drone, whose existence itself was shrouded in secrecy, to land at an Iranian airport by manipulating GPS location information. It is said that the technological secrets of the Sentinel were cracked through reverse engineering and were conveyed from Iran to Russia and that as a result, Russia succeeded in developing high-performance drones such as Okhotnik. See "Iran Shows Video It Says Is of U.S. Drone," *The New York Times*, December 8, 2011, <https://www.nytimes.com/2011/12/09/world/middleeast/iran-shows-us-drone-on-tv-and-lodges-a-protest.html>.

¹⁰³ See Figure 11 at the end of the text.

¹⁰⁴ In May this year, the U.S. Navy announced a successful test shutdown of a drone using a laser weapon. In the test, the laser weapon (Technology Maturation Laser Weapon System Demonstrator: LWSD, MK 2 MOD 0), installed on a trial basis on the USS Portland (LPD27), test-fired beams at a flying drone and shot it down. This laser weapon has an output power of 150 kW (equivalent to the total output of around 120 hair driers) and is closer to attaining shutdown capability than existing similar weapons,

which have an output power of approximately 30 kW. See "USS Portland conducts Laser Weapon System Demonstrator Test," U.S. Pacific Fleet Public Affairs, May 22, 2020, <https://www.cpf.navy.mil/news.aspx/130628>; In a Congressional report, the U.S. Department of Defense indicated that the output level required in actual combat is 300 kW. See Congressional Research Service, *Navy Lasers, Railgun, and Gun-Launched Guided Projectile: Background and Issues for Congress*, R44175, Updated April 2, 2020, <https://assets.documentcloud.org/documents/6827049/Navy-Lasers-Railgun-and-Gun-Launched-Guided.pdf>, pp.6, 18.

¹⁰⁵ According to a Chinese media report (Global Times), the Chinese military conducted a successful swarm exercise with the U.S. swarm tactics in mind, but the size of the swarm was far fewer than 2,000 drones. In an exercise of close air support conducted in 2016, a swarm of 67 drones was operated. See Liu Xuanzun, "Chinese military tests drone swarm-armored vehicle integration," *Global Times*, September 10, 2020, <https://www.globaltimes.cn/content/1200512.shtml>.

¹⁰⁶ The level of Japan's prowess in science and technology is undoubtedly world-class whatever humble view we may take of it. "Lagging far behind" here refers to a lag in terms of strategy. In other words, Japan still has a long way to go before making full use of its resources for the cause of peaceful development of defense strategy.

¹⁰⁷ A hybrid model of a certain carmaker has achieved an ultra-low fuel efficiency of 40 kilometers/liter, a revolutionary achievement, while a model of another carmaker achieved unparalleled fuel efficiency by drastically improving the combustion efficiency of a clean diesel engine. However, if companies develop strategy merely from their own perspectives, they cannot necessarily take the leading position, as is the case with military strategy. That is because technological races are affected by the international situation, as indicated by the Tokyo governor's announcement of the goal of ensuring by 2030 that all new vehicles sold in Tokyo involve some form of electric power as a driving force (abolishing sales of new vehicles powered only by an internal combustion engine), which reflected awareness about other countries' policies regarding environmental standards for automobiles. See "Tokyo to 30 Nen Madeni Shinsha Hanbai Subete Dendoushani—Chiji Ga Mokuhyou." *Nihon Keizai Shimbun*, web version, December 8, 2020; In any case, in order to achieve

the goal, the Tokyo government is expected to bear the cost of subsidy for purchases of green vehicles. There is no doubt that the development and diffusion of new technology is driven not only by market principles but also by policies.

¹⁰⁸ The intensification of the U.S.-China confrontation is attracting attention. In particular, the discord over trade matters is conspicuous. One reason is the military-civil fusion initiative being promoted under the Chinese government of President Xi Jinping. There are many possible approaches to such fusion, and the question of what approach to adopt in itself is a subject of strategy research. Bekir Ilhan, "China's Evolving Military Doctrine after the Cold War," SETA Analysis No. 59, January 2020; Jenny Bavisotto, "China's Military-Civil Fusion Strategy Poses a Risk to National Security," Bureau of International Security and Nonproliferation, January 30, 2020, <https://www.state.gov/chinas-military-civil-fusion-strategy-poses-a-risk-to-national-security/>; Kai Lin Tay, "China's Military Looks to Civilians to Boost Innovation," *IISS Analysis*, May 7, 2020, <https://www.iiss.org/blogs/analysis/2020/05/china-civil-military-innovation>.

¹⁰⁹ As Wernher von Braun, a German scientist known for his achievements concerning rocket development, was at first dreaming of space development, rocket technology tended to be considered to represent the conversion of scientific knowledge to military applications by Nazi Germany. Similarly, Albert Einstein's relationship with the Manhattan Project is also considered in some quarters to be problematic as an embodiment of military use of science and technology achievements. Those who accuse these scientists of complicity in war assume that war occurs because of the existence of weapons. However, such accusation is nothing more than an attempt to create scapegoats on whom the blame for war can be laid. At the least, this is not an issue over which any definitive conclusion can be drawn and over which various positions may be taken. The issue should be discussed in light of the history of thoughts on military application of civilian technology and changes in social values. See Yokoi Katsuhiko and Onozuka Tomoji (eds.) *Gunkaku to Buki Iten no Sekaishi—Heiki wa Naze Youi ni Hiromattanoka*, Nikkei Inc., 2012.

¹¹⁰ According to a media report (June 28, 2018), the Acquisition, Technology & Logistics Agency and the U.S. Department of the Air Force reportedly concluded a contract on the acquisition of the RQ-4B, worth

around 16.4 billion yen. "Kouku Saishin News," *Kouku Fan*, No. 791, Bunrindo, November 2018 issue, pp.111-121. As a result of the contract, three Global Hawks are scheduled to be gradually deployed, starting in FY2021. "Kuuji Misawa Mujin Teisatsuki de Rinji Butai Shinpen E," *Web To-o*, August 31, 2019. Global Hawks operated from the U.S. Andersen Air Force Base [訳注 : <https://www.andersen.af.mil/>] are already flying to and from Misawa Air Base. When Global Hawks belonging to the U.S. military take off and land at bases in Japan, they are remote-controlled from those bases at the time of landing and takeoff. After drones have reached a certain altitude after takeoff, their control is turned over to U.S. Air Force pilots in bases located in the mainland United States (Beale Air Force Base in California and Grand Forks Air Base in North Dakota). Tohoku Bureau of Defense, "Q & A concerning the Global Hawk," https://www.mod.go.jp/rdb/tohoku/gyomusyokai/08_tihotyosei/oshirase/global-hawk/qa.html (as viewed on June 11, 2020).

¹¹¹ As stated in the FY2017 defense budget request, "the introduction of the Global Hawk is part of the effort to enhance the information function in order to deal with various situations." It is described as a way to complement various measures (to strengthen the broad-area constant surveillance capability), including the renovations of the P3C patrol aircraft, the SH-60K patrol helicopter and the E0767 early warning aircraft to extend the duration of operational life. The Ministry of Defense, *Defense Programs and Budget of Japan—Outline of the FY2017 Budget Request*, https://www.mod.go.jp/j/yosan/yosan_gaiyo/2017/gaisan.pdf.

¹¹² The development of drones in Japan started relatively early, in 1984. The QF-104J, a remote-controlled drone modeled on the U.S.QF-104A, was developed in 1984. As for the autonomous type, the Technical Research and Development Institute (which was abolished in 2015 and was integrated into the Acquisition, Technology & Logistics Agency) started development, and the development work later focused on a system to enable drones launched from an F-15 to autonomously return to a base after gathering various data (a multi-purpose small drone program) (the development work was commissioned to Fuji Heavy Industries Ltd. in 1995). Ryoji Shirai, *Incorporating Unmanned Aerial Systems into the Japan Air Self-Defense Force*, Foreign Policy at Brookings, Policy Paper, September 2014, pp. 4-5, 33.