Expendable Remotely Piloted Vehicles for Strategic Offensive Airpower Roles

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Abstract

The future holds an accelerating ascent of changes, technological advancements, and potential threats never before imagined just a decade ago. Many lessons of the past may no longer apply to the vastly different conditions of the future. However, past experiences provide the foundation from which we can undertake rational leaps of visionary faith. Hopefully, these attempts will land on firm ground to reveal accessible approaches to meet future challenges. Military visionaries must have open minds to explore new ways of applying the military instrument of power. The United States can no longer simply adapt to the changing environment with belated upgrades to existing military systems and strategies. In order to remain the world's greatest superpower, America's leaders must be openly aggressive in the pursuit for operational and organizational innovations.

This study analyzes the concept of using expendable remotely piloted vehicles (RPV) for strategic offensive airpower. The author first outlines the historical base of the larger category of unmanned aerial vehicles (UAV). The assessment of this background is that limited UAV development is primarily due to circumstantial historical events, including lack of user support, as opposed to technological restraints. Second, the author addresses strategic offensive airpower. Airpower provides unique advantages to a strategic offensive force. Likewise, unmanned aircraft can provide unique advantages as an integral part of this force. Following the historical base and strategic offensive airpower areas, the writer looks into the expendability aspect of RPVs. The finding is that "one-use, throw-away" RPVs offer many viable advantages to supplement existing strategic offensive airpower means. Finally, the author presents a notional scenario involving conceptual expendable RPVs. This scenario provides one theoretical example as to how future forces could employ and control RPVs in a strategic attack. The overall purpose of this paper is to not only highlight the author's concept of future unmanned aircraft but to also encourage pursuit into all areas that may possess the potential to advance airpower.

About the Author

Maj Dennis Larm received his commission in 1982 through the Air Force Reserve Officer Training Corps as a distinguished graduate of the University of Southern California. He completed the Imagery Intelligence Officer Course and the Intelligence Precision Photographic Officer Course with honors at Lowry Air Force Base (AFB), Colorado. Major Larm's first intelligence tour was at Osan Air Base (AB), Republic of Korea. Following completion of the Computer Systems Development Officer Course at Keesler AFB, Mississippi, he served on the headquarters staff at Hickam AFB, Hawaii. Major Larm subsequently earned a master's degree in strategic intelligence as a distinguished graduate of the Defense Intelligence College in Washington, D.C. At Goodfellow AFB, Texas, he was an intelligence instructor and directed acquisition efforts for computer-based intelligence training systems. At Randolph AFB, Texas, he was an intelligence training program element monitor and an executive officer. Major Larm is a graduate of Squadron Officer School and Air Command and Staff College. Following graduation from the School of Advanced Airpower Studies, Maxwell AFB, Alabama, he will be assigned to Osan AB, Republic of Korea. Major Larm is married to the former Mia Park, and they have a daughter, Tina, and a son, Derek.

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Chapter 1

Introduction

Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur. In this period of rapid transition from one form to another, those who daringly take to the new road first will enjoy the incalculable advantages of the new means of war over the old.

—Giulio Douhet
The Command of the Air

Early airpower theorists—such as Giulio Douhet, Hugh Trenchard, and William "Billy" Mitchell—all recognized the revolutionary nature of airpower that would forever change warfare. These pioneers expressed their visions of airpower through descriptions of its inherent qualities and prescriptions of propositions for its employment. Much of what they articulated is invaluable and timeless in nature. Unfortunately, many other airpower predictions proved incorrect; and many promises remain unfulfilled through the test of war and conflict over time. Today we better understand airpower's strengths and weaknesses. Using doctrinal underpinnings, lessons of war, and technological advances as guidelines, the quest continues to further comprehend and exploit the numerous advantages of airpower.

This study examines the feasibility of developing expendable remotely piloted vehicles (RPV) and explores future concepts of conventional US strategic offensive airpower roles. This research has three objectives. The first is to broaden the airpower profession's scope of understanding on unmanned aerial vehicles (UAV).[1] The second objective is to explore the option of using RPVs for strategic attack. The third objective is to examine what expendability offers in terms of making an unmanned aerial attack vehicle an airpower asset.

In concert with these objectives, the author presents three assertions: (1) UAV development is experiencing and must overcome difficulties that virtually all replacement warfare technologies tend to encounter during early stages of evolution; (2) the RPV offers a viable means to conduct strategic offensive warfare, which is of contemporary importance; and (3) in a strategic attack role, RPVs offer an increased number of advantages by incorporating expendability up front into their design.

In order to maintain a focused subject scope, this study is limited in several ways. It specifically explores options of expendable RPVs to complement current airpower means and strategies for employing strategic offensive airpower. This study makes no arguments to replace existing systems and strategies.[2] This study will not propose to take the pilot out of the cockpit, but it examines the concept of taking the cockpit out of the

aircraft. Incorporating the added dimension of employing one-use vehicles to the above concept, this study attempts to reveal representative, though not all-encompassing, innovative airpower ideas.

Research and analysis for this study focuses on strategic airpower roles in a conventional war (i.e., without weapons of mass destruction).[3] This does not mean other situations are not relevant. In this study, the word *strategic* describes airpower that is "designed to strike an enemy at the sources of his military, economic, or political power."[4] Theoretically, however, military leaders can decide to employ systems primarily developed for strategic airpower in all types of conflict, as well as in different levels of war. For example, bombers can serve a strategic nuclear triad role, they can attack targets located deep within an enemy's territory in a conventional war, and they can attack enemy ground forces in support of low intensity conflict operations.

This study is not a treatise on how to procure systems, nor is it a doctrinal study. It does acknowledge, however, potential impacts and implications that the development of expendable RPVs can have in both these areas. A final limitation is its classification level. The author intentionally kept references and the product unclassified to make them readily accessible at the broadest level. The intent is to not only raise the level of knowledge of UAVs but also to promote interest and prompt further research into airpower issues of contemporary relevance.

Throughout the evolution of unmanned, self-propelled flying vehicles, there have been a variety of terms and varying interpretations of terminology used to describe them. In order to understand why no universally accepted definitions exist, it may be helpful to see an illustration of broad aerial vehicle categories from the recent past for comparison to the present view. Figure 1 is a family tree of aerial vehicles representative of late 1980s technology and development.[5]

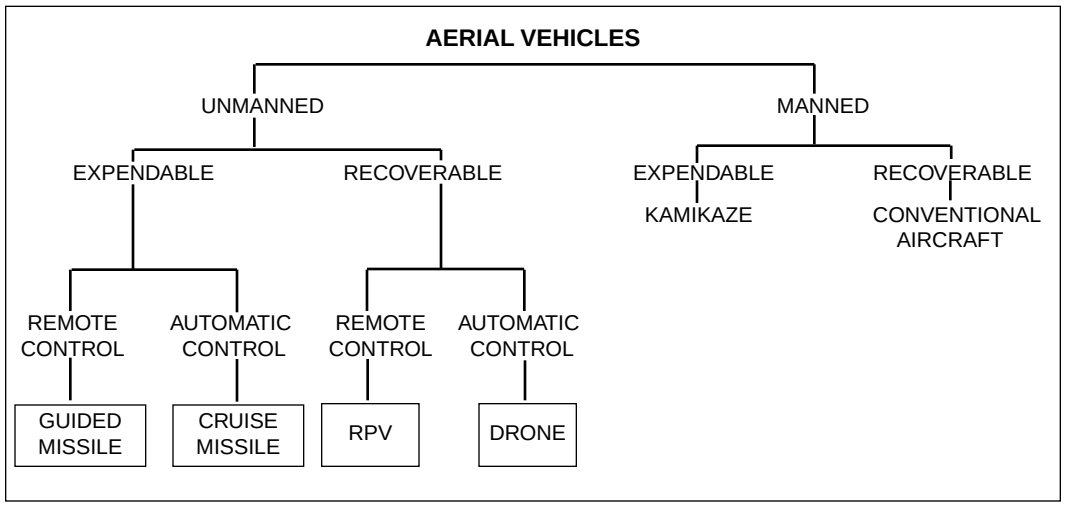


Figure 1. Family Tree of Aerial Vehicles (1988)

The problem with the figure 1 view is that it is out of date since different types of vehicles now overlap more than one category. New technology often prompts the revision of original meanings and the appearance of new acronyms. For example, cruise missiles were initially only capable of flying a single, preprogrammed route. Recent technologies now make it possible to perform changes during flight, either via human or autonomous inputs. Also, *drone* is an older term that initially did not refer to a remotely controllable vehicle. Today, *Webster's Ninth New Collegiate Dictionary* defines it as a pilotless vehicle "controlled by radio signals"; however, this is not always the case.

Literature on unmanned aircraft (UMA) includes many different terms used to describe them. Some, such as UMA[6] and unmanned vehicle (UMV), [7] never gained wide acceptance. The most recent acronyms, UCAV (uninhabited combat air vehicle) and URAV (uninhabited reconnaissance air vehicle), were developed "to distinguish the aircraft enabled by the new technologies from those now in operation or planned."[8]

Classes of Aerial Vehicles

This study uses some of the more widely used terms in order to delineate classes of aerial vehicles not having a pilot on board. For the purpose of this study, the following terms and meanings will apply.

Definitions

Definitions are primarily author-derived and not based on any one source. The attempt was to use terms and meanings from which the reader could logically distinguish one from the other.

Aerial Vehicle. The all-inclusive term applied to a self-propelled airpower conveyance designed to operate without a human physically residing on board but capable of being directed by a human and/or directing itself during flight. Three major categories under UAVs are drones, cruise missiles, and RPVs.

Drone. The category of UAVs possessing preprogrammed autonomous flight control capability. Drones can be recoverable or expendable.

Cruise Missile. The category of UAVs designed to have preprogrammed autonomous flight control capability but may possess limited data input and/or output interaction with a human controller to guide it. Cruise missiles traditionally carry destructive payloads and are expendable.

Remotely Piloted Vehicle. The category of UAVs designed to have some degree of interaction with a human controller via a data link but may possess autonomous flight control capability. An RPV receives data to influence its flight and mission operations. It transmits data to provide flight sensor information, as well as mission information from any number of information-gathering sensors carried on board the vehicle. RPVs can be recoverable or expendable.

UAVs were more easily defined when they could be positively categorized as either expendable or recoverable and either remotely or automatically controlled (as illustrated in fig. 1). Terms and definitions are more logically categorized according to the degree of remote and/or automatic control. In this manner, the family of drones consists of strictly autonomous (automatic control) pilotless aircraft. A cruise missile and an RPV can have internal automatic navigation control systems as well as human reliance control characteristics; however, they are distinct according to the degree of control they typically require.

Table 1 shows the relationship of primary UAV types used throughout this document. Unlike figure 1, the author does not categorize UAVs as either expendable or recoverable. This study contends one should not use expendability as a classification, but rather as a characteristic in the same manner that stealth is a design option. This study primarily focuses on RPVs for strategic offensive airpower roles and explores the value of expendability as a design option.

Table 1€
Unmanned Aerial Vehicle Types and Control Mechanisms€

UAV TYPE	CONTROL MECHANISM
DRONE	AUTONOMOUS CONTROL
CRUISE MISSILE	AUTONOMOUS CONTROL REQUIRED HUMAN OVERRIDE CONTROL OPTIONAL
RPV	HUMAN CONTROL REQUIRED AUTONOMOUS CONTROL OPTIONAL

As noted earlier, original terms and definitions often evolve when people conceive new ideas with no existing words to adequately describe them. We could view the concept of an expendable RPV as a remotely piloted cruise missile, particularly in an attack role. This study, however, describes fusing kamikaze (suicide aerial attack), RPV, and cruise missile characteristics into a single system resembling more of an RPV. The following coined terms and definitions clarify hypothetical concepts on how operators could remotely control this vehicle in the future.

Cybornautics. The technological concept of using cybernetics, or communication and control theory, to integrate a human controller with an RPV. This technology takes current advanced concepts such as virtual reality control to a theoretical level of man-machine interface. In essence, the human is remotely linked to the machine in such a fashion that the person experiences a degree of being part of the vehicle (as opposed to an experience as a separate entity within the vehicle). For example, the operator would not visually

experience a scene looking out from within a cockpit. Instead, the individual would experience an unobstructed wide-ranging view, only limited by the range of the vehicle's sensors. "Looking down" and visualizing the ground pass beneath him/her, the operator could experience a sense of flying like a bird (as opposed to a pilot). This study explores cybornautics for use in airpower vehicles; however, it could have applications for controlling land-, sea-, and space-based systems as well. From this concept, the author conceived the word *cybornaut*.

Cybornaut. The human controller who is linked to an RPV via cybornautics. A comparison with the term *cyborg* may be helpful in understanding this concept. Webster's dictionary defines a cyborg as "a human being who is linked (as for temporary adaptation to a hostile space environment) to one or more mechanical devices upon which some of his vital *physiological* functions depend" (emphasis added).[9] A cybornaut is a human being cybernetically data-linked to an RPV; the human is required to perform vital control and decision functions for the machine.

The main assumption of this study refers to its intended audience. The subject of aircraft without onboard pilots raises with it a significant measure of controversy and emotion. During this study's research process, the author engaged in constructive and thought-provoking discussions with faculty and fellow students of the School of Advanced Airpower Studies. It is noteworthy that each individual expressed a definite opinion of UAVs. Because this should be expected from those dedicated to the study of airpower, it highlighted possible preconceptions on the part of the reader. The author assumes that the readers will likewise possess a great interest and a high degree of knowledge on the subject of airpower. Regardless of initial impressions on unmanned aircraft—even the most critical—the author asks that an open-minded approach be taken when evaluating this subject.[10]

To demonstrate assertions on expendable RPVs for strategic attack, the author has organized this study into six chapters. This introductory chapter presents the major theme and background of the research.

Chapter 2 addresses the question: What is the history and background of UAVs? Unmanned aircraft are a unique form of airpower. They present various advantages and capabilities, as well as disadvantages and limitations, deserving study and comparison with other airpower means. This chapter presents a chronological series of key events, as well as the major difficulties encountered by developers of UAVs.

Chapter 3 examines the question: Why focus on strategic offensive airpower roles for RPVs? Airpower's inherent attributes—such as speed, range, and ubiquity—make it very well suited to reach and strike an enemy's vital sources of power. Airpower is the dominant form of strategic offensive power.[11] This chapter shows how the RPV can play a strategic offensive warfare role by building upon the foundation provided by the previous chapter.

Chapter 4 answers the question: Why limit the study of strategic attack RPVs to expendable means? Critical to the thesis are the values advanced societies place on pilots and aircrews, as well as the values associated with the aircraft they operate and support. Other influences are the many factors associated with ensuring aircraft are survivable and recoverable. In an attempt to overcome or bypass these limiting factors, this chapter explores expendability versus recovery for an RPV intended for strategic offensive airpower roles.

Chapter 5 presents a notional scenario involving expendable strategic attack RPVs. This scenario outlines one conceptual application stemming from the author's theoretical vision into the future. A wide variety of expendable RPV design options are possible, and the author hopes that this chapter will foster the search for new and innovative airpower ideas, whether they involve UAVs or not.

Chapter 6 reviews the major conclusions resulting from this research study. First, the author addresses reasons for limited UAV development. Second, he assesses the pros and cons regarding RPVs in strategic attack roles. The third evaluation area reveals the advantages and disadvantages of expendability as a design option for RPVs. Fourth, the author provides an overall assessment on the concept of an expendable RPV for strategic offensive airpower roles.

Notes

1. Unmanned aerial vehicles (UAV) refer to the broader category of aircraft without humans on board; remotely piloted vehicles (RPV) are a subset of UAVs.

2. Lt Col Dana A. Longino, *Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios* (Maxwell Air Force Base [AFB], Ala.: Air University Press, 1994), xi. This is a common caveat among UAV documents. Some authors present it to appease critics of UAVs.

3. Maj Jeffrey N. Renehan, *Unmanned Aerial Vehicles and Weapons of Mass Destruction: A Lethal Combination?* (Maxwell AFB, Ala.: Air University Press, 1997). It is feasible that the conceptual RPV presented in this study could carry weapons of mass destruction; however, one could write a separate dissertation on this subject. This study highlights platform characteristics and limits discussion to more conventional (including nonlethal) payload types.

4. *Webster's Ninth New Collegiate Dictionary* (Springfield, Mass.: Merriam-Webster Inc., 1990), 1165.

5. Air Chief Marshal Sir Michael Armitage, *Unmanned Aircraft* (London: Brassey's Defence Publishers, 1988), xi. This is a tailored portion of a figure illustrating "bodies traveling in air." The author acknowledges "ill-defined boundaries" regarding unmanned aircraft.

6. Kenneth Munson, *World Unmanned Aircraft* (London: Jane's Publishing Company Ltd., 1988).

7. Jay Womack and Arthur Steczkowski, "Review of Past and Current Trials and Uses of Unmanned Vehicles," Report no. HSD-TR-87-011/United States (Dayton, Ohio: Air Force Systems Command, 1988).

8. While this is the justification from the document that introduces these terms (1996 *New World Vistas* study produced by the Air Force Scientific Advisory Board), it appears

an ulterior motive was to establish a more *politically correct* "uninhabited" term, as opposed to the gender-specific "unmanned" term. The author apologizes if he offends any reader by the preferred use of more established and recognizable—but admittedly politically *incorrect*—terms used throughout this study.

9. *Webster's Ninth New Collegiate Dictionary,* 319.

10. In essence, both researcher and evaluator should not be expected to reflect the model of a classic courtroom jurist but rather follow G. K. Chesterton's assertion: "If a potential juror can be forced under sharp questioning to admit that he has formed an opinion upon a case, he is regarded as unfit to conduct the inquiry. Surely this is unsound. The mere fact that he formed some temporary impression from the first facts as far as he knew them does not prove that he is not an impartial arbiter—it only proves that he is not a cold-blooded fool."

11. Col Phillip S. Meilinger, *10 Propositions Regarding Air Power* (Washington, D.C.: Air Force History and Museums Program, 1995), 8–19. Colonel Meilinger states, "Air Power is an inherently strategic force" and "Air Power is primarily an offensive weapon," as two of his 10 propositions which cover the essence of airpower. It therefore follows that all forms of airpower, unmanned as well as manned, should be explored to the fullest to exploit these advantages.

Chapter 2

History and Background

We have just won a war with a lot of heroes flying around in planes. The next war may be fought with airplanes with no men in them at all. It certainly will be fought with planes so far superior to those we have now that there will be no basis for comparison. Take everything you've learned about aviation in war and throw it out of the window and let's go to work on tomorrow's aviation. It will be different from anything the world has ever seen.

—Henry H. "Hap" Arnold

Gen Henry H. "Hap" Arnold's vision of fighter aircraft "with no men in them at all," has yet to materialize despite the fact that he spoke those words more than half a century ago. This particular vision, however, is still alive and being pursued today as we continue to work on tomorrow's aviation. Secretary of the Air Force Sheila E. Widnall released a study titled *New World Vistas*, which projects advanced air and space concepts into the future.[1] Prominent among the report's futuristic initiatives is the concept of uninhabited fighter aircraft capable of flying 10 to 15 times the speed of sound, maneuvering at 20 times the force of gravity, and using high-powered lasers to destroy air and land targets. Despite Widnall's assertion that "this study is not going to sit on the shelf and gather dust,"[2] the trend of UAV development indicates it will be difficult to implement such futuristic initiatives. Another half century may pass, only to result in an updated restatement of the *New World Vistas'* vision. Unless the UAV development trend changes, actual progress towards operational fielding of uninhabited fighter aircraft will remain limited.

One major obstacle to the wider development of UMA is that eventual users of any new technology are historically reluctant to embrace it. This is particularly true when military leaders and operators deem existing systems adequate and there appears little reason to replace them. After the attack on Pearl Harbor, the US Navy designed and successfully tested attack RPVs. Despite these successful experiments, Adm Jack Towers, head of US Naval Aviation, "was opposed to any program of production until the new device had shown itself to be *superior* in combat to the conventional manned aircraft of the fleet" (emphasis added).[3] When the war in the Pacific turned in favor of the United States, Adm Chester W. Nimitz, commander in chief of the US Pacific Fleet, "was reluctant to accept a new and untried weapon [attack RPVs] when the combat resources already available to him were performing so well."[4] Retired Maj Gen I. B. Holley (author and lecturer on military subjects) points out the paradox that military failures are often more valuable than successes in understanding lessons of war. "Successes stimulate blind pride and complacent self-confidence," he noted, "which invite failure in future battles."[5]

In the early 1900s, military historian J. F. C. Fuller accurately recognized that replacing cavalry with armored forces would encounter institutional difficulties. "To establish a new invention," he wrote, "is like establishing a new religion—it usually demands the conversion or destruction of an entire priesthood."[6] This sentiment remains applicable among the airpower "priesthood" of today. In an atmosphere of competition for funds with manned aircraft, it is logical that there currently exists a reluctance to embrace UAVs. In turn, this institutional bias has resulted in a failure to recognize their latent capabilities.

Nearly all new inventions which provided some form of "high ground" advantage in war (i.e., balloon, dirigible, and airplane) were first used as reconnaissance platforms. Military leaders eventually recognized their true potential and would effectively use them in other new and innovative airpower roles. Even the balloon had interesting applications in World War I. Because they were such tempting targets for enemy aircraft, balloon observers resorted to carrying weapons. In April 1917 "a French balloonist named Peletier was credited with downing an attacking 'Albatross' with a shot from his Winchester."[7] Allied units also conceived and deployed lethal balloon basket decoys, occupied by a dummy observer and filled with several hundred pounds of explosives. One British unit reported of dramatically destroying a German attacker with this type of "aerial mine," which it had electrically detonated from the ground.[8]

Institutional bias and initial lack of vision for more diverse applications appear to be common trends for new forms of airpower. Even manned aircraft had initial difficulties gaining military acceptance and recognition as influential weapons of destruction. Shortly after the birth of powered flight, Gen Ferdinand Foch reflected the classic disdain that cavalrymen had for the airplane. He dismissed the Wright brothers' invention as good for sport but of no value for the Army.[9]

Airpower in general underwent major growing pains as theorists attempted to determine its role in warfare. The airplane's first use in war was as a flying platform for observation and artillery spotting. In the United States, the airplane was first adopted by the Army Signal Corps, who used it for reconnaissance. As airpower's potential became more apparent, aircraft acceptance grew; and militaries eventually applied them in more diverse combat roles, such as close air support and strategic bombing.

Today, all advanced nations better understand and appreciate airpower. This understanding, however, is limited primarily to manned aircraft. The US military currently uses RPVs for reconnaissance and has yet to explore their full range of offensive and defensive capabilities. By examining its past, we can attempt to discover reasons for the limited state of RPV development. The author raises two questions for this area of research: Were RPVs initially developed for reconnaissance roles (as was the case for other airpower means)? Did lack of military vision restrict diversification of RPVs into other roles? Table 2 is a listing of significant UAV historical events from which this study will attempt to answer these questions.

The Wright brothers are deservedly famous in aviation history. By comparison, the first developers of UMA (e.g., René Lorin of France, Professor A. M. Low of Great Britain, Lawrence Sperry and Charles F. Kettering of the United States) are virtually unknown by even those in the airpower profession.[10] All these early pioneers experimented with military applications, and their first concepts of UAVs were as expendable "flying bombs." Still, it is remarkable how quickly after the "dawn of aviation" at Kitty Hawk in 1903 that unmanned as well as manned airpower evolved for use in war.

Prior to World War I—and even before the required technology fully existed—Lorin, a French artillery officer, first proposed the concept of flying bombs to attack distant targets.[11] In Germany, experiments on guided aerial vehicles began in 1915 and included launches from airships. In the United Kingdom, experiments beginning in 1917 produced UMA with newly designed, expendable engines.[12]

Table 2€
Significant Unmanned Aerial Vehicle Events€

1917	FIRST UNMANNED "FLYING BOMBS" DEVELOPED The "Dawn" of Unmanned Aerial Vehicles
1928	FIRST RADIO-CONTROLLED AIRCRAFT DEVELOPED The Beginning of Remotely Piloted Aerial Vehicles
1933	BRITISH DEMONSTRATE UNMANNED AIRCRAFT SURVIVABILITY Also Demonstrate Vulnerability of Naval Ships to Aerial Attack
1935	FIRST MINIATURE, REMOTELY PILOTED AIRCRAFT Design Not Constrained to Accommodate Pilot
1939	FIRST JET-PROPELLED UNMANNED AERIAL VEHICLE Germany Develops V-1 Buzz Bomb Prototype
1941	FIRST VIDEO GUIDANCE CAPABILITY DEVELOPED Research Spans Across Electromagnetic Spectrum
1944–45	FIRST OPERATIONAL USE OF JET-PROPELLED UNMANNED AERIAL VEHICLE IN WAR; FIRST STRATEGIC TERROR WEAPON Germany Launches 10,500 V-1s Against England
1951	US DEVELOPS FIRST JET-ENGINE TARGET DRONE "Firebee" Will Represent Basic Model for Decades
1960	GARY POWERS SHOT DOWN IN U-2 OVER RUSSIA US Focuses on Reconnaissance Role
1964–73	US USES UNMANNED AIRCRAFT IN SOUTHEAST ASIA First Successful American Use
1973	ISRAEL USES UNMANNED AIRCRAFT IN YOM KIPPUR WAR First Successful Israeli Use
1976	SAC TRANSFERS CONTROL TO TAC Support for Unmanned Aerial Vehicles Wanes
1982	ISRAEL USES UNMANNED AIRCRAFT IN BEKÁA VALLEY Second Successful Israeli Use
1990	US USES UNMANNED AIRCRAFT IN DESERT STORM Second Successful American Use
1995	US AIR FORCE ESTABLISHES UAV SQUADRON First Such Air Force Unit Since 1976

British Professor Low led the research program to design and develop a true RPV (one that could actually be remotely piloted). Some historians have bestowed upon him the title "Father of the Remotely Piloted Vehicle" for being a pioneer in this field.[13] During World War I, the British suffered heavy pilot losses against German Fokker monoplanes over the western front. In response to this situation, the Royal Flying Corps (RFC) assigned Low to a secret program titled "RFC Experimental Works." As a newly commissioned second lieutenant, Low attempted to develop an RPV "that could serve as both an interceptor and ground-attack weapon."[14] Numerous problems—many attributed to using existing aircraft components to save on time and money—restricted development beyond the prototype.

The Royal Aircraft Factory, attempting to build upon lessons learned from Low's early prototype, produced an unmanned Sopwith biplane which could carry a 50-pound warhead in its nose. Its performance during an important test was disastrous: "During a test flight . . . for a gathering of important Allied dignitaries, the AT [aerial target] went astray and dove upon the guests, who scattered in every direction."[15] This unfortunate incident halted further development and destroyed any British hopes of deploying RPVs during World War I.

During the same time period in the United States, the Navy and Army began separate programs which, respectively, developed the Sperry–Curtiss "Flying Bomb" and the Kettering "Bug." Upon reaching a preset range, the wings of these "aerial torpedoes" released and their fuselages fell as gravity bombs. Sperry, son of Dr. Elmer A. Sperry (who developed the gyro-stabilization system, making autopilot possible in 1915), led the Navy program.[16] Sperry's Flying Bomb was the first UAV to achieve autonomous flight. Kettering, who used Orville Wright as his aeronautical consultant, led the Army program. Kettering's Bug was capable of carrying an explosive payload of 180 pounds and could fly distances up to 40 miles at 55 miles per hour.[17] After World War I ended, defense budget cuts eventually terminated these aerial torpedo programs.

Better remote control of an aircraft required advanced radio technology, which came in the 1920s. The US Army Air Corps performed research into remote control by radio on Curtiss Robin and Stimson Junior aircraft. In 1928 a Curtiss Robin monoplane became the first remotely controlled, bomb-carrying aircraft.[18] Lack of funding caused the military to cancel the program within four years. It would be an additional six years before the Army Air Corps would pick up on RPV research again.

The British also conducted extensive experiments with radio control and produced UMA with speeds much greater than manned aircraft of the era.[19] Follow-on British efforts focused on developing remotely piloted aerial targets. In 1933 a radio-controlled floatplane revealed the vulnerability of ships to attack from the air. Simulating an air attack on the British Royal Navy, the UMA survived more than two hours of heavy naval gunfire before being safely recovered, undamaged. While General Mitchell first demonstrated ship vulnerability (by test sinking several warships with

aerial bombs), the British took the test to another level. In one flight, "not only had the inadequacy of naval anti-aircraft weapons been demonstrated, but so had the undeniable feasibility of remotely piloted aircraft."[20] Following this demonstration, the British developed an expendable, all-wooden version of the aerial target called the Queen Bee. A total of 420 were built for Royal Navy and Army antiaircraft gunners. According to Air Chief Marshal Sir Michael Armitage (Royal Air Force [RAF] writer and lecturer on airpower and UAVs), "The fact that nearly all of them rendered very valuable service before being destroyed says more about the state of contemporary anti-aircraft defenses than it does about the resilience of the Queen Bee aircraft."[21]

In 1935 Reginald Denny (American movie star and model airplane enthusiast) founded the Radioplane Company, which produced a radio-controlled, miniature monoplane.[22] The Army Air Corps and Navy purchased nearly 1,000 Radioplane RPVs to provide their antiaircraft gunners with realistic flying targets.[23] The following year, the Navy modified full-sized airplanes to serve as aerial targets. Upon learning of the Navy's efforts, General Arnold desired to initiate a similar target program in the Army Air Corps. In 1939 he requested and received a suite of identical equipment for Air Corps research.[24]

During the years between the world wars, militaries of different nations explored various areas of technology having potential application to UAVs. The most well-known product, however, used a simple, inexpensive engine first developed and patented in France in 1907.[25] In 1939 German scientists and engineers used its design to create prototypes of the Fiesler 103, now more widely known as the V-1 (*Vergeltungswaffe Eins*) Buzz Bomb. With a launch of 10 weapons on 13 June 1944, the V-1 became the first operational cruise missile. It was also the first jet-propelled weapon and the first strategic terror weapon used in war. The V-1 had three important advantages: it was relatively cheap to build, it did not place any undue demands on Germany's limited strategic resource materials, and it avoided the loss of scarce and valuable Luftwaffe crews.[26]

From June 1944 through March 1945, the Luftwaffe launched 8,892 V-1s from ground sites and approximately another 1,600 from aircraft. Allied fighters and antiaircraft guns destroyed most of these before they reached their intended targets. However, the 2,419 V-1s which did reach the London region killed 6,148 and seriously injured 17,981.[27] While they also caused some considerable physical damage, their use as retaliatory weapons had much wider ramifications.

By August 1944, after only three months into the V-1 campaign, an estimated one and one-half million Londoners had fled the capital. Coupled with time spent in shelters, absenteeism, and an overall strain on civilian morale, productivity in the city's factories suffered. The Allies diverted extensive airpower resources away from other missions to bomb V-1 launch sites and to shoot down V-1s in flight. These operations were costly—

"nearly 450 aircraft were lost and 2,900 valuable aircrew lives were sacrificed."[28]

In a separate program, the German army also produced its own retaliatory weapon—the A-4—which was later called the V-2. The V-2 was essentially a ballistic missile. Although less vulnerable and more physically destructive, the V-2 was a significant burden on Germany's war-making capability. It was expensive, it used extremely complex technology, it required scarce materials, and it greatly overstressed Germany's electric and component industries. Comparing the V-1 and V-2 in terms of cost (in German marks) and labor: the V-2 cost 10,000 marks compared to 1,500 for the V-1, and it required 13,000 hours of slave labor compared to 280 for the V-1.[29] In terms of total destructive potential, because Germany produced and launched significantly fewer V-2s (3,200 compared to 22,400 V-1s), the V-1 delivered many times more explosive loads.[30] Ironically, because there was no apparent defense against the V-2, the Allies diverted few resources to counter it.

In addition to the V-1 cruise missile and V-2 ballistic missile, Germany employed other UAV weapon systems during World War II. Despite lessons learned in 1933 from the British test of the unmanned floatplane against naval defenses, the Royal Navy and the US Navy both suffered significant losses from German glide bombs. The two most prominent glide bomb systems were the Fritz X remotely guided bomb and the HS 293 remotely piloted jet-propelled aircraft.[31] Luftwaffe airborne controllers released these radio-controlled weapons and directed them by line of sight onto surface targets. From September 1943 through August 1944, German glide bombs sunk or significantly damaged the following naval vessels: Italian flagship *Roma*, Italian ship *Italia*, USS flagship *Savannah*, HMS *Uganda*, hospital ship *Newfoundland*, HMS *Warspite*, HMS *Janus*, HMS *Jervis*, hospital ship *St. David*, sister ship *Leinster*, HMS *Egret*, and others (not identified by name).[32]

A number of German UAV experimental systems also demonstrated potential, but none were far enough advanced to become operational before World War II ended. German RPV research into acoustic, television, infrared (IR), radar, and wire guidance systems would eventually be used to create remotely controlled and autonomous weapon systems in existence today. The United States and the Soviet Union were the primary beneficiaries of this work, as many prominent German scientists eventually ended up in one of these two countries.[33]

Allied UAV research and development (R&D) efforts conducted during World War II were not as advanced as German accomplishments. Some are noteworthy, however, for their innovative concepts. In February 1941 the US Navy pursued research into UAV television transmission. This led to the development of an assault drone, which was remotely controlled with the aid of video guidance. The Navy demonstrated the first successful US kamikaze-type mission by flying such an aircraft into a target. Despite this research, the United States limited operational employment of

UAVs during World War II to a few glide bomb missions and the use of converted war-weary or time-expired B-17s and B-24s.

Project Aphrodite was the US effort to convert war-weary manned aircraft into unmanned flying bombs.[34] Ironically, the United States initiated the special project to develop a means to attack hardened German V-weapon launch sites which were practically invulnerable to normal bombing attacks. By the time the US Army Air Forces (USAAF) could launch its first war-weary in July 1944, Allied aircraft and airmen losses from attempts to knock out V-1 sites were considerable.[35]

Stripped of all unnecessary equipment, USAAF personnel reconfigured B-17 bombers with a radio control system and loaded them with 20,000 pounds of explosives. One pilot and a technician launched the aircraft towards enemy target areas and bailed out before crossing the English coastline. An escort B-17 remotely controlled the flying bomb towards its designated target. No war-weary aircraft ever scored a direct hit on its intended target, and the Aphrodite project was plagued with tragic as well as somewhat comical results.

On the side of tragedy, launch crews from the first 10 war-weary B-17 missions suffered the death of one pilot in a crash and the injury of seven others during bailout. US Navy participation in Project Aphrodite involved radio-controlled PB4Y (B-24) Liberators. Lt Joseph P. Kennedy, brother of future president John F. Kennedy, was killed on the first naval Aphrodite mission in August 1944; his B-24 prematurely exploded before he could bail out over England. According to military historian Conrad C. Crane, "fears of his father's reaction caused much consternation at many military headquarters," and the Navy subsequently suspended the project.[36]

Three war-weary missions provide a humorous side to Project Aphrodite. In the first case, "one enterprising controller, finding that he could not dive his robot, flew it around an unsuspecting German flak battery until a direct hit destroyed both the war-weary and the battery." In the second event, one war-weary went out of control and eventually crashed and exploded in Sweden; "Swedish military authorities just sent a polite note with regrets that they could find no trace of any crewman." The last incident also involved a war-weary that went out of control and disappeared. In this case the escort B-17 finally discovered the UMA circling the English town of Ipswich, whereupon "a frantic controller barely managed to dump it into the North Sea."[37]

In spite of a series of later improvements (adding a television monitor, altimeter readout, and remote control throttles), war-weary aircraft were very vulnerable to German defenses and thus proved highly ineffective. In light of mission failures, Lt Gen James H. "Jimmy" Doolittle delivered sharp criticism upon the Aphrodite project: "It seems to me that this whole project is put together with baling wire, chicken guts, and ignorance."[38]

Despite the lack of operational UAV successes in World War II, the United States conducted valuable research and increased its knowledge

base in this form of airpower. The military took great strides in guided vertical bomb research in radio, radar, television, and IR controls.[39] In October 1945 the US Navy released drawings of unmanned jet aircraft concepts. Designers claimed that speeds up to 300 miles per hour and 4-G dives would be achievable. The Navy described the projects as "heralds of a supersonic age where only the mind of man can match the speed of the deadly creatures his genius has conceived."[40] Concepts such as these, however, came too late for operational employment during the war; and they were not further pursued.

The Korean War did little to prompt advances in UAV technologies. Some World War II-era guided bombs were used, but many were in poor condition due to severe deterioration from a long period in storage. Three specially modified B-29s employed approximately 30 glide bombs, and they accounted for destroying six bridges and damaging one.[41] While their poor accuracy was not a major factor against World War II-era targets (i.e., German cities and industries), they were essentially useless against most North Korean targets. Also during the Korean War, various manned aircraft were converted into flying bombs, which were remotely guided into heavily defended communist targets.

In 1951 the United States produced its first jet-engine target drone called the Firebee. Virtually every US air defense weapon has been tested against Firebee drones developed by Teledyne Ryan Aeronautical.[42] "The long term significance of the Teledyne Ryan family of unmanned aircraft was their adaptability, and in particular their operational potential."[43] It is noteworthy that Teledyne Ryan, founded by Claude Ryan, is the company that built both Charles Lindbergh's *Spirit of St. Louis* in 1927 and the Firebee jet-propelled RPV in 1951.[44]

The watershed event, which redirected RPV R&D towards its current state, came on 1 May 1960.[45] It was the shootdown over the Soviet Union of the U-2 reconnaissance aircraft piloted by Francis Gary Powers.[46] The United States subsequently focused on developing unmanned intelligence collection platforms, and this directed efforts away from development of attack RPVs. The United States quickly established the Red Wagon project to study drone reconnaissance potential. In July 1960 the United States awarded Ryan Aeronautical Company an initial $200,000 contract for an RPV demonstration. The result was an RPV which successfully demonstrated stealth characteristics and the ability to carry photographic reconnaissance cameras. While competing against satellite systems and the emerging SR-71 project, however, continued support for RPVs slipped. According to Air Chief Marshal Armitage, "This promising start was however followed by disappointment for the designers when shortage of Pentagon funds caused all the available budgetary resources available for new reconnaissance assets to be devoted to the emerging SR-71 Mach-3 reconnaissance aircraft."[47]

After nearly two years of being held in abeyance, approval was given in February 1962 to proceed again with the RPV reconnaissance program.

On 27 October of that year, another U-2 (this one piloted by Rudolph Anderson Jr.) was shot down over Cuba during the missile crisis. Under the Big Safari acquisition program, US efforts were accelerated to develop an unmanned aerial reconnaissance platform. Of the many variations developed, one concept advanced UAVs into a unique role. An RPV was fitted to carry a wave tube, which gave it the radar characteristics of a much larger aircraft. This decoy system was intended to stimulate the SA-2 radars in Cuba in order to collect transmission data on them.[48]

The first UAV photographic reconnaissance flight came in 1963. The Gulf of Tonkin incident on 4 August 1964 led to operational involvement of reconnaissance RPVs over China and Vietnam. The first combat loss of an RPV came when China downed one in November 1964. By April 1965 four more were lost to Chinese air defenses, and China held a news conference to display wreckage of downed US pilotless aircraft to the public. The significance of this event is its lack of impact on US as well as world opinion. While it showed the vulnerability of such aircraft, "the most significant feature of the American losses," according to Armitage, "was that clearly identifiable US manufactured aircraft did not receive the same public attention as would have been the case with captured American crew members from, say, U-2 reconnaissance aircraft."[49]

In April 1969 another US manned reconnaissance aircraft was lost. In this incident a Super Constellation EC-121 (an electronic countermeasures aircraft) was shot down as it deliberately attempted to stimulate and collect North Korean radar transmissions. Although nearly 200 such flights had been previously conducted, on this occasion North Korea not only activated its surface to air missile (SAM) radars but also launched two MiG interceptors. One of the MiGs intercepted and shot down the Super Constellation aircraft, killing all 31 crew members. The incident prompted President Richard M. Nixon to end the program of conducting electronic warfare missions against North Korea with manned assets. More importantly, however, according to Armitage: "This incident led directly to a proposal that the recently developed 147T [Teledyne Ryan RPV Model] should be used to carry a relay system by which electronic emissions could be collected and re-transmitted over an FM radio link to a ground station, thus obviating the risk of further losses to conventional aircraft and their operators."[50]

From 1964 to 1973, Strategic Air Command (SAC) operated 148 RPVs for Buffalo Hunter operations in Southeast Asia. Conducting nearly 3,500 sorties with less than a four percent loss rate, SAC completed high-risk missions in photographic, communications, and electronics reconnaissance, as well as leaflet and chaff dropping.[51] These operations resulted in many operational lessons, prompting new innovations in UAV development. Improved command guidance, intelligence gathering, active defense, and flight control systems were the result of Buffalo Hunter operations.[52]

The survival rates of US RPVs in Southeast Asia were remarkable given their missions were flown in the full range of weather and combat condi-

tions. One specially modified drone was reported to have drawn 10 or 11 SAMs before being shot down.[53] The top performing drone flew an incredible 68 sorties, averaging twelve targets per mission.[54] In the latter part of the war, survival rates of UAVs exceeded 90 percent. While difficult to make a direct comparison, there is a definite contrast with manned aircraft statistics: "In that same war America lost more than 2,500 manned aircraft, about 5,000 of her airmen were killed, and nearly 90 percent of *all* US servicemen taken prisoner were pilots and crewmen."[55]

At the same time that the United States was attempting to understand and appreciate unmanned aircraft, the Israeli Defense Force effectively used UAVs over battlefields in the October 1973 Yom Kippur War and again in the 1982 Bekáa Valley air battle. The Israelis innovatively employed UMA to "fingerprint" SAM radars, simulate full-size decoy attack aircraft, perform electronic countermeasures, and conduct real-time intelligence gathering.[56] Most noteworthy was their effective use as decoys. By sending in UAVs to spearhead an attack, virtually all enemy SAMs were expended at once. This revealed SAM locations, and Israeli suppression of enemy air defenses sorties were thus able to follow and knock out missile defenses while the enemy was reloading. It was reported that one RPV safely returned for recovery after surviving attacks by 32 SAMs.

Despite the successful US missions conducted over Southeast Asia, there were difficulties associated with UAVs. Initially, novice operators and maintenance crews were only able to generate three to four sorties per airframe. By the end of the war, they managed to increase this number to 25. During this learning experience, any UMA loss still caused repercussions. This was because military leaders treated it in the same manner as the loss of a manned aircraft. In 1979 US Air Force (USAF) Col William E. Krebs authored a paper titled, "Did We Err in the Development of RPVs (RPVs)?" One of his findings was that during the Vietnam War, "an RPV loss was treated like an aircraft loss—fleets were grounded, boards formed, data generated, commanders fired, and worst of all, prejudice against RPVs vis-à-vis manned aircraft developed."[57]

The time frame of US involvement in Southeast Asia was a period of extensive UAV research and testing. The evolutionary program for Teledyne Ryan's Firebee consisted of 26 configurations, 903 airframes, and 1,100 major modifications.[58] RPV test demonstrations extended well beyond reconnaissance into attack roles; however, it was the Navy, not the Air Force, leading this effort. According to *Jane's Remotely Piloted Vehicles:* "The US Navy has even evaluated RPV interceptors in simulated air combat against a McDonnell Douglas F-4 Phantom II flown by a highly experienced aircrew. The results were thought-provoking. All the Sparrow and Sidewinder missiles launched from the Phantom missed the RPV, but the latter maneuvered itself several times into positions from which it could have brought down the Phantom had it been armed."[59]

In light of tests and operational applications in Southeast Asia, lack of advocacy and proper oversight have restrained any motivation in the

United States to look beyond reconnaissance roles. The Air Force did develop ballistic missiles and precision-guided munitions, but this was not because research revealed these systems should be pursued while others discounted. In fact, the Air Force conducted a study in 1974 on missions for UAVs and found itself guilty of ambivalence: "The study found that the concept of air combat drone/RPV systems was formulated in 1970, but little had been done subsequently to either promote the development of these systems or to dismiss them as viable systems for Air Force consideration."[60] There even arose an accusation that the Air Force suppressed the study because it revealed UAVs could perform several missions flown by pilots more cheaply and more effectively.[61]

In 1976 the USAF restructured command responsibilities, and SAC passed control of RPVs to Tactical Air Command (TAC). Because of promising results from industry and Navy tests—as well as successful RPV operations over China, North Vietnam, and other Far East areas—a whole range of additional roles was envisioned. Transference of ownership was another watershed event which would adversely affect the timing and extent of all future UAV development. Under TAC, Air Force support for unmanned systems deteriorated due to the increasing competition for funds against manned aircraft. In 1978 Sen. John Tower (R-Tex.) emphasized this point in the following statement: "I suggest that a full-blown strike RPV program that would really impact on the numerical differences will not be easy for the Air Force to be enthusiastic over. The reason is that the Pentagon budget process is such that new programs are seldom recognized as complementary to, but rather as substitutes for."[62] Under TAC there was no serious follow-on study of UAVs to determine potential capabilities, roles in war, place in the force structure, nor concept of operations.[63] A 1974 Air University study, however, described conceptual programs capable of developing and fielding strike RPVs by the 1980s.[64] A 1975 industry study also revealed the heightened focus on RPVs during this time frame: "A great deal has been written in both the general and trade press over the past two years about drones and RPVs with much of the space devoted to the more exotic applications of unmanned vehicles such as aerial combat with manned aircraft."[65] The actual result is that only five years after proving their use in Southeast Asia, the United States would not have a single operational RPV in its inventory.

Lack of user support also restricted development of UAVs more than technological hurdles.[66] Speaking at an RPV symposium in June 1977, Lt Gen James D. Hughes, Twelfth Air Force commander, expressed operator discontent with the evolution of RPVs. "Most of the problems encountered in the AQM-34V Program," he stated, "are because the drone is antiquated; the launch platform is antiquated; control technicians are antiquated; and the recovery of the vehicle is far too complex—and once recovered, the turnaround takes too long."[67]

In 1981 a General Accounting Office (GAO) study stated, "RPVs appear to suffer from the attitude of the users and not from technological drawbacks

or infeasible systems."[68] It also reiterated that RPVs were not popular with the military due to user reluctance and lack of funding support.[69] While it is difficult to prove reluctance for past users, it is almost impossible to do so for present users.[70] Many sources assert or mention user reluctance as a barrier to UAV development, but they offer no proof. Since the time of Hap Arnold, there has yet to appear a US military leader who has even come close to displaying his level of interest and support for unmanned aircraft. While this may not prove reluctance, it does indicate indifference exists in decision-making ranks to support this form of airpower.[71]

In 1989 the Unmanned Aerial Vehicles (UAV) Joint Project Office was officially established in response to congressional direction. In 1988 (with updates in 1991 and 1994) the Department of Defense (DOD) developed the "Unmanned Aerial Vehicle Master Plan." In spite of these efforts to establish oversight of UAV development in the United States, the GAO severely criticized DOD's plan. Some major criticisms are summarized as follows.

The Master Plan:

- does not eliminate duplication between services concerning UAV research, development, test, and evaluation;
- increases the risk of additional duplication by excluding its coverage of UAVs intended to destroy targets (called lethal UAVs) and target drones that involve largely the same technology;
- gives insufficient attention to payload commonality;
- permits continued proliferation of single-service progress; and
- does not adequately consider the cost savings potential from manned and UMA trade-offs.[72]

Despite doctrinal statements that it "should be in the forefront of developing and exploiting aerospace power,"[73] the USAF has not aggressively pursued UAV development. Similar to the way the Army developed armed helicopters (for close air support) in the face of the 1948 Key West Agreement, the Army, Navy, and Marine Corps have each pursued RPVs to support their service-unique, "organic" reconnaissance requirements. During Operation Desert Storm, 43 Pioneer UAVs flew 330 sorties among the three services with only one loss. These assets provided intelligence, targeting information, artillery spotting, and battlefield damage assessment. One Pioneer aircraft on an artillery support mission actually imaged Iraqi troops trying to surrender to it.[74] In contrast the Air Force relied on RF-4 aircraft for its tactical reconnaissance missions. These manned assets required "SAM suppression, electronic countermeasures, aerial refueling, Airborne Warning and Control System (AWACS), and Airborne Battlefield Command and Control Center (ABCCC) support."[75]

In July 1995 the USAF stood up its first UAV squadron at Nellis Air Force Base (AFB), Nevada. The first of its kind since Vietnam, the squadron was scheduled to receive 10 Predator UAVs in 1996. In Febru-

ary 1996, Gen Ronald R. Fogleman, Air Force chief of staff, said the Air Force has "embraced" the UAV.[76] Also in February 1996, the vice chairman of the Joint Chiefs of Staff, Adm William Owens, told the Senate Armed Services Committee that UAVs "could replace a number of manned aircraft that do similar things."[77] While these statements indicate UAVs are gaining acceptance, approval is still limited to UMA for reconnaissance roles.

In summary, by tracing its historical roots it is evident the United States had no organized plan nor structure which purposely led UMA to their current state of existence. Unlike other airpower means (and even space-based systems), UAVs were not initially developed to serve as reconnaissance platforms in war. Camera and photographic technologies to support this concept did exist at the time; as early as the 1890s, US Army researchers "experimented with an aerial photography system that hung a camera from a large kite."[78]

The first UAVs were envisioned, researched, and developed to be weapons of destruction. Lorin's first UAV concept was of a flying bomb to strike distant targets. The first drones and RPVs were flying bombs. Professor Low worked on developing unmanned airplanes for interceptor and ground attack roles. Sperry and Kettering developed aerial torpedoes. Subsequent developments of RPVs focused on providing aerial targets for antiaircraft gunners to test their skills. The first operational use of UAVs in war—by Germany as well as by the United States—was for strategic attack. While the potential for more diverse roles clearly existed, the United States would eventually focus and fixate on reconnaissance applications.

The shootdown of Powers clearly was the key event that made reconnaissance the primary driver for US development and operational use of UMA since 1960. Proven effective in Southeast Asia, it appeared that UMA had secured at least intelligence gathering, decoy, and chaff/leaflet dispensing roles for high-risk missions. After the Vietnam War, responsibility passed from SAC to TAC, and subsequent USAF interest waned. Over the past two decades, the Air Force has displayed an indifferent attitude towards exploration and exploitation of UAVs. This has not prevented the world's greatest airpower force from gaining and maintaining its present state of superiority. It has, however, prevented the United States from appreciating and harnessing the full potential of RPVs; this may prove to be of great consequence in the future.

Notes

1. US Air Force Scientific Advisory Board (SAB), report, *New World Vistas: Air and Space Power for the 21st Century*, 31 January 1996. This report is the result of a one-year study conducted by the SAB. It is fitting that it was General Arnold who established the SAB in 1944 to provide scientific and technical advice to the US Army Air Forces. The SAB, organized and led by Theodor von Kármán, produced an 11-volume report during its first year of existence that was instrumental in shaping US airpower. Arnold was so impressed by the report that he made the SAB permanent advisors to the Air Force.

2. MSgt Gary Pomeroy, Air Force News Service, "'New World Vistas' Study Focuses on AF's Future," *Maxwell–Gunter Dispatch*, 9 February 1996, 16.

3. Air Chief Marshal Sir Michael Armitage, *Unmanned Aircraft* (London: Brassey's Defence Publishers, 1988), 34.

4. Ibid., 35.

5. Maj Gen I. B. Holley Jr., "Of Saber Charges, Escort Fighters, and Spacecraft: The Search for Doctrine," *Air University Review*, September–October 1983), 2.

6. Jay Luvaas, *The Education of an Army*: *British Military Thought, 1815–1940* (Chicago: University of Chicago Press, 1964), 355.

7. Lee B. Kennett, *The First Air War, 1914–1918* (New York: Free Press, 1991), 27.

8. Ibid.

9. B. H. Liddell Hart, *Foch: The Man of Orleans* (London: Eyre and Spottiswoode, 1931), 47. Of significance is that General Foch, who later became supreme commander of the Allied forces in France, was an astute observer of warfare and authored *Principles*, which was used at the war colleges.

10. "The RPV/Drones/Targets Market, 1975–1985," marketing study (Greenwich, Conn.: DMS, Inc., 1975). One could argue that the first pioneers in aviation were also the first to develop UAVs via their earliest experiments. "First flights of the Montgolfiers' balloon were unmanned as were those of the Wright brothers' Flyer."

11. Armitage, 1. Lorin proposed using gyroscopes, barometers, jet engines, and guiding radio signals from an accompanying piloted aircraft in his weapon design. Other French inventors of similar designs were Victor de Karavodine and Georges Marconnet.

12. Ibid.

13. John W. R. Taylor and Kenneth Munson, eds., *Jane's Pocket Book of Remotely Piloted Vehicles: Robot Aircraft Today* (New York: Macmillan, 1977), 11. It was suggested that Professor Low is the "Father of the Remotely Piloted Vehicle." Others bestow Kettering with that title.

14. Steven M. Shaker and Alan R. Wise, *War Without Men: Robots on the Future Battlefield* (Washington, D.C.: Pergamon-Brassey's, 1988), 21.

15. Ibid.

16. Shaker and Wise, 24. Lawrence Sperry died in 1923 when he crashed an aircraft into the English Channel. The airplane he was flying at the time was a subscale, one-seater biplane his company had designed. Named the M-1 Messinger, this aircraft was developed to test control mechanisms for aerial torpedoes.

17. Jay Womack and Arthur Steczkowski, "Review of Past and Current Trials and Uses of Unmanned Vehicles, " Report no. HSD-TR-87-011/United States (Air Force Systems Command, 1988), 2-1; Maj James E. Biltz et al., "The RPV: Yesterday, Today, and Tomorrow" (Maxwell Air Force Base [AFB], Ala.: Air University, 1974), 13–16; Shaker and Wise, 22; and Armitage, 3. The Kettering Bug's official name was the Liberty Eagle. The Army Air Corps initially ordered 75 copies, but only 20 were produced due to World War I coming to an end.

18. Womack and Steczkowski, 2-2.

19. Shaker and Wise, 24.

20. Armitage, 6; and Shaker and Wise, 25.

21. Ibid.

22. Womack and Steczkowski, 2-4. The first president of Radioplane was Whitley Collins. He became the president of Northrop after Radioplane merged with Northrop in the 1950s.

23. Shaker and Wise, 26.

24. Womack and Steczkowski, 2-3.

25. Armitage, 7.

26. Ibid., 16–17.

27. Ibid., 16.

28. Ibid., 17.

29. Shaker and Wise, 28.

30. Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (New York: Free Press, 1995), 274.

31. Armitage, 19.

32. Ibid., 19–24.

33. Ibid., 22–24.

34. Biltz et al., 22–24; Shaker and Wise, 26; Armitage, 30–32; and Conrad C. Crane, *Bombs, Cities, and Civilians: American Airpower Strategy in World War II* (Lawrence, Kans.: University Press of Kansas, 1993), 78–89. Crane's book gives a good account on Project Aphrodite.

35. Crane, 80. As noted earlier 2,900 men and 450 aircraft had been lost.

36. Ibid.

37. Ibid., 80–82. Contains quoted material on these three war-weary missions.

38. Ibid., 78.

39. Armitage, 27–30.

40. Shaker and Wise, 30. Introduced were three conceptual aircraft named Glomb, Gorgan, and Gargoyle, and they were described by the Navy to be "robot craft."

41. Biltz et. al., 25; and Armitage, 30. In one attack, two bridge spans were taken out with one glide bomb. It is noted that these bombs did eventually become more effective with improvements in materials and crew training. One major drawback was the inability to safely jettison them from damaged aircraft.

42. The Firebee was capable of carrying a wide variety of weapon systems including infrared or television-guided bombs and missiles. It had a maximum speed near Mach 1, had a range of 1,415 miles, and could reach altitudes of more than 60,000 feet. The Firebee II had a maximum speed of Mach 1.8 and could sustain 5-G turns. Both Firebee models can be seen at the Air Force Armaments Museum (AFAM) at Eglin AFB, Florida. AFAM claims to be "the only museum in the world dedicated to the collection, preservation, and exhibition of artifacts and memorabilia associated with Air Force armament and its delivery platforms."

43. Armitage, 65–86.

44. Taylor and Munson, 28.

45. Two months later, the Soviets shot down an American RB-47 electronic intelligence collector over the Barents Sea; five crewmen were killed or missing, and two were captured. The United States subsequently suffered an 18-month gap in its reconnaissance capabilities, from the U-2 downing until the first US surveillance satellite could be launched.

46. Col L. Fletcher Prouty, USAF, retired, letter to *Air Force Magazine*, April 1996, 5–6. This is usually referred to as the "U-2 shootdown"; however, there is evidence that the aircraft was not actually shot down. Regardless, this paper will conform to how the vast majority of documents describe the event and continue to reference it as the U-2 shootdown.

47. Armitage, 66; and Dana A. Longino, *Role of Unmanned Aerial Vehicles in Future Armed Conflict* (Maxwell AFB, Ala.: Air University Press, 1994), 2. Longino provides a discussion on the decision to turn off the reconnaissance RPV program in light of developing satellite systems and the SR-71.

48. Armitage, 68.

49. Ibid., 71; and Shaker and Wise, 31. This was the public's first view into the world of RPVs performing roles deemed too dangerous or too politically sensitive to be performed by human pilots. New versions of the drones reached altitudes higher than what the Chinese SA-2 missiles could intercept. These flights continued until the establishment of improved US–China relations, and overflights were suspended in 1973.

50. Armitage, 75–76.

51. Longino, 3.

52. Ibid., 3–5.

53. Armitage, 74. This version carried an electronic countermeasures package along with its photographic reconnaissance equipment.

54. Kenneth Munson, *World Unmanned Aircraft* (London: Jane's Publishing Company Ltd., 1988), 7. This drone was appropriately named Top Cat.

55. Ibid.

56. C1C Matthew M. Hurley, "The Bekáa Valley Air Battle, June 1982: Lessons Mislearned?" *Airpower Journal,* Winter 1989, 60–70. While many sources detail Israeli use of UAVs during the Middle East conflicts, a unique perspective on their most recent application is provided by C1C Hurley.

57. Col William E. Krebs, "Did We Err in the Development of Remotely Piloted Vehicles (RPVs)?" Research Report no. MS 018-79 (Maxwell AFB, Ala.: Air War College, 1979), 50.

58. Ibid., 15.

59. Taylor and Munson, 30–33.

60. General Accounting Office (GAO), study, "DOD's Use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars" (Washington, D.C.: GAO, 3 April 1981), 8.

61. Anne Marie Cunningham, "Unmanned Flying Vehicles," *Technology Review*, April 1991, 16.

62. Krebs, 47.

63. Krebs, 48. General Sylvester made these arguments at a 1978 RPV symposium.

64. Biltz et al., 56–63.

65. "The RPV/Drones/Targets Market, 1975–1985."

66. Maj Ronald L. McGonigle, "Unmanned Aerial Vehicles (UAVs) on the Future Tactical Battlefield—Are UAVs an Essential Joint Force Multiplier?" (Fort Leavenworth, Kans.: 8 December 1992). This argument has been made in various forms. For example, a related assertion is that overcoming organizational resistance, not technology, is the major barrier to RPV acceptance.

67. Krebs, 27.

68. GAO study, 8.

69. Ibid., 10.

70. This chapter referenced a few past military leaders (e.g., Foch, Towers, and Nimitz) who criticized new technologies.

71. Shaker and Wise, 170–72. This is an excellent reference on the classic treatment of user reluctance. They present the argument that militaries are "primarily run by skilled operators who have been promoted up through the ranks," and "there is a natural reluctance on the part of the leadership . . . to embrace robotic vehicles that may reduce the influence of the manned systems and their operators."

72. GAO, "Unmanned Vehicles: Assessment of DOD's Unmanned Aerial Vehicle Master Plan" (Washington, D.C.: GAO, December 1988).

73. Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force,* vol. 1, March 1992, 17.

74. Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 312.

75. Longino, 9–13. The author provides a good account of UAV and RF-4 operations in Desert Storm.

76. MSgt Merrie Schilter Lowe, "Air Force May Need Fewer Aircraft in the Future," *Air Force News,* on-line, Internet, 1 March 1996. General Fogleman made the statement at the annual Air Force Association symposium in Orlando, Florida, on 15 February 1996.

77. "UAVs Could Replace Several Manned Aircraft, Owens Says," *Air Force News,* on-line, Internet, 1 March 1996. Admiral Owens's words were spoken days before he was about to retire after 34 years in service.

78. Shaker and Wise, 21.

Chapter 3

Strategic Offensive Airpower

A high-altitude attack by American bombers against Cologne has been turned back by the fierce antiaircraft fire defending the city, and no bombs were dropped. The accompanying fighter cover, however, composed of small and exceedingly fast twin-tailed aircraft, came over the city at low altitude in a strafing attack. So good were the defenses that every single fighter was shot down; much damage was done by these falling aircraft, all of which exploded violently.

—German News Release (1944)

The interesting "rest of the story," to the strategic attack reported by the above German news report is that bombs were actually dropped while no fighters were shot down. The mission was against the Eifeltor railway marshaling yard near Cologne on 28 May 1944. The USAAF assembled 54 B-17 bombers from three bombardment groups stationed at Molesworth, Kimbolton, and Grafton Underwood in the United Kingdom. The bombs, however, were 108 specially built UAVs. Specifically, they were 2,000-pound glide bomb drones with 12-foot plywood wings and twin tail fins. Attacking the city from beyond the outskirts, the bombers were able to stay clear of antiaircraft fire while launching the glide bombs. The Germans evidently mistook the drones for fighter escort.[1]

The well-documented Cologne mission is significant but not because of the physical destruction it inflicted. The results were actually disappointing due to the fact that all the drones actually missed the intended target. The significance is that the United States took an operational first step towards realizing that UAVs had strategic offensive airpower potential. This came at a time when USAAF were suffering high losses of aircraft and crews. In the month just prior to the attack on Cologne, the Eighth Air Force lost 577 aircraft—missing or damaged beyond repair. More than 60 percent of these losses were heavy bombers.[2]

The strategic attack on Cologne has further significance in its very selection as a strategic target. An American airpower theorist highlighted the city as a potential target in a 1917 bombing plan. This was before the United States had an official strategic bombing doctrine and before its military even possessed the aircraft to support such a plan.

Col Edgar S. Gorrell developed his bombing plan in November 1917; it would later serve as the precursor to the precision-bombing doctrine produced by the Air Corps Tactical School (ACTS). The plan focused on the bombardment of Germany's manufacturing centers in order to break the morale of its civilian workers. "Some towns' morale seemed especially vulnerable," according to Gorrell, "and he surmised from press reports that bombing Cologne 'would create such trouble that the German Government might be forced to suggest terms.'"[3]

Gorrell and other airpower theorists generally agreed that strategic bombardment was the airpower solution to avoid the trench warfare tragedies of World War I. The manned bomber, envisioned as the only means capable of reaching and striking deep targets, came to symbolize the principal weapon of strategic warfare. The theorists gave fighter development a much lower priority as they believed that pursuit aircraft would rarely intercept the superior bombers. While they all viewed strategic bombardment as the means to shorten and win wars, they varied slightly in their reasoning. Douhet theorized air forces should bomb *people;* this would destroy their will and lead to the collapse of the enemy. The British RAF theorized air forces should bomb *industry;* this would destroy the will of the people and lead to the collapse of the enemy. The ACTS also theorized air forces should bomb industry; however, its reasoning was that this would destroy their *capability*, which would destroy the will of the people and lead to the collapse of the enemy.[4]

During World War II, the United States, Great Britain, Germany, and Japan all resorted to the practice called "morale bombing" or "terror bombing."[5] Regardless of whether selected targets were entire cities or specific industries, the intent of their bombing campaigns was to destroy national morale. Supplemental expectations were the destruction of an enemy's war-making capability and the diversion of its military resources. Strategic attacks did inflict destruction and cause diversion to varying degrees; however, attrition and retaliation also ensued. The result was a prolonged war where adversaries exchanged strategic bombardment blows.

From World War II through the Persian Gulf War, the USAF has maintained bombing as a key element of major air campaigns. Until the Gulf War, however, its planners did not always adhere to a precision-bombing doctrine. In conflicts like Southeast Asia, the bombers seldom performed surgical strikes on strategic targets. Airpower advocates see the Gulf War as the definitive moment when technology caught up with theory, and strategic offensive airpower accomplished exactly what the early airpower theorists had predicted. Unlike in previous wars, Desert Storm's air campaign planners logically identified strategic targets; and coalition air forces successfully attacked them with precision. Donald B. Rice, former secretary of the Air Force, emphasized these points in a paper on American airpower in the Gulf War:

> This new age [new era in warfare] also realized the concept of a strategic air campaign. Air power did exactly what air power visionaries said it could. With roughly 1 percent of the bombs dropped in 11 years in Vietnam, allied air assets shut down Iraq's gasoline production, electricity, transportation, communications, offensive-weapons production, and air defenses.[6]

One can easily get the wrong impression from Rice's statement (and others like it) that airpower alone can defeat an adversary with significantly fewer but more technologically capable strategic airpower assets. While US airpower in the Gulf War did paralyze the enemy in a short and decisive air campaign, it required a considerable expenditure rate of

bombs, as well as a high sortie rate of airpower assets to deliver them. Despite being a short war, Desert Storm required high levels of airpower assets and supporting resources. Had they not been available (or not existed) within the war's narrow time frame, the air campaign could have lasted much longer; and the results could have been very different. In order to make a comparison between the last four major wars, the following sections illustrate US bomb tonnage and combat sortie statistics.

In analyzing bomb tonnage statistics, the USAF's expenditure in the Gulf War was less than 1 percent of the tonnage expended in Southeast Asia (as previously referenced by Secretary Rice), 13 percent of the tonnage expended in Korea, and less than 3 percent of the tonnage expended by the USAAF in World War II (against both Japan and Nazi Germany). However, if one views these measures in terms of tonnage per month, the statistics reveal a more stable rate of expenditure across the wars. Gulf War tonnage per month was nearly 92 percent of the tonnage per month expended in Southeast Asia, 329 percent of the tonnage per month expended in Korea, and nearly 85 percent of the tonnage per month expended in World War II. Table 3 provides a summary of the data used to compute bomb tonnage percentages.[7]

Table 3

US Army Air Forces/US Air Force Bomb Tonnage Statistics for Four Conflicts

WAR	TONNAGE	LENGTH	TONNAGE/MONTH
World War II	2,150,000	45.0 months	47,777.78
Korea	454,000	37.0 months	12,270.27
Vietnam/SE Asia	6,162,000	140.0 months	44,014.29
Gulf War	60,624	1.5 months	40,416.00

Source: Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 190.

In analyzing sortie rates, the Gulf War's combat sorties per month were nearly 138 percent of the sorties per month conducted in Southeast Asia, over 212 percent of the sorties per month conducted in Korea, and over 50 percent of the sorties per month conducted in World War II. Table 4 provides a summary of the data used to compute combat sortie percentages.[8]

Desert Storm was unlike any previous warfare operation, but similarities do exist. Strategic offensive airpower delivered destruction and synergism as never before witnessed by any nation. On the positive side of technology, stealth and precision weapons provided the means to avoid attrition. On the negative side, the air campaign did not deter retaliation; and the ensuing Scud-hunting campaign resulted in a futile diversion of coalition airpower assets. Like Germany's V1/V2 weapons, Scuds were

Table 4•

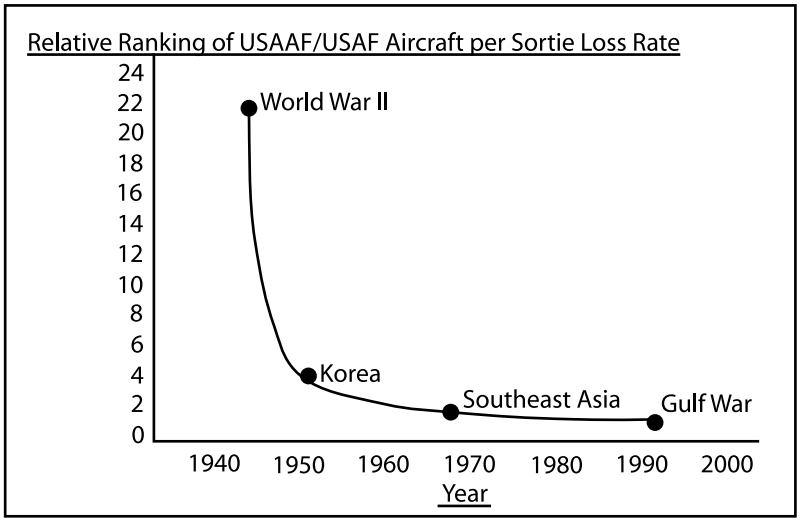
US Army Air Forces/US Air Force Combat Sortie Statistics for Four Conflicts•

WAR	COMBAT SORTIES	LENGTH	SORTIES/MONTH
World War II	1,746,568	45.0 months	38,812.62
Korea	341,269	37.0 months	9,223.48
Vietnam/SE Asia	1,992,000	140.0 months	14,228.57
Gulf War	29,393	1.5 months	19,595.33

Source: Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 190.

not a significant military threat; however, they did cause implications which political and military leaders simply could not ignore.

The USAAF and USAF have always demonstrated the will and ability to conduct large bombing campaigns with high sortie rates. What makes the Gulf War air campaign so impressive is that it achieved more successful target strikes in a significantly shorter span of time, and it did so with a remarkably lower percentage of aircraft losses. In Southeast Asia, the USAF suffered 1.7 times the number of losses per sortie as those it experienced in the Gulf War. In Korea the losses were 3.6 times as great. In World War II, the USAAF tragically suffered over 21 times the number of losses per sortie compared to those of the Gulf War.[9] Figure 2 illustrates the decline rate of US aircraft losses per sortie in World War II, Korea, and Southeast Asia compared to the Gulf War.



Source: Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 190.

Figure 2. Relative Decline of US Aircraft Losses per Sortie over Four Conflicts

It thus follows that future air campaigns must provide mechanisms to satisfy popular or domestic expectations. Decision makers may call upon airpower to not only deliver a decisive blow leading to a quick end to the conflict but also to do so with minimal casualties.

Various theories have evolved for air campaigners to base their strategic targets upon. Col John A. Warden III authored the theory attributed as being "the conceptual basis for the air campaign against Iraq."[10] As technology improved throughout history, so did the ability to support the doctrine of precision strikes. Many nations now view modern airpower, developed with the most advanced technology, as the universal means to shorten and win wars.

Technology has delivered precision, and precision has delivered what some describe as an airpower revolution. For example, Richard P. Hallion in his book, S*torm over Iraq: Air Power and the Gulf War*, states that airpower technology was a big winner in the Gulf War: "Sophisticated technology consistently demonstrated its leverage and power in the Gulf War. The F-117A stealth fighter best exemplified the new revolution in aerospace power made possible by advanced technology."[11]

New technologies have likewise added credence to strategic attack doctrines of early airpower theorists. From lessons of the Gulf War, military strategists now realize it is viable to look at *paralyzing* instead of *destroying* an enemy. Liddell Hart said, "It should be the aim of grand strategy to discover and pierce the Achilles' heel of the opposing government's power to make war."[12] Colonel Warden would say that the emphasis should not be on the enemy's ability to *wage* war, but instead on its ability to *direct* war. Military planners now have opportunities to recognize and understand previously overlooked target options, such as complex electric grids.[13] Planners must likewise consider and understand all available means to attack identified targets.

Debate has already taken place, and arguments will continue for some time to come, on the actual effect of precision strategic attack doctrine and the value of airpower versus ground power and/or sea power. Despite concerted attempts to avoid collateral damage and civilian casualties, televised misses of smart weapons coupled with the high percentage of unguided bomb inaccuracies will be highlighted by those arguing against the results of airpower precision in the Gulf War. Such arguments emphasize the need to ensure doctrine and technology are properly advanced to clearly define what we can and cannot deliver.

US military technologies, particularly strategic offensive airpower systems, are currently the most advanced in the world. Cruise missiles and manned aircraft represent the two existing means to deliver precision strategic attack. Both have the ability to destroy vital targets of military or political significance. The cruise missile represents a form of UAV, and its use does not put a pilot at risk. Although we can view autonomous capability as an asset, this characteristic does not offer the benefit of man-in-

the-loop weapons control nor does it provide feedback. Hallion provides the following observations on cruise missiles:

> Being incapable of interpreting what they were seeing with the flexibility of a human mind, they could not adjust or compensate for the images they saw that contained blasted or ruined buildings from previous strikes in correlating those images against stored memory. Thus previous damage from earlier raids could cause the terminal guidance system of later missiles to misread their internal "map," possibly sending the missile off course during its terminal phase.[14]

Present analysis of cruise missiles indicates that technology is far from delivering desired precision and may never substitute for having the man in the loop. The most recent example of how far technology has developed, while at the same time illustrating the strength of the human mind, was a landmark man-versus-machine match in February 1996. World chess champion Garry Kasparov defeated the world's most powerful chess computer, despite the machine's ability to calculate 50 billion moves within minutes.[15]

On the other end of the man-machine spectrum, proponents for having man-in-the-loop control argue the case for manned aircraft. Improvements in aerial bombing precision have increased dramatically in the last half-century of warfare. Table 5 illustrates the number of bombs and aircraft required in the last four major conflicts, to strike a target with a 90 percent hit probability.[16] The target size is 60 by 100 feet, and the attacking aircraft use 2,000-pound unguided bombs from medium altitudes. The CEP (circular error probable) shows the average bomb miss distance in feet.

Table 5

Bombing Accuracy for Four Conflicts

WAR	# OF BOMBS	# OF AIRCRAFT	CEP (feet)
World War II	9,070	3,024	3,300
Korea	1,100	550	1,000
Vietnam/SE Asia	176	44	440
Gulf War	30	8	200

Source: Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 283.

Although the trend in bombing accuracy has improved, table 5 only includes the number of bomb-carrying aircraft in the strike package. What is not evident in the chart are the high numbers of aircraft and people required in the support package. Proponents of guided bombs argue that Vietnam and Desert Storm have demonstrated the case of "one target, one smart bomb."[17] While the accuracy of precision munitions has made it

possible for small formations to achieve what required hundreds of aircraft in World War II to accomplish, there is much more involved in manned strategic attack missions.

During Operation Linebacker in Vietnam, the strike package typically consisted of 32 F-4s carrying laser-guided as well as unguided bombs. The following describes the extensive support package required to carry out a successful Linebacker mission:

> The support package of a typical Linebacker strike consisted of one or two flights of F-4s configured for air-to-air escort against the immediate MiG threat, a flight of four F-4s or F-105 Wild Weasels proceeding the flight in search of SAMs, a hunter-killer team of two F-105s and two F-4s in the SAM and flak suppression role, and two flights of four F-4s in the MiGCAP role. In addition, a chaff delivery flight and its escorts preceded this complex formation. The chaff flight consisted of four-to-eight A-7s or F-4s, and was escorted by a flight of F-4s and possibly a Wild Weasel and a MiGCAP flight. "Alone, unarmed, and unafraid," a single or a pair of RF-4C reconnaissance aircraft followed the strike to record target damage.[18]

In addition to the support package, additional aircraft were required or standing by to conduct standoff electronic countermeasures jamming, radar coverage, airborne command and control (C^2), refueling, and rescue. "The support/strike ratio ran as high as five-to-one on missions where the US anticipated strong opposition."[19]

During the Gulf War, similar strike and support packages were employed. The 5:1 strike/support aircraft ratio was again typical to ensure the desired measure of survivability. The following is an example of one such mission during Desert Storm:

> On one attack against one airfield, four A-6Es and four Tornadoes striking the airfield were protected by four F-4G Wild Weasels, five EA-6B radar jammers, and twenty-one F/A-18C Hornets carrying radar-homing missiles. This package of thirty-eight aircraft (and sixty-five men) was needed to ensure that eight aircraft could hit one target with a good expectation of survival, a ratio of support aircraft to strike aircraft of almost 5 to 1, and an aircraft-to-target ratio of 38 to 1.[20]

Again, planners required additional assets to perform many other functions, such as aerial refueling, C^2, and combat search and rescue.

The Gulf War set the stage for the F-117 to demonstrate that stealth technology works and it works well. Unlike the strike packages described above, the stealth fighter does not require an extensive escort support package. Although it does require necessary peripheral support assets (aerial refueling, standby combat search and rescue, etc.), a stealth aircraft works best alone because it survives on being nearly invisible to radar. According to Gen Merrill A. McPeak, former Air Force chief of staff, stealth has restored surprise to air operations. "There is a sense," he stated, "in which the F-117, the ATF [F-22], and the B-2 will render all other air forces obsolete."[21] While there is some rationale behind this statement, the security of stealth does have limitations.

The F-117 is limited to nighttime operations and, as with all manned aircraft, there are weather restrictions. Hallion states, "Weather severely

impacted F-117 operations in the first two weeks of the war, although even late in the campaign, it posed problems."[22] The aircraft alone is expensive; Hallion lists the cost (1992 figure) of an F-117A at $42,600,000.[23] The aircraft requires specialized training, maintenance, logistics, and supply support in terms of both equipment and personnel. While we cannot easily put the value of a human life into monetary terms, all airmen would generally agree that a pilot is of greater value than the aircraft he or she flies. Given the high value placed on the F-117 and its human operator, Desert Storm planners used the stealth fighter only against high-value targets, such as air defense headquarters, C^2 centers, and integrated air defense networks. Because of its value, the F-117 also requires additional security measures, which limits locations where the United States will base it. Its high status is now at a level whereby the shootdown of a stealth fighter in a conflict, no matter how arguably unlikely this may be, could cause serious repercussions both militarily and politically. In turn this could limit the type of conflict the United States will employ it in, as well as limit the type of targets the United States will employ it against.

Other primary US manned aircraft for strategic attack are the B-1 and B-2 bombers. Initial development of the B-1 began in 1962, but President James E. "Jimmy" Carter Jr., canceled the program before production could begin. President Ronald Reagan resurrected the B-1 program, and 100 advanced models became operational in 1986. During Desert Storm, the B-1 sat on alert as part of its role in the US strategic nuclear triad. It also lacked nonnuclear weapons versatility; therefore, the B-52 once again was the bomber called upon to serve in war.

The B-2 was not yet operational during Desert Storm. Unlike the B-1, had it been in service it very likely would have played a role. "General Horner in Riyadh said the one aircraft that he most could have used in this campaign was the B-2 stealth bomber."[24] The B-2 is designed to operate as a single ship against heavily defended, high-value target sets; and it has the capability to deliver conventional bombs. With proper mission planning, it can hit multiple aim points in a single pass. One B-2 pilot asserts that the bomber "has all the advantages of an F-15E in terms of precision, with all the advantages of the B-52 in load, coupled with the advantages of the F-117 in stealth."[25] However, while the B-2 can carry eight times the bomb load of an F-117, it costs over 14 times as much.[26] Because of its markedly high value, it would likely take a major regional conflict of at least similar magnitude to the Gulf War in order for political and military leaders to agree on B-2 employment.

Operation Desert Storm—Opening Night

The most defining moment of strategic attack in war is the instant it is initiated. On the opening night of Desert Storm, coalition forces used an incredible orchestration of airpower to achieve monumental results. De-

spite the successes, it is easily possible to envision how strategic attack RPVs could have been of value. The following sections cover the significant airpower events during the first night of Desert Storm. Concepts of how RPVs could supplement Desert Storm operations, particularly in strategic offensive airpower roles, will follow each section. Chapters 4 and 5 of this paper will expand upon many of these RPV concepts and roles.[27]

B-52 Bombers

The B-52 Stratofortress is an age-defying aircraft which embodies USAF "Global Reach, Global Power" doctrine. The decision to use a B-52 represents the serious level of US political and military resolve. In order to participate in Desert Storm on opening night, B-52s launched from four international locations—the most distant being Barksdale AFB, Louisiana. While the release of payloads was over in minutes, the time required to travel to launch points and back took as long as 24 hours. In addition to a large and versatile weapons payload capability, the B-52—nicknamed "Buff"—conveys a great deal of psychological influence; this can be a positive influence on friendly forces and a very negative influence on the enemy.

Complementing manned bombers such as the B-52, RPVs could also perform strategic attack missions rapidly, accurately, and with intensity. All the US services could theoretically launch and control them from a variety of platforms, which would provide more speed, flexibility, and precision. Used in large numbers they could also be a significant psychological force, especially if they were used in harassment or decoy roles.

Tanker Support

Just hours before the first strike, "one hundred sixty tankers—American KC-10s, KC-135s, and KC-130s; British Victors, Tristars, and VC10Ks; and Saudi KE-3Bs among them—took off and flew to multiple refueling tracks, staying out of range of Iraqi early warning radar."[28] The tankers were required to refuel hundreds of strike, suppression, and other support aircraft. If tankers had failed or were somehow restricted in performing their vital mission, some manned attacks would have been impossible to achieve.

Depending upon their design and function, RPVs would not normally require refueling. This would likely be the case if they were expendable, which could double their range and time over areas of operation since a return trip would not be necessary. General McPeak, however, believes the United States should look into the concept of UAV refueling. A problem worth thinking about, he indicated, is "how to do pilotless air refueling—because range is very important."[29]

Operational Security

Launches of multiple aircraft from any base can provide indications and warning of an impending attack. The size and status of military aircraft—

particularly bombers—limit the number and locations of bases they can operate from. Operational security can be a nightmare, as was the case in Dhahran on the first night of Desert Storm: "A commercial pilot captaining a waiting jumbo jet from a coalition nation impulsively complained to the airport's tower controllers about a flock of RAF Tornadoes . . . that suddenly cut ahead of him from a taxiway and took off into the dark, afterburners flaring."[30]

As stated earlier, all services could covertly launch RPVs from a variety of air-, ground-, and sea-based platforms. In essence, a limitless variety and mix of launch and control options exist. One conceptual example is the McDonnell Douglas RC-17 UAV Carrier. This is a UAV launch and recovery module envisioned for the C-17 Globemaster. As stated in company literature, the module is capable of supporting six UAVs, a UAV fuel storage tank, and in-flight launch and recovery of UAVs.[31]

F-117 Stealth Fighters

F-117 stealth fighters were critical airpower assets during Desert Storm. On opening night they attacked the most heavily defended and hardened targets. The F-117 stealth "fighter" is somewhat a misnomer because its primary purpose is to drop laser-guided bombs.[32] It avoids a fight at all costs; and it is designed to be survivable, not by sheer speed or maneuverability but instead by being nearly invisible. In order to make detection more difficult, the F-117 operates only at night.

An RPV may complement the F-117 by providing the ability to attack during the day and in all weather conditions. For greater survivability it could be designed and developed with more advanced stealth characteristics; the absence of a cockpit allows more freedom to create signature suppressive designs. If intentionally developed to have the radar signature of a manned aircraft, it could act as a decoy or harassment aerial vehicle. In this role it would intentionally attract antiaircraft threats towards itself. The *New World Vistas* study points out that a UAV "can be designed symmetrically to accelerate in any direction immediately," and that "survivability can be increased by increasing maneuverability beyond that which can be tolerated by a human pilot."[33]

Cruise Missiles

On the first day of Desert Storm, the Navy launched 105 Tomahawk land attack missiles (TLAM), and the Air Force fired 35 air-launched cruise missiles into Iraq. The launching of cruise missiles was significant because "unlike manned aircraft, the little missiles could not be recalled. Once these missiles left their launch canisters or fell away from their B-52 motherships, there was no turning back: the coalition was at war."[34] RPVs can be recalled, redirected, or even self-destructed. Remote pilot control, rather than sophisticated guidance systems, could make them cost substantially lower than the $1.2 to $1.5 million for a cruise missile.

The transmissions used by a controller to operate the RPV could provide information feedback before, during, and after an attack. RPVs could also be designed to carry larger as well as a greater variety of payloads, including nonlethal weapons.

In summary, while opposing nations attempted to put their strategic airpower doctrines through the test of World War II, the technology of the time was insufficient to provide the desired precision. The British felt justified in their policy to conduct indiscriminate night area bombings. The United States, having developed the Norden bombsight and the B-17 bomber, felt justified in adopting daylight precision bombing against carefully selected industrial targets. In the Pacific, however, the United States eventually converted to an indiscriminate bombing policy which included city fire bombings and the eventual use of the atomic bomb.

The first theories of strategic bombing had to rely upon technological developments to come of age relative to early concepts. Today, the debate continues on airpower's role in war. Does airpower have more to offer in offensive or defensive roles? Can it have a greater impact in war through independent operations or in support of a ground campaign? While the strength and intensity of support for one view over the other will vary from conflict to conflict, there will nearly always be sufficient grounds to argue for operations directed against strategic targets that are only accessible by air.

The US Army's Combat Studies Institute produced a study on the evolution of military doctrine from 1946–76. "The great value of doctrine," it concluded, "is less the final answers it provides than the impetus it creates toward developing innovative and creative solutions."[35] Airpower advocates should not restrict doctrine and tactics to current means and, likewise, they should not tie technology to established doctrine. General Arnold emphasized these points when he gave his final report to the secretary of war in 1945. The Air Force must keep "its doctrines ahead of its equipment," he stated, "and its vision far into the future."[36] Strategic offensive airpower, whether for strategic bombardment or strategic paralysis, is an integral part of the USAF and its doctrine. RPVs possess the potential to be an innovative and creative solution for future strategic offensive airpower problems.

Notes

1. Air Chief Marshal Sir Michael Armitage, *Unmanned Aircraft* (London: Brassey's Defence Publishers, 1988), 25; and Conrad C. Crane, *Bombs, Cities, and Civilians: American Airpower Strategy in World War II* (Lawrence, Kans.: University Press of Kansas, 1993), 85–86.
2. Armitage, 24–25.
3. Crane, 13.
4. Col Phillip S. Meilinger, School of Advanced Airpower Studies Course 631 class notes, August 1995.
5. Crane, 1.

6. Donald B. Rice, "Air Power in the New Security Environment," in *The Future of Air Power in the Aftermath of the Gulf War,* Richard H. Shultz Jr. and Robert L. Pfaltzgraff Jr., eds. (Maxwell Air Force Base [AFB], Ala.: Air University Press, 1992), 11.

7. Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 190. This is a partial copy of table 6.3 from Hallion's book. World War I statistics were not included because they came before strategic bombing theories; also, the planes of that era generally had payloads no greater than 500 pounds.

8. Ibid. Numbers of combat sorties are from table 6.4 and lengths of conflicts are from table 6.3.

9. Ibid. Figures used in calculating relative numbers for comparison are from table 6.4.

10. Quote by retired Maj Gen Perry Smith, endorsing Col John A. Warden's book, *The Air Campaign: Planning for Combat* (San Jose, Calif.: toExcel, 1998).

11. Hallion. Caption to last photograph of F-117A fighters.

12. B. H. Liddell Hart, *Strategy* (New York: Meridian, 1991), 212.

13. Bruce M. DeBlois et al., *Dropping the Electric Grid: An Option for the Military Planner* (Maxwell AFB, Ala.: Air University Press, October 1994). The first project of its kind, specifically developed for the military planner to better understand electrical systems and how to attack them, is "A Concept Prototype of the Electrical Power System."

14. Hallion, 250.

15. James Kim, "Chess Match Measures More Than Who Wins," *USA Today*, 9 February 1996. The computer, named Deep Blue, possessed 32 microprocessors able to draw on 32 gigabytes of memory and 128 gigabytes of hard disk space. A machine cannot match a human's creativity, intuition, and experience. Kasparov stated, "The computer is not flexible, you can accurately guess what kind of decisions it will make."

16. Hallion, appendix, table 2, 283. Hallion thanks Col John A. Warden III and Lt Col Dave Deptula for making the chart available to him.

17. Ibid.

18. "The Tale of Two Bridges and the Battle for the Skies over North Vietnam," USAF Southeast Asia monograph series, vol. 1, ed. A. J. C. Lavalle (Washington, D.C.: Department of the Air Force, 1976), 152–53.

19. Ibid., 153.

20. Hallion, 249.

21. Gen Merrill A. McPeak, *Selected Works 1990–1994* (Maxwell AFB, Ala.: Air University Press, 1995), 14.

22. Hallion, 117.

23. Ibid., 362.

24. McPeak, 45. This quotation was part of a statement/question posed to General McPeak in a 1991 DOD news briefing.

25. John A. Tirpak, "With the First B-2 Squadron," *Air Force Magazine*, April 1996, 41.

26. Tirpak, 38–40. The B-2 flyaway cost is $600 million, and it can carry up to 16 2,000-pound bombs. This is compared to the F-117, which can carry two bombs and has a cost of $42.6 million.

27. Hallion, 162–200. First day scenario of Desert Storm is based on many sources as compiled in chapter 6 of this book.

28. Ibid., 165.

29. McPeak, 351.

30. Hallion, 165.

31. McDonnell Douglas Aerospace (C-17 Improvements and Derivatives), *A Pocket Guide to Mission Module and Derivative Concepts*. Although not classified, proprietary rights by other industries working on future UAV concepts currently restricts disclosure of specific platforms being studied.

32. *Webster's Ninth New Collegiate Dictionary* defines a fighter as "an airplane of high speed and maneuverability with armament designed to destroy enemy aircraft."

33. Air Force Scientific Advisory Board (SAB), report, *New World Vistas: Air and Space Power for the 21st Century*, summary volume (Air Force SAB, 1996), 35.

34. Hallion, 165.

35. Maj Robert A. Doughty, *The Evolution of U.S. Army Tactical Doctrine, 1946–1976* (Fort Leavenworth, Kans.: Combat Studies Institute, 1979), 2.

36. Robert F. Futrell, *Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force*, vol. 1, *1907–1960* (Maxwell AFB, Ala.: Air University Aerospace Studies Institute, 1971), 168.

Chapter 4

Merits of Expendability

Recovery is an alternative *for an unmanned aircraft. Brave men freely give their lives for a cause but, in the West at least, it is unacceptable that they be required to do so. Consequently military aeroplanes are designed to reach a place of safety at the end of their mission.*

—Noel Falconer
Bristol, U.K. (1984)

Assuming that RPVs hold potential as supplementary means to support existing strategic attack systems, design decisions can directly lead to the success or failure of their future development and employment. Much time and money will have been wasted if an aircraft system, manned or unmanned, is deemed obsolete before an operational sortie is ever flown. While attributes of RPVs cannot totally overcome the limitations of airpower, they can provide significant advantages by decreasing such restraints. For example, they can provide more persistence by conducting operations extending beyond the limits of human physical endurance. In an effort to exploit greater advantages of airpower, expendability is one design factor of an RPV worthy of exploration. To begin, it may be beneficial to point out some differences which separate manned aircraft well apart from UAVs.

High-speed manned vehicles (whether they be ground-based, sea-based, or air-based) represent objects of risk to any onboard human controller or occupant. If a fatal crash occurs, it is not the loss of machine but the loss of human life that we mourn. Manned aircraft must provide their pilots and other occupants with unlimited safe flights. They must be survivable. UAVs do not have this requirement. "Thus the choice is between a long-life machine and an expendable only, without intermediates."[1]

Few manned aircraft are expendable by design because Western societies do not view such systems with respect or admiration.[2] Japanese suicide aircraft serve as historical examples of expendable manned vehicles. Contrary to Western thinking, the Japanese revered the kamikaze ("divine wind") pilot as part of their culture. During the closing months of World War II, they used *Kugisho Ohka* aircraft which were specifically designed for suicide attack. These "suicide bombs" were particularly effective against US naval forces during the invasion of Okinawa in April 1945.

Final tallies estimate that 4,000 Japanese kamikaze pilots sacrificed their lives flying the *Ohka* and other suicide aircraft. In turn, however, they accounted for sinking 34 American ships and damaging 288 others. Included in these numbers were 36 aircraft carriers, 15 battleships, and 87 destroyers. Also, between 17 April and 11 May 1945, the United States

diverted 75 percent of its B-29s away from strategic missions to knock out kamikaze bases. The US Strategic Bombing Survey noted that "kamikaze attacks wrought such damage that, had they been sustained with greater power or concentrations, they might have forced the US to withdraw or revise its strategic plans."[3] While the United States will not pursue development of kamikaze aircraft, an expendable RPV is feasible.

In terms of eliciting emotion, people simply do not view manned and unmanned systems alike. At air shows manned aircraft, not UAVs, draw the crowds. Within air and space museums, visitors can usually find UAVs hanging from the ceiling up and away from the main exhibits. At the Paris air show in 1995, a reviewer used the term *cult classics* to describe aircraft without pilots:

> Away from the main displays . . . there was a subtler *succès d'estime:* an odd-looking species of machines that appealed mostly to a small band of aficionados. These aircraft may never be crowd-pullers: they do not have the big-dollar charm of blockbusters, and they are not star vehicles. As the crowds watching the stunts outside know, pilots are the true stars of flight—and these are aircraft without pilots.[4]

When manned aerial "firsts" are performed, people remember (and even revere) both the pilot and aircraft involved. Achievements by unmanned aircraft attract hardly any attention. For example, upon crossing the Atlantic Ocean, Charles Lindbergh and his *Spirit of St. Louis* earned a prominent place in aviation history. On the other hand, very few people are aware of the unmanned B-17 that USAAF researchers remotely piloted from Hawaii to California. They accomplished this feat as part of RPV radar and television control experiments conducted in the early 1940s.[5]

The crash or downing of manned aircraft is typically front-page news. A major international incident can result if the aircraft shot down was in violation of foreign airspace. On the other hand, "if an intruder aircraft, shot down over a foreign nation, contains no human crew, even the formalities of a diplomatic protest are seldom observed."[6] When a manned aircraft is lost in exceptional circumstances, particularly a conflict, it can be the focus of major media attention. An example of this was the shootdown of USAF Capt Scott F. O'Grady over Serb-held territory in Bosnia on 2 June 1995. News reports continued throughout the year of his efforts to evade capture for six days and his subsequent rescue by US Marines (with NATO air support).

According to the GAO, military aircraft crashes cost DOD more than $1 billion per year; and human error is a factor in 75 percent of these crashes.[7] During the first four months of 1996, four F-14 Tomcats and one F/A-18C crashed. The unusually high F-14 loss rate (the first three occurred within a single month) caused the news media to focus public attention on the US Navy and its supersonic fighter. News media reports especially highlighted the second and third F-14 losses because they occurred within four days of each other. Six months earlier, the loss of two RPVs, also within four days of each other, was not nearly as newsworthy.[8]

Advantages and Disadvantages of Remotely Piloted Vehicles

Table 6 is a GAO illustration of advantages and disadvantages of RPVs for military missions.[9] The greatest advantage for RPVs is pilot risk, and the greatest disadvantage is recovery.[10] Although this view is based upon 1980s technology and does not directly deal with cruise missiles nor expendable RPVs, the advantages and disadvantages are still pertinent. The following sections of this chapter will address each area of advantage or disadvantage in greater detail. Using the same 21 areas developed by the GAO, comparisons will be made between four aircraft categories designed to conduct strategic attack. The four categories are manned aircraft, cruise missiles, reusable RPVs, and expendable RPVs. Within an area, each asset's advantage or disadvantage will be judged relative to the other three assets. In certain areas, an asset will more clearly warrant either having a major advantage (represented by the symbol "●") or else as having a major disadvantage (represented by the symbol "○"). An asset having counterbalancing advantages and disadvantages (represented by the symbol "◘") may have some ill-defined boundaries. At the end of each section, a rank (symbol) will be given to each asset according to the evidence. A chart at the end of this chapter will display the compiled results.

Pilot Risk

Pilot risk is a major handicap for manned aircraft, and it is the greatest advantage for UAVs.[11] Heavy air losses during World War I led to the following British Air Staff statement which remains applicable today: "The air force have never been unwilling to face heavy losses; but it must be realized that highly trained pilots cannot be replaced with the same ease as infantry soldiers."[12] Simply stated, manned aircraft put pilots at risk whereas UAVs do not. While this is obvious, the importance of pilot risk deserves greater discussion.

As stated before, it is not possible to put a price on the life of a human; but many factors can make the high value of a pilot even greater. For example, a shortage of pilots can have serious repercussions. During the Battle of Britain, the British were producing all the aircraft they needed; but it was pilots they had trouble replacing. On the German side, the Luftwaffe created and suffered a pilot shortage by taking the air war over British territory. If an RAF pilot was shot down and survived, he was able to fly and fight another day. On the other hand, if a German pilot was shot down and survived, he was captured and taken out of the war.

Search and rescue (SAR) of downed pilots and aircrew personnel is an emotional and enduring issue. The Vietnam War saga of "Bat 21" represents the great sacrifice that Americans are willing to risk to rescue one airman. Debate continues on this case study as to whether the morale factor associated with saving one comrade was worth the heavy cost in

Table 6

Remotely Piloted Vehicle Advantages and Disadvantages

AREA OF RPV ADVANTAGE OR DISADVANTAGE	RELATIVE RANK
Pilot Risk	●
System Cost (Excluding Operating Cost)	●
Operating Costs	●
Fewer Design Constraints	●
Flight Duration	●
Payload Flexibility	◉
Fuel Savings	●
Small and Less Visible Silhouette	●
Better Performance in Hazardous, Boring, or Fatiguing Conditions	●
Flight Noise	●
Airspace Safety	◉
Safety of Ground Personnel/Facilities	◉
Development Costs	●
Control of Payload	◉
Less Complex Communication and Control System	◉
Aircraft Control (Navigation, Stability, and Maneuverability)	◉
Aircraft Flight Performance	◉
Reliability	◉
Systems	◉
Performance Under Emergency or Unforeseen Conditions	○
Recovery	○

Source: "DOD's Use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars," General Accounting Office (GAO) survey (Washington, D.C.: GAO, 1981), 19.

KEY: ● Major Advantage
◉ Counterbalancing Advantage/Disadvantage
○ Major Disadvantage

lives, sorties, and diversion of resources. In April 1972 12 days of intensive SAR efforts resulted in an additional 15 Americans being shot down as they attempted to rescue Lt Col Iceal E. Hambleton, navigator of a downed electronic warfare aircraft (call sign Bat 21). Dozens of aircraft became involved in the rescue operation, but it finally took a Marine ground team and Army of Vietnam rangers to pick up Hambleton.[13] More recently, coalition SAR difficulties and failures during the Gulf War not only wasted additional manpower and time but they had a demoralizing impact on fellow pilots. "After we saw the videotape (broadcast by CNN in Baghdad) of Eberly (downed and captured F-15E pilot, Col Dave Eberly), our confidence in JRCC (Joint Rescue Coordination Center) went to zero."[14]

Manned aircraft are of no value if trained and experienced pilots are not available to fly them. Likewise, if there are very few or no aircraft assets available, a surplus of highly skilled pilots is essentially useless. As S. L. A. Marshal phrased it in 1947, "War is always an equation of men and machines. Efficiency comes of a proper balancing of the equation."[15] In order for expendable RPVs to be of greatest value for strategic attack, a high ratio of machines to operators is desirable. It is theoretically possible to design a system whereby one highly skilled operator could manage and control several RPVs during each mission. In the 1970s, one concept (by Radio Corporation of America) recommended having one operator handle as many as a half dozen RPVs during the en route phase of the mission."[16]

Relative Ranks for Pilot Risk Area

Manned Aircraft	○
Cruise missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

System Cost

System cost is a difficult area to compare between manned and unmanned assets because it alone does not reveal whether the dollar cost is truly worth the product. For example, we can never positively determine whether specific development and production of a relatively expensive military aircraft, such as the B-1 bomber (which has never flown a mission in a war or conflict), was instrumental in deterring war. If it did, it certainly was of immeasurable value. Nevertheless, the system cost factor will be ranked according to the premise that the lower the unit cost, the greater the relative advantage.

The United States is the world leader in developing high-technology airpower assets with a "quality over quantity" focus. The result is the world's best, as well as the most expensive, manned and unmanned aircraft. Manned aircraft for strategic offensive missions cost tens to hundreds of

million dollars each. The unit flyaway cost of an F-117 stealth fighter is nearly $43 million, and that of a B-2 stealth bomber is $600 million.[17] At a somewhat lower level of cost, strategic cruise missiles and reusable RPVs cost millions of dollars each. A TLAM costs about $1.2 million, and a Predator UAV costs about $3.2 million.[18]

Expendable RPVs could best supplement existing assets with the production of greater quantities and lower unit costs. This is possible because such vehicles need not be restricted to manned aircraft specifications.[19] Considering cheaper UAVs from the past and those in current inventories, one-use, throwaway types could cost as low as tens of thousands of dollars each. The initial cost of the Firebee was $10,000.[20] A single Pioneer UAV costs $16,000. The total cost for the SR Pioneer UAV system used in the Gulf War was about $200,000, and it consisted of four UAVs, a ground control unit, and accessories.[21] In a report on DOD RPV technology, the GAO stated that cost reduction in unmanned aircraft design and construction is possible by using materials such as "fiberglass, plastic, foam, fabric, and cardboard."[22]

Relative Ranks for System Cost Area

Manned Aircraft	○
Cruise Missiles	◐
Reusable Remotely Piloted Vehicles	◐
Expendable Remotely Piloted Vehicles	●

Operating Cost

Compared to UAVs, operating costs are higher for manned aircraft due to the added requirements associated with a more expensive airframe required to support a human on board. Maximum levels of reliability require that extremely tight tolerances be maintained on airframes, engines, hydraulics, electrical systems, and other components. Manned aircraft require life support systems (ejection seats, oxygen systems, etc.) as well as redundant systems.[23] As an example, the B-2 has a quad-redundant, fly-by-wire system requiring specialized maintenance personnel.[24] Small quantity buys of specialized aircraft, like the B-2 and F-117, have made the cost of spare parts relatively high.

UAVs allow lower operating, maintenance, and training costs with maximum use of simulators.[25] Relative to cruise missiles, operating costs are higher for reusable RPVs due to man-in-the-loop systems, maintenance, and spare parts. However, maintenance and spare parts expenses could be eliminated if they were designed to be throwaway like the cruise missile. Reusable RPVs may have similar cost requirements as manned aircraft. Depending upon the recovery system, they may require a significant number of additional support personnel, which will increase associated operating and maintenance costs. The logistic support for the Firebee was

estimated to cost $65,000 per sortie.[26] This could cost more than the airframe itself. By eliminating the expenses associated with recovery, an expendable RPV could have operating costs on a similar level as a cruise missile.

Relative Ranks for Operating Cost Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◐
Expendable Remotely Piloted Vehicles	●

Fewer Design Constraints

Fewer design constraints are made possible with fewer operational requirements. Manned aircraft must accommodate pilots with cockpits, they must have life support systems to protect humans on board, they must survive many missions, and they must be able to land. At the other end of the spectrum, cruise missiles and expendable RPVs do not require any of these design features or functions. Near the middle, reusable RPVs must survive many missions and be recoverable. The absence of a pilot on board, however, opens up many design possibilities. Air Force chief scientist, Gene McCall, recently described one possible concept: "UCAVs, by eliminating the pilot, could present a completely smooth, seam-free surface to ground-based radars during a flight. The landing gear, the seams of which are impossible to hide, would be on top of the aircraft. When ready to descend, the aircraft could simply roll over and lower its landing gear, a feat impossible with a pilot on board."[27]

The Advanced Research Projects Agency is currently working on projects to provide existing fighters with "autopilot and autolanding capability," as well as to make the last production of joint strike fighters be pilotless aircraft.[28] This approach, however, may not produce an RPV with optimal design. The Air Force Scientific Advisory Board states that when it comes to designing unmanned aircraft, "It appears logical to begin with cruise missile parameters such as those of the Advanced Cruise Missile and then to increase capabilities by scaling. The inverse procedure of scaling down from an inhabited aircraft, say the F-22, will lead to higher cost and cross section."[29]

Taking a manned aircraft design and making an RPV out of it is no more ideal than vice versa. In order to achieve maximum performance, developers should avoid basing RPV designs on current systems with existing design constraints. An expendable RPV has relatively fewer constraints, and future developments should involve new and innovative design concepts.

Relative Ranks for Fewer Design Constraints Area

Manned Aircraft	○◨
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◉◨
Expendable Remotely Piloted Vehicles	●

Flight Duration

Flight duration is a disadvantage for existing strategic attack systems but for different reasons. Manned aircraft are limited in flight duration due to the physical endurance of a human pilot. Cruise missiles are limited by their relatively short-range capability and lack of flexibility for missions of longer duration. RPVs, reusable and expendable, are capable of enduring extended flight. This offers the potential to support surveillance, communication and data relay, as well as many other functions.[30]

Relative Ranks for Flight Duration Area

Manned Aircraft	○◨
Cruise Missiles	○◨
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Payload Flexibility

Payload flexibility is a disadvantage for cruise missiles due to lack of man-in-the-loop control. In addition to reconnaissance and strategic attack packages, designers have planned and designed nonlethal payloads for UAVs. For example, researchers have proposed and designed a variety of payloads such as moving target indicators; electronic intelligence; electronic countermeasures; decoy; communications intelligence; jamming; laser designator and range finder; mine detection; search and rescue; communications and data relay; psychological operations; and nuclear, biological, and chemical (NBC) sensors.[31] Because of the lack of a human on board, RPVs are more ideal than manned aircraft to carry certain payloads (e.g., NBC sensors) into potentially hostile air and space environments.

Relative Ranks for Payload Flexibility Area

Manned Aircraft	●
Cruise Missiles	○◨
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Fuel Savings

Fuel savings is an area disadvantageous for manned aircraft and advantageous for unmanned means. The GAO made a comparison on fuel consumption of an F-4 and a UAV for the same mission and found the following: The F-4 consumed 460,000 gallons of fuel compared to the UAV's consumption of 2,280 gallons.[32] Manned aircraft require considerable amounts of fuel for sustained combat operations. This area is often overlooked in importance, as indicated in the *Gulf War Air Power Survey:*

> A dozen airfields had to take air refueling tankers, mostly KC-135s. No other aspect of CENTAF's early planning fell so far short of what combat operations required. The planners at Shaw had failed to estimate how dependent air operations would be on air refueling, given the distances in theater. They had called for sixty-eight tankers; in the end combat operations required over 230.[33]

Relative Ranks for Fuel Savings Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Small and Less Visible Silhouette

Small and less visible silhouette is an area in which UAVs have greater design potential over manned systems. The first Firebee prototype had stealth characteristics in 1960 that future aircraft designers would continue to use.

> It is interesting to note that this early RPV was to be designed with low radar-reflectivity in mind, a very important aspect of covert flying . . . Experiments with scale models had shown that radar reflectivity could be reduced in a number of ways, including the introduction of a screen of mesh wire over the intakes, coating the nose-section with non-conductive paint and attaching a sheet of radar absorbent material to each side of the fuselage. These measures were successfully applied to full-scale versions of the RPV.[34]

The design flexibility of UAVs offers many possibilities for smaller radar cross sections as well as daytime operating advantages over current systems such as the F-117 and the B-2. "Design freedom allowed by eliminating the pilot will permit the radar cross section of UCAVs to be reduced by one-fourth and effectively reduce the enemy's area of radar coverage by one-sixteenth."[35]

Manned aircraft, like the F-117 and B-2, have stealth technology to minimize radar reflections. The performance of the F-117 in the Gulf War proves the value of this technology; however, its missions were limited to nighttime operations. "High visibility and distinctive shapes are a major limitation of the F-117, F-22, and, in particular, the large, black B-2 bomber."[36] During a bombing run (the most dangerous portion of a B-2's

mission) the open bomb bay doors significantly increase the aircraft's radar cross section.

There are many efforts currently under way to further improve radar masking. One method uses an electrical charge across the skin of the aircraft: "The manned/unmanned aircraft's coating, considered a forerunner of the smart-skin concept, is activated by a 24-volt charge that helps trigger both radar and visual masking. The electrically charged coating attenuates radar reflections better than current stealth coatings."[37] For UAVs, size and materials not suitable for manned aircraft can be used: "Tests conducted with smaller vehicles at low altitudes and larger ones operating at higher altitudes indicate that the unmanned aircraft can be made all but undetectable by conventional radars. Plastics and fiberglass have proved extremely effective in this respect."[38]

Relative Ranks for Small and Less Visible Silhouette Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Better Performance in Hazardous, Boring, or Fatiguing Conditions

Better performance in hazardous, boring, or fatiguing conditions is an area of advantage for UAVs. Methods do exist to extend the endurance of humans involved in combat operations, but these involve chemical stimulants: ". . . if they tire during an extended crisis, they may be able to rely on drugs that enhance or extend performance with few side effects."[39] With multiseat, manned aircraft the pilots can alternate control responsibilities during extended flights. However, strategic strike aircraft such as the F-117 do not offer this luxury.

RPVs offer the greatest advantage in this area as pilots or controllers can operate on a rotating shift without breaking mission continuity. Such an operational concept would be required for UAVs, which can stay aloft for long durations. For example, the high-altitude, long-endurance UAV is designed to fly above 65,000 feet and stay airborne for several days.[40] Alternating between remote control and autonomous operations would also be a part of operational procedures. Military and industry studies have been performed on potential RPV operators, and a variety of options exist for future concepts.[41] For example, one scenario uses air traffic controllers to operate multiple RPVs in a holding pattern; pilots would receive control to fly them during the en route

phase and weapons support officers would receive control to perform attack operations.[42]

Relative Ranks for Better Performance in Hazardous, Boring, or Fatiguing Conditions Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Flight Noise

In a 1994 speech, General McPeak addressed flight noise as an area which required greater attention. "Surprise conveys almost overwhelming combat advantage," he stated, "so it is very important that we continue to 'quieten' aircraft, as we have submarines."[43] Various measures are being used to decrease the noise of jet engines; however, some level of output will always exist.

Strategic aircraft, such as the F-117 and the B-2, have engines which generate a great deal of noise. The F-117 may attack at higher altitudes making them more difficult, but not impossible, to hear. The B-2, redesigned for low-level attack, is more vulnerable in the area of flight noise. Despite this, these assets were designed for single-ship operations—making large formations (and the high levels of noise they generated) a thing of the past.

Air Chief Marshal Armitage addressed how RPVs can offer lower noise signature design possibilities. He states that "only small and lower powered propeller driven aircraft are likely to offer extremely low acoustic signatures." He continues, "many small drones and RPVs take advantage of this factor."[44]

RPVs may actually be more effective as noise generators on certain missions. For example, decoy drones may purposely want their presence known as they conduct 24-hour-a-day harassment missions. This would not only affect the morale of the enemy but also force the enemy to expend resources to deal with it. This was the case with the V-1 Buzz Bomb: "One of the ironies of the Luftwaffe's 'buzz bomb' (which cost a fraction of the V-2) was that not only did its noisiness create more terror, the fact that it could be shot down diverted much more Allied effort into stopping it."[45]

All unmanned aircraft were assigned an advantage rank in this area because they offer the design potential to have lower acoustic signatures than manned aircraft. General McPeak acknowledged this as he continued to address the aircraft quieting requirement. He stated, "really low signatures may require removing the pilot."[46]

Relative Ranks for Flight Noise Area

Manned Aircraft	◐
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Airspace Safety

Airspace safety is a major area of concern for all aircraft. It would be a great tragedy if any two aircraft inexplicably collided with each other during flight. Airspace deconfliction can be a problem; and it would be best to ensure separation, in time or space, and between manned and unmanned assets. RPVs offer the potential capability to fly above other aircraft at operational altitudes of 85,000 to 125,000 feet.[47] They also offer the option of flying at very low altitudes. (Reusable RPVs have a disadvantage in that they must be recovered; this makes airspace deconfliction a return flight concern.) RPVs offer the flexibility of being recovered away from manned aircraft bases.

In the Gulf War, airspace restrictions limited combat operations for manned aircraft. "Airspace was the primary limitation for air refueling in Desert Storm. It was also a major factor for Proven Force operations. During heavy flying periods in the AOR, additional tankers, regardless of configuration, could not have been used because of airspace congestion."[48] There was one midair collision during Desert Storm, but equal concern lies with the near misses: "the Air Force Inspection and Safety Center received 37 NMAC [near mid-air collisions] reports for Desert Storm. It is estimated that reported NMACs equaled only a small fraction of those actually occurring."[49]

Relative Ranks for Airspace Safety Area

Manned Aircraft	◐
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◐
Expendable Remotely Piloted Vehicles	●

Safety of Ground Personnel and Facilities

Safety of ground personnel and facilities is an advantage for cruise missiles and expendable RPVs. It poses a considerable disadvantage for manned aircraft and a lesser degree of negative aspects for reusable RPVs. UAVs, which are intended for one-use missions, do not require the significant number of personnel and facilities to recover and turn vehicles around for continuing operations.

Manned aircraft require basing facilities and support personnel, which are prime targets for attack. In the 1994 speech referenced to earlier in this chapter, General McPeak highlights air base vulnerability as another major Air Force concern:

> We sent about 55,000 airmen to Desert Storm to support a relative handful of active air combatants. We created a very nice target array for the other guy. We were lucky and got away with it, although the Army was on the receiving end of an example of what might have happened when that Scud missile hit their dormitory in Dhahran. We must find ways to reduce the density of the target array we present to the opposition.[50]

In one respect, the ability of strategic aircraft to fly great distances, with air refueling support, offers an optional measure of protection. On the other hand, highly specialized aircraft are traditionally based at locations that can support and service their special needs. The B-2 bomber is based at one continental US location. "The Whiteman facilities built to support the B-2 were designed and constructed bearing in mind that the B-2 has a very long life expectancy."[51] No matter how well protected, "putting all your eggs into one basket" poses a highly undesirable security risk not just to facilities but also to specially trained personnel.

Vertical take-off and landing aircraft can provide the capability for dispersal and basing at more discreet locations. Reusable RPVs currently can be launched from air-, land-, and sea-based assets and recovered by fully automated means. Cruise missiles and expendable RPVs do not require personnel and facilities for recovery operations. Thus, they have an advantage in this area over manned and unmanned assets, which must safely return for recovery.

Relative Ranks for Safety of Ground Personnel and Facilities Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◉
Expendable Remotely Piloted Vehicles	●

Development Costs

The extremely high development costs for manned systems is an area of disadvantage and is actually contributing to recent calls for alternative airpower means such as UAVs. The more systems an aircraft requires, the higher the cost and inevitably the more numerous the acquisition program problems and development delays. Although certainly not inexpensive, the cost to develop cruise missiles is more stable than RPVs due to absence of controller requirements.

Before retiring as vice chairman of the Joint Chiefs of Staff, Admiral Owens stated that UAVs could replace several manned aircraft, resulting in savings for the services of "hundreds of million [dollars] per year."[52]

Owens also stated that the military may be overspending on tactical aviation programs.[53] Among the Pentagon's 20 most expensive programs, 45 percent of the funding goes to three tactical aircraft: the Air Force F-22, the Navy F/A-18E/F, and the Air Force/Navy joint strike fighter.[54] Interrelated with development costs are the long development times. The go-ahead decision to build the B-2 was made back in 1980; now, after a turbulent period of development, it takes six years to build one from start to finish. Because the quantity of original orders was cut, a B-2 has a unit cost of $600 million; but they each actually represent a total development cost of several billion dollars.[55]

UAV developments are certainly not immune to similar cost problems; however, they are on a much smaller scale. The original cost for the Compass Arrow program (established to develop a high-altitude drone) was $35 million. The final cost was $210 million before the program was terminated in 1970 due to Soviet development in high-altitude air defense systems.[56] On a related issue, development costs associated with training a manned aircraft pilot are greater compared to an RPV controller.

Relative Ranks for Development Costs Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	○
Expendable Remotely Piloted Vehicles	○

Control of Payload

Control of payload is an area that depends greatly upon having a man in the loop. Manned aircraft have an advantage in that the pilot is on-scene to directly control a variety of payloads. RPVs also offer this capability. Problems have occurred in the past, however, from attempts to mate existing payloads to existing reusable RPV airframes. This was the case with the Firebee program according to Colonel Krebs, who researched the development of RPVs: "Payloads were mated to existing RPV airframes on current launch, control, and recovery systems and the community would say it satisfied the operational need when these vehicles and support systems might not have been the best alternatives to the operational concept."[57]

Developers of modern-day RPVs have overcome this shortsightedness; however, current systems are designed primarily for reconnaissance roles. For strategic attack roles, RPVs can offer some unique advantages. With the absence of both pilot and cockpit, a greater percentage of the vehicle can be used for disposable load capability.[58] They can laser-designate targets longer because a pilot is not at risk. They can also loiter to provide bomb damage assessment on their own attack via electro-optical imagery.

Cruise missiles do not provide man-in-the-loop capability nor much flexibility to control their actions once launched. However, in essence they *are* the payload which is an advantage in itself. This is because all the factors associated with weapons loading (equipment, personnel, maintenance, training, etc.) are not required.

The expendable RPV has an advantage in that like the cruise missile, it *is* the payload. Unlike the cruise missile, it has a man in the loop to decide and control when and where it attacks. If for any reason targets are not suitable for attack, the controller can direct it to crash in a safe zone or self-destruct in the air.

Relative Ranks for Control of Payload Area

Manned Aircraft	●
Cruise Missiles	○
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Less Complex Communications and Control System

Less complex communications and control system is an area of advantage for the cruise missile. Although it is a complex system, a cruise missile is primarily autonomous; and its mission profile is set prior to launch. Manned aircraft, such as the F-117 and the B-2, have the most complex communications and control equipment. Redundant systems are necessary to ensure the pilot has reliable communications and control capabilities. Complex control systems are becoming more widely used, such as fly-by-wire (a system of computers which provide control inputs to permit operation of an aircraft beyond what is mentally and physically possible by a human).

For RPVs it is not that their currently complex control systems pose a disadvantage, it is the fact that they will have to become increasingly more complex over time in order to protect the data link. The data link is the major factor in determining whether an RPV can truly be remotely piloted. In order to obtain a secure data link, developers may have to work in concert with Global Positioning System defense efforts currently under way.[59] Militaries could establish concepts of operation whereby communications are kept to a minimum, and intermittent bursts provide updates. Should the data link be vulnerable, developers can design several optional systems to take control. Preprogrammed controls could direct the vehicle to specified areas (away from data-link interference or jamming) to reacquire a control signal. For expendable RPVs operating in a conflict, the program could direct the vehicle to autonomously attack (like a cruise missile). While this study's classification level restricts an in-depth discussion of this subject, the author fully acknowledges the data link is—and will always be—a major concern. The US military must take steps to secure its use for friendly forces and research ways to deny its use by adversaries.

All forms of manned and unmanned aircraft require complex communications and control systems. Cruise missiles are the least reliant on transmitting and receiving data. Manned aircraft are more heavily reliant on voice communication systems while RPVs are more heavily reliant on data control systems. Future efforts must keep ahead of the pace of countermeasure developments.

Relative Ranks for Less Complex Communication and Control System Area

Manned Aircraft	◐
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◐
Expendable Remotely Piloted Vehicles	◐

Aircraft Control (Navigation, Stability, and Maneuverability)

Aircraft control (navigation, stability, and maneuverability) is an area that is changing rapidly among both manned and unmanned aircraft. Navigation and stability are provided by various means in different systems, and all perform well according to their design. Maneuverability is the primary area that distinguishes the different aerial vehicles from one another.

A cruise missile has the least amount of flexibility in maneuverable control since its preprogrammed mission largely dictates its maneuvers. Manned strategic assets have a wide range of maneuverability. Stealth aircraft are maneuverable, but their range of maneuverability is limited by design to reduce radar cross sections. Future aircraft, such as the F-22 air superiority fighter and the multirole joint strike fighter, will incorporate stealth and maneuverability to the greatest extent possible. However, future UAV capabilities could conceptually go well beyond what any manned aircraft would be able to perform. According to *New World Vistas*:

> UCAV survivability can be increased by increasing maneuverability beyond that which can be tolerated by a human pilot. Acceleration limits for inhabited aircraft are, typically, +9g or 10g and -3g. A UCAV can be designed symmetrically to accelerate in any direction immediately . . . a UCAV with a +10g capability could outfly many missiles, and an acceleration capability of +20g will make the UCAV superior to nearly all missiles.[60]

Relative Ranks for Aircraft Control (Navigation, Stability, and Maneuverability) Area

Manned Aircraft	●
Cruise Missiles	◐
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Aircraft Flight Performance

Aircraft flight performance in normal situations is an advantage for all manned and unmanned aircraft. Today's current systems perform what their designers intended them to do, and they do so remarkably well. With advanced research into aerospace technologies, future systems are likely to demonstrate even greater improvements in flight performance. This is not to say major developmental problems will not occur nor that maintenance requirements will be trivial. Design and development challenges will always be present in the pursuit of better flight performances for manned as well as unmanned systems.

It is areas of exceptional conditions that distinguish the different types of vehicles from one another. For example, in hazardous, boring, or fatiguing conditions (ranked in a previous section), the performance advantage goes to UAVs. For emergency or unforeseen conditions (to be ranked in a later section), the performance advantage goes to manned aircraft.

Relative Ranks for Aircraft Flight Performance Area

Manned Aircraft	●
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Reliability

As with flight performance, reliability is an area of advantage across the different types of manned and unmanned aircraft. Technological advances in airframe materials, propulsion systems, avionics, fuels, sensors, and other equipment have made every modern US aerial vehicle very reliable. This is not to say aircraft problems and losses do not occur. Even the highly advanced and extensively maintained B-2 experienced a serious in-flight emergency when all cockpit displays went blank.[61]

Manned and reusable unmanned systems require maintenance, logistics, and other support in order to operate at optimum levels of performance capability. However, the US military effectively meets these requirements in order to maintain a consistently high level of mission readiness. The performances of manned aircraft, RPVs, and cruise missiles during the Gulf War have shown this area to be an advantage for all these airpower assets. For example, Pioneer, Pointer, and ex-drone UAVs flew 522 missions during Desert Storm compiling 1,640.9 hours of flight and suffering only one loss.[62] While reliability remains high for all US aerial vehicles, some require more support (particularly in the area of systems) than others in order to achieve and maintain it.

Relative Ranks for Reliability Area

Manned Aircraft	●
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	●
Expendable Remotely Piloted Vehicles	●

Systems

Despite the crashes highlighted in the press, manned military aircraft have reliable systems. However, compared to UAVs manned aircraft have more systems and require tighter tolerances on their specifications. This is because backup and redundant systems must be built in, and a variety of pilot/crew support systems are required to sustain a countless number of safe flights.[63] In turn, these systems increase the cost of maintenance and the training required to keep them operating at their highest possible levels of reliability.

Stealth aircraft pose additional requirements and constraints on aircraft design and maintenance. The B-2 bomber is an extreme example of an aircraft that contains advanced operating systems and requires more maintenance systems in order to achieve reliability, maneuverability, and stealthiness. Pilots and maintenance specialists acknowledge that it "requires more systems knowledge" to fly and maintain the "highly unstable B-2."[64]

RPV controllers also require advanced systems to operate their aircraft. In comparison to manned aircraft, however, these systems are fewer and less stringent in tolerance requirements because the survivability of a pilot is not at stake. Future RPVs and new versions of cruise missiles will likely incorporate redundant systems in order to assure a high degree of operator control. Compared with aircraft requiring man-in-the-loop control, however, cruise missiles hold the advantage in the area of systems.

Relative Ranks for Systems Area

Manned Aircraft	○
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	◐
Expendable Remotely Piloted Vehicles	◐

Performance under Emergency or Unforeseen Conditions

Performance under emergency or unforeseen conditions is an area of advantage to manned systems because a human decision maker is physically present to assess and respond to the situation. This, however, is assuming the pilot has not been injured and remains mentally and physically capable of responding. Cruise missiles have the greatest disadvantage due to the inflexibility of their autonomous operation. RPVs, both reusable and expend-

able, offer man-in-the-loop advantages; however, they "cannot exercise judgment or initiative if the control link or preprogrammed track is lost."[65]

Relative Ranks for Performance under Emergency or Unforeseen Conditions Area

Manned Aircraft	●
Cruise Missiles	○▯
Reusable Remotely Piloted Vehicles	◉▯
Expendable Remotely Piloted Vehicles	◉▯

Recovery

Recovery is an area that is advantageous for cruise missiles and expendable RPVs because they simply do not require it. For manned aircraft and reusable RPVs, recovery is a disadvantage because there are limitations on where and in what weather conditions they may land or be recovered. An example of the difficulty of an instrument approach in poor weather was the 3 April 1996 crash of a T-43 military passenger jet near Dubrovnik, Croatia.[66]

Reusable aircraft—manned as well as unmanned—require additional equipment, ground facilities, and associated personnel to be able to return and land safely. Researchers and developers have devoted much effort towards seeking easier and safer recovery methods. In the past, helicopters recovered unmanned Firebees by using a midair recovery system. This involved an additional number of operators, ground crew, and maintenance specialists.[67] More recently, the Navy Pioneer program highlighted the need for a better retrieval system. Before temporary suspension of tests in 1988, three out of five vehicles crashed upon landing and one never returned. Developers of manned aircraft and reusable RPVs must ensure their systems are optimized to survive a limitless number of missions. Cruise missiles and expendable RPVs must only complete one.

Relative Ranks for Recovery Area

Manned Aircraft	○▯
Cruise Missiles	●
Reusable Remotely Piloted Vehicles	○▯
Expendable Remotely Piloted Vehicles	●

Figure 3 displays the 21 areas of advantages and disadvantages and the compilation of relative ranks among manned aircraft, cruise missiles, reusable RPVs, and expendable RPVs. Each of the unmanned systems clearly has more advantages than manned aircraft in strategic attack roles. Of the unmanned systems, expendable vehicles (cruise missiles and expendable RPVs) have more advantages than reusable RPVs. While the cruise missile exists and has proven itself in war, the concept of an expendable RPV shows great potential to supplement all means of strategic offensive airpower.

AREA OF ADVANTAGE OR DISADVANTAGE	RELATIVE RANKS			
	MANNED AIRCRAFT	CRUISE MISSILE	REUSABLE RPV	EXPENDABLE RPV
Pilot Risk	○	●	●	●
System Cost (Excluding Operating Cost)	○	◉	◉	●
Operating Costs	○	●	◉	●
Fewer Design Constraints	○	●	◉	●
Flight Duration	○	○	●	●
Payload Flexibility	●	○	●	●
Fuel Savings	○	●	●	●
Small and Less Visible Silhouette	◉	●	●	●
Better Performance in Hazardous, Boring, Fatiguing Conditions	○	●	●	●
Flight Noise	◉	●	●	●
Airspace Safety	◉	●	◉	●
Safety of Ground Personnel/Facilities	○	●	◉	●
Development Costs	○	●	◉	◉
Control of Payload	●	◉	●	●
Less Complex Communication and Control System	◉	●	◉	◉
Aircraft Control (Navigation, Stability, and Maneuverability)	●	◉	●	●
Aircraft Flight Performance	●	●	●	●
Reliability	●	●	●	●
Systems	○	●	◉	◉
Performance Under Emergency or Unforseen Conditions	●	○	◉	◉
Recovery	○	●	○	●

KEY: ● Major Advantage ◉ Counterbalancing Advantage/Disadvantage
○ Major Disadvantage

Figure 3. Advantages and Disadvantages among Strategic Attack Systems

There is one major difference between a manned aircraft and an unmanned aircraft that studies rarely address: Humans can form strong emotional bonds to manned aircraft (at least in Western societies). For pilots and aircrews, this is especially true.[68] UAVs do not conjure up comparable levels or intensities of similar sentiments. For a UAV there is no steadfast requirement for recovery; the absence of humans on board eliminates the major driving factor to have a vehicle safely return and land. Political and military leaders should thoroughly explore various characteristics of airpower, both positive and negative, to determine what means are best suited for what roles. A part of this process is to determine whether missions exist that are worth the intentional loss of flying machines. At the same time, decision makers must consider how to overcome limitations associated with human emotional attachment to aircraft.

In summary, unmanned aircraft do not elicit human emotions associated with life or spirit, and they do not attract the attention given to manned aircraft. Manned aircraft are designed not only to perform aerial functions but also to sustain and protect humans on board. They must have protective qualities to safeguard the pilot. This means manned aircraft have inherent defensive characteristics. RPVs, with operators physically residing elsewhere, can be more offense oriented. As such, they offer potential advantages over manned aircraft in serving as a strategic force and as an offensive weapon. These advantages can be further exploited by designing RPVs to be "more economically replaced than rescued, salvaged, or protected."[69]

Notes

1. Noel Falconer, "Expend! Expend! Expend!" in *RPVs Conference, Bristol 1984* (spine title), *RPVs: Remotely Piloted Vehicles* (cover title) (Bristol, U.K.: Royal Aeronautical Society, 1984), 4.1.

2. Steven M. Shaker and Alan R. Wise, *War without Men: Robots on the Future Battlefield* (Washington, D.C.: Pergamon-Brassey's, 1988), 30. In contrast to Japanese suicide aircraft, there was a manned version of the V-1 Buzz Bomb (named the *Reichenberg*) developed by the Germans towards the end of World War II. While some Allied observers thought it was intended for kamikaze attacks, instead it "was an experimental test aircraft designed to iron out some control problems, rather than becoming a suicide bomber."

3. Information and data contained in this paragraph were obtained from display and video presentations found at the USAF Museum located at Wright–Patterson AFB, Ohio. The *Ohka* (Cherry Blossom) was carried beneath a "mother" aircraft, such as a twin-engine Mitsubishi "Betty" bomber. When the pilot reached a favorable position for his attack, he fired the rockets and dove at high speed into his intended victim.

4. "Predator, DarkStar and Other Cult Classics," *The Economist*, 17 June 1995, 81.

5. Peter R. Murray, "B-17 Flying Fortress—Unmanned Version," *IEEE Transactions on Aerospace and Electronic Systems*, vol. AES-15, no. 5, September 1979, as referenced in Jay Womack and Arthur Steczkowski, "Review of Past and Current Trials and Uses of Unmanned Vehicles," Report no. HSD-TR-87-011/United States (Dayton, Ohio: Air Force Systems Command, 1988), 2–7.

6. Ibid., 30.

7. "Report: Military Crashes Down," on-line, Internet, *Air Force News*, 6 February 1996. The General Accounting Office (GAO) found that the cost is still high despite the number of military air crashes declining from 309 in 1975 to 76 in 1995. Number of deaths from air crashes dropped from 285 in 1975 to 85 in 1995.

8. On 1 February 1996, an F-14A crashed in a Nashville, Tenn., residential neighborhood killing both crewmen and three civilians on the ground. On 18 February, an F-14D plunged into the Pacific off southern California, killing both crewmen. Four days later, an F-14A crashed in the Persian Gulf, but fortunately both crewmen ejected safely and were rescued. In August 1995 two Tier 2 Predator UAVs were lost over Bosnia within four days.

9. "DOD's Use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars," GAO survey (Washington, D.C.: GAO, 1981), 19. A questionnaire was sent to 85 people experienced in the RPV technology field, and 77 responded. Those that conducted the survey acknowledged it "may not be an unbiased forum of views on RPVs, but constituted the most knowledgeable source of information that the GAO could identify." The original chart displayed the results on a scale from 1.00 (major disadvantage) to 3.00 (major advantage). In order to allow for a greater margin of error (in bias and opinion), this author took the results and displayed them according to three ranges: 1.00 to 1.66 represented "major disadvantage," 1.67 to 2.33 represented "counterbalancing advantage/disadvantage," and 2.34 to 3.00 represented "major advantage."

10. Ibid. Pilot risk was given a numerical score of 3.00, and recovery was 1.32.

11. GAO survey, 19. For the representative RPV in table 6, all those surveyed unanimously gave it a perfect 3.00 (major advantage) rank score.

12. Lee B. Kennett, *The First Air War: 1914–1918* (New York: Free Press, 1991), 221. This was a statement made in 1939 by the Air Staff to British Army leaders. It referenced the 30 percent losses per day suffered during "trench flights" in November 1917.

13. "Airpower and the 1972 Spring Invasion," USAF Southeast Asia monograph series, vol. 2, monograph 3, ed. A. J. C. Lavalle (Washington, D.C.: Department of the Air Force, 1985), 35–43.

14. Lt Col Steve Turner, quoted in William L. Smallwood, *Strike Eagle: Flying the F-15E in the Gulf War* (McLean, Va.: Brassey's, 1994), 117.

15. S. L. A. Marshall, *Men Against Fire: The Problem of Battle Command in Future War* (1947; reprint, Gloucester, Mass.: Peter Smith, 1978), 204, as referenced by Conrad C. Crane, *Bombs, Cities, and Civilians: American Airpower Strategy in World War II* (Lawrence, Kans.: University Press of Kansas, 1993), 48.

16. Womack and Steczkowski, 2–15.

17. F-117 cost from Richard P. Hallion, *Storm Over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution Press, 1992), 294; B-2 cost from John A. Tirpak, "With the First B-2 Squadron," *Air Force Magazine*, April 1996), 38.

18. TLAM cost from Hallion, 250; Predator cost from *Air Force Link*, on-line, Internet, available at http://www.dtic.dla.mil/airforcelink/photos/c0196_predat7.html.

19. Col William E. Krebs, "Did We Err in the Development of Remotely Piloted Vehicles (RPVs)?" Research Report no. MS 018-79 (Maxwell AFB, Ala.: Air War College, 1979), 10.

20. Ibid., 55.

21. James Canan, "Steady Course for Unmanned Aircraft," *Air Force Magazine*, March 1991, 87.

22. GAO study, 3.

23. Maj Ronald L. McGonigle, "Unmanned Aerial Vehicles (UAVs) on the Future Tactical Battlefield—Are UAVs an Essential Joint Force Multiplier?" (Fort Leavenworth, Kans.: 8 December 1992), 33. Various sources assert that RPVs eliminate the need for life support and redundant systems.

24. Tirpak, 41.

25. Krebs, 10; and GAO survey, 3.

26. Ibid., 26.

27. David A. Fulghum, "Groom Lake Tests Target Stealth," *Aviation Week and Space Technology*, 5 February 1996, 27.

28. David A. Fulghum, "Pilots to Leave Cockpit in Future Air Force," *Aviation Week and Space Technology*, 5 February 1996, 26.

29. US Air Force Scientific Advisory Board (SAB) report, *New World Vistas: Air and Space Power for the 21st Century*, 31 January 1996, 36.

30. Krebs, 26, 30. The author addresses endurance UAVs.

31. Department of Defense, "Unmanned Aerial Vehicle Master Plan" (Washington, D.C.: 1994), 3-3.

32. GAO study, 33.

33. *Gulf War Air Power Survey*, vol. 2, *Operations and Effects and Effectiveness* (Washington, D.C.: Department of the Air Force, 1993), 20.

34. Michael J. Armitage, *Unmanned Aircraft* (London: Brassey's, 1988), 66.

35. Fulghum, "Pilots to Leave Cockpit in Future Air Force," 26.

36. Fulghum, "Groom Lake Tests Target Stealth," 27.

37. Ibid., 26.

38. "The RPV/Drones/Targets Market, 1975–1985" (Greenwich, Conn.: DMS, Inc., 1975), 1–12.

39. Fulghum, "Pilots to Leave Cockpit in Future Air Force," 26.

40. Breek Henderson, "Boeing Condor Raises UAV Performance Levels," *Aviation Week and Space Technology*, 23 April 1990, 36.

41. Womack and Steczkowski. The authors provide details on many studies performed by the military and companies such as RCA, General Electric, United Aircraft Corporation, Grumman, Sperry Univac, and so on. An interesting study was done by Decision Sciences, Inc., to determine optimal control techniques. Subjects ranged from people with no piloting experience (but with automobile driving experience) to attack fighter pilots from Miramar Naval Air Station.

42. Ibid. An excellent study on the operator aspect of RPVs.

43. Gen Merrill A. McPeak, *Selected Works 1990–1994* (Maxwell AFB, Ala.: Air University Press, 1995), 351.

44. Armitage, 122.

45. Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (New York: Free Press, 1995), 274.

46. McPeak, 351.

47. Fulghum, "Pilots to Leave Cockpit in Future Air Force," 27.

48. Department of the Air Force, *Gulf War Air Power Survey*, vol. 3, *Logistics and Support* (Washington, D.C.: Government Printing Office, 1993), 163.

49. Ibid., 207.

50. McPeak, 351.

51. Tirpak, 38–43. Each of the 20 B-2s planned for the 33d Bomb Squadron will have its own "purpose-built hangar with floor umbilicals that mate perfectly with the airplane."

52. "UAVs Could Replace Several Manned Aircraft, Owens Says," on-line, Internet, *Air Force News*, 1 March 1996.

53. "Pentagon No. 2: Too Few Weapons," on-line, Internet, *Air Force News*, 29 February 1996.

54. Ibid.

55. Tirpak, 38.

56. Krebs, 17.

57. Ibid., 43.

58. Krebs, 10. As early as the 1970s it was estimated that 50 percent could be disposable load capacity.

59. Peter Grier, "GPS in Peace and War," *Air Force Magazine*, April 1996, 79.

60. SAB, 35.

61. Tirpak, 42. The aircraft landed safely, and the incident has not been repeated.

62. McGonigle, 34.

63. Ibid., 33.

64. Tirpak, 41.

65. Lt Col Daniel T. Morris, "Unmanned Aerial Vehicles: Options for the Operational Commander," research report (Newport, R.I.: Naval War College, 1992), 19.

66. This was the crash that killed Secretary of Commerce Ronald H. Brown and 35 others. The airplane, flying through heavy rain and on instrument approach to Dubrovnik airport, crashed into a 2,300-foot hill.

67. Krebs, 7.

68. Good evidence of this can be found with a visit to the "boneyard" at Davis–Monthan AFB, Ariz. There, one can easily witness aviators who shed tears upon finding aircraft with tail numbers from the past. Personnel who work there say much emotion is also displayed by those that fly these aircraft to their final resting place.

69. Material within quotation marks is a definition of *expendable* from *Webster's Ninth New Collegiate Dictionary* (Springfield, Mass.: Merriam–Webster, Inc., 1990), 437.

Chapter 5

Future Notional Scenario

These new ships were ugly as he--. Just an open framework with clamps to hold you in place, swiveled lasers fore and aft, small tachyon power plants below the lasers. Everything automated; the machine would land us as quickly as possible and then zip off to harass the enemy. It was a one-use, throwaway drone.

—Joe Haldeman
The Forever War

The Roman god Janus, who is associated with new beginnings, has two faces gazing in opposite directions—one looks back and the other looks forward. The concept of a one-use, throwaway RPV offers a new beginning for airpower. Although this concept is certainly not new, air forces have yet to fully explore it. Previous chapters of this study focused on past events to establish the foundation for this concept. While the most difficult function of theory is to anticipate or predict the results of its application, this chapter attempts to provide a look beyond conventional modes of operation.

In order to perceive how controllers may pilot RPVs in the future, this study presents a future notional scenario involving expendable RPVs for strategic attack. The author introduced cybornautics and cybornaut in chapter 1, and the scenario will include these concepts in its theoretical response to a wartime situation. Research and technology labs are currently looking at a wide variety of ways that humans can better interface with future aerial vehicles, unmanned as well as manned. Although this scenario presents only one hypothetical situation, it offers an indication of many potential events to come. To set the scenario's stage, the author first presents assumptions and a brief background.

The first assumption is that it will be economically feasible to field a significant number of expendable RPVs in the future. The second assumption (closely tied to the first) is that they will be cheap, one-use, throwaway assets. Chapter 4 of this paper ("System Cost" section) provided cursory evidence that this will be possible. These assumptions are critical because the concept would literally never get off the ground if military leaders attempted to develop a small quantity of very expensive assets for kamikaze missions. The author views the concept of a large inventory of inexpensive RPVs as the best supplement to existing systems. In the latter part of chapter 3, this study gave indications as to how these assets could have contributed to a past operation like Desert Storm.

New systems must compete for funding against existing assets as well as those in current development. This competition becomes increasingly intense as defense budgets continually shrink. To evaluate the concept of

expendable RPVs, American political and military leaders must understand and appreciate what capabilities these assets can and cannot provide. The leaders must then weigh these capabilities against the value of other systems and programs. Expendable assets provide a greater benefit when they are lower in cost and greater in quantity.

For example, the author assumes that expendable RPVs could cost from $100,000 to $250,000 each and a quantity between 1,000 and 10,000 is a viable production number. The resulting total cost range would be $100 million and $2.5 billion. Added to this sum would be the cost for control stations. Control station per unit cost would logically be higher than the RPV; this is given that developers would locate the brains of the system here and not in each and every one of the RPVs. Theoretically, the military services would require 100 control stations, and they would cost from $1 million to $10 million each. This would add $100 million to $1 billion to the cost of RPVs. These costs could be higher or lower depending upon actual design requirements. In order to optimize cost *and* capability, we should develop a higher RPV to control station ratio.

Background for the scenario is as follows: The author purposely has not established a specific time frame for this scenario; it is set sometime in the future. Modular control stations exist on air-, land-, and sea-based platforms. Military and industrial designers have come up with space-based platform concepts, but political leaders have yet to give approval for development. Platform types currently include buildings, mobile vans, transport aircraft, and naval vessels. Some platforms have only one RPV control station while others have as many as six situated together. Several C^2 modules also exist on various platforms. Only one will direct RPV air operations in an air campaign while the others serve as alternates and relay stations. In any C^2 module, decision makers can view the big-picture status of all expendable RPVs, as well as be able to focus in on what each individual cybornaut is doing.

Notional Scenario

Current worldwide resources and inventories (from the airpower arms of all services) consist of 100 control stations, 300 trained cybornauts, and 10,000 expendable RPVs. In the scenario's theater of operations, the services have assigned 30 cybornauts to 10 modular control stations (three to each station), which they have dispersed in various locations and platforms around the region. Each cybornaut pulls an eight-hour shift, providing the capability to conduct continuous round-the-clock operations. The president has given approval for the military services to conduct a strategic attack on an adversary. The approved plan involves two phases. The first phase is an immediate attack with unmanned assets; the second phase is an attack with manned aircraft commencing in 24 hours. The C^2 module immediately sends the signal to launch 100 expendable

RPVs from various Air Force, Navy, Army, and Marine Corps locations around the region of interest. While air campaign planners identify the strategic targets to strike, these assets fly to designated air occupation areas.

One highly experienced cybornaut has a rating of 9, meaning she (this particular cybornaut is a female) can proficiently monitor the status of nine vehicles at a time. Military leaders at the C^2 module assign her nine expendable RPVs, as well as three targets. The first target priority is a major bridge. The C^2 module sends each cybornaut a situational update, as well as the latest information on assigned targets. The cybornaut brings up a display of all vehicles assigned to her and selects three for the first attack. She directs the six others to hover in preselected safe areas dispersed throughout the theater.

The three vehicles selected are presently north, south, and east of the intended target. Three displays now come up—one for each vehicle selected—and she directs them towards the bridge coordinates. At this point in time, she inputs heading, speed, and altitude information. Her intent is to avoid known enemy threat rings and to converge nearly simultaneously in the airspace over the bridge. On the way to the target area, one vehicle detects a missile radar signature at a previously unknown location; and the cybornaut immediately passes this information to the C^2 module. As the three vehicles near the bridge airspace, the cybornaut has them hover and activates specific cameras in each one.

Vehicle one is at a higher altitude, and the cybornaut sets it to collect synthetic aperture radar imagery to locate the bridge and other surrounding man-made objects. Vehicle two is at a medium altitude, and she uses IR imagery to detect levels of activity in the bridge area. It is nighttime, but starlight exists; and she switches on vehicle three's electro-optical camera (night-vision capable). Unfortunately, the area has lingering fog so she switches vehicle three to its IR camera. As vehicle three hovers and collects imagery of the target, the cybornaut flips down a visor and selects vehicle two for attack.

The visor provides a virtual reality world from the perspective of looking out from the RPV's nose portion. The cybornaut's entire field of view is the same as seen by the vehicle's camera. She now has the cybornautic sensation that she is physically flying as she looks out into air ahead, space above, and ground below. Similar to a heads-up display, the system provides information on the vehicle's flight characteristics in the cybornaut's area of vision. With each movement of her head, the camera in the nose of the vehicle corresponds accordingly. As she provides input to fly the vehicle via controls in the armrest, cybornautics has her chair roll, pitch, and turn to generally simulate the vehicle's movements. Taking aim at the center span of the bridge, she arms the vehicle's explosive weapons system and prepares to dive. At this moment the cybornaut spots a bus entering one end of the bridge. She pulls up and hovers as it crosses the bridge. When it safely reaches the other end, she resumes her dive. The

cybornaut activates engine thrusters and, at the end of an accelerated 20 G-force dive (the cybornaut visually sees the acceleration but does not physically experience G force), vehicle two explodes into the bridge's center span. At impact the connection ceases to exist, and she switches to take control of vehicle three.

Flipping the visor up, the cybornaut looks at her displays and rewinds the last 20 seconds of vehicle three's video. As she replays the video, she actually witnesses her own attack conducted less than a minute earlier; the cybornaut watches as vehicle two makes its dive attack into the bridge. Antiaircraft fire has begun and is increasing in intensity so she directs vehicle one to an even higher altitude. Flipping the visor back down, she regains cybornautic control of vehicle three and circles over the bridge. The cybornaut can see her attack with vehicle two has taken out a large portion of the center span, but one lane is still intact. From the intelligence report received just prior to the attack, she knows she must destroy the span to ensure she completely severs telephone cables running underneath it. She immediately arms the explosive weapons and cybornautically pilots vehicle three into the remaining portion of the structure. Keeping the visor down, she switches to vehicle one. Directing its synthetic aperture radar camera towards the target, the cybornaut sees that she has completely destroyed the center span. Alternating between other cameras, she collects different images of the destroyed center span. Looking back at the work station displays, she now directs vehicle one towards the next target—an electrical power plant. This particular target has heavily defended aim points, so she selects three additional expendable RPVs to join in the attack.

At the command post module, decision makers witness the bridge attack, as well as all other expendable RPV attacks, in near real time. Decision makers approve updates to situation displays, and they reallocate the remaining expendable RPVs as required. Leaders review and select portions of video from vehicle two and vehicle three used in the bridge attack described above; these they authorize for release to the Cable News Network, as well as other televised news media. The clips clearly show the precision of the attack, the limited collateral damage, and the documented fact that the cybornaut temporarily delayed the first strike until the bus had safely crossed.

In conclusion, this scenario presented a situation where the United States explored, developed, and successfully employed expendable RPVs in a strategic offensive airpower role. US military and political leaders realized they could no longer simply adapt to the changing environment with belated upgrades to existing military systems and strategies.

This study does not suggest taking the pilot out of the cockpit but rather taking the cockpit out of the aircraft. The idea that artificial intelligence will someday not only allow systems to operate autonomously but also to make decisions on their own has been in existence for quite some

time. Along with this idea has been the concern that loss of direct human control may lead to machines turning upon humanity:

> Can we allow an autonomous battlefield creation to roam the battlefield searching out the enemy who is defined by a software algorithm? What are the implications and what cost are we willing to incur for a wrong or errant machine decision made by this hardware? Has it been calculated? The escalation of large weapon systems run by internally controlled elements is inevitable; so also is the escalation of effect to be felt should that system revert to an unpredicted operational mode.[1]

While there may come a day when the above questions need definite answers, critics of unmanned weapon systems may be more willing to accept expendable RPVs in the interim.

Notes

1. V. Daniel Hunt as quoted in Steven M. Shaker and Alan R. Wise, *War Without Men: Robots on the Future Battlefield* (Washington, D.C.: Pergamon-Brassey's, 1988), 174.

Chapter 6

Conclusion

Constant evaluation of military forces must be conducted as a precaution against the wasteful use of national resources or costly errors of judgment, either of which might prejudice the welfare of the nation. The positive results of the evaluations must be reflected in the kinds of forces that are provided for the military instrument in being. The results must be reflected also in other forces which are authorized for future production and employment, and in the nature and priorities of research and development programs bearing on forces and weapons systems. These processes are necessary for the nation to produce forces which will meet the time, type, and quality requirements of the strategy.

—Air Force Manual 1-2
US Air Force Basic Doctrine
1 April 1955

The overall conclusion of this study is the sum of all chapter conclusions. First, the current limited state of UAV development was not due to lack of forethought nor to technological restraints but was more the result of circumstantial events. Second, just as airpower represents unique strategic and offensive capabilities, RPVs represent an ideal means to deliver these capabilities. Third, developing RPVs as one-use, throwaway assets increases their advantage to fulfill strategic attack roles. The final conclusion is that the use of expendable RPVs for strategic offensive airpower roles is a viable concept. The author urges those who understand and advocate airpower to continue research and evaluation into this concept as well as other potential means of airpower.

As the quest continues to exploit airpower to its true potential, the character of war continues to change. The United States was the clear victor in the Cold War against the former Soviet Union. With the realization of this historic event, many Americans believed that the United States government could cut defense spending, focus less on foreign affairs, and concentrate more on domestic issues. It is now evident that American intervention and involvement in international affairs will likely continue well into the future. Less direct threats to national security than those of the Cold War define profound challenges to the future organization and application of military forces. Airpower must effectively accommodate and implement future technologies in order to properly respond to these threats.

This study began with a look into the history and background of UAVs. Analysis revealed that the limited state of their development was primarily due to circumstantial events, as opposed to technological restraints. If American leaders had truly desired to develop remotely piloted bombers, remotely piloted fighters, or remotely piloted transports, they could have accomplished such technological feats long ago. Certain historical events,

such as the shootdown of manned reconnaissance assets during key international situations, led to the requirement for unmanned reconnaissance platforms. Lacking support for other roles, reconnaissance continues to be the primary mission for UAVs today. This paper highlights the question: While technologically possible to develop unmanned aircraft for a variety of other roles and missions, what actually makes sense?

Col Phillip S. Meilinger's pamphlet, *10 Propositions Regarding Air Power*, proposes that airpower is inherently and primarily a strategic force and an offensive weapon.[1] Airpower theorists often asserted the same messages in one form or another. Advocates have subsequently tried to prove the validity of such propositions through virtually all wars and conflicts involving airpower. With the strengths of airpower in mind, it is logical to look for any means suited to deliver them. RPVs offer ideal qualities to a strategic force. They also possess ideal qualities as offensive weapons.

The unique qualities of RPVs permit them to be more useful in offensive roles than current manned aircraft. Manned aircraft have inherent defensive characteristics in order to decrease the risk to the pilot on board. Cruise missiles are purely offensive weapons; however, they lack the flexibility and control that a human operator provides. Reusable RPVs must be recovered, and this results in a number of defensive characteristics being built into them. RPVs—designed to be one-use, throwaway strategic offensive weapons—can encompass the strengths of all existing assets while reducing their inherent weaknesses. Like manned aircraft, they can provide man-in-the-loop control. Like cruise missiles, they can attack with impunity. Expendable RPVs can be significant assets to the US force structure of the future.

Just as doctrine is based on experience, this document is based on strategic vision. This vision loses tremendous value if it is not dynamic; it must continually evolve and positively mature in direct response to influential developments occurring around it. Principles established through past experiences must be integrated with postulations on what the future will most likely reveal. The very potential nature of warfare is likely to become even more complex as many nations evolve to new stages of military, economic, informational, and technological capabilities. How the United States fights wars, as well as what it researches, develops, and employs in order to win them, must be advanced with renewed planning.

US airpower has traditionally advanced along an evolutionary line. This established a planning process focused on upgrades and enhancements to existing means as opposed to one which fosters the search for new approaches. Lt Gen Jay W. Kelley, former commander of Air University, emphasized these points when he stated: "You get yourself in a position of an evolutionary change. In other words, there's a follow-on fighter, follow-on bomber, follow-on airlifter, follow-on spacelifter, a follow-on anything that's on the chart. But what's missing from evolutionary planning is the maverick idea, the creativity and innovation."[2] An expendable RPV for strategic offensive airpower is but one concept outlining one means and

one role. A countless combination of other airpower means and roles exists. Dedicated study must continue in all areas imaginable to better comprehend and exploit the numerous advantages of airpower.

Notes

1. Col Phillip S. Meilinger, *10 Propositions Regarding Air Power* (Washington, D.C.: Air Force History and Museums Program, 1995).
2. TSgt David P. Masko, Air Force News Service, "Air University: Charting the Air Force Future," *Maxwell–Gunter Dispatch*, 2 February 1996, 12.