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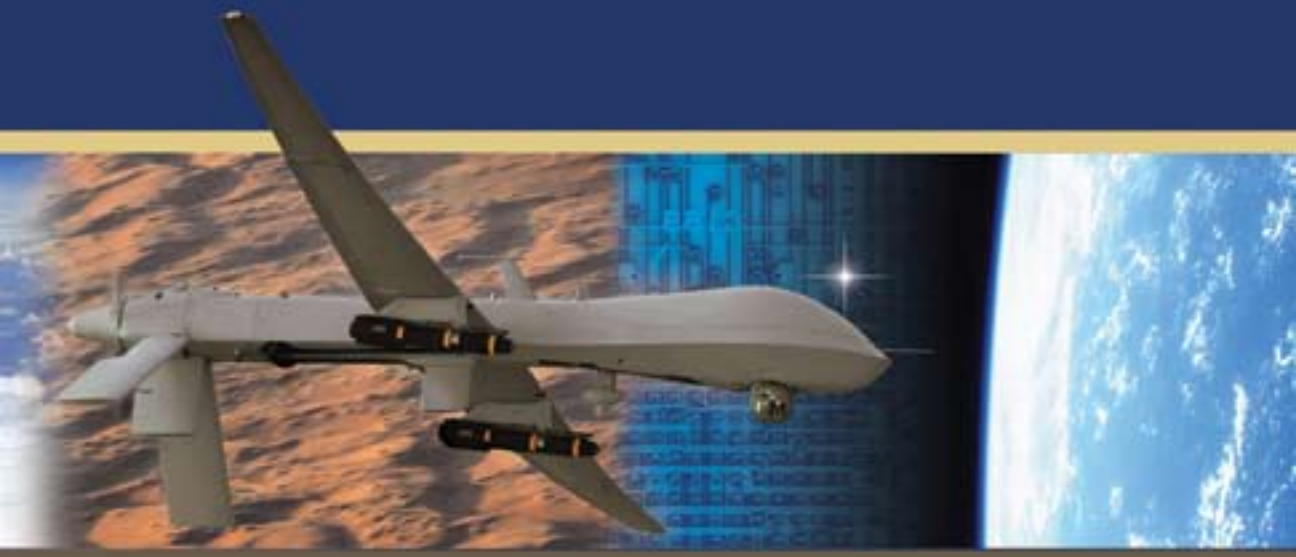
Revolution or Retrogression?

Dr. David R. Mets
Defense Analyst, Air Force Research Institute



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About the Author

Dr. David R. Mets (USNA; MA, Columbia University; PhD, University of Denver) is a professor emeritus at Air University's School of Advanced Air and Space Studies and a former military defense analyst at the Air Force Research Institute, Maxwell AFB, Alabama. He studied naval history at the US Naval Academy and taught the history of airpower at both the Air Force Academy and West Point. During his 30-year career in the Navy and Air Force, he served as a tanker pilot, an instructor navigator in strategic airlift, and a commander of an AC-130 squadron in Southeast Asia. On another tour there, he was an aircraft commander for more than 900 tactical-airlift sorties. A former editor of *Air University Review*, Dr. Mets is the author of *Master of Airpower: General Carl A. Spaatz* (Presidio, 1988) and more recently *Airpower and Technology: Smart and Unmanned Weapons* (Praeger, 2009).

RPAs: Revolution or Retrogression?

A historian's occupational disease is to find old precedents for practically everything new that comes along. And that is true for remotely piloted aircraft (RPA) as well. In one way they are merely the continuation of the millennia-old human longing for methods of striking or observing one's enemies while remaining safe. The purpose of this essay is to briefly explore that which is old, to dwell for a time on what seems to be new, and to conclude with some speculations about the future of unmanned systems.

George Patton once remarked that the object is not to die for one's country, but rather to make the other guy die for his. Thus, one way of looking at the history of military development is seeing it as an eternal search for standoff and precision to discover what one's enemy might be doing, or to strike him blows with minimum risk to one's health.[1] That is often achieved through skill with minimal force rather than brute strength as with David and Goliath. So, too, it is with Predator operators at Creech AFB, Nevada, reaching across the world to see and then strike with small Hellfire missiles launched from Predator or Reaper RPAs. Precision-guided munitions (PGM), cruise missiles, and intercontinental ballistic missiles (ICBM) have long shared these characteristics, but none of these can be reused—guidance and propulsion systems are consumed with each round. RPAs have had much in common in the development of the technology with those, but are intended for reuse of the power and guidance apparatus.

History of RPAs

The idea of striking or spying from afar with unmanned systems may be older than many think. In 200 BC, the Chinese used kites to soar above the walls of enemy fortifications to enable calculation by triangulation of the length of the tunnel needed to get under those walls. Kites were also used to fly noise devices over enemy camps in the hope of spooking the troops or at least keeping them awake.[2] From then until the early twentieth century there were thoughts of putting a man

on a kite to observe the enemy. In the Spanish-American War, a photographer actually flew a camera in a kite and got some pictures of the conflict from above.[3]

Close to 1,000 years ago, Genghis Khan was running wild. The way the story goes, he had a Chinese city under siege, a tedious operation that could wind up in a bloody assault. But Genghis was imaginative. He sent a delegation in to the Chinese town fathers and proposed a course that would avoid all the bloodshed, but would satisfy his requirements for prestige. The proposal was that the Chinese merely pay a tribute of 1,000 cats and 1,000 pigeons, and he would be content and go away with honor intact without the cost of an extended siege. The Chinese dignitaries could not believe their good fortune. They had too many cats and pigeons, so the price of peace was not onerous. They quickly gathered up the animals from the attics and cellars of the city, and sent them to the enemy camp. However, Genghis betrayed them. He had incendiary material attached to each cat and pigeon, ignited it and released them—and they streaked back to the cellars and attics of the city to burn the whole place down (standoff, precision, and economy of force!) (Unhappily, neither the cats nor pigeons could be recycled.)[4]

The idea of dropping lethal materials on bad people goes back at least to medieval times when dumping hot oil off a fort's walls upon the assaulting enemy was one defense. It was even better if it could be done without risking one's own soldiers. During the fighting accompanying the European Revolutions of 1848, the Austrians were attempting to bring the citizens of Venice into line. They could not make a conventional assault because they did not have enough soldiers or the amphibious capability to do it. Their solution was to devise some small, unmanned balloons to carry light warheads across to the city to terrify the citizens into capitulation. It did not work and some uncooperative winds blew some of the balloons back to their own lines. They had the standoff but not the desired precision and economy of force.[5]

The Japanese tried the same stunt at intercontinental ranges in World War II. The prevailing trans-Pacific winds were more reliable (if a continent was the target.) Though a few rounds from submarine guns had been lobbed into the US West Coast

early in the war, it was not long before the Japanese were taking a pounding in their own theater with no obvious ways of hitting back at the American homeland. Thus, they adopted the idea of using balloons as had the Austrians, but theirs were somewhat more sophisticated. Their balloons were unmanned and much bigger than those of the Austrians. They had clever altitude control devices. School children built them and the military operated the weapons. Not much was made of the balloon attacks in the media at the time, but they did cause some diversion of military effort. Several thousand were launched, and a few were shot down. Many others were lost due to various causes, but some did reach the continent. One, in fact, caused six fatalities when picnickers in Oregon found it and caused a detonation, killing five children and a woman. However, the results were not at all commensurate with the effort invested.[6]

Nikola Tesla immigrated to the United States and patented many things in electricity and radio in the late nineteenth and early twentieth century. The Whitehead Torpedo had come on line in the 1880s with a hydrostatic depth control and a gyro for directional control, but Tesla went further. He was to become more famous for the development of alternating current electricity, but his submersible was truly remotely controlled via radio as with the early PGMs. He demonstrated his device in Madison Square Garden in 1898. He controlled the rudder and the navigation lights by radio, and even had a device to prevent other radio transmissions from interfering. At the time, he tried to market it as a military device to the US Navy and Royal Navy. He later became a pacifist, and did no more with it.[7]

Tesla's control concepts were advanced for the day. They were more sophisticated than those of the Kettering Bug of World War I, or even those of the German "Buzz Bomb" of the Second World War. They had something in common with the German "Fritz" and American "AZON" bombs of World War II.

Eighteen years after Tesla's demonstration, Elmer Sperry was trying another approach to control based on the gyroscope. He did achieve some fairly impressive results onboard a seaplane, but at the time it was well realized that the methods would be very expensive and only useful against large area tar-

gets because of inaccuracy. Meanwhile in Europe there were some experiments going on with radio control of air vehicles, but at that point, the devices were not at all reliable.[8]

After the onset of World War I, Elmer Sperry, along with Carl Norden, continued the flying bomb work for the US Navy, but suffered many mishaps, partly because of the launching methods and partly due to the failure of the aircraft or its control systems. After the Armistice, the naval authorities suffered declining budgets and, though they saw some potential against area targets, thought that the accuracy would not be enough against ships. Thus they had to get out of the RPA business.[9]

The Army's principal unmanned effort in World War I was called the "Kettering Bug" after Charles Kettering, who had begun his rise by developing an electric starter for automobiles. In principle, the technology was very similar to that in the World War II German V-1 Flying Bomb. A revolutions-per-minute counter determined the range, cut the ignition, and folded the wings. A Sperry gyroscope controlled the direction. The aircraft did not have ailerons, but a rather large dihedral to manage stability. Many Bugs were built, and most of them crashed because of launch, control, or engine problems. They were autonomous once launched, but few of the vehicles survived their test flights to fly again, and that hampered the program. Orville Wright and Henry Arnold were among those involved in the effort. Though continued for a while after the Armistice, it ran out of steam in 1920.[10]

Neither Billy Mitchell nor Giulio Douhet thought that surface air defenses would ever amount to much.[11] Those notions were reinforced by the spectacular test sinking of the ex-German battleship *Oestfriesland* in 1921. The media made much of the event that with little notice, the ship had been at anchor, undefended, and Mitchell's bombers flew over it at 2,000 feet—something that would have been suicidal over an underway battleship in World War II. The loss of battleships at Pearl Harbor on 7 December 1941 seemed to confirm that, but they too were effectively undefended and motionless.[12]

Some in the Navy were well aware of the air threat and moved to build air defenses aboard the capital ships. There was room aboard for many small caliber guns, and to hit a maneuvering ship steaming at 30 knots was not an easy task. But for the

antiaircraft gunners, the problem was even greater, for their targets were smaller, faster, more maneuverable, and moved in three dimensions. Practice was essential, but difficult in the absence of realistic targets. Towing target sleeves was not effective because maneuver and speed were limited with a long cable behind, and in any event, it was not a popular sport for the pilots of the towing airplanes—boring, yet dangerous. Radio control seemed to provide a partial answer, and it had been coming along in civilian applications since Tesla. One of the pioneers was a Briton who immigrated to the United States after World War I and made a living as a Hollywood actor. Between films, Reginald Denny was involved with developing radio-controlled airplane models and actually opened a model shop before World War II. He parlayed that into a considerable business by marketing development of these models into aerial targets for the Army and Navy during World War II.[13] The radio-controlled targets were especially valuable at sea where they could be used and reused for target practice for the increasing number of high-rate-of-fire guns put aboard ships, other than aircraft carriers, in anticipation of the threat.[14] Some of the technical people who later became innovators in precision-guided weapons and RPAs at China Lake, California, and Eglin Field, Florida, had likewise started with an interest in radio-controlled models in the 1930s.

The Army Air Forces and the Navy were both involved in converting war weary bombers into unmanned combat aerial vehicles during World War II. Using either B-17s or B-24s, they carried as much as 18,500 pounds of explosives. They took off with humans at the controls but once at altitude, the crews put them on autopilot and bailed out. A mother ship then took over control through a radio link and in theory would guide the bomber through a television camera mounted in its cockpit to the target. It was deemed a failure after a few shots because of accidents and inaccuracy. However, the idea did not die, for some of the survivors became RPAs deployed to the Pacific islands for the postwar atomic bomb tests. There, they were used to sample the content of the mushroom clouds without putting humans at hazard. By that time, a system had been devised to launch and recover them unmanned by means of a ground crew sited near the runway.[15]

Jets were coming on strongly after World War II, and that generated the need for aerial targets with much greater capabilities than those of the earlier day. Reginald Denny was still in business and competed for a while, but Ryan Aeronautical of San Diego got started with its "Firebee" (fig. 1) that proved to be one of the most prolific of the period. Powered by a jet, its performance was competitive with the postwar fighters coming online, and its production ran into many thousands. Many were modified for more than target use, and they and the follow-on "Lightning Bug" did yeoman service in Vietnam in a reconnaissance role. Flying at high speeds and very low altitudes, they posed a tough problem even for sophisticated air defenses.[16]

Aircrews aboard the mother ship DC-130s controlled their flight, and they were reusable though the recovery was difficult to achieve without damage. Some were parachuted down, but later a system was used of snatching the descending parachutes with a helicopter. The latter method reduced the damage, and in the end, the average vehicle lasted through three and a half missions though some survived many more flights. For a while, there was a troublesome time between the collection of the data

(USAF Photo)

Figure 1. Ryan BQ-34 Firebee

and its production in usable form for the decision makers.[17] However, it was some years before the RPA systems became faster, cheaper, and safer than manned reconnaissance. Only after the DC-130 support airplane and crew became unnecessary and the images could be electronically transmitted was most manned reconnaissance made obsolete.[18]

Ryan Aeronautical modified Firebees and their follow-on RPAs for many different functions. They dropped leaflets and created chaff corridors for inbound bombers before Vietnam was over. One was even successfully tested to deliver bombs, but was not put into production.[19]

RPAs had fallen into the doldrums during the post-Vietnam drawdown in America, but the Israelis continued development. They used them with great success as decoys and surveillance platforms in the suppression of enemy air defenses (SEAD) campaign in the Bekaa Valley fighting in 1982. The Pioneer was a development of the Israeli RPAs.[20] Soldiers and Sailors operated them, and in the Navy case, they were recovered by driving them into a landing net aboard the ship. They had an endurance of about 48 hours, but did suffer a high accident rate. But Pioneer gained a considerable amount of fame for successfully spotting the fall of shot for the battleship guns in Desert Storm. Only 11 Pioneer systems were deployed, but they flew 300 sorties and had more than 1,000 combat hours.[21] Thus, it can be seen that the RPAs developed in a way similar to the early aircraft, being useful first in reconnaissance and spotting roles for the surface forces. This growing interest by Soldiers combined with the apparent disinterest among Airmen tended to revive an ancient debate between them.

Maj Gen Lloyd Fredendall had been the US ground commander in the early phases of the African Campaign of 1942–43. He is famous for requiring defensive air patrols in "penny packets" over his divisions versus centralized control for offensive operations. The experience was one of the origins of the eternal argument about decentralized control for immediate responsiveness and centralization for mass and efficiency. In 1943 the centralizers (Airmen) won the case with the publication of Field Manual 100-20, *Command and Employment of Air Power*, that July. Fredendall was relieved by George Patton who went on to greater fame. However, many in the ground forces were

never satisfied with the centralized control of air support.[22] Now, in the absence of an enemy air threat, the argument is coming to the surface again.[23]

The USAF has sometimes been criticized for allowing the RPA development to lag after Vietnam. To some extent that *may* have been due to the pilot culture[24] but there were some economic and technological obstacles. As long as the RPAs had to be carried under the wings of C-130s, the logistical footprint of the airplane's crew and maintenance structure had to be deployed along with their additional support. Too, the limitations of the RPA navigation methods meant airplane carriage, and that in turn limited the RPA wing span. But long wings are essential to long endurance, which was to be a major attraction of RPAs. Only with the coming of the global positioning system (GPS) was it made possible to dispense with the navigation assistance from the DC-130 and, at the same time, reduce costs by runway recovery. The GPS was not fully deployed until the mid 1990s.[25] The problem was different for the Israeli Defense Force in 1982, because their air forces are not required to deploy. In their operations in the Bekaa Valley, they could rely on line of sight communications.

Between the end of the Vietnam War and the fall of the USSR, the focus of US military planning was on a conventional war on the North European Plain against the Warsaw Pact. There was said to be a "never again" syndrome with respect to a Vietnam sort of war. The concept was that somehow the North Atlantic Treaty Organization (NATO) would have to fight greatly outnumbered and yet win. There had been real PGM development during Vietnam, and that was to continue as a part of the solution for fighting outnumbered. The laser-guided bombs were improved in several ways, as were the electro-optical missiles and bombs. Three new fighters were developed during the period and deployed in substantial numbers. One was optimized for the air-to-air battle, one was a swing-role bird that could participate in that and yet had an air-to-ground capability, and the third was optimized for the ground battle. Much effort was devoted to bombs, mines, and missiles that would be effective against tanks. It all was envisioned for a fight in a nonpermissive air environment where the first priority was air superiority.[26] Not much Air Force attention was focused on RPAs.

Meanwhile, the ground forces were much impressed by the potential of the ground-based air and armor defenses demonstrated in the Yom Kippur War of 1973 and later by the effective Israeli use of RPAs in the Bekaa Valley fighting of 1982. As had been the case in the infancy of aviation, the first practical uses of RPAs were in reconnaissance and artillery spotting. Israel for a time was a leader in RPA development, and, as noted, a modification of one of their systems was adopted in the "Pioneer" created for the American surface forces in the 1980s.

In its early days, the Predator (fig. 2) program belonged to the Army, but in the mid-1990s, it was reassigned to the Air Force.[27] It came online in the mid-1990s and was used for intelligence, surveillance, and reconnaissance (ISR) in the Balkans. Some bugs in the design were discovered there, and that led to modifications for bad weather operations. One difficulty was that the Predator operators had to talk the fighter strike pilots onto

(USAF Photo)

Figure 2. MQ-1 Predator

the target by audio radio communications, which was awkward and time consuming. A happy solution was found in rapidly equipping Predators with laser designators, which could be held on the target allowing the fighters to find the target much more quickly (with fewer mistakes). That reduced the time of the "kill chain" and suggested that it could be further improved by giving the Predators their own weapons.[28]

Thus, it was given a lethal capability with Hellfire missiles and got its first kill in 2002.[29] The Sky Warrior is a derivative of the Predator and is a bit larger with more payload, but both are smaller than the subsequent Reaper. From the outset, the Sky Warrior's intent was use in a decentralized way. Both RPAs are capable of operation at middle altitudes and raise concerns about deconfliction.[30] The Sky Warrior is to be organic to divisions. The Army has an automatic takeoff and landing capability, but the Air Force has not yet got one in operation in the Predator.[31]

Very often, the limitations of new systems get lost in enthusiasm for the innovation. Ideally, one constant is to get our precision, lethality, and standoff at a minimum price in lives and treasure.

Advantages of RPAs

In the early days of naval aviation, one of the huge attractions of airplanes was that they could do the scouting work not only faster, but also much more cheaply than could cruisers with their large crews and slow speed. So too could RPAs. As they could be built with less safety margins than aircraft, their systems do not have to be redundant. Too, life support and space for humans need not be included, and that saves weight, space, and money. Power plants can therefore be smaller with less fuel consumption. Their simpler systems promised that the maintenance costs would be less.

Since no human is airborne in an RPA, none is lost in accidents. But more than that, almost all the operator training can be done in simulators, keeping RPAs in storage instead of wearing them out and losing some in training accidents.[32] As there is no human in the cockpit, RPAs can be made more maneu-

verable, making tighter turns without risking the "blackout" for the pilot.

Finally, the machines have endurance far beyond that of human pilots, and their operators can be assigned in shifts, thus reducing the amount of transit time going to the target areas and returning. That in turn reduces fuel costs and the numbers of aircraft that have to be bought and maintained. Being smaller and quieter than airplanes, RPAs are stealthier. That can increase effectiveness and reduce costs as well.[33]

Another advantage of RPAs is that their developmental time is much shorter than it is for aircraft. This makes it cheaper to acquire, but perhaps more importantly, it shortens the acquisition cycle, so the system will have a longer service life before it becomes obsolescent.[34]

The Air Force operates Predators and Reapers[35] (fig. 3) in what are called remote split operations (RSO). The launch and recovery crews are deployed to theater, but once they have the aircraft airborne it is handed off for operation via fiber optic cable and satellite communications by crews in Nevada. That greatly reduces the RPA "footprint" in the combat theater. Not only do the operators remain at home, but so, too, do all the cooks, security police, intelligence personnel, and on and on who support them. That in turn reduces the number of airlifters,

(USAF Photo)

Figure 3. MQ-9 Reaper

tankers, and ships that would otherwise be required to move the people and material to the operational sites.

Too, as excessive troop presence can be detrimental to the political goals in theater, that is yet another advantage.[36] Hopefully, this networking can potentially reduce the time of the kill chain through quick reachback for needed intelligence and strike authority making the system more effective against time sensitive targets. All that yields a pretty rosy picture; what is the downside?

Disadvantages of RPAs

A wag once informed us that if it sounds too good to be true, it is. That is why we "Red Team" our wargames to try to identify the weaknesses of our plans before we get into action.[37] Certainly our potential adversaries are seeking asymmetric approaches to overcome our strengths. It is clear enough the rest of the world is well aware of our strengths in space—the Chinese have already tested an anti-satellite missile.

The RSO scheme is dependent upon nearly instant communications with the forces in theater, and there may be multiple ways of disrupting them.[38] No one who works on the Internet or who has tried to do so when the servers go down will fail to appreciate the importance of preserving the security of the system. The Army's less centralized RPA system is less vulnerable, but has its downside as well.

Science fiction writers and technology enthusiasts often assert that warriors will ultimately become completely autonomous—they will fight battles without any humans. But, many pilots are quick to assert that machines cannot be developed that will be prepared to handle every unexpected situation that might appear. That kind of judgment, they say, will never be possible in a machine.[39] Sometimes human judgment is affected by intuition or emotion, and that can never be duplicated in a mechanical device. Likewise, they argue there are factors that contribute to situational awareness that are not duplicated in RPAs. Pilots unconsciously, perhaps, react to the sounds of the machine around them or the G-forces varying that alert them to problems or opportunities that might not be possible with machines. According to Peter Singer, network-

centric warfare did not remove the fog of war and robots won't as well.[40]

Culture is important. The Air Force culture poses a personnel problem in connection with RPA manning. It has always placed those at the "pointy end of the spear"—the bomber and fighter pilots—at the head of the pecking order. Navigators and weapon systems officers were lower, and flyers in tankers and airlifters still lower. Non-flyers were even more clearly not a part of the elite.

With the coming of RPAs it has been difficult to get volunteers for their operation. They would neither fly nor be in any sort of danger or even discomfort.[41] It has therefore become an institutional imperative to develop a viable career track for them by a system of rewards. They were allowed credit for cockpit time[42] and later even allowed flight pay though they do not personally fly. Efforts are being made to build the force sufficiently to allow career broadening and attendance at the professional military education schools, both being conducive to career progress.

There has been a steady improvement in air communications since 1941 at the latest. Micromanagement has become an occupational disease among many commanders since then. During the evacuation of Saigon and the *Mayaguez* affair, the on-scene commanders were so busy answering calls from generals many levels above them that they hardly had time to do their jobs.[43] This is as great a danger as ever, and especially so with the RPA RSO. The operators are in Nevada answering to the local commanders there, and the launch and recovery crews are in theater subordinate to a joint force commander or a combatant commander. In between, their communications pass partly by cable and partly via space across many time zones and through different command regions.[44]

Command and control is complicated in yet another way. We have seen that both aircraft and RPAs generally started out as ISR platforms, but the addition of lethal capabilities generated contests for control between authorities even at the same level of command. Is the ISR function more important than striking the enemy? Troops-in-contact emergencies have traditionally commanded the highest priorities, but there are less urgent situations where the need for information may sometimes be

more important. Who is to be the ultimate authority in these situations?[45]

There has been much writing recently about differences in cultures and how that affects conflict. One of the taunts coming from al-Qaeda has been that westerners use RPAs because they are not manly enough to stand and fight one-on-one.[46] Even pointing out that improvised explosive devices (IED) also attempting to achieve kills from a standoff distance with minimum risk is the same sort of thing, is not enough. It is an old story dating back to the American Revolution and beyond when the Europeans thought it cowardly to fight from behind logs and stonewalls instead of standing up to the Redcoats, man to man. If the object, however, is to win the hearts and minds of the population, then the modes of fighting must be a consideration even if it does limit effectiveness. But the cynic might be inclined to say that one can always tell how effective one's weapons are by the shrillness of the enemy's charges as to their inhumanity and cowardliness. Given the Western culture, deliberately shortchanging the troops for the sake of imagined cultural gains is a hard sell.[47]

One of the standard arguments of the Cold War was that nuclear weapons are so horrific that they have made war, or at least world war, unthinkable. With the coming of RPAs, some have argued that leaders can contemplate risk-free war, thus making it more thinkable than it ought to be.[48]

A further question on RPAs has to do with their general applicability. The side-firing AC-47 was a booming success in South Vietnam, but nobody was interested in flying it up north. That was one source of skepticism at the Tactical Air Command headquarters at the time.[49]

Similarly, there are questions about the reliance on unmanned systems arising from the possibility that we will not always be flying in environments as permissive as Iraq and Afghanistan. Would the RPAs be viable over places with more formidable air defense systems? At least they would have to be made more survivable than they are now by building in greater stealth, electronic countermeasures, and even an air-to-air fighting capability. For the latter they would have to have much greater speed and an advanced system for situational awareness, which may be beyond technical feasibility. All that costs

money and reduces the economic advantages that RPAs bring to the force.[50] The one AC-130 that was lost in Desert Storm fell because the crew tarried beyond sunrise and a relatively simple, visually guided, man portable infrared surface-to-air missile brought it down.

The individual RPAs are relatively cheap. However, the satellites and associated equipment used to control them are not. Too, as adversaries develop countermeasures, the hardening of both the communications systems and the vehicles themselves again would reduce their economic advantages. The huge utilities of the visual images transmitted are obvious, but they do consume large chunks of bandwidth requiring more costly satellites.

Further, as many transmissions travel via commercial satellites, the American vulnerability is complicated in yet another way.[51] This vulnerability may be contained to some extent by the increasing capabilities of onboard processing equipment and software. Thus, less information would have to be transmitted from afar, but the requirement for bandwidth would probably remain substantial.[52]

When British Adm "Jackie" Fisher brought into being the new HMS Dreadnought, he was said to have sacrificed a huge numerical advantage over all other navies in a single stroke. The ship made all other war vessels obsolete, and the British advantage over the Germans and others with dozens of the old warships went down the drain—and Britain was faced with the newly formidable German and American industrial plants capable of duplicating the Dreadnought on short order.[53] What if the cheap RPAs really proliferate to make the expensive USAF and the American carrier fleets obsolete in short order? Will we have delivered to adversaries a cheap way to overcome our huge advantages in conventional warfare?

Another downside of being the leader in RPA (or any other major technological development) is that after you have made the investment in time, energy, and money in the new technology, then the rest can take a free ride on your work. They also know in advance what can work and can learn the defects of new systems before they commit their own resources to the development.[54] The Soviets never had to go through the toil and expense of a latter day Manhattan Project because espionage was quicker and cheaper. Too, in a way, the risk for

the USSR was less because they already knew it was possible before they started.

Possible Futures

Completely Autonomous RPAs.[55] There are some antiaircraft and antimissile systems that can be set to make a decision to shoot with no human intervention. The time to react is so short that humans cannot do it fast enough. Whether humanity is ready to freely grant machines the power to make life and death decisions on opening fire without human authority is widely questioned.[56] In a South African test in October 2007, a robotic automatic gun system went haywire and inadvertently killed nine people. The problem was a defect in the software. In the Gulf War, two F-16s were shot down by Patriot missiles. Yet, as Singer has pointed out, if we are to depend on centralized control for decisions like that, then all the adversary has to do is to find a way to hack into our communications systems.[57]

Laws of War.[58] The legal dimensions of battle are complicated by the RPA. Two requirements are that the force applied must be proportionate to the military benefit to be realized from the events, and that noncombatants be excluded from deliberate harm. Throughout history those decisions were usually made at the tactical or local level, but increasingly the improved communications and video have caused an escalation of the levels at which that is done. Whatever the dangers of micromanagement, though, to make that decision away from the emotional imperatives of direct combat may reduce mistakes.[59] But when a robotic mistake is made, who is to be accountable: the pilot at Creech AFB, the software programmer for the RPA, the manufacturer of the RPA, the designer, or the acquisition official?[60] Singer wonders whether the operator at Creech would thus become a legitimate target.[61]

Ethics of War. There are ethical problems that sometimes go beyond the requirements of law. During the Hoover Administration (1929–33), Henry Stimson was secretary of state, and some folks were proposing breaking into Japanese codes. His reaction was to forbid it, arguing that, "Gentlemen do not read each others [*sic*] mail."[62] That was a long time ago, before breaking the German codes yielded great savings in lives in World

War II (while Stimson was secretary of war). Count on it—RPAs will be one day be used for unethical purposes in civilian life. The use of them for perhaps drug smuggling and the threats of invasions of privacy are obvious. In war, it seems clear that rules of engagement could be programmed into unmanned systems, but it is hard to anticipate that machines could ever have built-in morality, empathy, fear, anger, or other emotional motivators and limitations. During the Cold War, once launched, the ICBMs were robotic. One of the reasons we maintained the B-52 leg of the nuclear triad so long was that they were *not* robotic—unlike the missiles, they could be recalled or held on airborne alert. Global Hawk has amply demonstrated the same advantage as the manned bombers.

The conventional upbringing in the West supposedly emphasizes the importance of fairness in conflict. Rules emphasize this in every sport. The taking of drugs of any kind to gain an advantage over the opposition is strongly forbidden—the contest must be equal. But war is not sport. To whom must the commander be fair: the mothers and fathers of the troops, or those of the enemy? A part of Douhet's motivation was said to be to shorten the next war so that millions would not die in the trenches. He argued that bombing cities would cause the people to rise up against their political leaders and force a peace within a few days rather than after many years of human agony in the trenches.[63]

Shock and Awe or Contempt. Contemporary experience with combat RPAs suggests that network-centric warfare, for all its virtues, has not removed the fog of war. The Predators and Reapers have been technological marvels in Iraq, Afghanistan, and Pakistan, but it is still uncertain as to whether they do more good than harm. As noted, al-Qaeda is harping on their cowardliness and the inhumanity of their killing of innocent civilians, and even that is an unclear message. Is it a sign that the leadership really feels beleaguered or that the RPA strikes make wonderful recruiting tools for the adversary? It is certain that many high-ranking Taliban and al-Qaeda leaders have been killed, and perhaps that has reduced the effectiveness of the survivors and also diminished the quality of the replacements. This has impeded al-Qaeda's ability at communication and absorbed a good deal of its attention in self-protection. It

seems to have sown distrust within its ranks, and even some flight to safer climes.[64] But on the other hand, there are bystanders who have been killed along with the enemies, and that may be undermining the effort to win the hearts and minds of the citizens of both Afghanistan and Pakistan. It also has been corrosive on America's reputation in some areas but helped it in others. Al-Qaeda's response using brutal methods may also be causing some Pakistanis to refocus their attention from the perceived threat of India in the east to the threat of the Taliban and al-Qaeda at home.[65]

Manned Air to Disappear. Less than 20 percent of Air Force officers are rated—and now the non-flyers who operate RPAs at Creech are to receive flight pay. It is a trend that has been going on for a long time, and there are many competent flyers in the other services. But more and more of the flyers' works of the past are being done by missiles and RPAs.

ISR. Reconnaissance was among the earliest missions of airpower. Its elevated viewpoint yielded a wide field of view, and its speed enabled much faster acquisition of the needed data than seaborne and land methods. But it has always been dangerous, and sometimes boring. The coming of RPAs has made it cheaper, safer, and deprived the enemy of the propaganda opportunities he can gain through the exploitation of prisoners of war.

SEAD. The suppression of enemy air defenses has been the most dangerous tactical air mission of all. When done by RPAs or extended range missiles, the danger can be removed and the potential for the enemy exploitation of downed pilots eliminated. In the case of RPAs in the role, their loiter time may enable them to remain on station long enough to strike when enemy radar starts emitting, or to decoy it into emitting to permit manned SEAD aircraft to either jam or destroy it.

Close Air Support (CAS). Through history, CAS has been one of the most dangerous missions, and often of limited productivity. In those situations, the enemy is often well hidden and antiaircraft weapons are emplaced and at the ready. In some situations, the manned aircraft's time on station has been so limited that it has reduced their value. When held on ground alert, the time it takes CAS aircraft to take off and fly to the threatened point limits their responsiveness to emergency situations. Combat RPAs, with their long loiter time and ability

to operate from many fields closer to the fighting, can reduce those problems. Because of this, the development of new unmanned combat air vehicles has tended to revive the Army-Air Force debate over centralization versus decentralization of the control of the aircraft.

Air Superiority. American air-superiority aircraft have not been in a dogfight for 35 years. Since then, all of their kills save two (made on helicopters) have been achieved by radar or infrared guided missiles.[66] If that pattern holds true in the future, then missile-armed RPAs become attractive. Ultimately, the processing and detection capability may even be enough to make the RPA superior to manned aircraft, even in a dogfight at close range. Here maneuvering is vital, and the RPA is not subject to the limitations of blacking out if the G-forces in that kind of flight exceed the pilot's capability. Aircraft can withstand much greater forces than can pilots, and computers can react more quickly than humans. But it is one thing for technologists working out equations in a computer laboratory, and quite another for a person actually in the aircraft. Too, building the capability to meet all the requirements of fighter maneuvering into an RPA would be an expensive proposition even if it is possible.[67]

Strategic Attack. It seemed for a while after the fall of the USSR that the strategic attack mission was declining in its utility. It had been the main reason for the establishment of the USAF, but a combination of factors caused the long decline in its aircraft component. The coming of ICBMs and submarine-launched ballistic missiles (SLBM) had much to do with that. But also, the building of a huge tanker force for its support was an indirect factor. Though many bomber units were deactivated, the reduction of the tanker units did not follow. Rather, they were found essential for fighter deployments and for the support of carrier and even airlift air operations. In fact with tanker support, fighters could carry out many missions that would formerly have fallen to bombers.

But the surviving bombers have been heavily utilized in operations since the fall of the USSR. In part this has been due to the reduction in the forward deployments of American forces and the consequent loss of facilities to accommodate fighter forces. Further, the large ordnance loads and long loiter times

of bombers have been found useful in recent conflicts. Simultaneously, the reduction of the Soviet threat has lessened allied interest in supporting US forces in their lands, and access to danger areas has become more difficult. Thus, there is reviving interest in the development of long-range strike capabilities at a lower cost than the most recent bomber programs.

Is there an application for RPAs in a follow-on program for strategic attack? Defense Secretary Robert Gates has commented that the next generation bomber may be unmanned[68] or perhaps optionally manned. The memory of the loss rates in Eighth Air Force and RAF Bomber Command in World War II yields one reason for making them so. Our ICBMs and SLBMs have been on the line for many years and are all unmanned. Global Hawk (fig. 4) already flies long-range ISR missions with great success. Its operators retain the capability to intervene in its operation if the situation so dictates. Its programs have failsafe features for autonomous return to base in case of communications failure. Building a long-range RPA with stealthy, high speed, and air refueling capabilities might well overcome the

(USAF Photo)

Figure 4. RQ-4 Global Hawk

limitations caused by the reductions in US forward force stationing. If the vehicle is unmanned, the degree to which human endurance is stretched in the current bomber force would be eliminated along with the risk. The coming of economical precision weapons in small sizes enhances the possibilities of such an unmanned force. Such bombers might even be equipped with small RPAs of their own that could be sent against the most dangerous defenses.

We have noted that no ICBM or SLBM has ever been launched in anger and that the B-52 has been long maintained as one leg of the nuclear triad precisely because it is not unmanned and it can be recalled. But once the missiles were launched with their nuclear warheads, it is all over. Thus, one suspects that it will be a long time before Western society will be ready to launch unmanned, nuclear-armed RPAs. Yet there are those who predict that the Air Force will be completely unmanned by mid-century.[69]

Airlift. Chad Manske, an experienced airlifter, argues that some of the factors that make RPAs attractive for tactical missions do not apply as much to airlift. However, he does see great potential benefits in economic terms. The perennial ton-mile capability shortfall in strategic airlift might eventually be overcome through the use of RPAs. He envisions a fleet of airlifters flying in formation with a mother ship. They would be cheaper to buy and maintain than the standard aircraft, yet by flying in formations, it might ease the problems with Federal Aviation Administration restrictions of RPA movements in controlled airspace. Incidentally, Global Hawk avoids many of those problems in that it flies above 65,000 feet where the rules do not apply. The Predator can be shipped in containers aboard other aircraft, so it also avoids some of the restrictions. But whenever those aircraft or any other RPAs are operating out of special use airspace in the United States, they must be controlled by a fully licensed aircraft pilot.[70]

Passenger Air Transport. Passenger airliners are nearly capable of autonomous flight even now, and aircrews spend large amounts of time as little more than a safety monitor. In October 2009, two airline pilots were preoccupied with personal laptops in the cockpit, and the plane flew for 150 miles beyond its destination before the flight attendants got their attention.

There had been numerous radio calls to which they had not responded, the Air National Guard was alerted (albeit with some delay), and the White House situation room notified.[71] That caused a considerable stir, and doubtless it would have been even greater if the airplane had been actually unmanned with a load of 149 passengers. Likely it will take a longer time before RPA passenger flight is accepted.

Medical Evacuation. Personnel transport of wounded warriors from the battlefield is another story. As the rescues of Lt Col "Gene" Hambleton in Vietnam in 1972 and the Marines from Koh Tang Island in 1975[72] demonstrate, such operations are costly. They also can cost more lives than they save. In the former case, 11 lives were lost in the effort to save one, and the operation distracted air units from major operations going on elsewhere. Thus, the development of remotely piloted aircrafts dedicated for that purpose may make good sense. In fact, in 2009 the Israelis were at work on just such a program.[73]

Why a Separate AF?
Speculations of an Ancient Aviator

The main reason a separate air force was established in 1947[74] was the strategic attack mission—not directly related to ground force or naval operations on the surface. Some people argued that pilots were "a separate breed of cats" and could not be properly managed under the command of armies or navies. In 1947, the idea that weapons of mass destruction (WMD) would soon be miniaturized seemed to be a pipe dream. The idea of a war against a mass land army seemed improbable. Even more improbable would be a naval war.

The Cold War was in the offing; if it were to become hot, it seemed that it would be an air war fought via the North Pole. Pilots dominated the Air Force. The national debt was astronomical. Pres. Harry S. Truman and others thought that the most economical security could be had by reliance on a long-range nuclear air force with minimal ground and naval forces. He capped the defense budget accordingly. After what seemed a temporary aberration in Korea, that reliance was restored

and the heyday of the Strategic Air Command and long-range strike followed.

Now the Cold War is gone. Interstate war is said to be unlikely. Future conflicts are predicted to be between governments and non-state actors—irregular war in various forms. Long-range strike, especially with nuclear forces, seems to some to be a quaint antiquity. The future seems to belong to ground forces searching for terrorists and fighting insurgents all over the world. Most of the Air Force bombers are gone. Pilots are a small minority of the officer corps. Strategic attack is improbable; close air support and airlift seem to be the order of the day. Some ask whether the day of the autonomous air force has reached its twilight.[75]

Firearms were introduced to western militaries in the fourteenth century, but the expense incurred by the necessity of accompanying pikemen to protect the musketeers during reloading from charging cavalry was very onerous. The ring bayonet that could be mounted without disabling the piece for firing did not come until 1709, *nearly four centuries later*. The bayonet enabled huge economies by eliminating pikemen or great growth in volume of fire by converting them to musketeers. But the coming of firearms and artillery was among the reasons for the end of feudalism and the coming of the nation state headed by kings. Only they could afford the maintenance of standing armies and the artillery needed to overcome the fortifications of the local barons and bishops. More centralized power was necessary to accumulate the wealth necessary to support those forces necessary to monopolize organized violence.

Robert Fulton applied steam engines to vessels in 1807, and the US Navy started its conversion to steam before the Civil War. But until the 1880s, steam vessels still carried sails to compensate for engine failures or to conserve the coal supply. But commercial vessels under sail continued all the way up until World War II. Further, the use of coal-fired power plants reduced the range of naval operations and required the acquisition of coaling stations. This reform took the *better part of a century*. The acquisition of an infrastructure to build iron and then steel ships, their armor, the increasing caliber armaments, the steam plants, and the empires to support all that was an expensive proposition. It was not accidental that Great Britain,

the United States, and Japan were the leaders in the building of great navies. Germany tried, but the others did not have the French army to the west and the Tsar's army to the east to consume great wealth and effort necessary for armies to protect the borders—additional factors promoting centralization of wealth and power in a few nation states. It took a century to go from Trafalgar[76] to Jutland.[77]

For the first century of West Point's existence, the branch of choice was the cavalry. For many centuries, it had been a main striking force for armies as well as the principal instrument for ISR. But then about 1840, some inconsiderate soul invented the minié ball that tripled the range and the rate of fire of infantry weapons. Thus, the horse and rider would have to endure three volleys of fire instead of one before they could slash the grunts. So their value as a shock instrument was gone by 1861 (though it took some time for folks to fully recognize it). Still, the ISR function was alive and well. But other souls invented first the balloon and then the airplane that undermined that.[78]

Balloons were used in the Civil War, and aircraft had taken over the ISR function in a matter of a half century. But an airpower capability is also dependent upon great industrial and training capabilities not affordable for many governments, still less insurgent operations.

Is the F-35 to Be the Last Manned Fighter?

Change is hard; there is a huge cost sunk in skills and infrastructure. Cavalrymen as well as Airmen have had to make an emotional investment in their professions as well, as do Sailors. Coast Guard cadets still do their summer training on the *Eagle*, which they call the slave ship—but when they graduate and become senior, there is not much movement to give up the sails. There are usually technological arguments that can be made in favor of conservatism. Steam technology was shaky for a long time, and the sails were an insurance against engine failure—and they saved money on fuel.

The USAF has often been accused of being slow to take up the RPA, but no one brought up caring for a 1950s TV set full of peanut vacuum tubes will doubt that component technology

common to PGMs, cruise missiles, airplanes, and RPAs has come a long way since World War II. That has been expensive and dependent also upon the rate of technological advance.

We have seen that the GPS was not completely ready until the mid-1990s, and supporting space assets to bring the bandwidth needed cost a lot and took some time as well. Is the F-35 the last of the line? The subway in the Atlanta airport is unmanned and few seemed worried about that—but the designed unmanned trains in the Washington Metro still carry human operators. As noted, there are still many who would not delegate the life and death decision to open fire to RPAs.

Is it possible that the technology of RPAs and other advances are about to bring on a massive human retrogression? Singer suggests that civilization may be at the dawn of a new age, or perhaps a return to an old one.[79] A large part of the reason for the end of feudalism in Europe was advancing military technology. The coming of effective firearms, artillery, and fortifications made war so expensive that it could only be managed by nation-states—often large nation-states. The feudal barons and their knights could not stand up to emergent nation-states and their kings. That went on through the end of the Cold War.

But now, perhaps the coming of cheap RPAs, IEDs, and general insurgency methods might be reversing that. Perhaps now the modern equivalent of the medieval knight is an individual jihadist armed with remotely detonated IEDs or some non-state actor equipped with a swarm of RPAs possibly armed with WMD warheads. Perhaps centralized power is not the wave of the future. The highest social service any government can provide is preserving the physical security of its citizens. Governments have done this in large part through a monopoly of organized violence in armies and police forces. When large nation-states can no longer do that, will they pass from the scene?

Notes

1. Ames R. Reinhardt et al., "Future Employment of UAVs: Issues of Jointness," *Joint Forces Quarterly*, Summer 1999, 36.

2. Brent K. Tornga, "Unmanned Aerial Vehicles," (master's thesis, University of Nebraska, Lincoln, 1995), 16.

3. Buhwan Sharma, "Kite World," *Wave Magazine*, October 2000, http://www.wavemag.com.np/issue/article1740.html (accessed 13 October 2009);

and Lt Col Richard M. Clark, *Uninhabited Combat Aerial Vehicles* (Maxwell AFB, AL: Air University Press, 2000), 6.

4. Bill Caraway, "Korea in the Eye of the Tiger, Ch 5-Koryo and the Mongols," *Korean History Project*, http://www.koreanhistoryproject.org/ket/co5/E0507.htm (accessed 13 October 2009). The story is widely reported, sometimes with pigeons, sometimes with swallows, but always with cats. The general idea was really tried in World War II with bats and incendiary devices attached to their legs. About $2,000,000 was spent on the project before it was abandoned. The idea was to refrigerate the bats to get them to hibernate long enough to be carried aloft in a bomber; then they were to be dropped and thaw out on the way to the ground in time to fly into Japanese attics. In one of the tests in New Mexico, one of the few that did survive the fall is supposed to have flown into a general's car and burned it; and Joe Michael Feist, "Bats Away," *American Heritage Magazine* (April/May 1982), http://www.americanheritage.com/articles/magazine/ah/1982/3/1982_3_93-print.shtml (accessed 14 October 2009).

5. "The First Air Bomb: Venice, 15 July 1849," *Airminded: Airpower and British Society, 1908–1941*, 22 August 2009, http://airminded.org/category/periodicals/ (accessed 14 October 2009); "The First Air Raid—by Balloons," *RPAV Remote Piloted Aerial Vehicles*, http://www.ctie.monash.edu.au/hargrave/rpav_home.html#Beginnings (accessed 14 October 2009).

6. Christopher Eger, "Japanese Balloon Bombs of WW II," *Suite101.com*, 10 February 2007, http://air-combat.suite101.com/article.cfm/Japanese_balloon_bombs_of_wwii (accessed 14 October 2009).

7. "Nikola Tesla," http://www.crhystalinks.com/tesla.html (accessed 14 October 2009); Nikola Tesla, "The Transmission of Electrical Energy without Wires as a Means for Furthering Peace," *Electrical World and Engineer*, 7 January 1905, http://www.tfcbooks.com/tesla/1905-01-07.htm (accessed 14 October 2009); and P. W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York, NY: Penguin, 2009), 47, reports that the Germans actually used the notion shortly afterwards. They loaded up some motorboats with explosives, and controlled them at first by means of a long wire. The idea was unmanned coastal defense, and later they tried to do it with radio control from airplanes flying above.

8. Kenneth Werrell, *The Evolution of the Cruise Missile* (Maxwell AFB, AL: Air University Press, 1985), 7–8.

9. Ibid., 10–12.

10. Ibid., 12–16.

11. Phillip S. Meilinger, "Giulio Douhet and the Origins of Airpower Theory," in Meilinger, ed. *Paths of Heaven* (Maxwell AFB, AL: Air University Press, 1998), 9; Mark A. Clodfelter, "Molding Airpower Convictions: Development and Legacy of William Mitchell's Strategic Thought," in Meilinger, ed. *Paths of Heaven*, 92; William Mitchell, file no. 240-49, US Army Military Institute Archives (lecture, Army War College, Carlisle Barracks, PA, 24 November 1922).

12. Since 7 December, the United States never has lost another battleship though the British, Italians, and Japanese have.

13. Clark, *Uninhabited Combat Air Vehicles*, 9.

14. Greg Gobel, "Early US Target Drones," *In the Public Domain*, http://www.vectorsite.net/twuav_01.html (accessed 15 October 2009). Incidentally, most of the battleships sunk at Pearl Harbor were raised and put back into service, but they served mainly as shore bombardment vessels in support of amphibious operations; the newer and faster battleships sailed mainly in support of aircraft carriers as antiaircraft platforms. That enabled moving the guns and ammunition off the carriers to the battleships leaving more room for bombs and aviation gasoline on the former.

15. Clark, *Uninhabited Combat Air Vehicles*, 9–11; and Anthony J. Lazarski, "Legal Implications of the Uninhabited Combat Aerial Vehicle," *Aerospace Power Journal* 16, no. 2 (Summer 2002): 75.

16. Christopher A. Jones, "Unmanned Aerial Vehicles: An Assessment of Historical Operations and Future Possibilities," (research paper, Air Command and Staff College, 1997), 5.

17. Ibid., 55.

18. Werrell, *Cruise Missiles*, 142–44; Houston R. Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicle in Air Force Culture" (thesis, School of Advanced Air and Space Studies [SAASS], June 2007), 9–13; and Jones, "Unmanned Aerial Vehicles," 12, shows that the DC-130 force with its UAVs was transferred to the Tactical Air Command in 1976, and it was deactivated three years later.

19. Clark, *Uninhabited Combat Aerial Vehicles*, 26; Cantwell, "Beyond Butterflies," 9; and Jones, "Unmanned Aerial Vehicles," 13, reports that Ryan successfully tested a Maverick missile from one of its Lightning Bugs in 1971.

20. Singer, *Wired for War*, 56.

21. Reinhardt, "Future Employment," 37.

22. David Syrett, "The Tunisian Campaign," in Benjamin Franklin Cooling, *Case Studies in the Development of Close Air Support* (Washington, DC: Office of Air Force History, 1990), 155–57, 161–70; and Jeffry Kappenman, "Army Unmanned Aircraft Systems: Decisive in Battle," *Joint Forces Quarterly*, 2nd Quarter 2008, 20–23, gives a good summary of current Army arguments on the command and control of RPAs.

23. Singer, *Wired for War*, 113, reports that the Army's Future Combat Systems plan calls for every brigade to have its own air corps made up of RPAs.

24. Singer, *Wired for War*, 252–53.

25. Cantwell, "Butterflies," 12–15.

26. Harold R. Winton, "An Ambivalent Partnership: US Army and Air Force Perspectives on Air-to-Ground Operations, 1973–90," in Meilinger, *Paths of Heaven*, 399–433; and Lon O. Nordeen, *Airpower in the Missile Age* (Washington, DC: Smithsonian, 1985), entire volume.

27. Cantwell, "Butterflies," 22; Sean M. Frisbee, "Weaponizing the Predator UAV: Toward a New Theory of Weapon System Innovation" (master's thesis, SAASS, 2004), 1.

28. Frisbee, "Weaponizing the Predator," 2–3.

29. "Are Uninhabited Combat Air Vehicles Coming of Age," *Pathfinder*, October 2004, www.raaf.gov.au/airpower (accessed 13 September 2009).

30. David A. Deptula, "Unmanned Aircraft Systems: Taking Strategy to Task," *Joint Forces Quarterly*, 2nd Quarter 2008, 49–51; and Singer, *Wired for War*, 202, reports that there is a record of a collision between a RPA and a helicopter in Iraq.

31. Travis A. Burdine, "The Army's 'Organic' Unmanned Aircraft Systems: An Unhealthy Choice for the Joint Operational Environment," *Air and Space Power Journal* 23, no. 2 (Summer 2009): 88–100.

32. Robert E. Chapman II, "Unmanned Combat Aerial Vehicles: Dawn of a New Age?" *Aerospace Power Journal* 16, no. 2 (Summer 2002): 66.

33. Clark, *Uninhabited Combat Aerial Vehicles*, 1, 41, and 70.

34. Timothy J. Sundvall, "USAF Robocraft: Engineering National Security with Unmanned Aerial Vehicles" (master's thesis, SAASS, 2006), 35; and Reinhardt, "Future Employment," 38.

35. The US Navy has recently deployed a Reaper detachment to the Seychelles Island in the Indian Ocean to assist in the effort against pirates. "Navy Deploys Drones in Anti-Piracy Effort," *San Diego Union-Tribune*, 22 October 2009, 9, http://ebird.osd.mil/ebfiles/e20091022711397.htm (accessed 22 October 2009).

36. Deptula, "Unmanned Aircraft Systems," 49–51.

37. A "Red Team" is a group of people designated to serve as adversaries in war games—anticipating the reactions of the enemy as best they can.

38. Singer, *Wired for War*, 200.

39. Chapman, "Unmanned Combat Aerial Vehicles," 62; and Jeff Mustin, "Future Employment of Unmanned Aerial Vehicles," *Aerospace Power Journal* 16, no. 2 (Summer 2002): 86–96.

40. Singer, *Wired for War*, 203; and James Jinnette (ex-F-15E squadron commander), "Robotic Systems Can't Replace a Pilot's Gut Instinct," *Armed Forces Journal*, November 2009, http://www.armedforcesjournal.com (accessed 11 November 2009).

41. James C. Dawkins, Jr., "Unmanned Combat Aerial Vehicles: Examining the Political, Moral, and Social Implications" (master's thesis, SAASS, 2005), 41–44; and Clark, *Uninhabited Combat Aerial Vehicles*, 63.

42. Since the 1960s, the Air Force has required pilots to serve in assignments where their primary duty is flying for specified numbers of months by certain waypoints of service in order to retain their flying status—it is called "Gate Time."

43. Thomas G. Tobin et al., *Last Flight From Saigon* (Washington, DC: Office of Air Force History, 1985), entire volume; Ralph Wetterhahn, *The Last Battle* (New York, NY: Carroll and Graf, 2001), 262; John F. Guilmartin, "The Mayaguez Incident, 12–15 May 1975: A 30-Year Retrospective," *Air and Space Power Journal*, Spring 2005, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj05/spr05/vignette3.html (accessed 19 October 2009); P. W. Singer, "Tactical Generals: Leaders, Technology, and the Perils of Battlefield Micro Management," *Air and Space Power Journal* 23, no. 2 (Summer 2009): 78–87.

44. Cantwell, "Butterflies," 65; Dawkins, "Unmanned Combat Aerial Vehicles," 24.

45. Cantwell, "Butterflies," 71.

46. Singer, *Wired for War*, 309.

47. John Edward Jackson, "More Than Three Laws of Robotics," *Naval War College Review* 62, no. 4 (Autumn 2009): 155–58, http://usnwc.edu/publications/Naval-War-College-Review/2009-autumn.aspx (accessed 22 October 2009).

48. Dawkins, "Unmanned Combat Aerial Vehicles," 12.

49. William W. Momyer, *Airpower in Three Wars*, (1978; repr., Maxwell AFB, AL: Air University Press, 2003), 237–39, 241.

50. "Uninhabited Combat Aerial Vehicles: Reality or Elusive Dream," *Pathfinder: Air Power Development Centre Bulletin*, June 2008), www.raaf.gov.au/airpower (accessed 22 October 2009).

51. Cantwell, "Butterflies," 72; and Singer, *Wired for War*, 200. Doubtless many other military systems are dependent upon space and the bandwidth requirements associated with that. The global positioning system has become so prevalent that many airlifters no longer carry navigators, and few people who do fly are still taught celestial navigation.

52. Sundvall, "USAF Robocraft," 20; and John D. Jogerst, "Airpower Trends 2010: The Future is Closer Than You Think," *Air and Space Power Journal* 23, no. 2 (Summer 2009): 101–10.

53. Elmer B. Potter, ed., *Sea Power: A Naval History*, 2nd ed. (Annapolis, MD: Naval Institute, 1981), 194–95.

54. Singer, *Wired for War*, 239.

55. Sundvall, "USAF Robocraft," 52, seems to think that ultimately we will permit completely autonomous RPAs to become a part of our inventory; and Singer, *Wired for War*, does not agree, 127, 133, and 418; Reinhardt, "Future and Employment," 39, declares that ". . . Simply stated, the rules of engagement will be controlled by humans, in part to mitigate the unsettling idea of uncontrolled aircraft deploying weapons autonomously. . . ."

56. "Small Air Forces, UAVs and Operational Flexibility," *Pathfinder*, October 2006, www.raaf.gov.au/airpower (accessed 13 September 2009).

57. Singer, *Wired for War*, 125, 127, and 192.

58. Dawkins, "Unmanned Combat Aerial Vehicles," 6, argues that RPAs or military operations with no risk to one of the participants are not illegal or immoral; and Lazarski, "Legal Implications," 74–83.

59. Dawkins, "Unmanned Combat Aerial Vehicles," 25–28.

60. Singer, *Wired for War*, 385.

61. Singer, *Wired for War*, 386, 408; and Jackson, "More than Three Laws," 158.

62. Henry L. Stimson, in *Quotations Book*, http://quotationsbook.com/quote/44728/ (accessed 28 October 2009).

63. Dawkins, "Unmanned Combat Aerial Vehicles," 6; and Giulio Douhet, *The Command of the Air* (new imprint, Washington, DC: Air Force History and Museums Program, 1998), 58.

64. Michael P. Noonan, "Disrupting the Foreign Fighter Flow," *Foreign Policy Research Institute E-Notes*, October 2009, http://www.fpri.org/note/woon10.noonanm.disruptingforeignfighterflow.html (accessed 25 October 2009).

65. Peter Bergen and Katherine Tiedemann, "The Drone War: Are Predators our best weapon or worst enemy?" *The New Republic*, 3 June 2009, http://www.tnr.com/article/the-drone-war# (accessed 23 October 2009); and Brian Glyn Williams, "Death from the Skies: An Overview of the CIA's Drone Campaign in Pakistan—Part One," *Terrorism Monitor* 7, no. 29 (25 September 2009), http://www.jamestown.org/single/?no_cache=1&tx_ttnews%5Btt_news%5D=35542&tx_ttnews%5BbackPid%5D=381&cHash=011c930244 (accessed 23 October 2009).

66. David Axe, in "Axeghanistan [*sic*] '09: Chopper-Bombing Drone-Killer," *WarIsBoring.com* (23 October 2009), reports that the same F-15 that killed a helicopter with a laser-guided bomb in Desert Storm recently shot down a stray Reaper with a missile to prevent it from damaging an unintended target. http://ebird.osd.mil/ebfiles/e20091024711850.html (accessed 24 October 2009).

67. Dawkins, "Unmanned Combat Air Vehicles," 8, reports that the USAF attempted to shoot down an Iraqi MiG from a Predator armed with a Stinger missile during Operation Southern Watch.

68. Tony Copaccio, "China's New Weapons May Threaten U. S. Bases, Ships, Gates Says," *Bloomberg.com*, 16 September 2009, http://www.bloomberg.com/apps/news?pid=20601080&sid=am6ExRzB1cjo (accessed 27 October 2009).

69. Tornga, "Unmanned Aerial Vehicles," 6, (a naval officer) argues that completely unmanned air forces would be feasible by 2025, but the society will not be ready to accept them; Singer, *Wired for War*, 168 and 389, argues that other societies are less sensitive about allowing machines the authority to fire, but that the West is probably not ready for that.

70. Chad T. Manske, "Unmanned Airlift: A Viable Option for Meeting the Strategic Airlift Shortfall" (master's thesis, SAASS, 2002); and Lazarski, "Legal Implications," 78.

71. "Distracted Northwest Pilots Alarms Experts," *CBS News.com*, 27 October 2009, http://www.cbsnews.com/stories/2009010/27/national/main5424085.shtml?tag=stack (accessed 27 October 2009).

72. Darrel D. Whitcomb, *The Rescue of Bat 21* (Annapolis, MD: Naval Institute, 1998), entire volume; and John F. Guilmartin, *A Very Short War* (College Station, TX: Texas A & M University Press, 1995), entire volume.

73. Yaakov Katz, "Israeli UAVs expected to steal the show at Paris expo," *The Jerusalem Post*, 14 June 2009, http://www.jpost.com/servlet/Satellite?cid=1244371095674&pagename-JPost/JPArticle (accessed 27 October 2009).

74. Robert Spalding, "America's Two Air Forces," *Air and Space Power Journal* 23, no. 2 (Summer 2009): 51–56, suggests that a single air organization cannot be effective in both counterinsurgency and conventional war, though he stops short of advocating the end of the Air Force as a separate service.

75. Robert Farley, "Abolish the Air Force," *The American Prospect*, 1 November 2007, http://www.prospect.org/cs/articles?article=abolish_the_air_force (accessed 28 October 2009).

76. The last great sea battle under sail was won by the British Royal Navy over the combined French and Spanish fleets in 1805.

77. The last great sea battle between steel battleships of the British and German navies was in 1916. (There were some gunnery duels between surface forces in the Second World War, but nothing of that great magnitude. By then the aircraft carriers were becoming the capital ships of navies.)

78. Thayer Hall at West Point was built as a riding hall and was used for equestrian training all the way up to the class of 1948. But probably it is fair to say, cavalry's final death knell came at Kitty Hawk and the full recognition of that took *about a half century*. Certainly there was more to it than that for the machine gun and indirect fire artillery equipped with fused and fragmenting projectiles made it impossible for cavalry to live on the battlefield even if aircraft had not taken over the intelligence, surveillance, and reconnaissance function.

79. Singer, *Wired for War*, 266.

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AFRI/DE
Dean, Air Force Research Institute
155 N. Twining St., Bldg 693
Maxwell AFB AL 36112-6026

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