Unmanned Aerial Systems: A Historical Perspective

John David Blom

Occasional Paper 37

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US Army Combined Arms Center
Fort Leavenworth, Kansas

Cover photo: A US Soldier from the 2nd Stryker Brigade Combat Team, 25th Infantry Division, prepares to launch a "Raven" unmanned aerial vehicle to help conduct a cache search in the rural region of Zobam Iraq on October 4, 2006. The site has been historically known to hold countless hidden weapons caches. *US Army photo by Specialist Daniel Herrera.*

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Foreword

In the Long War, formerly called the Global War on Terror, the armed forces of the United States have utilized unmanned aerial vehicles (UAVs) extensively to support combat, security, and stability operations. The concept of unmanned flight is nothing new to the military. Experiments with pilotless aircraft began at the end of World War I. The historical development of these aircraft and the Army's long use of aerial platforms for reconnaissance provide valuable insight into the future possibilities and potential pitfalls of UAVs.

Mr. John Blom's study describes the way that aircraft have been integrated into ground units since World War I. Mr. Blom traces this integration through World War II and the creation of an independent Air Force. In the ninety years since World War I, the quantity of aircraft organic to ground units has constantly expanded. In this period, many of the same debates between the Army and Air Force that continue today over UAVs first appeared.

This study addresses past and current systems, and does not address systems under development. The technological development of UAVs possesses as deep a history as the Army's use of aircraft for aerial reconnaissance. Mr. Blom details the long development of UAVs that has led the military to where it is today. Understanding this past may provide clues into where this technology may be going, and what problems could lie ahead.

We at the Combat Studies Institute (CSI) believe in our mission to support the warfighter with historical research relevant to their current tasks. *Unmanned Aerial Systems: A Historical Perspective* continues this long tradition in providing insight to a vital asset on the modern battlefield and assists commanders and staffs in its employment. Nothing is more important than protecting the lives of those who willingly risk them. Achieving a better understanding of the past can only assist in the execution of present and future missions. *CSI—The Past is Prologue!*

Dr. William G. Robertson
Director, Combat Studies Institute

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I also want to thank my family for their endless support. Most of all, I thank my wonderful wife Deborah, for following me across the country in pursuit of my dreams and supporting me in all things.

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Introduction

> *The King was sat a loss about how to deal with this impasse, but just then Ephialtes of Malis, son of Eurydemos, came to speak with him, expecting to win some great reward for telling the King of the path that led through the mountain to Thermopylae. By so doing, he caused the destruction of the Hellenes stationed there.*
>
> –Herodotus, The Histories 7.213.1 [Book 7. Paragraph 213, Verse 1] N

Of the various aspects of war, none is more critical than knowledge of the enemy. Over 2000 years ago, Xerxes' superior numbers proved incapable of defeating the entrenched Greeks at Thermopylae until a traitorous shepherd told the Persian King about a path through the mountains that allowed the Persians to outflank Leonidas and his men. In Europe, during the medieval period, castle towers provided elevated observation posts, from which an attacking army could be detected. The position of Fort Leavenworth, Kansas, on the bluffs of the Missouri River was a key factor in the construction of the post. One of the advantages of having the high ground was the ability to better observe the enemy. Once man found a way to ascend to the sky, it was inevitable that this ability would eventually be used in battle. During the French Revolution, the French Army formed balloon companies to provide reconnsaissance of enemy forces. Because of technical limitations of the era, balloon units mustered by both sides during the American Civil War experienced little success. Beginning in World War I, however, the United States Army utilized aerial reconnaissance in every conflict. What began as simple balloons floating above trenches in France evolved into a wide range of technologically advanced machines. The experience of manned and unmanned aerial reconnaissance vehicles (UAV) in the last 80 years provides insight into many of the questions about the current and future application of UAVs.

The story begins with those first units. Although lighter-than-air balloons seem far removed from the unmanned aerial vehicles (UAV) used today, the missions performed over the Western Front in 1917 and 1918 are almost identical to those conducted by UAVs in Iraq and Afghanistan. Both provided adjustment for indirect fires, information regarding enemy movements, battle damage assessment, and target acquisition.

Since the early 1920s, advocates of airpower have disputed its proper role in war. Initially, this debate focused on whether it should be applied tactically or strategically. In the terminology of the time, tactical airpower existed to support the ground forces through reconnaissance, supply, and communications. Eventually, close aerial fire support would be added to the list. Supporters of this line of thinking operated under the precept that only "boots on the ground" could decisively win a war. Those supporting strategic airpower believed that airpower possessed the potential to deliver victory through heavy bombing of cities and industrial centers. Naturally, the US Army Air Corps, and later the independent Air Force, embraced the latter of these ideas and developed their reconnaissance aircraft accordingly, leading to the creation of organic aircraft under the control of ground commanders. This organic, aerial reconnaissance capability continued to grow and evolve until the 1980s. With the emergence of aviation as its own branch and the creation of aviation brigades in each division, Army aviation reached essentially the same organization as it has today. This organic aviation capability laid the framework for the Army's use of UAVs.

The application of UAVs for a variety of missions in Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF) represents the culmination of over 60 years of technological development. The radio controlled target drones that originated as experiments of a Hollywood actor now provide real-time battlefield surveillance and strike capability. In the 1950s and 1960s, many of the basic concepts of today's UAVs began to emerge. The Navy experimented with arming a remotely piloted helicopter, while the Army deployed a UAV to Eastern Europe similar in size and mission to the Shadow system used today. During the Vietnam War, the Air Force used UAVs for gathering signals data, electronic warfare information, and photo/video reconnaissance.

The war in Europe from 1914 to 1919 demonstrated the potential of aerial reconnaissance, which came to maturity 20 years later in the same theater of operations. Similarly, Operations DESERT SHIELD and DESERT STORM provided the first glimpse of a UAV fleet spanning all services and operating at various levels—an idea that became reality a decade later in Afghanistan and Iraq.

This work generally avoids the complex, technical details and development of UAVs, except basic specifications and characteristics which affect the operational capability of a vehicle. Two terms that may require clarification are "unmanned aerial vehicle" (UAV) and "unmanned aerial system" (UAS). An unmanned aerial system includes one or multiple unmanned aerial vehicles (usually the same model, but not always), the ground control system, the datalink and sensory array on board the vehicle, and the terminal that receives data from the vehicle. Often, the greatest challenge and highest cost of a unmanned aerial system is not the vehicle itself, but the sensor array and datalink. Specific names, such as Predator, Shadow, or Raven, refer not only to the vehicle but to the system as well.

Throughout the time period discussed, unmanned aerial vehicles went through a number of name changes. From the 1940s through the 1970s, the military most often referred to UAVs as drones. Another term that became popular from the 1960s to the 1980s was remotely piloted vehicles. This term was problematic when aircraft flew pre-programmed missions, during which they were not actually remotely piloted. Unmanned aerial vehicles became the most common term in the late 1980s, although "remotely piloted vehicles" remained in usage in the 1990s as well. In an attempt at political correctness during the Clinton administration, the terms "unpiloted aerial vehicle" and "uninhabited aerial vehicle" briefly replaced the previously accepted "unmanned aerial vehicle" term, while keeping the acronym. The former ceased to be used since many vehicles were piloted, albeit remotely. The latter disappeared as well. Although the term UAV is used throughout, nomenclature from the source material for each period is used accordingly.[1]

Notes

1 Bill Yenne, *Attack of the Drones* (St. Paul: Zenith, 2004), 13.

Chapter 1

Aerial Reconnaissance in the Army, 1917-1991

> *To understand fully the role and mission of Army Aviation today and why it is best served by aircraft organic to the Army is to trace its history, underlining, with the benefit of historical perspective, the mistakes. The story roots itself in the requirements for battlefield reconnaissance: the need to know more information about the enemy and the terrain.*
>
> –D.F. Harrison

Although written nearly four decades ago, the preceding quote holds as much relevance today as it did when it was first written. The use of unmanned aerial vehicles (UAVs) in a reconnaissance role by the US Army provides enormous potential for improved battlefield intelligence with no risk to American soldiers. Utilizing this potential is not without its challenges. Potential issues over the future application of UAVs include interservice disputes over their control, debates over how to organize and integrate them with other forces, as well as the problem of how to distribute the intelligence material they provide to commanders who need it. While the topic of UAVs may be new, these questions are not. Since the Army Air Service became a separate corps in 1926 (and its own service in 1947), ground and air force commanders have disputed the best use of air power. Investigating how the military has approached similar questions in the past provides a foundation for approaching the questions regarding UAVs today and in the future.

World War I

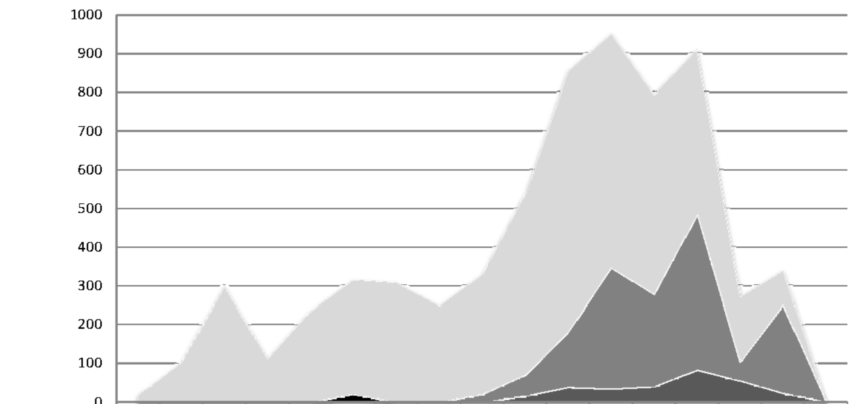
During the First World War military aviation finally realized some of its potential. All of the belligerents experimented with new technology on the Western Front. Two of the more important developments included fixed-wing aviation and wireless telegraphy. Although two-way radios small enough to deploy on aircraft were unavailable, wireless telegraphy allowed pilots to transmit small amounts of information to ground commanders. In September 1914, the British first employed aerial observation to direct artillery fire. Records of the No. 4 Squadron from 25 September detailed the pilot-observer adjustment of artillery fire, which led to the destruction of two German artillery batteries. The final message sent before the plane landed identified the location of three more batteries.[1]

The US Army entered World War I without a significant air force. Despite the pioneering efforts of the Wright brothers in Ohio and North Carolina in 1903 and 1904, the Army did not display interest in their aircraft until 1908. A year later, the Signal Corps purchased a single aircraft for the US Army. Army aviation grew slowly over the next eight years. In 1912, Congress approved $125,000 for research and development of aircraft, funds which were split between airplanes and balloons (that same year the French Chamber of Deputies allocated over $1 million for the same purpose). During a discussion of military aviation, one congressman allegedly asked, "Why all this fuss about airplanes for the Army–I thought we already had one." To the extent they showed any interest at all, decision makers in the War Department favored balloons over airplanes, possibly because of their familiarity due to their limited application in the Civil War and Spanish American War.[2]

The War Department believed the only use of aviation in war would be to improve communication in the field. Field tests in 1911 proved the adeptness of aircraft in this role. Using a plane rented for $1 a month from the owner of *Collier's* magazine, two officers flew 106 miles in two hours and ten minutes, dropping messages to various units enroute. Unfortunately, on the return flight two days later they crashed into the Rio Grande River and had to be rescued. Luckily for the Army, Congress had already approved the aviation budget for 1912. That same year, the Army opened its first aviation school in College Park, Maryland. Here, the Army first experimented with and recognized the potential of aerial photography.[3]

While the War Department slowly realized the potential of the airplane as an observation tool, the balloon remained the primary method of aerial observation before and during World War I. Balloons provided 93 per cent of aerial observation over the trenches. The Army operated a balloon school at Fort Omaha, Nebraska from 1908-1913. However, the moving of the Signal Corps from Fort Omaha to Fort Leavenworth in 1916 halted the development of lighter-than-air aircraft.[4]

Although outbreak of war on the Continent and the operational demonstrations of aerial observation provided some stimulation to both lighter-than and heavier-than air craft, when the United States declared war in 1917 the Aviation Section of the Signal Corps, the home to all Army aircraft, remained cripplingly small. It possessed around 200 aircraft, all of which were classified as trainers, none of which capable for combat. Furthermore, not a single manufacturer in the United States even produced such an airplane. This forced the United States to rely heavily on its wartime allies for both doctrinal and material assistance.[5] In August, the United States signed an agreement with France in which the French promised to provide 5,000 planes to the US Army by the following June. Although French demand for airplanes made it impossible to transfer that many planes so quickly, the French provided the majority of planes flown by the Army in World War I (see Figure 1). The following month the French agreed to provide the Americans with balloons as well.[6]



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	11-Nov	Nov	Dec
France	19	103	298	113	235	296	308	248	311	469	673	605	516	426	168	90	1
United States									19	54	143	312	237	401	50	227	
England										15	37	33	39	82	54	22	1
Italy						19											

Figure 1. Airplanes Received from All Sources.

The nature of trench warfare made observation balloons an ideal method for observing the battle and directing artillery fire. Both the Germans and French possessed balloons prior to the outbreak of war which they used from the start of hostilities. Since 1913, the British Admiralty controlled all lighter-than-air craft, leaving the British Expeditionary Force (BEF) without any balloons when they deployed to France. After seeing the Germans and French demonstrate their effectiveness, they immediately requested balloons from the Admiralty. The Admiralty supplied several balloons and the necessary support, while the Royal Flying Corps (RFC) operated the airships. Although functional, this relationship was not without its problems. In a preview of the next 80 years of US Army/Air Force relations, inter-service rivalry complicated the transfer of aerial observation to the BEF on the western front as the RFC, the Admiralty, and the Army General Staff bickered about under whose domain the balloons should operate. In July 1916, the War Office finally placed orders for their own balloons, to be fully under the control of the RFC.[7]

In addition to aviation procurement, the Army looked to the allies to train its pilots, observers, and mechanics. The British and French accepted some Americans into their own training schools for observers, pilots, and mechanics, but they were unable to absorb enough to meet the needs of the American Expeditionary Force (AEF). Effective training required combat capable equipment, none of which existed in the United States. This led to the establishment of an American training facility in Issoudun, France. Although the Commander of AEF General John P. Pershing believed the facility at Issoudun could solve the training issue, this proved incorrect. Training for all aspects of military aviation remained a significant problem for the Army throughout World War I. The AEF did the best with what it had, and by the signing of the armistice the Aviation Section had grown from 65 officers and 1,100 men at the start of the war, to 7,738 officers and 70,769 men.[8]

The Aviation Section of the AEF focused predominantly on observation and reconnaissance missions. The emphasis is evidenced by the inventory of planes in the Air Service. In April 1918, they possessed 8,000 observation aircraft, compared with 2,000 pursuit and 1,050 bomber types.[9] Army doctrine defined two major roles for aviation: tactical and strategic. Tactical operations provided support for ground forces by means of observation missions; strategic operations targeted the enemy's air force (air superiority missions) and bombing attacks deep in enemy territory. In its tactical role, THREE different observation and reconnaissance missions existed for AEF aircraft: visual and photo reconnaissance, adjustment of artillery fire, and contact missions.

The Air Service conducted more visual observation missions than any other task, with balloon companies the primary operators. While ascended, the observers watched for activity of enemy artillery and balloons, movement of supplies, and new fortification construction. Action within any of these spheres might precede an enemy attack. They transmitted their observations via the direct telephone connection to units on the ground. The balloon company field manual, which had been translated from the French version, instructed observers to report "only what is actually seen . . . to the exclusion of all personal interpretation." Commanders wanted the men in the balloons to be their eyes in the sky, providing raw intelligence data to analysts on the ground.[10]

Aerial photography missions represented the second most common mission of the Air Service. Like most other aspects of the war, the United States entered World War I with little experience in aerial photography. The AEF again looked to the British and the French for assistance in developing their military intelligence capabilities. The Signal Corps, the section within AEF responsible for aerial photography, went on a purchasing spree of civilian motion and still cameras immediately after American entry into the war. They found this equipment to be inadequate, and yet again the US looked to the British and French for suitable instruments. For doctrine, the Signal Corps translated the French field manual on aerial photography. Aircraft took two types of aerial photographs: oblique and mosaic. Oblique photos presented a horizontal line-of-sight image and could be taken from either a balloon or an airplane behind friendly lines. Mosaic photos were taken from directly above the target. These proved incredibly useful for map-making and damage assessment. Another concept borrowed from the French was to use aerial photography to validate intelligence gathered through other sources.[11]

The Air Service also adjusted artillery fire. Air observation complemented other developments in sound ranging and flash spotting to increase counter-battery operations. Aerial observation and photographs provided field artillery with targets deep behind enemy lines, such as supply areas or troop build-ups. After firing toward a specific target, an airborne spotter gave the necessary corrections to the battery. Although unknown at the time, this function of the Air Service proved critical in future decades for convincing decision-makers of the Army's need for airplanes separate from the future Air Corps and later Air Force.[12]

During a contact mission, the final task of the Air Service, the aircraft monitored the progress of friendly units during offensive maneuvers. Their reports allowed commanders in the rear to react more rapidly to unexpected successes or difficulties. Particularly in this mission, Army aviation began to fill a void created by the ineffectiveness of cavalry during World War I.[13]

Because the AEF did not possess a separate air service, each army corps included an organic tactical air unit. Pursuit and bombing aircraft, the strategic component of the Air Service, were assigned to an army, although pursuit aircraft often supported a specific corps. Each corps had an observation group consisting of three squadrons with 24 planes each, for a total of 72 aircraft. The corps also possessed a balloon wing compriseing of five companies, each with a single balloon. These corps assets nearly always operated under a specific division within the corps, although they might be transferred from one division to another depending on need. At the next higher level each army was supposed to have another 3 balloon wings for a total of 15 balloons and 2 observation wings, which consisted of 3 groups for a total of 220 planes. The actual assignment of squadrons often fell short of this standard. French squadrons were used to provide aerial support when insufficient numbers of American squadrons were available. Of primary importance, however, is that aircraft were utilized by units of division strength or greater. During World War I, the scale of the fighting made employment of aerial observation at any level below the division unnecessary.[14]

The intelligence section of the army, corps, or divisional general staff (G2) determined which areas were to be observed from the air. The G2 transmitted these orders via the branch intelligence officer of the air service to the commanding officer of the observation group. From there, the squadron operations officer assigned the missions to individual pilots and observers. When the squadron returned, the branch intelligence officer (BIO) disseminated newly gathered information among the observation group and to the corps intelligence staff. The system for tasking balloons followed an identical pattern, with the exception that missions were assigned to a specific company based on their sector of operations, eliminating the role of the group operations officer. If the mission included aerial photographs, they would be processed by the photo section of the corps observation group and distributed by the BIO to the corps or army G2 for analysis. The photo section was expected to develop the photos from the mission within six hours. AEF had copied this system of intelligence distribution from the British. The BIO represented the key component, acting as the liaison between the G2 and the air service. Tasking for artillery observation missions came from the commanding officer of either the army artillery or divisional artillery (see Figure 2).[15]

Despite the tremendous progress made in military aviation and aeronautics, numerous problems remained. Balloon companies created a tremendous logistical strain. They required a constant supply of hydrogen and material for rigging the balloons, as the strain of prolonged observation tended to wear down the rigging. Although balloons provided a constant eye on the enemy, adverse weather conditions could limit their use. Under normal conditions, they could not ascend if the wind exceeded 33 miles per hour, although during an attack they would tolerate wind speeds of 40 miles per hour. Rain could add as much as 220 pounds to the balloon, decreasing its ascension force. Thunderstorms created an even

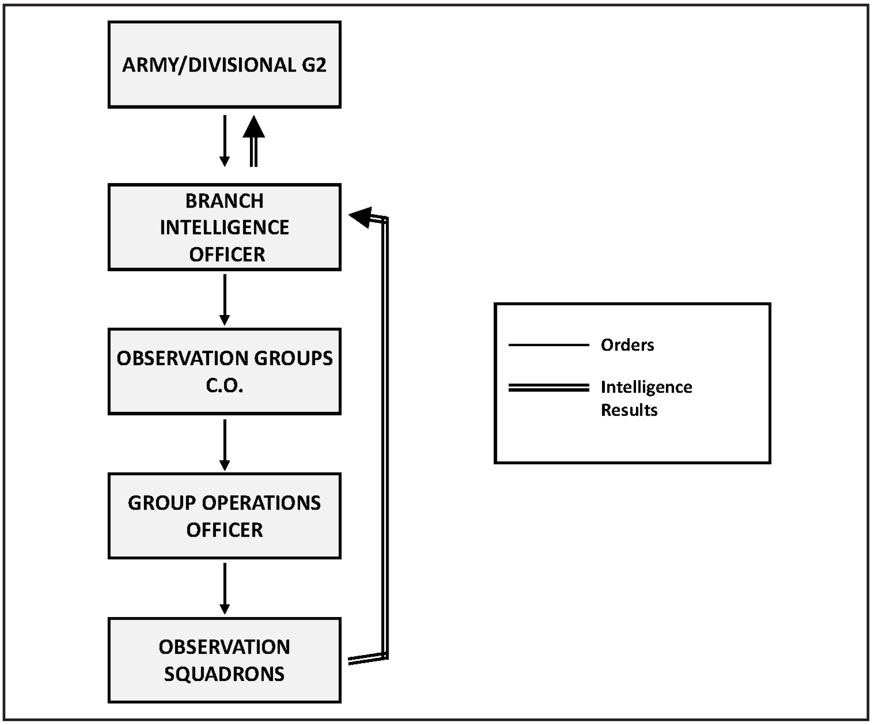


Figure 2. Orders and Intelligence Processing for World War I Squadrons.

greater risk, as lightning could ignite the hydrogen/air mix around the valve of the balloon. Balloons also made a tempting target for enemy pursuit planes. Each company included a spotter, whose task it was to watch for enemy planes. If a balloon was destroyed by enemy fire, the observers had a parachute attached to the basket they could use to bail out. Traditionally airmen defined an 'ace' based on the number of enemy planes shot down; in the balloon companies, this status related to number of jumps survived from a balloon.[16]

A final drawback of balloons was their visibility to the enemy. Just as balloon observers received instructions to watch for increased enemy balloon activity as an indication of an attack, enemy observers watched for the same signs. In preparation for an attack, the balloon companies had to be careful not to suddenly increase their activity, or they risked giving away the location of an impending attack.

Observation planes provide more flexibility than balloons because of their greater range. From an air park behind friendly lines, they possessed a much greater potential area of operations, although they could not loiter in an area anywhere nearly as long as balloons. They possessed the capability for mosaic photography, whereas balloons could only acquire oblique images. However, the amount of training required for pilots and the difficulty in producing a sufficient number of qualified pilots represented a significant obstacle and without a doubt contributed to the reliance by AEF on balloon companies for observation and reconnaissance.

Despite the deficiencies of the Army Air Service entering the war and the persistent logistical and training problems, the Air Service performed well in the AEF offensives. During the St. Mihiel offensive, Major General Mason Patrick, Chief of the Air Service, ordered the creation of mobile air parks to provide logistical support for the air units participating in the offensive. This helped alleviate many of the previous problems caused by stationary air parks. In the Meuse-Argonne Offensive, the air service of the 1st Corps developed 16,000 photos in a single day. Weather hampered aerial operations during both of these offensives, however, when air operations could be conducted they provided substantial intelligence information to AEF forces, particularly during the latter offensive.[17]

World War I demonstrated the potential of military aviation and aeronautics. Although heavier-than-air crafts have dominated military flight since 1919, balloons played an important role in the early development of aerial observation. Tethered balloons using a sophisticated sensor array continue to be used in Iraq and Afghanistan. However, since they lack a propulsion system, the Department of Defense does not classify them as UAVs.

Interwar Years

After World War I, the debate over air power as either a tactical or strategic tool emerged with greater force. In 1919 and 1920, several bills came before Congress which would have created an independent air force, all of which failed. During the early 1920s, Brigadier General William "Billy" Mitchell became the leading advocate for strategic air doctrine. The American counterpart to Britain's Hugh Trenchard and Italy's Guilio Douhet, General Mitchell fought for an independent air force whose role would be the destruction of an enemy nation's ability to make war. Despite being court-martialed in 1925, he had tremendous impact on the future of American air power.[18]

Despite the efforts of Mitchell and other air-power advocates, many of whom were less radical than he, Army aviation declined rapidly after the war. Only 220 officers (of over 7,000 at the time of the Armistice) remained in the Air Service by mid-1919 and 90 percent of the nation's aircraft industry, built to satisfy the needs of the Army during the war, was no longer operating. Bureaucratic opposition within the War Department and stingy Congressmen stifled the development of air doctrine in the early 1920s. At the end of Calvin Coolidge's first term, the government had reduced the spending of the War Department by $750 million. In 1926, however, the Air Service took a small step toward independence when Congress approved a proposal for a separate Air Corps. Although aircraft would still be attached to divisions, corps, and armies, these units would not be organic to the division.[19]

Observation aircraft changed direction in 1929 with the formation of the Air Corps Technical Committee. Following its investigation into the needs of the Army, the committee recommended observation aircraft be divided into two types: strategic, which operated no closer than 25 miles from the front and were coordinated at the army level, and tactical, to support the divisions and corps. Although the Air Corps theoretically emphasized tactical observation, it continually pursued high speed planes to fulfill this role, believing only these could survive in combat. Despite their good intentions, the focus on survivability led to a decline in capability, as high speed aircraft were unsuitable for tactical reconnaissance and artillery adjustment due to their limited time on target. The emphasis on building faster planes led to larger engines, which increased the weight of the planes. Heavier planes required more runway space to take off than was available at the front. The divisional and corps observation planes operated from an airfield far behind their assigned division, meaning they rarely interacted with the ground forces they were assigned to assist. Some of the planes developed for divisional support ended up better suited for corps or army support.[20]

World War II

From 1926 to 1939, the Air Corps continually increased its emphasis on strategic doctrine. The Air Corps Staff designed the observation squadrons accordingly, with long-range, strategic reconnaissance missions in mind. The arms and technical services of the Air Corps believed the divisional and corps airplanes had to be high-speed, maneuverable planes in order to survive on the battlefield. These two factors meant no light planes existed in the Army at the start of World War II.[21]

As war began in Europe, officers from all branches of the Army started calling for organic aviation to be assigned to their units. In 1939, the *Field Artillery Journal* translated and printed an article by Lieutenant Colonel Verdurand of the French Army which outlined the need and the capability of light aviation in support of artillery. Verdurand argued that light planes flying behind the lines could still observe light artillery at a range of 4 to 5 kilometers, and the larger pieces at 7 or 8 kilometers. Light planes also required far less training, eliminating any strain on the Air Corps' training capability. The author claimed that only allowing trained pilots to fly would be like only letting professional drivers operate vehicles.[22]

Not to be outdone by the artillery, in 1940 the *Infantry Journal* published an article calling for aviation to be assigned to infantry divisions. With biting sarcasm, the author, Lieutenant Colonel E.D. Cooke, argued:

> To be a big leaguer, our infantryman needs everything–including wings. Not the kind that depend on the cooperation of six staff officers, three headquarters and a liaison agent, but something of his very own. Something that sticks with him–like cooties, second lieutenants, and corned bill.[23]

The article stated that infantry did not need highly trained fighter or bomber pilots and expensive aircraft, just some "wild-eyed kids who would rather fly than do K.P." along with "something that could land in a cow pasture, hide in a smoke house, and take off from the General's pansy wagon when necessary." The small liaison planes eventually given to artillery were not far off his description.[24]

In 1939, the standard plane assigned to the corps and division was the O-47. Although slower than pursuit planes, it still travelled too quickly for effective observation, and certainly too fast for artillery adjustment. It also required 1,200 feet to take off, so it could only operate from an airfield far behind the lines. After seeing the destruction of British and French planes with similar capabilities of the O-47 by the Germans, the Air Corps decided not to use it in combat. The head of the Field Artillery, Major General Robert M. Danford, continued to push for organic aviation to be assigned to artillery units. During the Camp Beauregard maneuvers in 1940, several small planes manufactured and provided by the Piper Aircraft Corporation demonstrated the potential for small planes to adjust artillery fire. The following year, maneuvers in Louisiana, Tennessee, Texas, and the Carolinas confirmed the capability of small, light airplanes for artillery adjustment. During these tests, civilian pilots flew 11 planes loaned by aircraft manufacturers to the Army on 3,000 missions, totaling 400,000 miles, the equivalent of 16 trips around the equator. Unlike the divisional observation group, the civilian pilots could land their planes near the front. They regularly shared meals with the ground forces and slept under their planes, using the wings for cover. In addition to increasing their effectiveness through a better understanding of the troops on the ground, this endeared them to the officers and enlisted men alike.[25]

The Air Corps resisted any assignment of airplanes to the Field Artillery on matters of both principal and economy. First, aerial observation was clearly an Air Corps responsibility. After the bureaucratic battles they fought in the early 1920s to obtain marginal independence, any change which might render them unnecessary was unacceptable. Second, they argued that if the Field Artillery received aircraft, their missions would overlap and result in unnecessary waste. In theory, the leaders of the Air Corps presented sound arguments. In practice, they refused to adapt their mission to the desires of the ground forces. Air Corps leaders consistently opposed the development of light aircraft for ground support missions while making little effort to improve the training and capability of its tactical reconnaissance pilots. Pilots in the Air Corps saw observation flight as a path to nowhere and generally avoided it. Those forced into this role generally took the assignment grudgingly, and spent little time training for observation missions.[26]

The success of light planes in the 1940 and 1941 maneuvers convinced the War Department to allow General Danford to proceed with further testing. The following January, Lieutenant Colonel William W. Ford began training the first group of artillery aviators at Fort Sill, Oklahoma. In what became known as the Class Before One, 12 officers and 15 enlisted men volunteered for joint pilot-mechanic training. Ford divided the class into two groups, Flight A and Flight B. An additional six enlisted men volunteered for purely mechanical training. The pilot/mechanic training focused on general flying abilities and basic maintenance, as well as the art of artillery observation. In addition to their basic training, the mechanics participated in several hands-on programs, including working in the Piper Aircraft manufacturing plant and later at the local airport, providing free labor to pilots there. The training lasted only until the end of February, at which point the two flights were separated and sent to Florida and Texas for field tests with artillery units, in which they performed very well.[27]

On 6 June 1942, the War Department approved General Danford's request to make light aircraft organic to field artillery organizations. The Field Artillery created the Department of Air Training and expanded the facilities at Fort Sill to begin training pilots and mechanics (all pilots would continue to receive basic mechanical training as well). The Army Air Forces (AAF), as the Air Corps became in 20 June 1941, gave control of Post Field, an air field near Fort Sill, to the Field Artillery as well. Although established on paper, the Department of Air Training nearly collapsed in the first six months due to disputes between the Army Ground Forces (AGF) and Army Air Forces. One of the arguments revolved around the use of enlisted men as pilots. Lieutenant General Henry 'Hap' Arnold, the head of the AAF, argued that enlisted men should be trained to fly the liaison planes for the artillery. He believed that the requirements of flying any plane were too demanding to perform while observing, yet simple enough they did not require an officer. Artillery Brigadier General Leslie J. McNair believed only officers should be allowed to fly, since if an enlisted man flew the plane an artillery officer would have to be pulled off the line to serve as his observer, since only an officer could direct artillery fire. He instead wanted an officer to be trained to observe and fly simultaneously. The War Department ruled in favor of Brigadier General McNair and requiring all liaison pilots to be commissioned officers. The first training classes began in Fort Sill in November 1942 and by the end of 1943, 1,694 pilots had graduated from the program.[28]

The Army's first use of light aviation in combat during Operation TORCH ended badly. To begin with, the pilots assigned to the invasion forces had no opportunity to train with the ground units they would be supporting. Most of the planes had been packed in crates for the trip across the Atlantic, so the pilots could not train in the planes that would take them into battle. Four pilots assigned to the 3d Infantry Division saw their planes on the deck of the USS *Ranger (CV-4)*, which were in such poor condition they spent the trip across the Atlantic repairing them. The pilots completed the repairs in time to support the initial landing force. After taking off from the *Ranger* and heading for shore, they began taking fire from the USS *Brooklyn (CL-40)*, whose gunnery officer did not recognize their silhouette as that of a friendly plane. The pilots dropped their planes down to 20 feet and skimmed the waves for the duration of the flight over the ocean. Their fortunes did not improve once they reached land. The ground forces they intended to support had never trained with organic aerial support, and immediately fired on the three planes. One of the planes crashed and the pilot, who had been shot with 5 bullets in his leg, crawled to safety. Another went down behind enemy lines and was captured. After this, organic aviation had nowhere to go but up, which it soon did. With the assistance of the British, whose artillery aerial observation program was further along, the aerial observers quickly became a vital part of the war effort.[29]

During the invasion of Italy, L-4 Piper Grasshoppers (see Figure 3) directed artillery fire and offshore naval fire (sometimes at night, using hand-held flashlights to illuminate the instrument panels), laid wire, performed transport operations, and performed aerial photography and reconnaissance missions. By this time, the AAF had recognized the capability of light airplanes and created liaison squadrons to be deployed with the AGF. These squadrons first went to South Asia as part of a combined American-Chinese offensive against the Japanese. Originally intended to serve as couriers, these liaison squadrons performed a wide range of missions. Small bombs were attached to the wings or belly of a plane and dropped from a low-altitude. At least once, members of the liaison squadron threw hand grenades from their plane to flush out Japanese troops hiding beneath a bridge. At other times, they used smoke grenades to mark targets for heavy bombers. Other missions included the evacuation of wounded soldiers, aerial supply, transport of personnel, reconnaissance, and emergency rescue. Although not an organic army unit, these liaison squadrons demonstrated additional uses for light aviation that eventually became key components of Army aviation.[30]

Hoping these new liaison squadrons might demonstrate the AAF's ability to provide the necessary reconnaissance and artillery adjustment missions, General Arnold sent a memorandum in January 1944, to the chief of staff for the Army calling for the removal of organic aviation. In addition to the accusations of waste and inefficiency, General Arnold correctly argued that the AGF planes exceeded their orders by performing missions beyond

National Museum of the US Air Force photo.

Figure 3. L-4 Piper Grasshopper.

artillery adjustment. The ground forces attempt to acquire higher performance aircraft for their division seemed to justify his claim. Although the War Department refused to abolish the organic aviation, it promised General Arnold he could raise the objections again if the AGF aviation continued its mission-creep.[31]

The following year, the AGF again asked for more organic aviation. Although the War Department denied the request, they indicated an interest in a study of the liaison work being performed by the AAF. The study, conducted by a colonel and a lieutenant colonel who had served in both the AGF and the AAF, found the liaison pilots of the AAF did not possess the required knowledge or ability to sufficiently support the troops on the ground. Their findings revived the AGF request, and with the support of Army Chief of Staff General George C. Marshall, they finally received approval to expand organic aviation. An agreement reached in August 1945, provided six planes for infantry, airborne, and mountain divisions; nine for armored divisions; seven to cavalry divisions; one for each engineer battalion, and two for cavalry and tank destroyer groups. Although this decision came after the surrender of Germany and only shortly before the surrender of Japan, it established the precedent for organic aviation outside the artillery.[32]

By the time of the German surrender, the number of light planes operating in the European Theater numbered 1,380. Every division was assigned 10 planes, with additional planes at the corps and army level. Although the airplanes were part of an individual artillery unit within the division, the various artillery units pooled their aircraft. The planes operated on a divisional schedule to provide dawn-to-dusk aerial observation for all artillery within the division. The aircraft assigned to armored division artillery also assisted in the direction of columns. It became common for these planes to land alongside the advancing column and take the commanding officer up for a brief survey of the area, a practice that became common in later wars.[33]

Light aircraft flew nearly a quarter of a million missions in Europe, throughout the course of the war. The final report of the General Board listed the following missions as all being performed by light aviation:

> . . . selecting traffic routes, traffic control, selecting forward command post locations, observation of specific enemy attacks or retreats, observation of all types of bridges and roads, personnel of general staff sections observing front line terrain and installations, scheduled patrols along entire corps front, directing flights of fighter-bombers on close-in targets, photographic missions, adjusting naval gun fire.[34]

Even the enemy recognized the effectiveness of the liaison planes. In a letter written in December 1944, a German soldier wrote: “We all would be happy to see a few of our fighter planes which would bring an end to the . . . [aerial] artillery observers. Without any interference these dogs fly around all day . . . against that one can only hide like a little mouse.”[35]

As the General Board study indicated, ground commanders used their organic aviation for much more than its intended mission of artillery adjustment. This was because of the convoluted process to request aerial reconnaissance from the air force. The exact procedure varied slightly, depending on the army, however the following example from the 12th Army Group provides a general idea of the process. If a division commander desired aerial reconnaissance, he sent the request to corps headquarters. If approved, they sent it to the army G2 staff, which had a separate air section. They designed the aerial reconnaissance plan to best fulfill all the requests they received. They passed this plan to the reconnaissance section of the Air Force, who gave the orders to the reconnaissance group. The orders then filtered down through the operations officers to the squadrons who would actually fly the missions (see Figure 4). Once gathered, the intelligence information filtered back through a similar path (see Figure 5).[36]

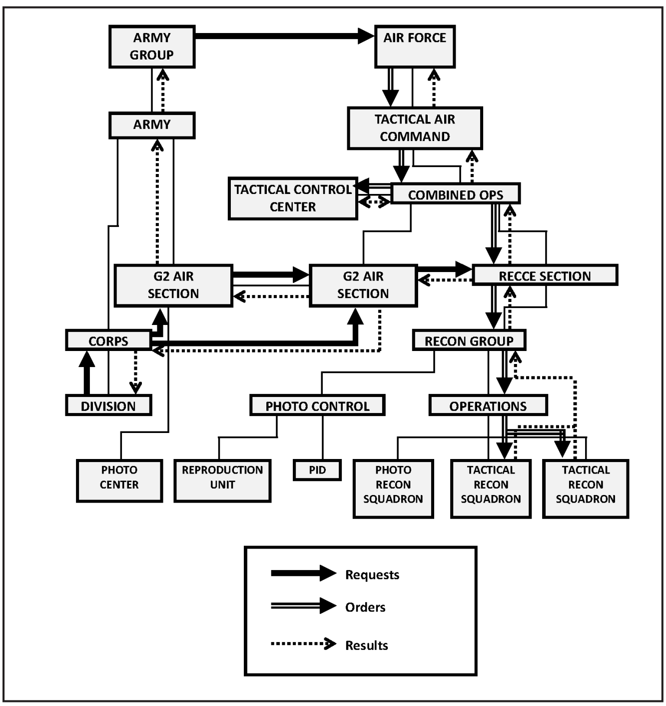


Figure 4. Requests and Orders for Army Air Forces Reconnaissance.

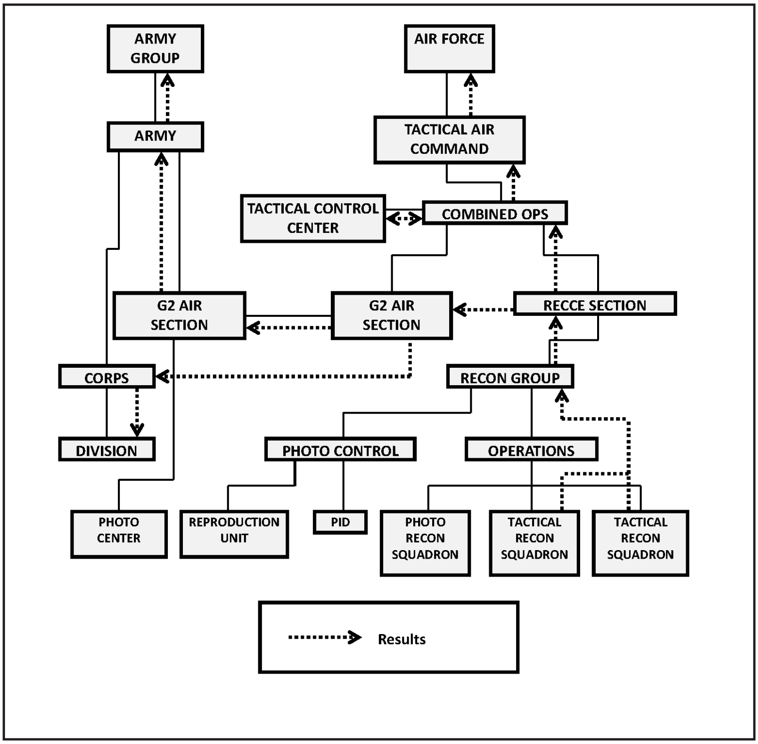


Figure 5. Army Air Force Reconnaissance Mission Results.

Early in the war, the AGF commanders experienced frequent dissatisfaction with the quality and quantity of the tactical air support provided by the AAF. They believed the AAF focused on strategic air power at the expense of the tactical components. The 1943 field manual for the command and employment of air power described tactical air support in way that made it appear more like strategic operations. According to the field manual, the first priority of tactical air power was the establishment of air superiority through attacks on enemy airfields. Isolation of the battlefield by targeting lines of communication and support appeared next on the list. Close support for ground forces ranked third and last. Much of the AAF's tactical reconnaissance that did occur related to aerial operations. During the campaign in North Africa, one AGF observer noted that despite a lack of photo reconnaissance for ground operations, aerial pictures of destroyed bomb targets plastered the walls of Air Force headquarters. When they did get the photos they requested, it generally took 24 hours from the time of the request until the photos were delivered.[37]

Some improvements were made by the 1943 landings in Italy. Gradual reorganization of the system for air-ground coordination which resulted in the creation of a G2 and G3 Air Subsection at the army level contributed to this progress. In operations in the Mediterranean Theater, staff officers generally used the color red to mark information from aerial photography in red and everything else was in purple. One officer estimated that nearly 80 percent of the information was annotated in red. During the landing at Salerno in September information from aerial photography proved invaluable to the 45th Infantry Division. A series of photographs spanning the previous eight months provided evidence of fortification of the town of Villa Literno. When he received this intelligence the division commander, Major General Troy H. Middleton, made the decision to bypass the town, and the enemy garrison eventually surrendered without a fight. In this example, information from aerial photography directly assisted a commanding officer in making a decision which saved lives. One of the major obstacles in regard to aerial photography was not flying the missions, but processing and distributing the results.[38]

The tremendous potential of aerial photography led some in the army to see it as the "silver bullet" of battlefield intelligence. An article in the August 1953 issue of *Military Review* illustrated the logistical strain if commanders received all the photographs they wanted, not just the ones they needed. When the Air Force became an independent service in 1947, it arranged a deal with the Army that divided responsibility for aerial photographic reconnaissance. The Air Force would perform the actual missions, but the Army assumed control of the reproduction, distribution, and interpretation of photographs. Based on the standard doctrine for front-line cover, an army sized force attacking on a 60 mile front would need over 4,000 negatives daily, which would be produced into nearly 20,000 prints. This would create "650 pounds of photographs having a volume of 16 cubic feet, or a stack of photographs 18 feet high."[39] Although the production unit possessed the ability to process these quantities at peak capacity, there was a further logistical strain in supplying them with the chemicals and water they needed to process the prints (over one ton per day), distributing the photos to the corps (214 pounds per corps), and finally evaluating the photos.[40]

The Army's final report on the AAF tactical reconnaissance work for the ground forces contained a mix of positive and negative findings. Aerial reconnaissance proved to be a tremendous aid during the planning phase of an operation. Once the operation began, the AAF continued to acquire quality intelligence, but due to the communication and logistical problems, much of this information never filtered down to the divisional commanders who needed it. While army level commanders generally felt satisfied with the intelligence they received, divisional and corps commanders often lacked sufficient close-in aerial reconnaissance. They attempted to use their artillery liaison planes for this purpose; however the vulnerability of these aircraft to enemy fighters and anti-aircraft fire limited their success.[41]

The experience of World War II solidified in the mind of the AGF the utility of organic aviation for reconnaissance missions. Simultaneously, the effectiveness of strategic bombing in disrupting German industry convinced the AAF that future wars could be won from the air. The nuclear bomb added weight to the latter of these arguments. During the five years between the end of World War II and the outbreak of war on the Korean peninsula, the Army underwent a number of adjustments. In 1946, the commands of the Army Ground Forces and Army Air Forces were eliminated and responsibilities reassigned between numerous new organizations. One of these new organizations, the Air Material Command, received responsibility for the development of new aircraft. This institution played an important role in military aviation for two decades. The National Security Act of 1947 further changed the military's organization by making the Air Force an independent branch of service, equal to the Army and Navy.[42]

Korean War

After the creation of the Air Force as an independent service, the Army continued to use organic aviation to support ground forces. The Key West Agreement, approved by President Harry S. Truman and Secretary of Defense James Forrestal in 1948, gave the Air Force responsibility for providing "close combat and logistical support to the Army, to include airlift, support, and resupply of airborne operations, aerial photography, tactical reconnaissance, and interdiction of enemy land power and communications." The following year, a new agreement between the Army and the Air Force solidified the Army'ss organic aviation. Under Joint Army and Air Force Adjustment Regulation 5-10-1, the Army could operate fixed wing aircraft weighing less than 2,500 pounds and rotary wing aircraft weighing less than 4,000 pounds. Missions for these aircraft included artillery adjustment, route reconnaissance, control of march columns, camouflage inspections, local courier service, emergency evacuation, wire laying, limited resupply, and limited front line aerial photography. The role of Army aviation continued to evolve and

Major Aviation Agreements Between Army and Air Force		
Date	**Agreement**	**Stipulations**
July 1947	National Security Act	Created an independent Air Force as a service equivalent to the Army and Navy
April 1948	Key West Agreement	Granted the Army primary control over doctrine and equipment for airborne operations of interest to the Army and Marine Corps
May 1949	Joint Army and Air Force Adjustment Regulation 5-10-1 (JAAFAR 5-10-1)	Placed weight restrictions on organic Army aircraft (3,500-4,000 pounds maximum for fixed wing and 2,500 pounds maximum for rotary wing); designated the type of missions organic aviation could perform
October 1951	Pace-Finletter Agreement	Abolished the weight limit for organic Army aircraft; expanded the responsibility of Army aviation to include limited transportation within the combat zone
November 1952	Pace-Finletter Agreement (revised)	Reinstituted a weight limit on organic Army aircraft (5,000 pounds maximum for fixed wing); further increased Army aviation responsibilities to include medical evacuation and topographic surveying

Figure 6. Major Army and Air Force Aviation Agreements.

numerous changes were made to this agreement. However, short-range aerial reconnaissance missions remained the responsibility of the Army (see Figure 6).[43]

A significant change that occurred between the end of World War II and the beginning of the Korean War was the addition of considerable numbers of helicopters to Army aviation. The Army experimented with rotary-wing aircraft prior to World War II, including the possibility of using them for the artillery's aerial observation posts. In 1939, an article in *Field Artillery Journal* argued the autogiro provided an ideal platform from which to perform artillery spotting. Like the balloons of World War I, the autogiro could loiter behind friendly lines at an altitude between 1,000 and 2,500 feet and direct fire. The threat of anti-aircraft fire from the ground made it an unfavorable target for enemy pursuit craft, and it could operate effectively far enough behind the front to avoid enemy anti-aircraft fire. Had war been delayed for another few years, rotary-wing aircraft might have been more involved in World War II. Autogiros did not attain the level of performance necessary to justify further development and the War Department scrapped further procurement. After cancelling autogiro development, the War Department proceeded with experiments on a different form of rotary-wing: the helicopter. By the time the first helicopters capable of performing in a combat situation were developed, the light airplane had been found to be a suitable observation craft and become the primary focus of the AGF aviation, although helicopters flew several missions during World War II. During the Korean War, helicopters supported the Army mostly through evacuation or supply missions. Although helicopters occasionally provided aerial reconnaissance, this remained primarily the task of light planes.[44]

Army aviation remained spread throughout the division, rather than being centralized into a single aviation unit. Each of the three infantry regiments included a fixed wing aircraft and a utility helicopter. The field artillery had two fixed wing aircraft for each of the four battalions. Additional fixed- and rotary- wing aircraft were spread among the division headquarters, the division signal company, the combat engineer battalion, and the divisional artillery headquarters battery for a total of 26 aircraft in an infantry division. Assignment of aircraft in armored divisions varied slightly, but followed the same general form. This system of dispersing aircraft to various units went directly against the recommendations of the Army General Board. The Army Field Forces Board No. 1, convened in November 1950, examined the possibility of centralizing all organic aircraft into a single aviation company. As previously discussed, the Board found that most divisions in Europe pooled their aircraft and concluded this to be a more effective method of utilizing aviation assets. This proposal failed to gain a majority, and aviation would continue, at least on paper, to be assigned to units within the division. Once in theater, however, almost every division pooled their air assets. In May 1952, the 7th Infantry Division tested the effectiveness of an Aviation Company, an experiment which proved so successful it spread throughout the 8th Army.[45]

Pilot training during the Korean War operated as it had during World War II. After completing the Air Force liaison course, future pilots would go to Fort Sill and complete their operational training. Pilot shortages during the Korean War inspired the Army to seek complete control of liaison pilot training from the Air Force. In 1953, the Army established the Army Aviation School at Fort Sill. Although the Army intended to train all of its pilots by the start of 1954, the Air Force opposed this move and the Army continued to rely on the Air Force to train many of its pilots. By the summer of 1954, the Army Aviation School outgrew its facilities and in September the entire program transferred to Camp Rucker, Alabama, which remains the home of Army aviation today. The interservice argument over who could train pilots continued throughout the rest of the 1950s.[46]

During World War II, the majority of Army aircraft were L-4 Piper Cubs. The additional missions being flown by the Army's liaison planes required a slightly higher performance aircraft. In the immediate aftermath of the war, the L-5 Sentinel, manufactured by Stinson, began replacing the L-4. Although slightly better performing than its predecessor, the L-5 was considered obsolete by most people in the Army at the start of the Korean War. The Army intended to replace the L-4s and L-5s with L-16 Grasshoppers and L-17 Navions, built by Aeronica and Ryan respectively, but budget restraints prevented them from doing so. Some pilots found the newer models, despite their better performance capabilities, still inadequate. Although the L-16 could fly faster than the L-4, the higher speed did not improve its capability in observation missions. In addition, it took the same amount of runway to land and takeoff, provided similar visibility for the pilot and observer, possessed a shorter operational time before requiring refueling, and demanded more attention to fly. A pilot of the era wrote that if anyone asked him what planes he wanted for World War III,

DOD photo.

Figure 7. Cessna L-19.

he would reply, “Eight [L-4] Cubs and two L-5’s.” Because of the dissatisfaction with the L-16, the Army held a competition in 1950 for a replacement of the L-16. The Cessna Model 305 won the contest and received the designation L-19 (see Figure 7).[47]

Until the arrival of the L-19 in theater, the older aircraft continued to operate. Army aviation performed similar missions to those flown during World War II. During the initial invasion by North Korea, Army aircraft provided invaluable information about the advancing North Korean tank columns. As had been done during World War II, aerial observation missions were organized to ensure that at least one plane was airborne from dawn to dusk. This constant observation provided information critical to the units responsible for delaying the North Korean advance. Prior to the landing of the X Corps, Major General Edward Almond went up almost daily in search of a better landing site for the 7th Infantry Division.[48]

Fire adjustment also continued to be a key task for Army aviation. Aerial observation adjusted as much as 90 percent of all artillery fire during the Korean War. In addition to directing ground-based artillery fire, Army pilots assisted Air Force fighter-bombers in close air support missions and provided adjustment for naval gunfire. In one instance, a pilot of an L-17 used his landing lights to direct an Air Force P-51 to a North Korean tank.[49]

During the Korean War, the Army tested the expansion of organic aviation in command and control operations, specifically for armored units. Most of the planes had two-channel radios, one of which was tuned to the combat command channel, the other of which was tuned to an Air/Ground channel. While flying an observation mission, the aircraft would normally be tuned to the combat command channel, allowing the commander on the ground to receive constant updates on enemy movement or position. Intelligence staff from subordinate units could also tune to this channel, to instantly receive the same information. If a subordinate unit required more detailed aerial support from the observation plane, the pilot would switch to the Air/Ground channel to provide direct support to that unit. Upon completing that mission, the pilot would switch back to the combat command channel. It is difficult to ascertain how extensively this command and control system was used during combat in Korea. However, it represented an attempt to improve the way intelligence was spread throughout a division, by making it possible for lower echelon commanders to receive real time intelligence information, as it was being sent to combat command.[50]

Helicopters provided another means for improved command and control. During combat, it became possible for commanders to easily see for themselves how the battle was progressing. In early October 1952, Lieutenant General Reuben Jenkins, commander of IX Corps, utilized the command helicopter assigned to him to observe the battle for White Horse Mountain. He used his observations to plan and coordinate a counterattack by the ROK (Republic of Korea) 9th Division. In another case, Major General Samuel T. Williams received conflicting intelligence reports from various sources. He decided to observe the enemy front for himself. Following his flight, he organized a very successful defensive plan. The ability of helicopters to land virtually anywhere made them even more effective for providing commanders a personal view of the battle, as well as increased contact with subordinate units. One soldier commented that in 500 days of combat in World War II, he saw only three general officers visiting with the infantry. This was not the case in Korea, where the helicopter made it possible for high-ranking officers to have far more contact with all levels of the division.[51]

In terms of tactics and organization, the Army's use of aerial observation in the Korean War remained remarkably similar to World War II. Aircraft remained divided amongst different units within the division, although the movement toward a centralized aviation company gained momentum. The Air Force continued to provide strategic aerial reconnaissance, while Army pilots conducted tactical observation missions. Although not without some risk, helicopters in particular made it possible for commanders to view the battlefield for themselves and plan their action accordingly. The greatest advances for Army aviation during the Korean War did not come in observation and reconnaissance, but in transportation. The possibility of aerial transportation to increase the maneuverability of units became a focus of Army for the next decade. The development of airmobility and its employment in Vietnam instigated a number of changes for Army aerial reconnaissance.

Airmobility and Centralization of Aviation

After the Korean War, American defense policy underwent a major change which had significant impact on Army aviation. A speech given by Secretary of State John Foster Dulles in January 1954 outlined this new approach. Described as the "new look," this new strategy focused on nuclear deterrent and limited the role of conventional warfare.[52] This new strategy created a significant challenge for the Army. Adapting in a manner that would allow the Army to retain its relevance would be an expensive endeavor, at a time when it was becoming difficult to maintain the level of funding needing to operate in the current fashion. The Chief of Staff of the Army, General Matthew B. Ridgway, began working on a plan for a more mobile Army, which could continue to play a role on a nuclear battlefield. His plan included a large increase in Army aviation. General Ridgway failed to implement his proposed changes; however his successor, General Maxwell Taylor picked up where General Ridgway left off. Their work resulted in the formation of the Pentomic Divisions, designated Reorganization of the Airborne Division (ROTAD), Reorganization of the Combat Infantry Division (ROCID), and Reorganization of the Combat Armored Division (ROCAD). Each of these divisions contained five battlegroups which could be deployed in a checkerboard pattern so as not to provide the Soviets with a single target for a tactical nuclear bomb. The amount of aircraft assigned to these new divisions nearly doubled, despite a decrease in the overall number of soldiers in each division (see Figure 8). The new infantry division had 36 airplanes and helicopters designed for observation and reconnaissance, armored divisions had 31, and airborne divisions had 27. Each of these divisions also received a number of utility airplanes and helicopters. The Pentomic Division also centralized control of aviation assets in a newly formed Aviation Company, a decade after such an organization had first been recommended by the General Board. Three platoons comprised the company: the direct support platoon, the general support platoon, and the service platoon.[53]

In addition to the organizational changes, the Army began to explore the possibility of increasing aerial transportation to provide greater speed and mobility for ground forces. In April 1954, Major General James M. Gavin published an article in *Harper's Magazine* that outlined the value of an airborne force utilized in a traditional cavalry role. The Army first tested this concept in Exercise SAGEBRUSH, a joint Air Force and Army exercise. The unit tested was the provisional 82d Airborne Reconnaissance Troop, which consisted of an airborne reconnaissance unit, an air-trans-

	Korean War Era	Pentomic Divisions	ROAD
Total Aircraft per Division	Infantry and Airborne – 26 Armored – 28	Infantry – 50 Airborne – 53 Armored – 51	103

Figure 8. Results of Reconnaissance Missions Flown by Army Air Forces.

portable heavy unit that could be used as a blocking force, an artillery and anti-tank force, and finally an aviation company, made up of transportation helicopters.[54]

In 1956, the Aviation Center at Fort Rucker formed a new unit, known as the Aerial Combat Reconnaissance (ACR) Company. While the reconnaissance troop unit tested in SAGEBRUSH integrated ground and aerial reconnaissance vehicles, this new unit exclusively focused on airborne operations.[55] The possibility of armed reconnaissance represented a fundamental change in the Army's use of aerial observation. With a few exceptions, during the two World Wars and in Korea Army aviation performed passive observation missions, in which they did not engage with enemy ground forces. In theory, the new ACR Company would be able to perform active reconnaissance missions, in which they sought out the enemy with the intention of engaging. Like the Airborne Reconnaissance Troop, the Aerial Combat Reconnaissance Company was not adopted by the Army, but served as a model for yet another experimental unit. The Army tested this third concept, the Aerial Reconnaissance and Security Troop, in 1960.[56]

In 1960, the Army commissioned a board to study the future of Army aviation. Although officially the "Army Aircraft Requirements Board," it was more commonly referred to as the Rogers Board, in honor of the Board Chair, Lieutenant General Gordon B. Rogers. After reviewing 119 proposals from 45 companies, the board made a variety of recommendations with long-term ramifications for Army aviation. Regarding observation aircraft, the board recommended the development of a new observation helicopter. Additionally, it called for more research into electronic reconnaissance tools. The board also concluded that further investigation should be done into the "concept of air fighting units." This recommendation paved the way for the Howze Board in 1962, from which the Airmobility concept emerged.[57]

In 1961, Army Chief of Staff General George Decker approved the "Reorganization Objectives Army Division (ROAD) 1965." This structure abandoned the five battlegroups in favor of a three brigade structure. The ROAD structure doubled the number of aircraft within each division. In the new divisions, the aviation company was elevated to battalion level. In theory, three companies comprised this battalion: headquarters, aviation general support, and airmobile (light). However, this organization changed dramatically once units began deploying to Vietnam. Within the general support company, the aerial surveillance and target acquisition platoon performed all aerial reconnaissance missions for the division. In addition to the fixed- and rotary-wing aircraft in the aviation battalion, the initial Field Manual included a drone section as part of the general support company. Although the Army did not utilize drones in Vietnam, they were used in Eastern Europe for photographic surveillance missions.[58]

In April 1962, Secretary of Defense Robert McNamara requested that the Army reevaluate its needs for aviation, after finding a previous report too conservative in its estimation of requirements. The Army created the US Army Tactical Mobility Requirements Board and placed Lieutenant General Hamilton H. Howze in charge. The study began in May and finished in less than 90 days. Despite the limited time given to them, the Howze Board conducted 40 tests, including a three-week-long exercise. The Board recommended the formation of a complete Airmobile Division. It followed ROAD organization with three brigade headquarters. For transportation, it used a total for 459 aircraft and decreased the number of ground vehicles from 3,452 to 1,000. One-third of the assault elements could be airlifted simultaneously. Although the amount of traditional artillery in the division decreased, each division included 35 UH-1 helicopters equipped with 2.75-inch rockets. The conclusions of the Howze Board survived criticism from the Air Force, members of Congress, and conservative elements of the Army and provided the blueprint for the 11th Air Assault Division, first tested in 1963.[59]

The instructions to proceed with the testing of an Airmobile Division came down from Secretary of Defense McNamara. The Army Chief of Staff placed Brigadier General Harry W.O. Kinnard in charge of testing the division. General Kinnard overcame numerous challenges in piecing together the 11th Air Assault Division, and successfully demonstrated the potential of his division in maneuvers against red forces comprising of the 82d Airborne Division in October 1964. The following June, Secretary McNamara announced the 11th Air Assault Division would be merged with the 2d Infantry Division, which would then switch designations with the 1st Cavalry Division in Korea. The new 1st Cavalry Division (Airmobile) was then deployed to Vietnam by the end of July 1965.[60]

Vietnam

The massive expansion of organic Aviation within the Army during the Vietnam War, in terms of quantity and missions, presents a far more complicated story than was the case in Korea or World War II. Before the Vietnam War, the majority of aviation missions revolved around aerial observation and reconnaissance. During Korea, the Army used helicopters in evacuating casualties from battle, but in Vietnam the use of aerial transportation grew to include movement into and out of battles. Another mission which assumed a major role was aerial fire support. Aerial transportation and fire support joined with aerial reconnaissance in two hybrid missions: long-range reconnaissance patrol and aero-scout missions. Aerial reconnaissance came from a variety of sources during the Vietnam War, each of which is briefly summarized below. In addition to performing new types of missions, the Army deployed a greater variety of aerial vehicles to Vietnam than any previous war.

Although the amount of Army aircraft assigned to ground forces exceeded any previous war, there still was not enough to fully supply every division. This led to the formation of the 1st Aviation Brigade in 1966 as a separate entity from ground units. Initially, many feared this might create the same operational friction and lack of support that the AGF dealt with during World War II. The commander of the 1st Aviation Brigade avoided this problem by handing over control of aviation assets to the ground commander who required them. Hence, the Army gained the advantages of centralized control (standardization and training), while avoiding the pitfalls (inadequate operational control for ground commanders). At its peak, the 1st Aviation Brigade contained 641 fixed-wing aircraft, 441 AH-1 Cobras, 311 CH-47 cargo helicopters, 635 OH-6A observation helicopters, and 2,202 UH-1 utility helicopters. The rapid increase of Army aviation in Vietnam led to a shortage of pilots in the early stages, a problem fixed by increasing the number of Warrant Officer aviators.[61]

The 1st Aviation Brigade was divided into groups, battalions, and companies. These units received assignments to geographic regions, in which they supported the corresponding ground forces. The new types of aircraft and equipment available to the Army during Vietnam led to the creation of a variety of specialized companies. Two types of companies performed the majority of fixed wing observation flights: the reconnaissance aviation companies and the surveillance aviation companies.

The reconnaissance airplane companies (RAC), initially called surveillance airplane light, directed artillery fire, flew convoy cover, provided radio relay, and at times transported personnel. However, 75 percent of the time they performed visual reconnaissance missions. RACs flew in L-19s although in the interim between Korea and Vietnam the Army changed the designation to the O-1. The companies were divided into four platoons and a company headquarters. The TOE (Table of Organization and Equipment) allotted 32 aircraft for each company, although the units often functioned with fewer. Most platoons supported a specific US Army or Republic of Vietnam Army Division. The number of planes per platoon varied from as few as four to as many as nine. When supporting a division, three aircraft were assigned to provide direct support to the division, while the others received a performed observation within a specific area of division's operations. The ground forces had operational control, and the G2 and G3 coordinated the platoon's missions. While flying a visual reconnaissance mission, the pilot usually flew low to the ground, looking for signs of enemy forces. A pilot from the 219th RAC claimed he flew so low he "could peer under the eaves of jungle huts." If the pilot observed enemy units or received fire, they marked the area with a smoke rocket and called in supporting fire, which could come from a gunship, artillery, mortars, or infantry assault troops. As the war progressed, the

DOD photo.

Figure 9. OV-1 Mohawk.

amount of fire taken by the O-1s decreased as enemy troops realized taking a few shots at an unarmed plane was not worth the trouble that usually followed.[62]

The surveillance airplane companies (SAC) of the 1st Aviation Brigade supported higher level units than the RACs. The SACs, equipped with OV-1 Mohawks (see Figure 9), divided its aircraft into two (and later three) platoons, each with a specific mission and unique modifications to their Mohawks. The visual and photographic platoon provided aerial photography. It also performed visual reconnaissance of coastal areas and the borders of Vietnam. The second platoon, known as the "exotic" or SLAR and IR platoon, flew Mohawks equipped with slide-looking airborne radar or infrared detection equipment. In 1966, the Army divided the exotic platoon into individual SLAR and IR platoons. The SACs supported Corps areas or the US Military Assistance Command. In the example of the latter, they received their missions from the J2, who processed mission requests from lower echelon commanders. Because they did not rely on good visibility to perform their missions, the aircraft of the SLAR and IR platoons could fly day or night, regardless of the weather conditions. The electronic detection equipment proved particularly effective in tracking the movement of enemy forces at night, their most active time.

DOD photo.

Figure 10. AH-1 Cobra.

Requests for visual or photographic reconnaissance came from Corps area headquarters. The visual reconnaissance and photo platoon also performed hunter-killer missions, in which they teamed up with AH-1 Cobras (see Figure 10) or aircraft from either the Navy or Air Force. Like the visual surveillance missions of the RACs, they would seek out enemy forces and mark the target. The RACs and SACs generally operated as part of a Combat or Combat Support Aviation Battalion. For example, in early 1968 the 223d Combat Support Aviation Battalion included the 183d, 219th, and 185th, and the 203d RACs and the 225th SAC. This battalion provided approximately 80 percent the intelligence for the II Corps Area, while half of the missions performed in that zone originated from information gathered by the 223d.[63]

The 1st Aviation Brigade also included a number of air cavalry squadrons, similar to those found within the ground based divisions. Operationally, these units generally were assigned to one of the Field Force headquarters, who would send them in support of a division or brigade within the Field Forces area of operations. Some of the platoons in these squadrons also performed "fire fly" missions, a night-time patrol designed to seek-and-destroy enemy sampans. The mission consisted of three helicopters: one flying high above armed with a .50 caliber machine gun, an observation aircraft equipped with seven C-130 landing lights, and another gunship flying low. The high flying ship provided cover for the two low flyers. The observer used the makeshift spotlight to search out the enemy. Upon discovery, the "invisible" gunships trailing both swept in to destroy the target with a combination of rockets and mini-gun fire. In just one of the missions, the fire fly team destroyed a convoy of 47 sampans carrying war material to Vietnam from Cambodia.[64]

As US forces began to withdraw from Vietnam, the Army Aviation continued to operate at nearly the same capacity as it had since 1965. In December 1970, ground forces declined to half of what they had been at their maximum. Army aviation reached its highest point in the same year. However, over the next two years the Army withdrew much of its aircraft. The 1st Aviation Brigade declined from 24,000 personnel in July 1971 to 5000 in July 1972. In March 1973, the last Army air unit departed. Over the course of the Vietnam War, the 1st Aviation Brigade flew 30 million sorties.[65]

The Aviation battalion field manuals published in 1965 and 1967 assigned the task of reconnaissance to the general support company. However, only two general support companies deployed to Vietnam: the 11th and the 163d. The 11th provided support to the 1st Cavalry Division (Airmobile) while the 163d served under the 164th Aviation Group in the IV Corps Tactical Zone. The aviation battalions assigned to the infantry divisions comprised two airmobile companies and an air cavalry troop, with other companies assigned to the battalion from the 1st Aviation Brigade as needed. The air cavalry troop provided the primary source for organic aerial reconnaissance within the division.[66]

Although considered a part of the armored cavalry squadron, the air cavalry troops worked closely with the aviation battalion. The primary responsibility of the troop was the aero-scout mission. Three main elements comprised the troop: a section of light observation helicopters, a squadron of air transportable rifles, and a section of armed helicopters for fire support. On an aero-scout mission, the observation helicopters would fly low to draw enemy fire. Upon contact with the enemy, the pilot of the observation helicopter would call for support. Small groups of enemy forces (squad or less) would be engaged by the aero-rifle platoon. Prisoners captured in this manner often provided valuable intelligence. If the enemy force was platoon size or larger, the observer would drop smoke grenades to mark the target, then hover nearby to help direct fire from the Cobras. It took only seconds from the time the observer marked the target for the Cobras to engage.[67]

DOD photo.

Figure 11. OH-13 Sioux.

DOD photo.

Figure 12. OH-6 Cayuse.

DOD photo.

Figure 13. OH-5832 Kiowa.

Accomplishment of the aero-scout mission relied on the diversity of aircraft available to the Army. The initial light observation helicopter used by the Army was the OH-13 (see Figure 11), which had been in service since the start of the Korean War. By 1966, the Army needed a new observation helicopter, and they wanted something small and cheap, since most did not survive long on the battlefield. In the competition to find a suitable replacement for the OH-13, the Hughes OH-6 Cayuse (see Figure 12) won. Nicknamed the "Loach," the OH-6A first arrived in 1967. The Loach was smaller, lighter, and faster than its predecessor, the OH-13 Sioux. It could fly beneath the jungle canopy along trails to seek out enemy forces. Hughes increased the price on the OH-6, forcing the Army to switch to the Bell OH-58 (see Figure 13) for observation.[68]

The second aero-scout component was the UH-1 Iroquois (see Figure 14). Better known as the Huey, the various models of the UH-1 performed the majority of transportation and MEDEVAC missions during the Vietnam War. Development for the Huey began in 1955 by Bell Aircraft Corporation and the first tests took place in 1958. In 1960, Bell delivered the first UH-1A's to the Army. The following year the UH-1B came into service. Although a number of other variants saw action in Vietnam, the UH-1B

DOD photo.

Figure 14. UH-1 Iroquois.

was the most common. The Hueys in the aero-scout mission transported the aero-rifle squads. If the Loach pilot or observer made contact with a small group of enemy forces, the aero-rifle squad would be inserted to engage. Before the development of helicopters capable of transporting units and keeping up with observation craft, the only way the Army could perform reconnaissance in force missions was by using their observation aircraft as forward air controllers for the Air Force. With the aero-scout mission, aerial reconnaissance in force could be performed entirely with organic units.[69]

Armed helicopters comprised the final aero-scout element. Army aviators had rigged their observation and liaison aircraft with armaments since World War II. These modifications were never official, due to a prohibition on weaponizing Army aviation in the AGF/AAF (and later Army/Air Force) agreements. Despite this ban, in the 1950s the Army began secret experiments at Fort Rucker, designed to test the feasibility of mounting machine guns and rockets on their utility helicopters. Initial concern existed as to the exact effect firing a weapon from an airborne vehicle would have. They performed the first weapons tests with the helicopter mounted on a wooden platform. Only when these tests showed that no structural damage occurred to the helicopter while firing the machine guns and rockets did they actually try firing weapons from the air. These tests demonstrated that rotary-wing craft could be used for fire support; however, not until the mid-1960s would the concept be fully refined. The first combat helicopters in Vietnam were utility helicopters modified to carry M-60 machine guns. Because of the limitations of these modified aircraft, in 1966 the Army ordered the AH-1 Cobra from Bell, the first dedicated attack helicopter in the Army. The Cobra made it possible to perform reconnaissance in force missions against enemy units too large for the aero-rifle squad.[70]

Post Vietnam and the 1980s

After Vietnam, the Army would not fight a large-scale war until Operation DESERT STORM. However, aviation within the Army continued to evolve. Helicopters proved themselves to be highly effective during the war in Southeast Asia, but opposing forces never possessed a specialized anti-air system until the end. This would not be the case, should a war break out with the Soviets in Europe. In the 1980s, this led to an increased emphasis on joint-operations between Army aviation and the Air Force. The Army could assist the Air Force in achieving air superiority by using its new AH-64 Apache helicopters to engage and destroy enemy air-defense radars, and laser-mark targets for Air Force A-10s and F-16s. AirLand Battle doctrine solidified the role of Army aviation with the national defense strategy. The ability of the Apaches to perform deep attacks fit exceptionally well within the AirLand Battle concept.[71]

In 1983, aviation became a separate branch within the Army, putting it on the same level as infantry, artillery, and armor. Prior to this, aviation officers divided their time between aviation and one of the other branches.The creation of divisional aviation brigades greatly increased the command opportunities for aviation officers. The 1980s were a period of almost continuous reorganization within the Army, during which multiple division types were tested and adapted, only to be changed yet again. Although the organization of organic aviation changed depending on the type of the unit supported, the basic responsibilities and types of units employed did not. All of the divisions contained an aviation brigade, which included a reconnaissance squadron. This squadron continued to perform the reconnaissance in force, aero-scout missions first conducted in Vietnam. Despite the numerous changes, the missions performed by air cavalry remained an important part of Army strategy. In an interview conducted by *Army Aviation Digest,* General Donn A. Starry stated, "Air Cavalry is essential to the battle in Europe."[72]

Control of electronic surveillance assets, specifically the EH-60 Blackhawks (a UH-60 with electronic surveillance sensors), went back and forth between the aviation brigade and the military intelligence battalion. The military intelligence battalion processed the results of the electronic surveillance missions; but lacked the required maintenance and logistical support. In the mid-1970s, the Army began experimenting with equipping UH-1s with a transmitter capable of sending real-time video back to the unit. This feed could be recorded and used by military intelligence in its briefing. The ability to provide real-time intelligence achieved the objective first set out by the Army in World War I, to see the battlefield as it truly was, not as the pilot or observer interpreted it. This allowed soldiers trained in interpretation to provide the analysis. This technological innovation was critical for the development of UASs. The OV-1 Mohawks also continued to provide electronic surveillance. In April 1978, the 15th Military Intelligence Aerial Exploitation Battalion was created to test the concept of bringing all these units together to support the Corps. This unit included both the aviation and military intelligence assets needed to perform the mission.[73]

Despite these and other changes, the role of Army aviation in the reconnaissance role changed very little after Vietnam. Aero-scout missions performed by Air Cavalry remained critical. Light observation helicopters provided visual reconnaissance of the immediate battlefield as well as command and control, while larger, utility aircraft like the Huey and Blackhawk were modified to perform electronic surveillance. These units operated organically within their assigned division, with the exception of fixed-wing electronic surveillance aircraft that could cover such a broad area it was better suited to be a corps asset. The Air Force accepted the necessity and benefits of the Army possessing its own air assets, including aerial fire-support.

From 1917 until 1990, the most significant changes in aerial reconnaissance occurred in the technological, not tactical, realm. In World War I and DESERT STORM, ground commanders wanted aircraft to provide information regarding the location and activities of the enemy. The type of aircraft used for reconnaissance mattered little, compared with the necessity of quick response and availability. Improvements in flight speed and endurance were irrelevant if they reduced either of these two critical areas.

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Chapter 2

Development of Unmanned Flight in the United States

In a test that took place several years ago, a small, pilotless biplane took off from Cook Field in Dayton, Ohio. A team led by the inventor Charles Kettering had developed the airborne contraption, conceived as a top-secret weapon to deliver explosives against enemy troops. That was 1918, toward the end of World War I. The craft was the first practical unmanned airplane.

–John DeGespari, "look, Ma, no pilot!" *Mechanical Engineering,* November 2003

Early Experiments

While the rapid growth of UAVs during the Long War could create the illusion that unmanned flight only recently became of interest, experiments with unmanned flight date to the early 20th century. Nikola Tesla, whose promotion of using alternating current for electrical distribution supplanted Thomas Edison's direct current system, first hypothesized about the possibility of unmanned flight in the 1890s. Although Tesla had more success in his experiments with remote-controlled torpedoes, he shared his ideas about remotely-piloted aircraft with Elmer Sperry. In 1917, Sperry received the first military contract for an unmanned flight system to develop an aerial torpedo for the US Navy.[1]

In most technological developments, inventors improve or add to the components designed by their predecessors, and the history of UAVs is no different. The Wright Brothers demonstrated the ability of a heavier-than-air craft to remain aloft. Operating such a vehicle without human control required a method of stabilizing the aircraft. Elmer Sperry, together with Glenn Hammond Curtiss, designed a gyroscope capable of keeping a plane level during flight. In an airplane safety competition in June 1914, Sperry displayed his work. While flying by the crowd, he took his hands off the controls and raised them up out of the cockpit while his mechanic walked out onto the wing. Sperry's gyroscope made it possible for an aircraft to remain stable in flight without constant human control.

The device also included a mechanism for causing the plane to dive after traveling a specific distance. Getting the plane into the air in the first place proved the next major challenge. After receiving the Navy contract in October 1917, Sperry delivered a total of six test aircraft to the Navy. After a dozen test flights, which tested different launch methods, Sperry found that a fly-wheel catapult worked best for getting the planes airborne; however, the fragile structure of the test planes caused them to crash before achieving flight. The flywheel catapult eventually succeeded in launching a new airframe model. Although the model launched properly, the device responsible for making the aircraft dive at a specific distance malfunctioned and the plane flew beyond its designated "crash site" and disappeared over the horizon into the Atlantic. After the war, the Navy continued some research into a "flying bomb" but cancelled the program in 1922.[2]

The Army became involved in unmanned flight research in 1918. In January, Charles Kettering, famous for his invention of the self-starting automobile engine, buuilt a prototype UAV for the Army. Known as the "Bug," Kettering's aircraft had a counter that measured the number of rotations made by the propeller. Upon reaching a preset number, the device cut power to the engine, sending the Bug toward the earth and, hopefully, toward its target. The Army ordered around 100 Bugs. However the war ended before they could be used in combat. In what became a trend for unmanned flight, the cessation of battle decreased the military interest in wartime programs. Accompanying this wane, came a decline in funding for research. Limited research into "aerial torpedoes" did continue until 1926, under Sperry. But it was not until the late 1930s that the military would again take a serious interest in UAVs.[3]

Elsewhere, the British constructed a number of UAVs during the interwar period, to be used both as flying bombs and as practice for targets anti-aircraft artillery. One of these craft, the Larynx successfully flew 112 miles in 1927, but still landed 5 miles away from its target. Although the British performed the initial tests over water, in late 1929 they began testing the aircraft in the deserts of Iraq. There 75 years later UAVs would become a critical tool of the US military. In 1933, a new British model, known as the Fairley Queen, successfully evaded naval gunfire for two hours, proving both the need for more gunnery training within the Royal Navy and the ability of remote-controlled aircraft to provide realistic training.[4]

Unmanned Flight in World War II

The British program led to great improvement in the skill of their naval gunners. When United States Navy Admiral William H. Standley observed the Fairley Queen in action, he recommended that the US Navy pursue a similar program. Research began on the project in 1936 and two years later the Navy successfully used a radio controlled aircraft to test the gunners of the USS *Ranger (CV-4)*. In 1942, the Navy conducted the first experiments adding weapons to a UAV. They attached a television camera and transmitter to the aircraft, along with a torpedo. Upon making contact with an enemy ship, the operator would use a small TV monitor to guide the UAV on an attack run and release the torpedo. Maintenance problems with the UAVs and the success of manned carrier aviation against the Japanese fleet made many naval commanders, including Commander of the Pacific Fleet Admiral Chester W. Nimitz, skeptical of the program. In a series of combat tests in September and October of 1944, the Navy tested 46 of the drones in which 29 hit their target. The program's critics eventually triumphed, and Chief of Naval Operations Admiral Ernest King cancelled the program even before the tests were completed.[5]

The Army pursued UAVs for anti-aircraft target practice at the same time as the Navy. Reginald Denny, an actor and inventor, became interested in a military application for unmanned flight after successfully marketing a remote control toy plane. Flying enthusiasts could purchase the frame for Denny's toy aircraft for $10, the engine for $17.50, and the propeller for $2; or, they could purchase the whole kit for $25. He first approached the Army about producing a remote controlled plane for the military in 1935, but his proposal failed to generate any interest. In 1938, however, the Artillery Branch asked for a demonstration of one of his models. The subsequent show so impressed the observers that they purchased the prototype and Denney signed a contract to produce three more aircraft to be used for further testing. In 1940, he received a contract to produce the RP-4, based on his latest model, which the Army redesignated the OQ-1. Denny and his team continued to refine their product. Throughout the war, his radio plane company produced and sold 50 OQ-1s, 600 newer models OQ-2s, 5,822 OQ-3s, and 2,084 OQ-14s to the Army and the Navy. The performance capabilities of these UAVs increased dramatically over time. While the OQ-2 was powered only by a 6.5-horsepower engine capable of reaching speeds of 85 miles per hour, the OQ-14 had a 22-horsepower engine and could fly at 140 miles per hour. The various models possessed a wingspan of between 12 feet 3 inches to 11 feet 6 inches, and a length of between 8 feet 8 inches and 9 feet 3 inches. During the war Denny's planes only operated as target drones. However, after the war the Army adapted the RP-4 into its first reconnaissance drone.[6]

The most famous use of unmanned flight in World War II was Germany's deployment of V-1 and V-2 rockets. Not particularly effective, only one-fourth of the V-1s launched at London actually hit the city. However, they made the Allies spend far more resources and effort in defending against the attacks than it cost to launch them. In 1944, engineers in the US built an American rocket based on pieces of V-1s. Logistical problems kept the US version, the JB-2, from being widely used in the European Theater of Operation. American engineers spent considerable effort improving the guidance systems of the JB-2 and subsequent models.[7]

Two other American experiments in unmanned flight, Operation APHRODITE and Project Anvil, constituted part of the Allied effort to eliminate the menace of the V-1s. In Operation APHRODITE, a two-man crew flew old B-17 bombers with explosives toward a V-1 launch site. With 25,000 pounds of explosives onboard, these remote controlled bombers held the largest nonnuclear payload in history. Before crossing the channel, the crew bailed out and another B-17 controlled the aircraft via radio controls. Known as the BQ-7, the aircraft never succeeded in destroying their targets. Some suddenly turned around half-way across the Channel and had to be destroyed. German anti-aircraft fire shot down the others. The US Navy attempted similar tests, known as Project Anvil, using B-24s instead of B-17s. The older brother of President John F. Kennedy, Joseph Kennedy, died when his BQ-8, the nomenclature for the explosive filled B-24, exploded before he and his co-pilot could bail out. Project Anvil did achieve a minor success, when a BQ-8 damaged a German sub pen.[8]

In spite of the shortcomings in operational use, World War II represented a milestone for UAV development. The Army and the Navy purchased UAVs in mass for target practice. Now that the concept of unmanned flight had been validated, researchers could begin experimenting with them in other roles. The beginning of the Cold War assured that defense spending would continue to be a priority in the Federal budget. Although many UAV projects withered during the Cold War due to budgetary constraints, there would never be another gap as there had been during the late 1920s and early 1930s in which no research into unmanned flight was conducted.

Early Cold War Tests

In the 1950s and 1960s, the Army, Navy, and Air Force developed new missions and new UAVs to perform them. The majority of UAVs tested after World War II based their design on previous aerial targets or existing manned aircraft. Most of the programs of the era never became operational as a result of technological and budgetary limitations. Despite enormous differences in technology between then and now, many of the concepts developed into the 1950s and 1960s remain the same. The Army tested small, tactical UAVs, similar to the Shadow being used today and the Navy experimented with mounting weapons on a remotely controlled helicopter. Some military leaders worried that the growth of UAVs might eventually make pilots obsolete. Research into unmanned flight during the 1950s began to take on some of the characteristics still present today. A survey organized by branch of service follows.

Army

In tests representing the first attempt to use a drone to replace a manned aircraft, the Signal Corps conducted a number of experiments with unmanned flight for the Army. One of the first projects examined the feasibility of using a remotely controlled drone to lay communication wire along the battle front. A catapult launched the aircraft with wire attached. Once airborne, a controller on the ground guided the drone to its

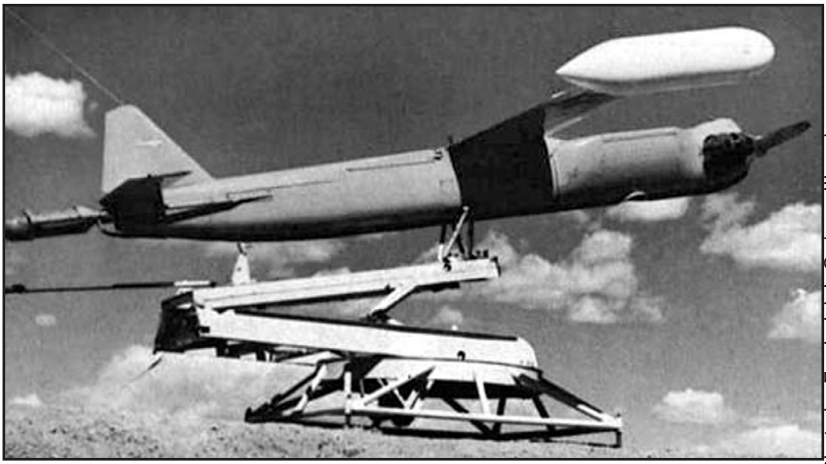


Figure 15. RP-71 from Radioplane.

Photo by Frederick I. Ordway III and Ronald C. Wakeford.

destination, at which point the engine cut out and a parachute deployed. The drone was then recovered and reused. As discussed in the first chapter, the Army had used liaison planes for a similar mission in World War II.[9]

In 1955 the Army began experiments with using UAVs to perform reconnaissance missions. The Signal Corps tested the RP-71 (see Figure 15) at Fort Huachuca, Arizona. The design of the RP-71 was based on Denney's RP-4 target drone. It had an identical wingspan and length of 12 feet. The RP-71 could ascend at over 3,000 feet per minute and reach a top cruising speed of between 185 and 224 miles per hour (different sources record varying top speeds). It operated at altitudes between several hundred feet and four miles high and could stay in the air for around 30 minutes. The drone could be launched with only five minutes of preparation, and its catapult launch system allowed it to operate from the front lines, under the direct control of a ground commander. An operator on the ground used a stick box and an onboard camera to control the aircraft. After performing its mission, the controller flew the RP-71 back over friendly lines, cut the engine and deployed a parachute for recovery. Aerial photographs taken by the drone were processed and in the hands of the commander in under an hour. Even in its earliest form, the RP-71 solved many of the traditional problems Army ground commanders had with aerial reconnaissance support. It was stationed with his forces, it could fly in weather that would ground other aircraft, and the intelligence it gathered could be processed by the unit's staff and be available for use in a timely manner.[10]

Although the RP-71 never deployed in a combat environment, the Army used them in limited capacity until at least 1970. It operated under numerous designations, including SD-1 (SD for surveillance drone, also AN/USD-1), MQM-57A, and "Falconer." During the 1960s the Army deployed the drones to Germany as part of the divisional aviation unit. A drone section functioned as part of the aerial surveillance and target acquisition platoon. During a mission, the controller sat in the mobile radar and tracking cabin to guide the RP-71 to its target. While in the cabin, the radar tracked the flight on a map overlay. Other instruments in the cabin provided the operator with the altitude, speed, and distance from the cabin. Once the drone reached the target, the controller activated the camera. The use of the radar allowed the RP-71 to function beyond the visual range of the controller, greatly increasing its value. In 1961, the British military purchased 35 of the RP-71s from Radioplane.[11]

Four other models received the SD designation. The units that followed became progressively larger and heavier, while achieving higher flight and faster speeds that made them more suited to strategic reconnaissance than tactical missions. The SD-2 first performed tests for the Army in 1958. Initially designed to be a reconnaissance drone, Aerojet weaponized the initial design, adding the capability to distribute a chemical or bacteriological agent. It could also be equipped with side-looking airborne radar. The Army awarded Aerojet several contracts for this model. The mobility of the SD-2 system represented one of its key aspects, as only two standard 6x6 trucks with trailers were needed to transport the drone, its launcher, and control system. Aerojet built a total of 35 SD-2s, however they never entered active service for the Army. The Army Combat Surveillance Agency, formed in 1957, managed the development of the SD-2, as well as the SD-4 and -5. They cancelled the SD-2 program in 1966 due to problems with the navigations system.[12]

The SD-3, -4, and -5 went through only limited testing before being cancelled by the Army. The SD-3 possessed a twin-boom structure with push propellers, similar to the Pioneer and Shadow UAVs used today. The SD-3 system included different sensor arrays built into interchangeable nose units. Capable of film, infrared, and radar, these nose units could be changed quickly and easily to correspond to its mission. Both the SD-4 and -5 received their power from jet engines. This made them substantially heavier (3,500 and 8,500 pounds respectively), but capable of flying at almost the speed of sound. Like the SD-3, the SD-4 possessed interchangeable noses with different sensor arrays. High costs led the Army to cancel the SD-4 in 1961, before it could be test flown. The SD-5 was designed

Designation	Years in Operation (including development)	Weight (lbs)	Length	Wingspan	Top Speed	Maximum Altitude	Engine Type	Endurance
SD-1 (RP-71, MQM-57A, 'Falconer')	1955-1970	430	Information Not Available		184 mph	15000 ft	Piston Engine	40 min.
SD-2 (MQM-58A, 'Overseer')	1958-1966	1135	16'1"	13'4"	345 mph	20000 ft	Piston Engine, 2 Booster Rockets	45 min.
SD-3 ('Sky Spy')	1958-1963	Information Not Available						
SD-4 ('Swallow')	1959-1961	3500	32'0"	11'0"	800 mph	60000 ft	Jet Engine, 2 Booster Rockets	
SD-5 ('Osprey')	1960-1963	8500	36'0"	24'0"	Mach 0.9		Jet Engine, 1 Booster Rocket	3 hr 55 min

Figure 16. Early Army Reconnaissance Drones.

to perform electronic reconnaissance, and could be equipped with side-looking airborne radar, infrared, or various cameras. It first flew in 1960 in Yuma, Arizona. Like the SD-4, however, the Army believed it too expensive to be worth pursuing and cancelled the program in 1963 (see Figure 16).[13]

Although a project of the Marine Corps, the "Bikini" produced by Republic deserves a mention with the Army UAVs because of its similarity to the current Shadow UAV. The Bikini went against the trend of larger and faster drones. It weighed only 60 pounds and could be carried in a single trailer and launched from the back of a jeep. For takeoff, it used compressed air cylinders that were recharged by the flame-thrower compressor already within an infantry battalion. The operator had to maintain visual contact with the drone, limiting its 30 minute flight time to a range of 2,000 meters. However, the photographs captured by the Bikini could be processed and printed within minutes of its return. At the time, the Commandant of the Marine Corps defined the Bikini as "a small item that covers large areas of interest." The Corps intended to assign a drone platoon to each infantry battalion and one more for the regimental commander. However, technical problems led to the project's termination in 1967.[14]

During this period, the Army made significant progress in developing a key component of reconnaissance UAVs: photo transmission systems. *Military Review* reported the development of one such system in 1959 that was scheduled for testing by the end of the year. Although no follow-up article reported on the test results, by 1964 the Fairchild Corporation had developed a system capable of transmitting photographs from an airborne camera to a ground station. The system took two minutes to display the initial picture, with subsequent pictures becoming available every eight seconds. Traditional film continued to be used in the camera, so after landing it could be developed for further scrutiny. The airborne component weighed 125 pounds, a significant payload for all but the larger, jet-propelled UAVs. As this technology progressed, however, it greatly increased the potential of UAVs in the reconnaissance role.[15]

Navy

The Navy pioneered the use of UAVs as a weapons platform with experiments during World War II, and it continued to pursue this application in the 1950s. Apart from target drones, the Navy continued development of two UAVs in the 1950s and 1960s. In 1953, Kaman modified the HTK-1, initially designed as a pilot trainer aircraft for the Navy, to be controlled remotely. During the initial tests, a safety pilot rode in the cockpit, in case something went wrong with the remote control. After nearly 100 hours of flying time, the Navy ordered three more of the drones for further testing in June 1955. The controls for the rotary wing Kaman Drone functioned similarly to the controls for other UAVs of the era. It required a slightly more complicated system because of the ability of a helicopter to fly straight up and down, as well as backward. Despite the more complicated controls, the drone could be controlled by someone without pilot training after only a few hours of instruction. In 1957, it flew its first mission without a safety pilot onboard. The Navy experimented with arming the Kaman Drone, research that laid the groundwork for their next project. Other missions envisioned for the UAV included surveillance, laying communication cable, and transporting cargo. Utimately a new UAV, the DSN-1, replaced the Kaman Drone. The DSN-1 was part of the Drone Anti-Submarine Helicopter (DASH) program.[16]

In 1960, the Navy acquired the DSN-1 from Gyrodyne. Like the Kaman Drone, the DSN-1 evolved from a previously developed manned helicopter. The DSN-1 successfully landed onboard a destroyer at sea in July 1960.

US Navy photo.

Figure 17. Navy QH-50 "DASH" UAV.

The Navy envisioned using UAVs to increase the strike capability of older destroyers against submarines. In World War II, once a destroyer made sonar contact with an enemy submarine, the ship would have to maneuver toward the target and close the distance between sonar range and weapons range. During this time, the submarine had time to escape or launch its own attack. The DASH program, part of the Fleet Rehabilitation and Modernization (FRAM) Project, sought to give the destroyer an improved anti-submarine weapon. Launching a torpedo from an unmanned helicopter greatly extended the strike range of a destroyer.[17]

The DSN-3 used a turbine powered engine that provided nearly four times the horsepower of the DSN-1 and became the standard UAV for the DASH program in 1963 (see Figure 17). The designation changed to QH-50C shortly after this. Unlike the Kaman Drone, the QH-50C could operate beyond visual range of the destroyer. It still used line-of-sight controls for takeoff, landing, and while flying near the ship. Once the drone closed on the target, control passed to the ship's combat information center. From there, the new controller used sonar and radar to guide the drone to the target. In 1965, the QH-50D entered production with a more powerful engine. Although the Navy initially intended to only outfit older destroyers with DASH, the success of the program led to its expansion to newer destroyers as well.[18]

Despite the initial promise of the DASH system, the program literally and figuratively crashed in 1969. The *Journal of the Armed Forces* had published an article the year before which claimed that of the 800 DSN-3s built, only 375 remained in service. The average DSN-3 lasted only 80 hours before crashing. This represented a very poor return on the over $236 million invested in DASH through fiscal year 1966. The control system, based on a 20-year-old-design, held a significant responsibility for the high attrition rate. Adding a new control system would have increased the cost from $125,000 per unit to $200,000. The Navy found itself in a situation in which it could not afford the continued failure, nor could it afford to fix the problem. A report by the General Accounting Office (GAO) in 1970 found that the concurrent development of the destroyers and the UAVs led to some of the problems encountered by the Navy. Some of the destroyers being rehabilitated to be equipped with the DSN-3 finished undergoing the updates three years before Gyrodyne finished the first aircraft. As a result, Gyrodyne rushed the testing of the drones before delivering the initial models to the Navy. The Navy amplified the problem by ordering the drones in large quantity before they completed their own testing of the initial delivery. As a result, Gyrodyne came under heavy pressure to put the DSN-3 into production before it was adequately tested. The GAO warned that in the future, concurrent development and production of military systems should be avoided.[19]

The DASH proved so problematic that when *Sea Power* featured an article on naval applications of remotely piloted vehicles in 1973, the article did not mention the Navy's earlier tests. Despite this "selective amnesia," the article lays out several of the possible benefits of UAVs which continue to be echoed by UAV advocates today: lower cost and less risk for pilots. Although proponents of UAVs have consistently touted their economic advantages, the majority of UAV programs that failed during the Cold War did so because of high development costs. The Army's SD-2, -3, -4, and -5, as well as the Navy's DASH drones all fell victim to budgetary constraints. The article also addresses a concern that UAVs might eliminate the need for pilots, both of which linger to this day. The author's response is just as true then as it is now. He argued that the development of cruise missiles did not eliminate the need for manned bombers, and neither would unmanned reconnaissance or utility UAVs remove the need for manned reconnaissance flights. Second, UAVs will always require some form of human guidance, either via in-flight controls or preprogrammed missions.[20]

Air Force

Of the three armed services, the Air Force's experiments with unmanned flight in the early Cold War proved to be enduring. Like the other services, the initial interest in unmanned flight revolved around aerial targets. In 1948, Ryan Aeronautical Company sold the Q-2, a jet-propelled target drone, to the Air Force. Known as the Firebee, its reconnaissance derivatives continued to serve in a modified role as recently as Operation DESERT SHIELD. However, it took over 10 years for the Firebee to make the transition from target to reconnaissance missions. In 1958, Ryan began production of the Q-2C, the first model to be modified for reconnaissance missions. It could travel just below the speed of sound at heights of up to 60,000 feet and with a range of 800 miles.[21]

Ryan Aeronautical started experimenting with adapting the Firebee to function as a reconnaissance drone in late 1959. The development team faced two initial problems. First, the range of the Q-2C limited its ability to perform strategic reconnaissance over the heart of the Soviet Union. To provide full coverage, an aircraft required a range of over 2000 miles. For the Q-2C to achieve this kind of range, it required a larger wing to support a newer engine and increased fuel capacity. The second major problem was related to the radar signature of the drone. If the Q-2C was to fly across the Soviet Union, it had to be nearly invisible to radar. The developers reduced radar reflectivity by covering the engine air intake with a mesh cover, using non-conductive paint on the nose, and by adding a cover of radar absorbing material on the sides. Although the service picked Ryan's design over a Boeing model, many in the Air Force believed the manned SR-71 supersonic reconnaissance aircraft better suited the service's needs. Support for the SR-71 continued even after Francis Gary Powers' U-2 was shot down over the Soviet Union in 1960, an event which showed the risk of manned reconnaissance flights. The Air Force proposed $1 million for the development of a reconnaissance UAV and sent it to the Secretary of Defense. He did not sign the request, but instead left a note which read, "I thought we weren't going in this direction." Shortly after, John F. Kennedy won the Presidential election and all new projects were put on hold until the new administration took office.[22]

The team at Ryan Aeronautical labored two more years in search of a contract, but every time they got close, someone in the Air Force turned them down. In 1962, the Air Force finally awarded the company a small contract to produce four reconnaissance drones for testing. The contract was part of the "Big Safari" program, a procurement method designed to streamline the contract process. Big Safari allocated money for the alteration of existing aircraft, exactly what the Ryan team intended to do with the Q-2C. The first test flights of the Ryan 147A Fire Fly occurred only two months from the time Ryan received the contract. On April 27, the first test was performed with a camera on board. Both the performance of the drone and the quality of the pictures taken achieved the required standards. The only remaining question related to the survivability of the modified drone in hostile airspace. In May, the Air Force conducted a live-fire exercise using the modified 147A as a target. Although the pilots regularly flew against the Q-2C, the 147A proved a far greater challenge. The Air Force scrambled five F-106s against the Fire Fly, each of which fired four air-to-air missiles, none of which succeed in bringing down the resilient drone.[23]

Convinced that the concept of a reconnaissance drone could work, the Air Force gave Ryan a contract to build nine more aircraft from scratch. The new model, the 147B, was four feet longer than the 147A and had a wingspan of 27 feet, double that of its predecessor. Contracts for other models with various adjustments followed soon after. By 1964, models B, C, D, and E were all in various stages of testing. In July 1963, the first drone reconnaissance unit in the Air Force became operational, as part of the 4080th Strategic Reconnaissance Wing. Despite the progress being

Ryan Model	Military Model	Length	Wing Span	Thrust (lbs.)	Mission	Operational Period	Number Launched	% Return
A		27'	13'	1700	Fire Fly - first demo drone	Apr 62-Aug 62		
B		27'	27'	1700	Lightning Bug - first big-wing high-altitude day photo bird	Aug 64-Dec 65	78	61.5%
C		27'	15'	1700	Training, low altitude tests	Oct 65		
D		27'	15'	1700	From C, electronic intel	Aug 65	2	
E		27'	27'	1700	From B, high-altitude electronic intel	Oct 65-Feb 66	4	
F		27'	27'	1700	From B, high-altitude electronic intel	Jul 66		
G		29'	27'	1920	Longer B with larger engine	Oct 65-Aug 67	83	54.2%
H	AQM-34N	30'	32'	1920	High-altitude photo; more range	Mar 67-Jul 71	138	63.8%
J		29'	27'	1920	First low-altitude day photo	Mar 66-Nov 67	94	64.9%
N		23'	13'	1700	Expendable decoy	Mar 66-Jun 66	9	0.0%
NX		23'	13'		Decoy and medium-altitude day photo	Nov 66-Jun 67	13	46.2%
NP		28'	15'	1700	Interim low-altitude day photo	Jun 67-Sep 67	19	63.2%
NRE		28'	13'	1700	From NP, first night photo	May 67-Sep 67	7	42.9%
NQ		23'	13'	1700	Low-altitude NX, hand-controlled	May 68-Dec 68	66	86.4%
NA/NC	AQM-34G	26'	15'	1700	Chaff and electronic-countermeasures	Aug 68-Sep 71		
NC	AQM-34H	26'	15'	1700	Leaflet dropping	Jul 72-Dec 72	29	89.7%
NC(M1)	AQM-34J	26'	15'	1700	Interim low-altitude day photo and training			
S/SA		29'	13'	1920	Low-altitude day photo	Dec 67-May 68	90	63.3%
SB		29'	13'	1920	Improved SA low-altitude	Mar 68-Jan 69	159	76.1%
SRE	AQM-34K	29'	13'	1920	From SB, night photo	Nov 68-Oct 69	44	72.7%
SC	AQM-34L	29'	13'	1920	Low-altitude workhourse	Jan 69-Jun 73	1651	87.2%
SC/TV	AQM-34L/TV	29'	13'	1920	From SC, with real-time TV	Jun 72-	121	93.4%
SD	AQM-34M	29'	13'	1920	Low-altitude photo, real-time data	Jun 74-Apr 75	183	97.3%
SDL	AQM-34M(L)	29'	13'	1920	From SD, with Loran navigation	Aug 72	121	90.9%
SK		29'	15'		Navy operation from aircraft carrier	Nov 69-Jun 70		
T	AQM-34P	30'	32'	2800	Larger engine; high-altitude day photo	Apr 69-Sep 70	28	78.6%
TE	AQM-34Q	30'	32'	2800	High-altitude; real time communications intel	Feb 70-Jun 73	268	91.4%
TF	AQM-34R	30'	32'	2800	Improved long-lange TE	Feb 73-Jun 75	216	96.8%

Figure 18. Model 147s in Vietnam.

made, the Air Force continued to resist the development of unmanned reconnaissance drones. Some Airmen resisted out of a lack of confidence in the technology; others out of fear of being replaced.[24]

UAVs during the Vietnam Era

Operational Use

Reconnaissance UAVs made their first combat appearance during the Vietnam War. Although the Army did not deploy its SD-1 drones in Southeast Asia, both the Air Force and the Navy sent in the UAVs developed in the late 1950s and early 1960s. From 1965 and 1975, Lightning Bugs (the new name given to the Firebees) performed 3,425 reconnaissance missions. Depending on the model, they flew both high and low altitude flights, as well as visual and electronic signal intelligence missions (see Figure 18). The Air Force also experimented with an ultra-fast reconnaissance UAV, capable of reaching Mach-3. The Navy modified some DSN-3 drones to provide live video feed back to the ship, which they used to direct naval gunfire.

The Lightning Bugs arrived in Southeast Asia and performed their first operational mission on 20 August 1964 (see Figure 19). Two 147Bs were attached to wing pylons of a GC-130 and flown from Kadena Air Force Base on Okinawa toward Vietnam, although their targets lay in mainland China. Ideally, once they reached the drop point (all the Lightning Bugs were air-launched), the GC-130 released the drones which flew a pre-programmed route over the coast of mainland China and back toward Taiwan, their recovery point. All of the initial missions followed a pre-programmed route. The operators, who were Ryan employees, programmed the flight plans up to two weeks in advance of the mission, making adjustments for the estimated wind. Very few of the early missions went according to plan. Some crashed, some made mysterious turns while in flight and never returned, one failed to switch to remote control for landing and flew past the recovery zone before running out of fuel, and even when everything did go right the Lightning Bugs often sustained considerable damage on the landings. After some modifications in late September, the controllers could take control of errant drones, which reduced the number of missions that failed due to navigational errors. The drones also began operating out of Bien Hoa in South Vietnam and by the end of 1964 the number of successful missions greatly increased. In mid-1965, new models of the 147

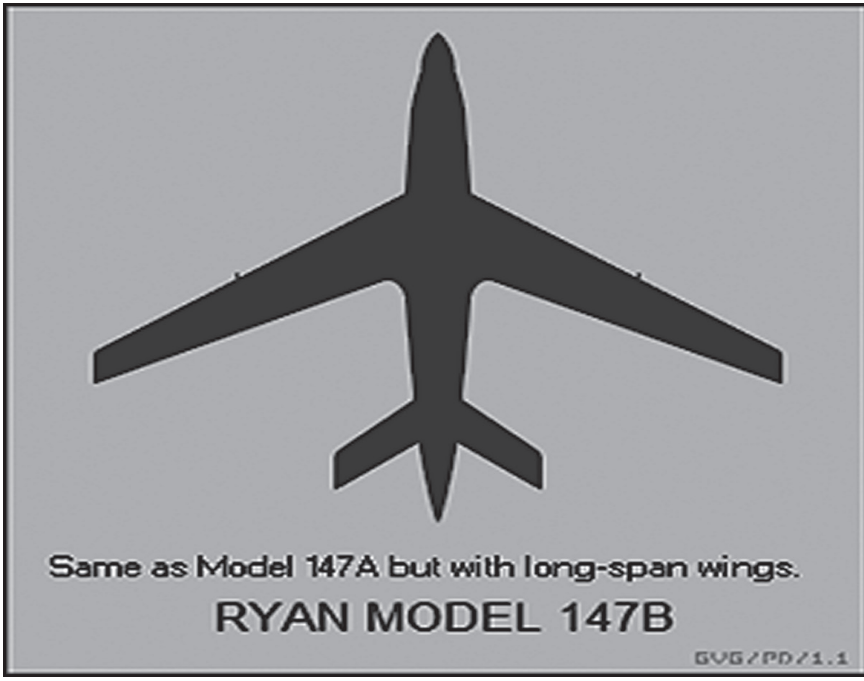
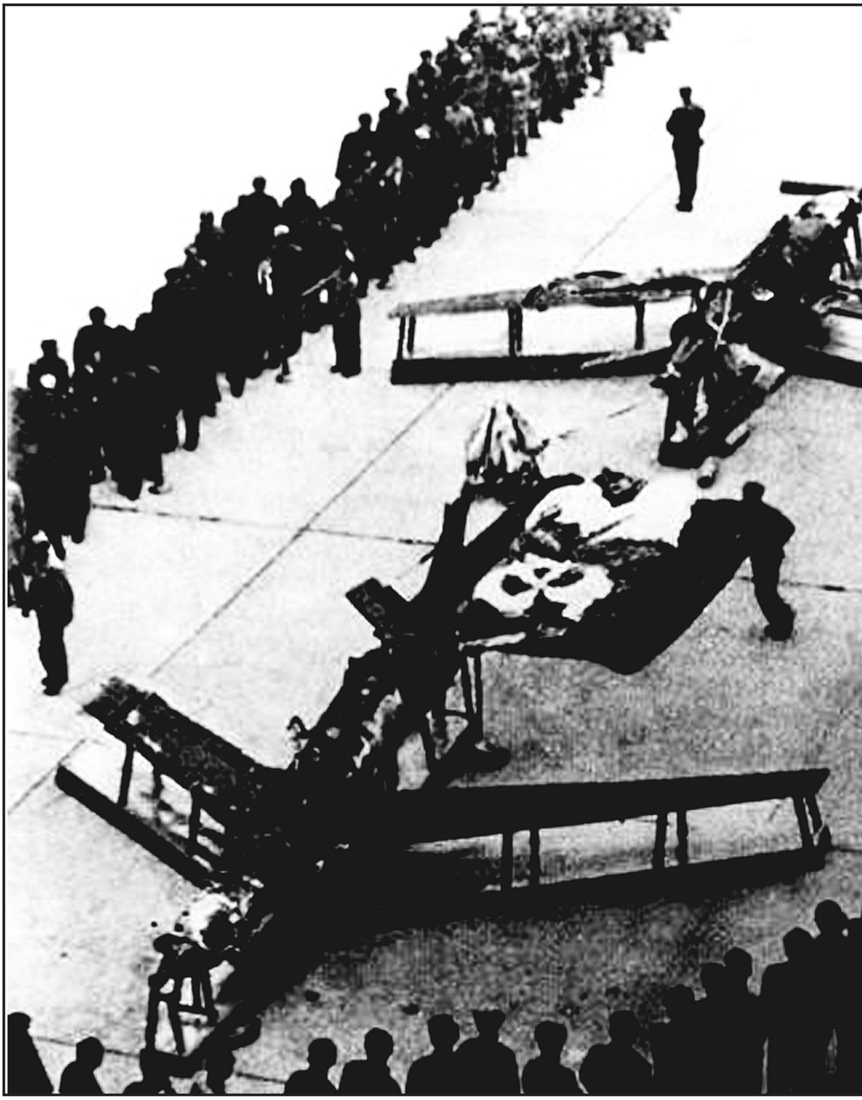


Figure 19. Ryan 147B "Lightning Bug."

began replacing the 147B. The 147Bs flew a total of 78 missions, 48 of which ended successfully. The average B model flew 2.6 missions before crashing.[25]

In mid-November, the United States Air Force lost a 147B to enemy action for the first time. While flying a mission over China, the Chinese People's Liberation Army Air Force shot down the drone. Some speculated the Air Force used the drone to provoke the Chinese Air Defense, while manned electronic intelligence aircraft recorded the radar activity on the ground. The US government neither confirmed nor denied flying drones over China. One week after, a *New York Times* article described the possibility of unmanned reconnaissance aircraft being used in Southeast Asia. The development of the Army's SD series had been mentioned in *Military Review* in the 1950s, so the existence of reconnaissance drone projects was not classified. It was not known, however, to what extent they were operational, if at all. The author of the *Times* article speculated that the Air Force likely used drones for some reconnaissance, but questioned whether unmanned flight could provide as good intelligence as traditional manned reconnaissance planes because of limitations on the flight time



New China News Agency photo. by Xuan

Figure 20. Reconnaissance Drones Shot Down Over China on Display.

and range of drones. Unlike the Soviet U-2 incident, the loss of a 147B did not deter the US from future unmanned flights over China. By May 1965, the Chinese had shot down eight of the drones, but they continued to fly and provide valuable intelligence (see Figure 20).[26]

By early 1965, the 147Bs proved the viability of reconnaissance UAVs. With a market established, Ryan began developing new models of the 147 for the Air Force. Some of the new models increased the capability of the B model, while others possessed unique characteristics. During the monsoon season, cloud cover limited the coverage the high altitude B model could provide. The first step in overcoming these challenges was to find a way to get the drones to fly at a lower altitude. Ryan installed a newly developed barometric low altitude control system (BLACS) on several 147Cs to test its capability. Although the BLACS worked effectively, the developers believed a better airframe was necessary to carry the system. This led to the development of the 147J, which entered service in 1966. In 1969, the 147SC entered service. This low-altitude model flew more missions than any other.[27]

Enemy action, specifically the newly deployed SA-2 anti-aircraft missiles, created an opportunity and a challenge for the Lightning Bugs. After observing an SA-2 shoot down a Lightning Bug over Hanoi, a U-2 pilot told the drone operators they could have the high-risk missions from now on. This pilot's sentiment soon became Air Force policy. The danger created by these new missiles led to more and more reconnaissance missions being tasked to the drones than to manned reconnaissance. Although they did not risk the life of a pilot, the Lightning Bugs were useless if they could not survive their flights over North Vietnam. To counteract the SA-2, Ryan developed the 147E model using electronic intelligence sensors from the 147D and the frame of the 147B. Their objective was to get the 147E shot down by an SA-2 missile, so sensors could record and transmit important information about the SA-2s fuse and guidance system. After a number of failed attempts, on 12 February 1966, a 147E provided all of the necessary data to the Air Force. This information allowed for the development of electronic counter measures to the SA-2 which helped protect American pilots for the next six years. The 147F tested the ALQ-51, a counter-missile package, for the Navy in 1966. One of the missiles flew 10 missions in high danger areas without being hit. Unmanned aerial vehicles provided a way of gathering technological capabilities of enemy weapons and testing counter-measures, all without risking the life of a pilot.[28]

In 1966, Ryan developed another component that increased the effectiveness of drone reconnaissance. The 147H (lighter than the 147B, but with a longer range) became the first model to test a mid-air retrieval system (MARS), which eventually was used on the 147J. In theater, the MARS worked 97 percent of the time, eliminating damage to the drone and the on-board film which was sometimes sustained during chute landings.[30]

Contractors from Ryan played a large role in the operations of the Lightning Bugs. In the early stages, they worked side-by-side with Air Force personnel, training them how to program and maintain the drones. The Air Force struggled to staff the drone units, and Ryan contractors filled this void, even flying on the C-130 launch aircraft to control the drones. One employee, Dale Weaver, served as a launch control operator for the drones on more missions than any military personnel. Another, Ed Christian, volunteered to be lowered from a helicopter into dense jungle, to recover the film from a drone that failed to be retrieved using MARS. The role played by contractors illustrates two issues that reemerged during the Long War. First, hostilities in Vietnam decreased the time between development and deployment. As a result, Ryan personnel were needed to troubleshoot the drones in theater to fix problems that would normally be solved in the development phase. Additionally, because the reconnaissance drones entered production so close to the escalation of the war, the Air Force had limited time to train personnel before placing them in theater. The second problem had to do with the outlook of Air Force personnel. Many believed, perhaps correctly, that working in a drone unit (as opposed to a U-2 unit) could stall their career. In an attempt to rectify this, the Air Force eventually created an airborne missile maintenance squadron, which put the Lightning Bug units on the same organizational level as the U-2s.[31]

During the Vietnam War, Ryan Aeronautical's Lightning Bugs performed many of the same missions, with similar problems, as the UAVs used in the Long War. They flew both high- and low-altitude missions,

US Air Force National Museum photo.

Figure 21. Beechcraft Bonanza QU-22B.

gathered electronic signal intelligence, provided real-time data, launched from air, land and sea, provided targeting information for missiles, and used photographic, infrared, and radar to acquire information on enemy forces. In the early 1970s, Ryan tested the 147 for use as an unmanned combat aerial vehicle (UCAV), attaching a Maverick missile to the bottom of a Lightning Bug that could be fired on command. The low-cost of the various 147 models, when compared with the expense of a plane like the SR-71, the high-speed, high-altitude replacement for the U-2, caused some pilots to fear for their budget. In 1971, Ryan sold a number of Lightning Bugs to Israel, which fueled that nation's interest in UAV development.[32]

Photographic intelligence gathered from UAVs helped the Air Force disprove propaganda regarding the extent of bombing in Hanoi and Hai Phong. Communists accused the Air Force of carpet bombing these cities and causing tremendous damage to civilian areas. Although not released until 1973, long after the bombing campaign, reconnaissance drones had taken over 600 pictures of the actual objectives and the effects of the bombing.

In addition to the various Ryan 147 Models, the Air Force modified a Beechcraft Bonanza Model A36 for unmanned flight. Under the designation QU-22B, these converted utility aircraft served as communication

CIA photo.

Figure 22. SR-71 Air-launching a D-21 Drone.

relays. Despite being able to fly without a pilot onboard, one usually flew with the plane to insure successful takeoff and landing. The QU-22Bs first entered operation in 1971 as part of the Pave Eagle program (see Figure 21). High losses led to the withdrawal of them from active service late in 1972.[33]

The Navy revived the DASH program during the Vietnam War to provide an unmanned reconnaissance capability for its ships. Under Project Snoopy converted the DASH drones were related to provide real-time video images to destroyers off the coast. Equipped with a television camera and transmitter instead of a torpedo, the UAV flew over the coast to assist in the acquisition of targets and adjustment of fire for the ship's 5-inch guns. In 1968, the Marine Corps tested three of these modified QH-50s for use in ground operations. The Defense Advanced Research Project Agency further modified the drone to carry a moving target indicator (MTI) radar and various weapons systems. These systems never reached combat operations. Ryan's Lightning Bugs flew the majority of successful UAV missions during the Vietnam War, with the Navy's ship-launched QH-50 reconnaissance drones a distant second. During this time, however, the military intelligence community tested several other systems.[34]

Research and Development

The D-21 represented the most extraordinary of these systems. Designed with the objective of photographing China's Lop Nor nuclear development facility near the Mongolian border, Lockheed's secret "Skunk Works" lab built a drone capable of being air-launched from an SR-71 (see Figure 22), which could fly at Mach 3 at an altitude of 100,000 feet, take pictures of the Chinese facility, then return to international waters and drop its film to a waiting destroyer. Lockheed pitched the idea to both the CIA and the Air Force in the early 1960s. Although the CIA initially showed little interest, they reversed their position once the Air Force decided to invest in the project. The D-21 project, codenamed Tagboard, showed potential, although it never fully worked. During its tests in 1965, it successfully launched from the SR-71 on the first three tries. On the fourth try, however, the drone collided with the SR-71 "mother-ship," leading to the death of the copilot and the loss of the SR-71. Following this tragedy, the Skunk Works developers changed the launch vehicle to a B-52. After numerous successful tests (and a few unsuccessful), President Richard Nixon approved the first operational mission for the D-21 in 1969. The drone launched successfully and flew to its target, Lop Nor, but instead of turning around, went on to the Soviet Union and eventually crashed in

Siberia. Everything went fine on the next mission, until the chute on the film failed to open and the package crashed into the ocean. Finally, on the third mission all aspects of the flight and drop went according to plan, but rough seas prevented Navy destroyer from retrieving the package. On the fourth and final attempt, the D-21 disappeared over Chinese air space. The Defense Department cancelled the program in July 1971.[35]

Ryan Aeronautical also developed a reconnaissance UAV capable of penetrating deep into Chinese airspace: the Model 154, (also known as the Compass Arrow, or Fire Fly). Instead of flying extremely high-speeds like the D-21, the Fire Fly possessed a unique design that made it nearly impossible to pick up on radar. Despite its top secret classification, the drone made headlines when it descended prematurely and landed near the perimeter of the Atomic Energy Commission complex at Los Alamos, close enough to the fence to be within view of the public. After undergoing extensive testing by Ryan and the Air Force, President Nixon's efforts at reconciliation with China in the early 1970s prevented the Model 154 from being used over China. Despite never reaching operational status, knowledge gained from the project was applied to stealth aircraft and UAV development.[36]

Another line of development followed by the Air Force focused on high-altitude long-endurance (HALE) aerial vehicles in 1968. The initial program, Compass Dwell, experimented with both manned and unmanned variants. A later program, Compass Cope, exclusively worked on developing a HALE-UAV. LTV Electrosystems upgraded the design of a sailplane to construct a manned aircraft. The company performed three tests with a pilot onboard, before testing the unmanned version, the XQM-93. In January 1972, the XQM-93 set an endurance record by remaining aloft for 22 hours. Martin Marietta also submitted a prototype for the Compass Dwell program, the 845A. Similar in design to the XQM-93, it bested the endurance record by flying for 27 hours and 55 minutes in July 1972. The prototypes designed for the Compass Dwell program demonstrated the potential for HALE-UAVs. However, budgetary priorities prevented the Air Force from purchasing either craft for operational use.[37]

In 1970, the Air Force joined with the National Security Agency for Project Compass Cope. The NSA wanted a HALE-UAV with electronic signals intelligence capability. Sharing the project made it more affordable for the Air Force. The program gave out two contracts, one to Boeing and one to Ryan. Boeing's prototype, the YQM-94A or Compass Cope-B ("B" for Boeing), flew one successful mission in June 1973 but crashed during the next flight. A second YQM-94A performed better, remaining aloft for 17 hours in one flight. The YQM-98A (Compass Cope-R, for Ryan) first flew in August 1974. It surpassed the endurance records set by the Compass Dwell program with one flight lasting over 28 hours, without refueling. That record remained for 26 years until another Ryan UAV, the RQ-4 Global Hawk, flew for over 30 hours without landing or refueling. Although the tests demonstrated the potential for HALE-UAVs, many people still believed all the needs for intelligence gathering could still be accomplished by more reliable, manned flights. The program was cancelled soon after setting the endurance record.[38]

UAV Development After Vietnam

Despite high expectations for UAV development after Vietnam, another decade passed before the military seriously pursued new systems again. The armed forces continued to use target drones, while some research persisted into the development of reconnaissance UAVs. Although spending on research and development of UAVs did increase in the 1980s, most notably on the Aquila program, costs tended to overrun the budget and raised questions about whether UAVs actually could save money.

Sky Eye

The largest program during the 1970s was Developmental Sciences Incorporated's (DSI) Sky Eye program. The prototypes developed dramatically throughout the course of the program, which lasted over a decade. The RPA-12, its official designation, initially possessed a swept-wing, tailless design with a rear propeller. It had a wingspan of 11 feet 6 inches, but an overall length of only 5 feet 7 inches. DSI started development in February 1973 with the first successful flight less than two months later. The Sky Eye I-A, the original model, took off and landed from a runway. In a second model, the Sky Eye I-B, DSI made minor adjustments to the design and changed to a launch takeoff and parachute recovery. The I-B could fly at speeds of up to 138 miles per hour for up to nine hours, whereas the I-A could only reach 105 miles per hour and stay aloft for six hours. By the mid-1970s, DSI began producing the Sky Eye II, which the Army purchased in small numbers. The Sky Eye II was essentially the same as the earlier models, but constructed with different materials. In 1975, the Sky Eye program went in two different directions. DSI continued using the name Sky Eye for many of its UAVs,

	Wingspan	Length	Weight	Top Speed	Altitude Limit	Endurance
I-A	11'6"	5'7"	55 lbs	105 mph	13,000 ft	6 hr
I-B	11'6"	5'7"	60 lbs	138 mph	15,000 ft	9 hr
R4D	12'4"	6'11"	100 lbs	150 mph	20,000 ft	6 hr
R4E-5	8'9"	6'1"		81 mph	5,000 ft	30 min
R4E-10	11'	7'1"		115 mph	10,000 ft	3 hr
R4E-30	17'7"	12'2"	263 lbs	144 mph	15,000 ft	8 hr
R4E-40	17'7"	13'10"		155 mph	15,000 ft	9 hr
R4E-70	20'10"	18'11"		184 mph	20,000 ft	

Figure 23. Models of Sky Eye.

although the vehicles grew significantly in size from the original Sky Eye I and IIs. In 1975, DSI received a contract from the Army to develop a small-UAV similar to the Sky Eye II. This was the start of the Aquila program, and DSI subcontracted this out to Lockheed Missile and Space Company.[39]

By 1979, the primary version of the Sky Eye in operation was the R4D. The model contained only minor changes from the previous designs. The following year, DSI began production of the R4E series. The different models of the R4E varied in design from the R4D, and ranged greatly in size and mission capability. Each of the models possessed a twin-boom design, similar to the Hunter system still used today. The smallest model, the R4E-5, served as a trainer for the rest of the series. The slightly larger R4E-10 provided a tactical reconnaissance capability. It could be transported in the back of a truck, and a crew of three men could launch and operate it, while receiving real-time video transmission. The next model, the R4E-30, designed as a UCAV, was evaluated but never ordered by the Army. It could carry and fire 2.75 inch rockets, Viper rockets, and potentially even “smart” munitions. The R4E-40 possessed the same frame as the 30 model, but had a larger fuel tank and carried reconnaissance equipment instead of weapons. The final model, the R4E-70 was the largest and was designed for longer range reconnaissance missions. The Royal Thai Air Force purchased a squadron of R4E-30s in 1982, two years before the US Army first purchased a squadron of R4E-40s for testing. This squadron later deployed for operations in

Central America. In 1985, the Army purchased a second squadron for $8.2 million. Acquisition of the Sky Eye remained limited, as the Army remained focused on the development of the Aquila system (see Figure 23).[40]

The normal crew for a Sky Eye consisted of six people: a team commander, mission planner, RPV (remotely piloted vehicle) operator, payload operator, electronics technician, and mechanic. The Sky Eye could be flown in one of three ways: direct control, auto-pilot control,

Redstone Arsenal photo..

Figure 24. Aquila.

or pre-programmed missions. In auto-pilot control, the RPV operator set a course and altitude, and the auto-pilot maintained those settings. On a pre-programmed mission, the RPV followed a course of up to 256 way-points. Altitude, heading, and airspeed could be adjusted at each way-point. The mission planner programmed these missions, and the RPV operator controlled the Sky Eye on direct control and auto-pilot missions, using two monitors (one for instrumentation and one for the video feed from the on-board camera), a pair of joysticks, and several other controls. The payload operator had responsibility for controlling whatever sensors (or weapons) the RPV carried on a mission. Possible payloads included daylight television, low-light-level television, forward-looking infrared, infrared line scanner or a 35-mm panoramic camera. He viewed the in-coming information on a monitor, which also recorded the data.[41]

Aquila

Lockheed Missiles and Space Company (LMSC) began development of Aquila (Latin for "eagle") in 1975, after receiving a subcontract from DSI (see Figure 24). The Army wanted a UAV that could provide laser designation for the Copperhead precision munitions being developed at the same time. DSI provided LMSC with 23 Sky Eye units to assist in development. The first test flight occurred in December 1975. After three years and almost 200 flights, Aquila demonstrated its ability to mark a target using its onboard laser, guiding a Copperhead round to a stationary tank. The Copperhead was fired from nearly seven miles away. The initial stage of the program, which ended in 1978, appeared promising enough for the Army to grant a $123 million dollar contract to LMSC in 1979 to enter full scale development, with $440 million for acquisition of 780 RPVs and other equipment.[42]

While in development, Aquila experienced several significant problems. In 1982, the GAO commissioned a study of the Aquila program. By this point, the expected costs had risen to $1.6 billion. The data link and the mission payload represented the two greatest obstacles. The size of these components remained too large to fit inside the vehicle. Lockheed experimented with using a different data link that met the specifications regarding size, however this alternate component was not as sophisticated as the original. The simultaneous development of multiple components of the UAV led to problems similar to those encountered by the Navy's DASH program two decades earlier. The developers sacrificed performance in an effort to meet development and production timelines. Simultaneous development allowed Lockheed and the Army to perform tests on individual components, without waiting for another component to be completed. For example, in 1981 they tested an interim data link in a manned aircraft. Even if the individual components worked, the matter of integrating all of them into a design that met performance specifications remained difficult. The initial development contract contained a 43-month timeline for development; however, the technical challenges set this timeline back significantly.[43]

In 1985, Congress refused to allocate the funds requested by the Army for Aquila to enter production, as they felt the system had not been adequately tested. The year before, the Army tested seven other UAVs as possible replacements for the Aquila. They found that despite the problems in development, to achieve the desired performance Aquila would still cost less and could be ready faster than any alternative. The Army based this decision mainly on the original mission intended for the program: target acquisition. Although other UAVs could perform the additional reconnaissance tasks for which they intended to use Aquila, to add the targeting capability to a UAV already in operations would be too expensive. In response to rising projection for production costs, the Army reduced the number of systems it planned to purchase from 995 to 548 in 1984. The budget for procurement remained at $1.1 billion, only slightly less than the previous amount allocated for almost double the number of vehicles. The Army reduced the number planned for purchase again the following year, dropping to only 376 systems. The Army halted development tests in 1985, due to continued problems with several components. In an effort to keep the Army or Congress from ending the program, Lockheed promised to pay over $30 million to supplement development costs in 1986 and 1987. Congress agreed to continue the program, but Lockheed was not able to overcome the problems in the system.[44]

The GAO published another report on the Aquila system in October 1987. By 1987, development costs had risen from the initial budget of $123 million to $868 million. The report contained by far the most critical assessment of the UAV to date. The report focused on the Army's series of operational tests conducted from November 1986 to March 1987. A completed mission included successful launch and flight operations, detecting enemy targets and directing artillery to them, and finally recovery. Out of 105 test flights, the Aquila fulfilled the requirements on only seven missions. The GAO also found that an enemy with a good aerial defense system would likely be able to detect the Aquila and engage it with anti-air weapons. During the operational testing, the Army did not include enemy air defenses, which would have further decreased the number of successful flights. In addition to survivability, the GAO judged launch, detection, recognition, and location of enemy targets, reliability and maintenance, and human engineering to be areas of "major problems." The problem of human engineering came from the complicated system used to control the UAV. Before widely deploying the Aquila, the Army realized it needed to either simplify the controls or spend a significant amount of time training its operators. The GAO found minor problems in artillery adjustment and questioned its growth potential. On a positive note, the report deemed Aquila's flight, recovery, mobility, and electromagnetic compatibility successful (although the electromagnetic compatibility testing was not fully completed at the time of the review, and the use of radios during the tests was banned during flight

US Navy photo, 2nd Class Daniel J. McLain.

Figure 25. Pioneer UAV.

testing for fear they might interfere with the control system). The GAO recommended that much further testing needed to be done before a decision on whether or not to begin production of Aquila could be made, a decision slated for 1988. The Department of Defense believed the GAO finding to be overly pessimistic and argued that despite its problems, the Aquila provided the best possible option for UAV development. Despite these objections, the Army decided in 1987 to end the program, before it ever entered production.[45]

The Aquila's expensive sensor and data-link package represented a growing trend in UAV development. The majority of costs of many UAV programs in the 1980s were not for the vehicle itself, but for its sensor payload. In 1986, before the program underwent further complications, the Army estimated the production cost of the Aquila to be around $1 million for each UAV (not including its support system). Of this $1 million, only $240,000 went toward the basic air vehicle. Between 1982 and 1986, the Army spent $91.9 million to develop the data link and $38 million on the FLIR package. While the cost of building unmanned vehicles capable of remote control remained steady, the cost of the onboard electronics grew higher and higher.[46]

Pioneer

The Navy acquired the Pioneer UAV (see Figure 25) system from Israel in 1986. The Israelis first developed an interest in using UAVs for reconnaissance in the mid-1960s. They visited with people from Ryan Aeronautical in 1967 and 1969, but no purchases came from these early visits. After Egypt shot down two Israeli F-4 Phantom reconnaissance jets, the Israeli Air Force began to look seriously for a reconnaissance UAV. They met with representatives from Ryan again in the spring of 1970 in Israel. A short time later, Israel agreed to buy a dozen of Ryan's model 124 target drones, modified to be nearly identical to the 147SD. After taking delivery in the middle of 1971, they used these UAVs to patrol the Suez Canal zone, sometimes even daring to send them over Cairo for photo reconnaissance. During the Yom Kippur War, the Israeli Air Force used the Ryan model and another reconnaissance drone, known as the Chucker, for intelligence missions over both Syria and Egypt.[47]

In 1978, Israel tested its first domestically produced UAV: the Mastiff Mk I. The Mastiff was part of a new generation of what were called mini-UAVs, although compared with some of the UAVs in service today as part of the Long War, the Mastiff was hardly "mini." It measured 8 feet 6 inches long, with a wingspan of 13 feet 9 inches, around half the size of the Ryan's 147. A new model, the Mk II entered service in 1980, as did Scout, another domestically built mini-UAV. The Mastiff Mk II and the Scout possessed a somewhat limited range, but they could provide intelligence from Lebanon and southern parts of Syria. Before the invasion of Lebanon in 1982, the Israelis sent some decoy UAVs coupled with RF-4Es aircraft to map the deployment of Syrian SA-6 anti-aircraft missile batteries. Although never confirmed by the Israelis, they likely recorded fire control and electronic counter-measure data during these flights. As part of Operation Peace for Galilee in 1982, the Israelis deployed two decoy UAVs, named Samson and Delilah, to trick the Syrians into activating their radar. Once the Syrians responded, the Israelis used the intelligence gathered before the war to destroy 17 of the 19 SA-6 batteries in Lebanon. The following day the Israelis eliminated the final two batteries.[48]

After the bombing of the Marine barracks in Beruit, Lebanon, October 1983, officers from the Navy had the opportunity to observe the Israelis use of UAVs for artillery fire adjustment. Their recommendation of a similar system led the Navy to acquire a Mastiff for testing. A group of Marines who flew remote control planes as a hobby formed the basis of the 1st RPV Platoon. They performed tests onboard the USS *Tarawa* in 1985, and in 1986 the Navy purchased Israel's newest UAV, the Pioneer. After taking delivery, the Navy discovered some adjustments were required to give the Pioneer the capability of taking off and landing from a ship. Research and development of these modifications cost an addition $50 million and caused much frustration within Congress, which believed the Pioneer to be operationally ready upon delivery. Once modified, the Pioneers served with the Navy until 2002, including operations in Operation DESERT STORM and SHIELD. The Marine Corps continued to use Pioneers throughout the Long War.[49]

Inter-service Cooperation and the UAV Master Plan

From 1986 to 1988, the House and Senate Armed Services Committee and the Senate Appropriations Committee called into question the effectiveness of each service maintaining their own UAV program. The House Armed Services Committee requested the Department of Defense compose a report outlining how it planned to minimize the waste within UAV development. In the budget for Fiscal Year 1988, Congress transferred the funds from each service's UAV program into a joint program managed by the Secretary of Defense. In 1988, the Department of Defense (DOD) published the first of what became an annual Master Plan for UAV Development. This report outlined the types of UAVs needed by each service and the process which would be employed to reduce overlap and increase interoperability. Although it can hardly be considered a blueprint for what actually happened, the Master Plan represented one of the first comprehensive policy statements by DOD regarding UAV development. Many of the concepts detailed within the report eventually emerged as operational vehicles over the next two decades.[50]

After outlining the committee responsible for authoring the report and defining some important terms, the Master Plan proceeded to describe the types of missions in which DOD hoped to employ UAVs. These included reconnaissance and surveillance, target acquisition (RSTA), target spotting, command and control (C^2), meteorological data collection, nuclear biological and chemical (NBC) detections, and lastly, disruption and deception. Not every UAV needed to be able to perform all of these missions; these simply comprised the range of missions that various UAV systems might perform. Next, the plan went into detail as to the various types of UAVs, in terms of range, endurance, and specific mission, each service required.[51]

The Army divided their UAVs requirements into the battalion, brigade, division, and corps echelons of command. Battalion commanders needed reconnaissance, surveillance, and target acquisition (RSTA) for the area directly in front of them, up to a depth of 15 km. At the next higher level, brigade commanders possessed similar mission needs but with a greater range: 30 km beyond the front line. Divisional and corps commanders required far more than either of the two lower echelons. The description of their needs included every type of mission described above and an endurance of 6 to 12 hours. The depth of coverage represented the only difference between the two. Divisional commanders needed coverage 90 km past the front line, compared with 300 km for a corps commander. The concept of UAV division based on range and echelon of command became a standard the remains in use today.[52]

The Marine Corps articulated a need for two types of UAVs: a small system that could be used at the company or battalion level for real-time video, and a larger system to provide RSTA and C^2 for the task force commander. The Corps also expressed an interest in using UAVs for electronic combat operations for signals intelligence gathering and jamming of enemy communications. The task force commander was responsibile for these missions. Although the plan did not clearly state whether these missions should use the same vehicle as the task force RSTA/C^2 with a modified payload, or a completely separate vehicle, it implied the use of a single vehicle.[53]

The Navy outlined three separate UAV groups to support the fleet. Battleship Battle Groups required a vehicle for RSTA both at sea and on land in support of amphibious operations. They also desired this vehicle to be able to provide long-range communications relay. The Battleship Battle Group UAV needed a range of 100 nautical miles (the weapons range of the battleship in the 1980s) and an endurance period of five to seven hours. The Navy required a second UAV for target acquisition in support of the Carrier Battle Groups. The description for this vehicle did not include an endurance requirement; however the larger strike range of the carrier necessitated an operational limit of 350-400 nautical miles. The last UAV was to support smaller ships (destroyer or fast frigate), providing RSTA and electronic warfare capabilities. The Navy envisioned a vehicle similar to the one supporting Battleship Battle Groups, but smaller and with a more limited range.[54]

The section on Air Force UAVs began by emphasizing that UAVs were “viewed as complementary to existing manned systems.” This theme emerged several times throughout the Air Force’s paragraphs and seems

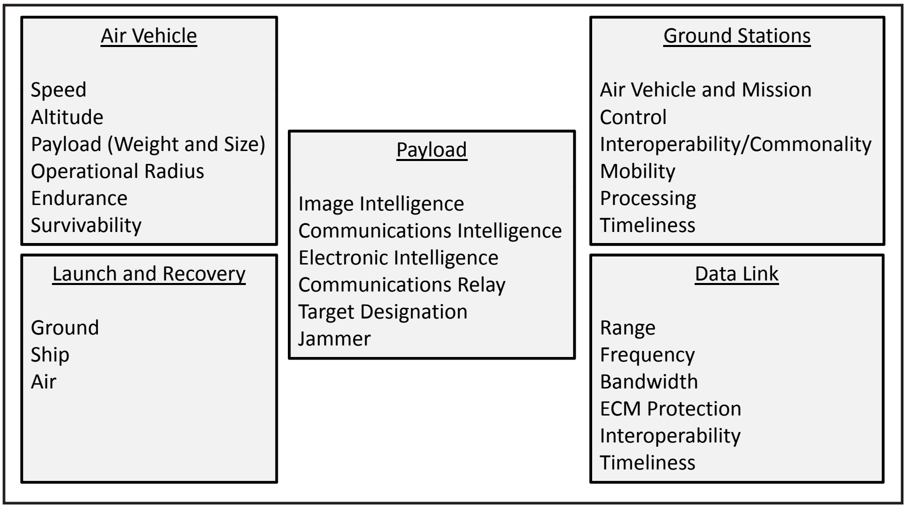


Figure 26. Five Components of UAV Systems (with Requirements).

to illustrate the ongoing conflict in the Air Force. While UAVs protected a pilot's life by flying a particularly dangerous mission, they potentially endangered his livelihood if they ever became "too" effective. The Air Force wanted its UAVs to be air-launchable, and capable of performing RSTA (including bombing damage assessment), C^2, meteorological data collection, and nuclear, biological, and chemical detection. Their needs closely paralleled that of Army corps commanders, with the exception of the expected range, which went beyond 300 km.[55]

The Joint Chiefs of Staff examined the requirements of each service and concluded that DOD needed, at minimum, four different UAV systems. The primary difference between each system was the operational range. However, the unique demands of each service meant it was highly unlikely that only four vehicles could perform the necessary tasks efficiently. Five major components comprised a UAV system (see Figure 26). Altering components to fit the need of an individual service increased the price of the vehicle. Each of the four UAV systems required multiple launch and recovery systems, which would likely necessitate expensive changes to the air vehicle structure itself (as mentioned previously, modifying the Pioneer to be able to launch from sea cost $50 million). The Aquila program proved the difficulties and expense of developing a complex payload and data link, and making such a system interoperable between services could only add to the cost. Finally, several of the proposed UAVs required both ground and ship-based control system. It is impossible to determine whether the DOD Master Plan would save money, or even whether such interoperable systems were even technically possible at the time. The DOD did not even propose spending money on these four joint programs until FY 1990. Instead, they requested that money continue to go to individual service programs, with the idea that the components developed by the services could later provide the foundation for the joint UAV programs.[56]

When the GAO reported back to the House Subcommittee for Defense Appropriations regarding the DOD Master Plan, it criticized the proposal on a number of points. First, the plan did not eliminate single service UAV programs for another two years. Second, by limiting the plan to nonlethal and recoverable UAVs (excluding armed UAVs and target drones), the potential for overlap continued. The GAO recommended that future Master Plans include these programs as well. Next, the plan failed to adequately address payload commonality. Since a large portion of the cost of a UAV system was a result of the payload, more attention needs to be given to this aspect of DOD programs.[57]

The DOD, the JCS, and the individual services formulated the original UAV Master Plan within the context of the Cold War. In 1988, the most probable scenario for future war was against the Soviets in Europe. The collapse of the Soviet Union led to changes in defense policy in the 1990s. At the same time, technological progress allowed UAVs to finally start achieving their long anticipated potential. During Operations DESERT SHIELD and DESERT STORM, UAVs provided direct support to ground forces in combat for the first time. Albeit in a very limited fashion, the invasion of Iraq in 1991 first brought together the long history of aerial reconnaissance in support of ground forces and unmanned flight.

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Chapter 3

UAVs in the 1990s

Airborne reconnaissance is enduring, but it is not unchanging. As we look to the future, we see our mix of airborne reconnaissance assets evolving in response to new technologies as well as joint strategies, doctrine, and a more diverse threat. . . . we see unmanned aerial vehicles playing an ever-increasing role, not only in the intelligence, surveillance reconnaissance world (ISR), but in other mission areas as well.

–Major General Kenneth R. Israel, UAV Annual Report,
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The Joint Program Office

In the late 1980s, in an effort to eliminate waste in the Department of Defense's various UAV programs, Congress mandated that all research and development be centralized. This resulted in the creation of the Joint Remotely Piloted Vehicle Program. The Joint Program Office (JPO) managed all research, development, and procurement of UAVs for each of the services. Congress also required that the JPO provide an annual report detailing their activity. Major Congressional and JPO concerns, were the concepts of interoperability and commonality. Interoperability meant that all UAV systems possess the capability of integrating with the various other command, control, communication, and intelligence systems used by the services. Commonality referred to the ability of components from one system to be used with another. For example, the ground control station for one vehicle should be able to control a vehicle from a different system. Fuel type represented another part of the push for commonality.[1]

The JPO oversaw the development of new UAV systems and managed existing systems from 1988 to 1994. None of the JPO's development programs entered full production before the JPO was absorbed into the

Defense Aerial Reconnaissance Office in 1995. Although the developmental programs within the JPO never reached maturityduring its tenure, it successfully deployed multiple UAVs with US forces during Operations DESERT SHIELD and DESERT STORM.

Before describing the various programs, it is necessary to explain the JPO development process steps through which a UAV system advances. After determining the requirements for a UAV system, the JPO issued a request for proposals to the defense contractor industry. From these proposals, the JPO gave out multiple contracts to develop a prototype for technical evaluation testing. Through technical evaluation testing the JPO evaluated the feasibility of a system and its potential for success. Successful prototypes moved on to limited-user testing. This testing proceeded, in theory, to discover any major problems not previously detected. Limited-user testing also represented the first chance for military personnel to use the system for themselves. If major problems emerged, the program could be scrapped. The program could also move forward into operational testing. The final option was for the program to enter low-rate initial production (LRIP). Low-rate initial production could be used to acquire additional systems for operational testing, or to begin delivering systems to the end user. Upon the completion of operational testing, the JPO and DOD would make the final go or no-go decision on whether to enter full production.

The JPO formed the plan for a family of UAV systems which maximized their common interoperability and fulfilled the identified requirements from the initial 1988 report, as discussed in the previous chapter. The JPO classified the systems as close-range, short-range, and endurance. Within the family, the short-range system served as the centerpiece of the concept and was the focus of the JPOs efforts. The close-range program received some attention, and the endurance vehicle never amounted to anything more than a concept. DOD continued development of a medium-range system, also described in the 1988 Master Plan, although the JPO excluded this system from the family classification.[2]

Short Range UAV Program (Hunter)

The JPO focused first on the short-range (SR) system. DOD's initial design proposal called for a ground-launched UAV system capable of providing near real-time intelligence, reconnaissance, and surveillance to the Army at corps and higher units and to a Marine Air-Ground Task

Force (MAGTF). Later, the concept of fielding expanded to include Army divisions. After acquiring a base model, the JPO developed a number of upgrades to expand the capabilities of the system. The Block I upgrade added the means to launch the system from a ship. In Block II, the basic engine size increased and the payload capability was expanded. When the Navy decided to decommission two of its four battleships, the USS *Iowa* and the USS *New Jersey*, the JPO realized that any maritime UAV would likely require a smaller vehicle than the one intended for the Army and the Marines. Although it continued to seek interoperable components, the JPO began looking for alternate vehicles, specifically a vehicle capable of vertical take-off and landing (VTOL), to fulfill the Block I upgrade to the SR UAV. The JPO hoped that by fielding a basic system and planning systematic upgrades, it could avoid the high cost incurred by programs like the Aquila, whose development cost increased heavily as the Army sought to add more capabilities to the basic model.[3]

The JPO granted contracts for prototype development in September 1989 to McDonnell Douglas Missile Systems and Israeli Aircraft Industries. The contracts gave each company 18 months to deliver a system for evaluation and testing by the JPO. During the first technical evaluation testing of McDonnell Douglas's Sky Owl and Israeli Aircraft Industries "Hunter" systems, neither proved ready to move forward. After a few modifications, in 1992 the JPO picked the Hunter system (see Figure 27) as the SR UAV. The following year, the Defense Acquisition Board approved the start of the LRIP process. Further testing of the Hunter system continued simultaneously as the LRIP, during which numerous problems with the system began to emerge.[4]

Even before commencing LRIP, the General Accounting Office (GAO) warned that the Hunter system possessed numerous problems and advised against any production before further testing. The practice of concurrent development had led to problems in the Navy's DASH program in the 1960s, and more recently with DOD's electronic warfare systems. The GAO warned that history had shown that once a program entered production, flaws discovered in testing were ignored in order to maintain the production timeline. The GAO raised concerns about the conditions under which the JPO tested the Hunter system. Although in theory it had strict requirements for the testing of its UAV systems, the investigation of the program found that in practice the JPO routinely ignored its own criteria. The GAO report discovered numerous examples of this practice in the first limited-user tests of the Hunter system, which were conducted in 1992.

US Air Force photo, SSGT Jocelyn M. Broussard.

Figure 27. Hunter UAV.

One of the required capabilities for the SR-UAV was the ability to take-off from an unimproved surface. During Operation DESERT STORM, the lack of this capability limited the operational use of the Pioneer system. There was not enough engineering equipment available to build adequate runways. During the initial limited-user testing of the Hunter, the vehicle took-off from improved surfaces. The JPO program manager argued that in an operational environment, engineer battalions could construct a surface similar to the one used in the tests, despite contrasting evidence from Operation DESERT STORM.

There were several other operational problems with the UAVs used in DESERT STORM. Another problem was electromagnetic compatibility. According to the JPO, two of the Pioneer vehicles that were lost during the war were the result of electromagnetic interference. Rather than account for this during user tests, the JPO made an effort to eliminate any possible interference from the test zone. The JPO also failed to evaluate the survivability of UAVs in combat situations, which was considered a critical system requirement. However there was no real way to measure survivability. While the JPO did gather some information as to the Hunter's survivability on the battlefield, this evidence was not considered when deciding whether or not to enter LRIP.

Finally, throughout the limited-user testing, contractor personnel continued to conduct the majority of UAV system maintenance which raised concerns about whether the military could provide the necessary logistical support for the system. Logistical support conducted by the military was yet another of the JPO's own paper requirements which was ignored in practice. Congress, however, had already approved funds for LRIP of the Hunter system, and the DOD and the JPO ignored the findings of the GAO and moved forward with production.[5]

A second set of limited-user tests in 1993 confirmed the concerns raised by the GAO. The JPO continued to ignore its own requirements throughout these tests. When directed from a ground control station, the Hunter system had a very limited range since its datalink operated via line of sight. To compensate for this, the concept of operations for the system planned for a second vehicle to be operated in close proximity to the ground control station, to relay the commands from the ground and imagery data from to the operational UAV and the imagery data back to the ground terminal. JPO requirements stated that the system should operate in this manner 84 percent of the time. With two vehicles airborne, the chances for mechanical failure doubled. During the tests, the JPO encountered numerous problems with the relay component. As a result, only 20 percent of the flight time during the second set of limited-user tests utilized a relay vehicle. When it was used, the relay system functioned correctly in only 4 of 11 tests. The system also demonstrated problems in target acquisition, transportability, engine durability, and self diagnostic equipment. These new problems came in addition to the issues found in the 1992 tests, which the GAO reiterated in a December 1993 report. In response to the system failures during limited-user testing, the DOD delayed operational testing for 18 months. However, the go/no-go decision for full-rate production was only delayed three months, meaning full production would start before the completion of operational testing.[6]

Further problems in 1995 led to three more negative reports from the GAO. One of the contract provisions stated that the developer was responsible for providing the logistical information to DOD, including training manuals, maintenance requirements, and a description of the functions of the support team for the system. At the end of 1994, the contractor provided training for some military personnel. After the training provided, however, the military personnel completed only 56 maintenance tasks correctly the first time, out of 3,107 total tasks. Further training significantly improved this number, but military personnel could still only perform about half of the total prescribed tasks. The system itself continued to experience difficulties with the air vehicle, the relay system, and artillery fire-adjustment.[7]

In September 1995, the GAO again criticized the DOD plan to move forward with full production before the completion of operational testing. They used the Pioneer system as an example of a system being purchased without being fully tested. DOD submitted an official response to this report, in which it disagreed with the GAO regarding the extent of problems with the Pioneer system. The response also argued that limited-user testing could be substituted for operational testing, although they still planned to perform the operational testing. DOD partially concurred on several other points, including the need to adequately test all systems before entering full production. Three months later, the GAO released its final critique of the Hunter program. This final paper stated that the Naval Commanders of the Atlantic and Pacific Fleet of Naval Forces in Europe, opposed Hunter. DOD agreed that the acquisition of Hunter systems for shipboard use should be curtailed. Once the goal of a common vehicle for Army, Marine and Navy use disappeared, the Hunter program lost much of its support. In January 1996, DOD allowed the LRIP contract to expire without renewal, although it continued to search for a vehicle similar in size and capability.[8]

It is possible that in its zeal to cut costs, the GAO acted unfairly in its evaluation of the Hunter program. However, the JPO's annual reports from 1992-1994 contain no information that contradicts the GAO's findings. Additionally, in testimony before Congress in 1997, a high-ranking DOD official, the same official who authored the response to GAO's critiques, confirmed that the Hunter program experienced all of the problems detailed in the GAO reports. Hunter was not a total loss, however. Through the low-rate initial production, the DOD acquired seven Hunter systems, each with multiple air vehicles. The Defense Airborne Reconnaissance Office revived the Hunter program. Hunter systems deployed to the Balkans in 1999 and to Iraq in 2003 in support of the Long War.[9]

Close Range UAV Program

The second priority of the JPO was the close-range (CR) UAV program. This program called for a small, aerial vehicle that could integrate with the control systems developed for the SR vehicle. This approach was intended to insure interoperability between the two systems. The JPO selected six contractors to develop a vehicle for testing. One of the key aspects of the contract was a maximum weight of 200 pounds. In addition to vehicle design, the program was responsible for reducing the size of the ground components for CR UAV deployment at the battalion level and developing a light weight forward-looking infrared radar (FLIR) system. In January 1992, three companies presented a FLIR system weighing less than 50 pounds, the weight requirement set by the JPO. Six months later, all six contractors presented acceptable vehicle concepts. In 1993, the JPO merged the CR and SR programs and created the Joint Tactical Project Office. The maneuver variant, as the CR vehicles were now called, progressed slowly as the Hunter system encountered one problem after another. No vehicles entered development before DOD disbanded the JPO, effectively ending maneuver variant development.[10]

Another offshoot of the SR UAV program was the maritime vertical take off and landing (VTOL) system. As discussed before, the JPO initially intended to modify the vehicle used by the Army and Marines to fulfill the Navy's short range reconnaissance needs at sea. Once the Navy's interest in the Hunter waned the JPO began to pursue a different vehicle. The maritime VTOL program worked with the Canadian military and the primary vehicle tested under the program was the Canadair CL-227 Sentinel. The Sentinel conducted numerous test flights in 1993 and 1994. Although the Navy did install a system on the frigate USS *Vandegrift* in 1994, the Sentintel was never widely deployed.[11]

Medium Range UAV Program

The JPO also worked on a medium-range (MR) UAV system, a program which predated the estalishment of JPO by several years. The MR UAV program began as a Navy project in 1985. When Congress mandated all funds for UAVs be spent on joint programs, the other services agreed to join the Navy. In June 1989, Teledyne Ryan received a contract to modify the Teledyne 324 system, which they had sold to the Egyptian government, to fit the JPO's MR UAV needs. The JPO expected the BQM-145A, the military designation of the Teledyne 324, to possess a range of 350 km and reach speeds of Mach 0.9. It was to be launchable from either the ground or the air, via an F/A-18 or an F-16. In 1991, the MR UAV program ran into problems when the GAO reported that the Advanced Tactical Air Reconnaissance System (ATARS), the sensor payload that the DOD intended to use as the standard payload for future manned and unmanned aerial reconnaissance vehicles, did not fit into the BQM-145A.

DOD concurred with the GAO on this and a number of other technical problems, but believed the issues could be resolved. Development continued until it became clear that the problems with the payload could not be solved. DOD stopped work on both the MR UAV program and the ATARS in 1993, in response to both projects exceeding their budget.[12]

In the years the JPO oversaw DOD development of UAVs, not a single system moved from development to full production. This failure cannot be blamed on a lack of funding from Congress. From fiscal years 1989-1994, the DOD received its full budget request for research and development in all but one year. In three of those years the final Congressional budget included more money for UAV research than the JPO's own budget submission. The only year in which the Congressional budget for research and development came short was FY 1994, the final year of the JPO. This deficit came mostly from Congress cutting the $72 million requested for further research on the MR UAV program. JPO received less in procurement funding in two of those years, including one year in which Congress withheld all procurement because it felt JPO was not complying with their guidelines regarding joint programs; for only one year was their procurement funding higher than their request. The shortage in procurement funds resulted from the JPO requesting funds for the SR UAV. Although Congress approved the first LRIP contract, it subsequently withheld money for SR UAV procurement, likely under the advice of the GAO (see Figure 28).[13]

UAVs in DESERT STORM

The JPO managed a number of existing UAV programs, several of which deployed with US Forces to the Persian Gulf in 1990-91. The most expensive of these was the Pioneer system. As discussed in the previous chapter, the Navy purchased a number of Pioneer systems from Israel in 1986. The JPO intended to use Pioneer as an interim system until the SR UAV entered service, originally scheduled to be in the late 1990s. Pioneer saw extensive service in the Persian Gulf and the Balkans. In addition to its active duty, the services also used the Pioneers to evaluate what would be needed from future UAV systems.[14]

The Navy deployed two Pioneer detachments to the Persian Gulf, one on board the battleships USS *Missouri* and USS *Wisconsin.* On 3 February 1991, the Navy first used the UAV to direct naval gunfire onto the shore. In this barrage, over 18,000 pounds of explosives were launched against

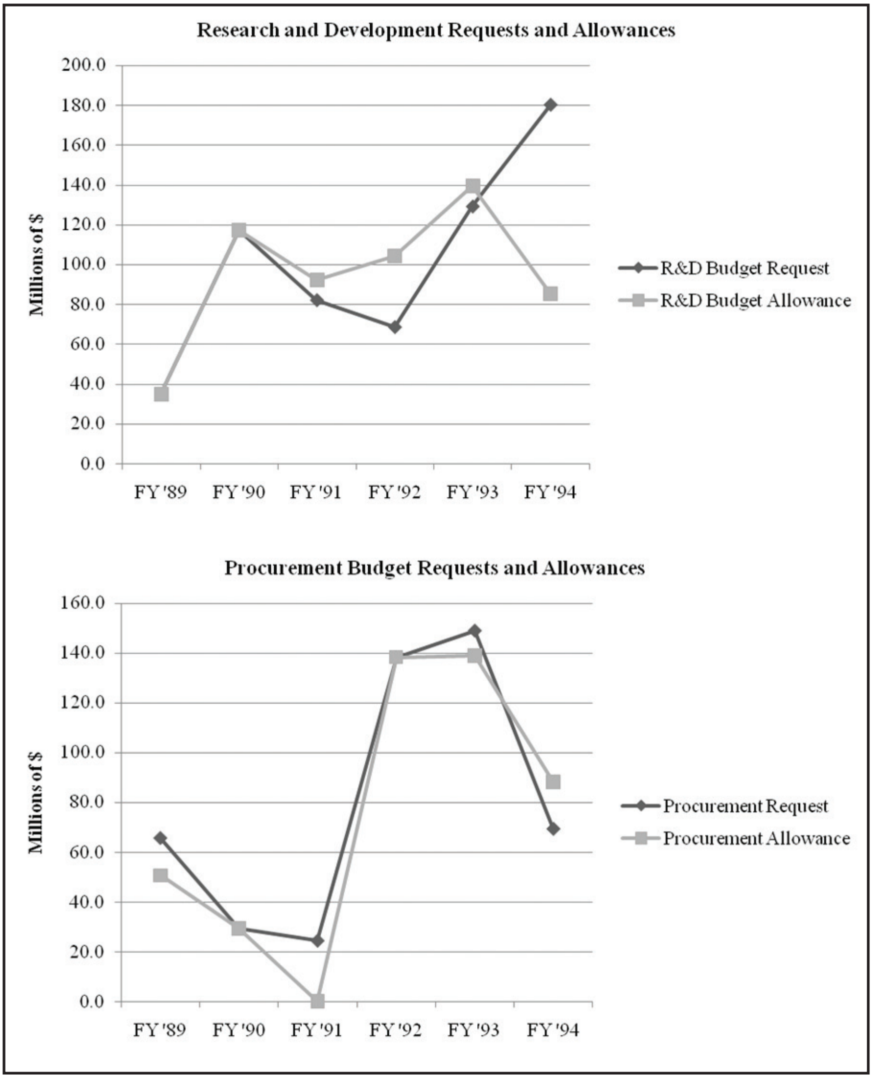

Figure 28. UAV Program Requests and Allowances.

Iraqi targets with the help of the Pioneer. Throughout the rest of the month, it acquired targets on land and sea. On various missions, Marine ground forces, Navy attack aircraft, and naval gun fire were used to destroy targets acquired via the Pioneer. During DESERT STORM, the *Missouri* sent over one million pounds of ordnance against Iraqi targets with the assistance of a UAV. While supporting a Marine assault on Faylaka Island, a group of Iraqi soldiers waved white flags toward an approaching Pioneer.

For the first time in history, enemy units surrendered to an unmanned vehicle. The Navy subsequently released the video feed from this mission to the media, which resulted in a spectacular public affairs success. In addition to target acquisition, Pioneer provided intelligence as to Iraqi Army movements. After a Pioneer spotted a group of Iraqi tanks moving toward a Marine position, air support was dispatched and destroyed the Iraqi forces before they could reach the Marines. Even after the cease-fire, the UAVs continued to provide reconnaissance data to the Navy. In February 1990, Navy Pioneers alone flew over 177 hours in support of Operation DESERT STORM.[15]

Ground forces from both the Marines and the Army also used Pioneer in DESERT STORM. The 7th Marine Expeditionary Brigade used the UAV to direct artillery fire and close air support. The Army's Pioneer platoon deployed in support of VII Corps operations. It flew 43 missions in February. On one especially productive mission, a single vehicle discovered three Iraqi artillery battalions, three free-rocket-over-the-ground sites, and an antitank battalion. Despite this univeersal use of the Pioneer, each service had a different video format. This hindered any effort to share footage between the services. Only one vehicle was left to enemy action during operations in the Persian Gulf. Additionally, there were no significant problems with air space management. The successful deployment of the Pioneer system in DESERT STORM proved the value of UAVs in combat operations.[16]

Another program operated by the JPO was the aptly described "very low cost" program, which focused on developing inexpensive UAV systems to support smaller units (originally company and below, later expanded to include battalions). Two UAVs within this program also supported US forces in Kuwait and Iraq. The low-cost program searched for systems that in addition to being inexpensive, could easily be transported, operated, and maintained with minimal training. The JPO examined two different systems as part of this program: the FQM-151A Pointer and the BQM-147A Exdrone. The hand-launched Pointer vehicle traveled in a backpack and weighed only 45 pounds. Two soldiers put the vehicle together and launch it in under five minutes. Once assembled, it measures six feet long with a nine foot wingspan and weighs only nine pounds. DOD acquired six systems in 1990, which underwent testing with the 2d Infantry Division (ID), 25th ID, 7th ID, 82d Airborne, 8th Marine Regiment, 7th Marine Expeditionary Brigade, and the Drug Enforcement Agency. During DESERT STORM, it deployed with the 82d Airborne, 1st Marine Expeditionary Force, and the 4th Marine Expeditionary Brigade. The system underwent various operational tests throughout the early 1990s. In 1993, a Pointer vehicle assisted the Oregon Army National Guard and local law enforcement in a dozen raids. The Pointer later supported US forces in both Afghanistan and Iraq as part of the Long War.[17]

The other system was the Exdrone, originally designed as an expendable unmanned platform for communication jamming, it was later modified to be recoverable and carry a reconnaissance payload. At almost 90 pounds, the vehicle weighed significantly more than the Pointer vehicle. Its lower cost, however, made it possible for the vehicle to be used in support of smaller units with less concern about losses. Once launched, it generally flew a preset course, loitering over a target for over two hours and transmitting live video back to a monitoring terminal. It also possessed the capability to be controlled remotely while on mission. The Exdrone provided support to the Marines in DESERT STORM and provided useful information that allowed Marine forces to enter Kuwait City sooner than expected. A total of 500 Exdrones were built and deployed. Thirty-eight of these underwent modifications beginning in 1997 and were redesignated as Dragon Drones. Dragons deployed with Marine expeditionary units on multiple occasions between 1997 and 2000. Through their experience with Pointer and Exdrone, the services gained insights which helped in the development of various hand-launched UAVs during OEF and OIF.[18]

The Birth of the Predator

The most successful program began during the final year of the JPO. After cancelling the MR UAV system, the JPO began working on a medium-range endurance system known as Predator (see Figure 29). Rather than follow the previous process of competition, various stages of testing and later production, the new program used a new process known as Advanced Concept Technology Demonstrations (ACTD). ACTDs were a way for DOD to acquire new technology more quickly and at a lower cost than the traditional developmental process. In an ACTD program, a developer was given a contract to take a mature piece of technology and improve its deployment for the intended user. After applying the technology, the user then identified what modifications were required for the system to be useful and determined if it justified further development. In January 1994, the DOD awaited a contract to General Atomics for three systems with a total of ten aircraft based on the GNAT 750, a UAV which had been previously developed and sold to the CIA. Predator was the first

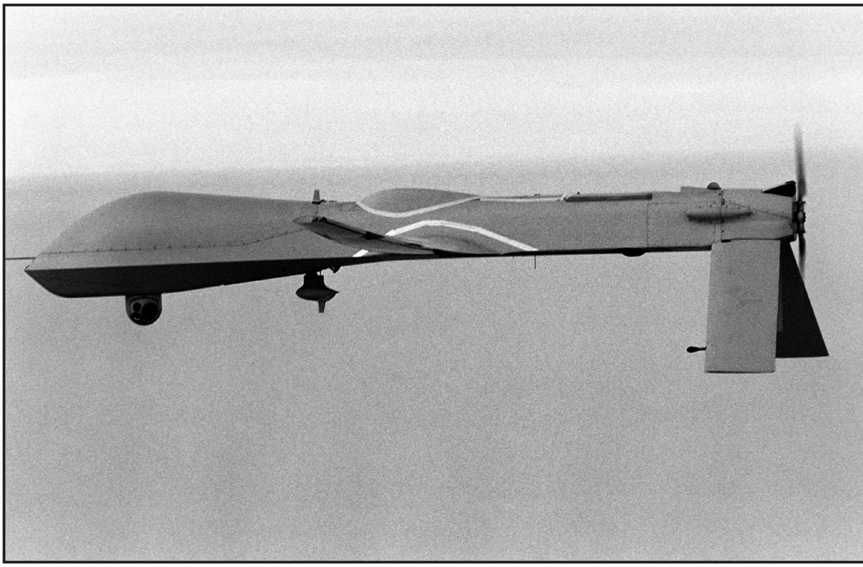

Figure 29. Predator UAV.

medium-altitude endurance UAV developed by the US military. Previous experiments with endurance UAVs, such as the Compass Cope program, focused exclusively on high-altitude long-endurance vehicles. The Predator flew within 3,000 and 25,000 feet and could remain aloft for over 20 hours. Although founded under the JPO, the Predator would demonstrate its full potential under the Defense Airborne Reconnaissance Office, the organization which assumed control of UAV programs in 1994.[19]

The Defense Airborne Reconnaissance Office

In November 1993, DOD consolidated its reconnaissance program into the the Defense Airborne Reconnaisance Office (DARO), however, the JPO did not completely dissolve. It continued to exist as a part of DARO and remained responsible for the Joint Tactical UAV program. Like its predecessor, DARO was short-lived. In 1998, the office for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance, (C^4ISR) replaced it as the overseer of UAV development. Never the less, in its four years, DARO enjoyed slightly more success than its predecessor agency. The ACTD process made failure far less expensive. When DARO cancelled the Outrider and Dark Star programs, the loss to DOD was substantially less than what had been incurred as a result of Hunter or Aquila UAVs. DARO also made substantial gains with the Predator system, initiated by the JPO, and the Global Hawk high-altitude endurance UAV.[20]

UAVs in Bosnia

The first operational use of UAVs after the formation of DARO came in 1995. The USAF deployed its first Predator unit, designated the 11th Reconnaissance Squadron, to Bosnia in July 1995. The squadron provided critical aerial reconnaissance data until November. Although two vehicles were lost in this period, one to enemy action and another to an engine malfunction, the remaining Predator provided vital support to NATO forces. The Predators in this first deployment to Bosnia communicated with the operators on the ground via a UHF satellite connection. This connection allowed for real-time still images to be transmitted back to the ground terminals. Intelligence acquired via the Predator flights confirmed that several of the belligerents violated arms-removal agreements and assisted in providing targets for the subsequent bombing campaign. This bombing campaign succeeded in bringing the warring factions back to negotiations, which resulted in the signature of the Dayton Accords in 1995.[21]

Although the Predator's first deployment was generally successful, a number of shortcomings emerged. General Atomics addressed several issues in the next generation of Predator vehicles, which deployed to Taszar, Hungary in March 1996. The new Predators possessed a synthetic aperture radar, which could "see through" cloud cover. This allowed the Predator vehicles to fly above low-level clouds, decreasing the risk of targeting by anti-aircraft fire. The installation of de-icing equipment made it possible to fly in weather that previously would have grounded the system. Most importantly, the installation of a Ku-band satellite link provided enough bandwidth for real-time full-motion video to be sent from Predator to the terminals on the ground. This also facilitated Predator's integration with the Joint Broadcast System, which allowed multiple users to view incoming video simultaneously, a first for UAV reconnaissance. This capability further increased its ability to assist in command and control operations by making it possible to re-task a Predator in-flight to respond directly to the needs of a commander all the way down to the divisional level. During this second deployment, Predator systems monitored polling stations during the September elections and helped with security during VIP visits, including a visit by Pope John Paul II in April and Secretary of State Madeline Albright in October.[22]

Two other UAV systems supported the NATO effort in Bosnia. One of these was operated by the CIA and not the military. Early in 1993, two years before the first Predator deployed, the CIA sent two GNAT-750s, a predecessor of Predator built by General Atomics, to Bosnia. During this deployment, the GNAT 750, also known as Lofty View, followed UN convoys and took pictures of artillery and surface-to-air missile sites. CIA UAVs also deployed in July 1994 for another tour of duty. Although relatively inexpensive, the GNAT 750 lacked some of the capability that made the Predator so effective. Because it possessed only a line-of-site data-link, there was a manned aerial vehicle to transfer data back and forth between the ground control system and video terminals. This limitaion reduced its ability to stay aloft for only two hours. It also meant the GNAT 750 could not integrate with the Joint Broadcast System, which limited its ability to share intelligence data.[23]

The success of Pioneer in DESERT STORM led to the acquisition of several new systems. In late 1993, Pioneers were successfully deployed to support military action in Somalia. The Pioneer first deployed to Bosnia with the USS *Shreveport (LPD-12)* in 1995. The following year, a Marine Expeditionary Unit brought several more Pioneer systems into theater and the USS *Austin (LPD-4)* employed another ship-based Pioneer system. However, despite its strong showing in Iraq and Kuwait, the Pioneer system struggled in Bosnia. While it successfully provided tactical level intelligence, including over 30 missions with the 1st Marine UAV Squadron, and it proved adept at quick retasking, the systems experienced numerous mechanical failures. Five vehicles crashed as a result of engine, generator, rocket-assisted takeoff, or computer failure. Additionally, the mountainous terrain proved to be a major hindrance to the Pioneers data link. This link which depended on line-of-sight guidance. Like the GNAT 750, video-feeds from the Pioneer could not be distributed via the Joint Broadcast System. Despite some shortcomings in application, Pioneer systems further demonstrated the potential of the tactical UAV concept.[24]

Development under DARO

In the midst of these deployments, DARO continued to develop new UAV systems. All new development followed the ACTD process. Although several of these systems never fully matured, the ACTD process reduced the cost of failure and made it easier to cancel programs. DARO did develop three vehicles, two as part of the high-altitude endurance system, and a third as tactical system intended to replace the Pioneer and Hunter.

The tactical system known as Outrider first came under DOD contract in May 1996. It performed its first flight in March 1997, four months behind schedule. The system made a total of 17 flights between March and

November, including participating in the Army's Force Exercise XXI and Advanced Warfighting Experiment at Fort Hood, Texas. During these tests, Outrider provided real-time tactical intelligence to battle commanders. Despite the new acquisition process, the Outrider program suffered some of the same problems which had previously affected the Hunter. None of the DOD conducted tests evaluated whether the vehicle could be controlled and monitored via the same system which controlled Predator, a key aspect of interoperability and commonality. Additionally, the data-link was analog as opposed to digital, which reduced its range and capability. Despite these problems, DARO intended to move forward with an LRIP contract to acquire more Outrider systems. However, after objections from the GAO, DARO and DOD did not award an LRIP following the expiration of the initial ACTD.[25]

DARO's high-altitude endurance (HAE) system integrated two different vehicles designed to complement each other. The DarkStar (see Figure 30), or low observable HAE, was designed to perform broad sweeping aerial reconnaissance in defended airspace. It carried a simpler payload, remained airborne for a lesser period of time than the Predator or Global Hawk (the other HAE under development), and possessed a more limited range. It compensated for these features with its minimal radar signature. The director of DARPA described the potential of DarkStar as similar to the U-2 or SR-71 in terms of performing aerial reconnaissance in heavily defended airspace. The DarkStar part of the HAE program experienced a major setback when its first and only operational vehicle crashed in April 1996. A new vehicle resumed testing in 1997. However, in January 1999, DOD and C^4I (the program that followed DARO) cancelled the DarkStar program and focused the HAE program entirely on the Global Hawk vehicle.[26]

The Global Hawk system, manufactured by Teledyne Ryan, possessed far superior flight capabilities than DarkStar. It had a range of over 3,000 nautical miles and an endurance of greater than 40 hours. However, vehicle testing of the Global Hawk system followed that of DarkStar by several years. The first Global Hawk flew in February 1998. The program advanced throughout that year, with multiple vehicles completing numerous flight tests. The Global Hawk experienced its first major setback in March 1999, when one of its air vehicles crashed with only a complete sensor payload on board. During this test flight, the vehicle flew from Edwards Air Force Base over the China Lake Naval Air Weapons Station. Unaware of the flight test, developers at nearby Nellis Air Force Base were working on the flight-termination system. When they tested the flight-termination

Figure 30. DarkStar UAV.

code, the Global Hawk picked up the signal, terminated flight operations, and crashed. DARPA estimated the value of the lost vehicle and payload at $45 million.[27]

The common ground between the systems constituted one of the core concepts of the HAE program. This system included the launch and recovery element as well as mission control. It was intended to be able to control three UAVs simultaneously, allowing for contimuous coverage. Like the Predator, it would use line-of-sight and satellite communication links, so that images from DarkStar or Global Hawk were easily disseminated via the Joint Broadcast System. The designers of the common ground segment adapted DarkStar for use with the system. The DarkStar program never progressed far enough for the vehicle to be tested with the common system, and following the cancellation of DarkStar the control system reverted to controlling just the Global Hawk. Another element of commonality incorporated within the HAE UAV program was the common imagery ground/surface system. This system integrated images from both manned and unmanned aerial reconnaissance vehicles into a common file format to ease the process of sharing intelligence data. Although the common ground segment never actually operated as a multiple vehicle control system due to the cancellation of DarkStar, this system and the common imagery system represented significant progress in the area of commonality and interoperability of UAV systems.[28]

In 1998, DOD began transition in the way it managed UAV programs. The C^4I office assumed oversight of UAV programs. However it did not control funding to the extent that the JPO and DARO had. Beginning in

FY 1998, appropriations for UAVs returned to the individual services, while the C^4I worked to coordinate programs as much as possible. Although not always under the office for C^4I, this has remained the basic approach of DOD for the next ten years, with generally positive results. In September 1998, the Congressional Budget Office (CBO) entered the fray by publishing a report which supported the creation of service-driven UAV development. The CBO studied ways to make DOD UAV spending more efficient. The report marks a stark contrast from previous GAO reports, which criticized existing programs with minimal suggestions for recommended improvements. The CBO presented five options. The first two favored increasing the number of UAV systems to better fit the needs of the individual services.[29]

The first option dealt with the tactical UAV program, and proposed two possible choices. The attempt to develop a single, tactical UAV, to support both the Navy and the Army greatly increased the development costs of the system. The CBO recommended either cancelling the Outrider system and reviving the Hunter program for the Army, or making the Outrider program funded exclusively on Army assets for all of the services. In both options the Navy and Marine Corps would continue to field the Pioneer until a better UAV was developed for them. "Mission creep" or the continually growing concept of the operation, had consistently interrupted the UAV program. The pursuit of a single UAV capable of a broad range of missions seemed more cost-efficient than the development of multiple systems. However, the cost and complexity of building such a system became prohibitively expensive. The DOD cancelled Outrider in 1999, and later that year began development of the Shadow UAV for its tactical needs.[30]

The second option suggested using the Hunter system to support the Army's need for corps and divisional UAVs. The Army planned to rely on the Air Force Predators for reconnaissance at those command levels. The CBO worried that the limited number of Predator systems currently in the Air Force would restrict the amount of coverage the Army might receive. The CBO admitted this would create additional logistical demands on the Army and increase the Army's spending on UAVs. This approach was less costly than if the Army later determined that Air Force's Predators could not provide adequate support and tried to purchase their own Predators.[31]

From 1988 to 1998 all funding for UAV development was channeled through either the Joint Program Office or the Defense Airborne Reconnaissance Office. This maximized the interoperability and commonality of the developed systems. The approach proved effective only in theory. The design of a minimal number of unmanned vehicles and systems to perform a maximum number of missions led to technical problems and high costs. Even after spending large amounts of money, performance often failed to meet the initial criteria. Almost all of the UAV programs failed to meet minimal requirements. Their criticism, however, was usually accurate. Both the JPO and DARO often failed to adequately test UAV systems before moving forward in their development process. However, the operational potential for UAV systems could only be fulfilled by actually deploying the systems in the field. The Congressional requirement that all programs needed to be interservice compatible made the fielding of any UAV systems much more difficult. In 1998, the individual services again began to run their own UAV development programs, although joint programs continued to be encouraged and facilitated through various DOD offices.

UAVs in Kosovo

UAVs from all services played an important role during the 78 days of Operation ALLIED FORCE in 1999. The Army had embraced the recommendations of the CBO and deployed Hunter as a corps asset. During its time as a residual program from 1996 to 1999, the Army resolved a number of the problems that had earlier led to the cancellation of the Hunter program. The mountainous terrain in Kosovo required two Hunter vehicles to be airborne for each mission, one to perform the actual mission and one to relay signals back and forth from the mission vehicle to the ground control element. Despite earlier problems experienced with the relay system, only two vehicles were lost as a result of mechanical or system failures. The Army also developed a system to solve the problem of disseminating data transmitted via a line-of-sight link. After receiving the video feed, the ground station digitized the signal and transmitted it over the Joint Broadcast System. This allowed multiple users to view the feed in near real-time. Although still not as efficient as the Predator feeds, which were instantly transmitted via satellites, this process increased the usefulness of the Hunter system.[32]

It addition to its standard surveillance and reconnaissance missions, the Predator proved to be very capable at monitoring cell-phone and portable-radio transmissions of enemy forces. Additionally, the Air Force developed a new technique for marking targets in which two Predators identified a target using electro-optical and infrared sensors, while a third

Predator used mapping software to direct its laser designator on the target. An F-16 or A-10 plane would then engage and destroy the target. The rules of engagement for Operation ALLIED FORCE created new limitations for both the Predator and Hunter. Before engaging any target, the mission had to be verified as a legitimate target by two sources. Both vehicles served as the second intelligence source for targets spotted by forward air controllers.[33]

Although UAVs demonstrated several new capabilities during Operation ALLIED FORCE, a number of problems emerged. The integration of UAVs with other aircraft in air control environments represented one of these challenges. NATO limited the number of UAV flights to certain areas in order to reduce the risk of collisions. The predictable flight path increased the risk on each mission. Throughout the course of the air campaign, the Army lost four Hunter vehicles to enemy action, and four more to mechanical failure. Additionally, four of the Air Force's Predators and four of the Navy's Pioneers were lost.[34]

UAVs at the end of the 20th Century

Before DESERT STORM, UAVs possessed far more potential than immediately practical. Under thecontrol of the JPO and DARO, this began to change. Despite numerous failures, by the time DOD dissolved DARO in 1998 the services possessed a more sophisticated arsenal of UAVs than they had 10 years before. Changes in the acquisition process made failures less costly. Technological progress and necessity coupled to revive previously failed programs such as Hunter. Some Hunter systems underwent further modification during the Long War and continue to serve today. The Predator and Global Hawk, both still operational at the time of this writing, originated during this time period. Changes within the Army also fostered further development of UAVs. The Force XXI concept emphasized the potential of digital communications and information sharing, an area particularly well suited for UAVs. Experimental vehicles like the hand-launched Exdrone demonstrated a concept that today is widely deployed. Some of this technology did not fully mature until the Long War. However the technological progress of the 1990s laid the foundation for the rapid growth of the early twenty-first century.

Before DESERT STORM, the United States had only used a few UAV systems in support of combat operations. Technological progress and the nature of the United States' military engagement during the 1990s provided the opportunities for numerous deployments. In this decade, Pioneer, Hunter, Pointer, Exdrone, and Predator all operated in combat situations. Experience gathered from these deployments proved vital during the Long War.

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Chapter 4

UAV Systems in Iraq and Afghanistan

> *Unmanned systems cost much less and offer greater loiter times than their manned counterparts, making them ideal for many of today's tasks. Today, we now have more than 5,000 UAVs, a 25-fold increase since 2001. But in my view, we can do—and we should do—more to meet the needs of men and women fighting in the current conflicts while their outcome may still be in doubt.*
>
> –Secretary of Defense Robert M. Gates,speech
> to Air War College, 21 April 2008

The invasion of Afghanistan in October 2001 marked the beginning of the Long War. In March 2003, Operation IRAQI FREEDOM opened a second front in this war. During these two wars, UAVs performed far more missions, in type and quantity, and received far more attention than any previous conflict. Procurement of existing and development of new systems expanded exponentially. The limited wars in Bosnia and Kosovo demonstrated that UAVs had finally reached their potential. The Long War provided the stimulus to fully exploit these new tools. Existing systems such as the Predator and Hunter, underwent further modifications to expand their capabilities and prolong their operational life. New systems, such as the Raven and Shadow, moved quickly from initial development to large-scale production in a relatively short period of time. The growth of UAVs has provided commanders at all echelons with a better understanding of battle space and improved command and control. However, the rapid pace of the expansion raised several issues about the future of UAVs, including the long-term costs for logistical support and maintenance, concerns about the bandwidth required to support current and future UAV operations, and the proper balance of manned and unmanned vehicles within the services.

UAV Systems Deployed in Support of the Long War

A complete, narrative history of UAV operations in the Long War far exceeds the scope of this manuscript. In compensation, this chapter describes the development of the key systems, provides a few operational examples, and summarizes discussions of UAV roles today.

Although each service categorized UAVs differently, the vehicles and systems are generally are divided into five categories: strategic, operational, short-range, small and micro. Figure 31 outlines these categories, their specific systems, and the Army echelon that is supported. This classification is inexact, but it provides a framework for the discussion of UAVs used in support of the Long War.

<table>
<tr><th>UAV Category</th><th>System</th><th>Echelon Supported</th></tr>
<tr><td>Strategic</td><td>Global Hawk</td><td>Corps/Joint Command</td></tr>
<tr><td rowspan="2">Operational</td><td rowspan="2">Predator, Reaper, Sky Warrior</td><td>Division</td></tr>
<tr><td rowspan="2">Brigade</td></tr>
<tr><td rowspan="2">Short Range</td><td rowspan="2">Hunter, Pioneer, Shadow</td></tr>
<tr><td rowspan="2">Battalion</td></tr>
<tr><td rowspan="2">Small UAV</td><td rowspan="2">Raven, Dragon Eye, EagleScan</td></tr>
<tr><td rowspan="2">Company and Lower</td></tr>
<tr><td>Micro UAV</td><td></td></tr>
<tr><td colspan="3">Note: Vehicles in italics are designated as multi-purpose vehicles (potentially armed)</td></tr>
</table>

Figure 31. Categories of UAVs.

Global Hawk

The Air Force's Global Hawk UAV flew at the strategic level providing ISR missions for an extended period high above that achieved by the Predators, Reapers, and Sky Warriors. The Global Hawk (see Figure 32) transitioned from an ACTD production to an operational program in 2001. The first operational production model was deployed to Central Command in 2006. Prior to this period, residual aircraft from the ACTD program flew missions in both Iraq and Afghanistan. By March 2005, the new system had flown over 4,000 hours of combat operations. A more advanced 'B' model performed its first flight in March 2007. Like the

US Air Force photo by Bobbi Zapka.

Figure 32. Global Hawk UAV.

Predator, operators in Europe and the United States usually controlled Global Hawk while in theater. Because Global Hawk is a relatively new system, control from the United States has allowed for more rapid adjustments and improvements to the control system than was possible if the vehicle had been controlled in theater. If an operator experienced a problem or simply could not develop a target, he could call a developer on his cell phone and talk to him about how to fix the system. In one case a hard drive in the control system overheated. The intelligence operator assumed the mission was not recoverable and started to leave the control center. An engineer diagnosed the problem, and the mission commander sent someone to the post exchange to buy a fan. This $15 fix cooled the drive and allowed the mission to continue successfully.[1]

Predator and Variants

Of all the UAVs supporting American forces in Iraq and Afghanistan, none received as much attention as the Predator system. During the 1990s, the USAF designated the Predator as the RQ-1. The Air Force had used 'Q' to designate unmanned aircraft as early as World War II. The 'R' stood for reconnaissance. As early as 2001, the Air Force used a Predator aircraft to launch a Hellfire air-to-ground missile against an enemy target. This

	Weight	Length	Wingspan	Endurance	Operation Radius	Payload Capacity	Fuel Type
Predator (MQ-1)	2250 lb	27'	55'	24 hr	500 nm	450 lb	AVGAS
Warrior Alpha (I-GNAT-ER)	2300 lb	27'	49'	30 hr	150 nm	450 lb	AVGAS
Sky Warrior (MQ-1C)	3200 lb	28'	56'	40 hr*	648 nm	800 lb	JP-8
Reaper (MQ-9)	10,500 lb	36'	66'	24 hr	1655 nm	3750 lb	JP
*w/ 250 lb payload							

Figure 33. Predator and Its Successors.

new capability prompted a change in designation from RQ-1 to MQ-1, the 'M' represented the Predator's new multi-mission capability. As discussed in the previous chapter, in Kosovo Predators flew equipped with laser designators. The armed models used this designator to mark targets for their onboard Hellfire missiles. Both the CIA and the Air Force operated Predators using this new capability in the first six months of Operation ENDURING FREEDOM.[2]

In September 2008, the Air Force had an inventory of 110 Predators. During the surge that year in Iraq, Predators provided over 13,000 hours of video to the troops on the ground each month. At one point, the Air Force conducted 24 simultaneous combat air patrol missions, with each one providing coverage around the clock. This operation intensity was possible through the development of "split remote control." In this model, take-off and landing was directed by line-of-sight control in theater. Once airborne, operators in the continental US assumed control of the vehicle. This method, which increased the number of operators available, nearly tripled the number of operational Air Force's Predators at any given time, from 30 percent to 85 percent of the inventory.[3]

Simultaneously with the expansion of the Air Force's Predator, operational availablility was the Army's purpose for its own endurance UAV (see Figure 33). Army efforts focused on the General Atomics Sky Warrior, initially known as the Improved GNAT–Extended Range (I-GNAT-ER). The vehicle itself closely resembled the Predator, but powered a diesel (instead of aviation gasoline) engine. The first Warriors were deployed to Iraq in 2004. A newer version, known as Sky Warrior, entered service in 2008. Sky Warrior possessed a superior weapons payload to the

Predator or Warrior, and was capable of carrying four Hellfire missiles. Initial plans called for a system of 12 vehicles to be assigned to each divisional aviation brigade, further divided into 3 platoons. Each deployed system also included five ground control stations. In addition to its own lethal payload, the Warrior (and later Sky Warrior) acquired targets for the hunter-killer teams of OH-58 and AH-64 helicopters. Before Warrior, these teams functioned basically as they had in Vietnam: the OH-58 sought out targets and the helicopter gunship engaged it. Now, manned helicopters remained on strip alert until Warrior acquired a target. Also, because it was organic within the division, the operation team was in sync with the operations and activities of the ground forces that the vehicle supported. In one case, a Warrior imagery analyst detected insurgents placing an IED on a road several miles ahead of an approaching convoy. Because the operator knew where the convoy was headed, he warned the convoy commander. The commander stopped his vehicles, the Warrior lased the target, and a team of Apache and Kiowa helicopters engaged both the IED and the insurgents. An operator and analyst working from the continental United States would have identified the IED being set and directed other units to destroy it, but the analyst might not have known to warn the approaching convoy and save US Soldiers lives.[4]

The Air Force and Navy also pursued a succession to the Predator system. Initially known as the Predator-B, the name later changed to the MQ-9 Reaper. Similar to the Warrior and Sky Warrior systems, the Reaper was a response to increased needs and greater funding resulting from the initiation of the Long War. The Air Force's Air Combat Command approved the Reaper's concept of operations in 2003. The following year, the Air Force set up the 42nd Attack Squadron as the Reaper organization, first received in March 2007. The Reapers possess a greater capacity operational radius and payload capability than the Predator and they first operated in combat in Afghanistan in the fall of 2007.[5]

Short Range Systems—Hunter, Pioneer, and Shadow

During the Long War, three UAV systems performed the short range ISR mission. Two of these programs possessed operational experience in previous conflicts: Hunter and Pioneer. The third system, Shadow, debuted during the Long War. Hunter systems were deployed to Iraq in January 2003 in support of Operation IRAQI FREEDOM. During the first 30 days, Hunter vehicles were not in service due to the fact they had not been assigned an operational frequency, but by January 2004, Hunters had flown over 3,100 hours in theater. In October 2003, the Center for Army Lessons Learned published an article praising the Hunter's role in high-intensity operations, but the article criticized the system's effectiveness in support and stability operations. The vehicle's limited vision made it difficult to find small groups of enemy forces over large geographical areas. For example, even when the vehicle operator received intelligence from other sources that located enemy forces, by the time Hunter reached the target the enemy had usually left the area.[6]

Despite these initial problems, the Army decided to purchase upgraded Hunters in FY 2004. The new Hunters, designated MQ-5B, were powered wih a heavy fuel engine and modified to be able to carry Viper Strike munitions. The laser-guided Viper Strike munitions caused little collateral damage, which enabled them to be used in tight situations when a Hellfire or other aerial fire munition could produce unwanted collateral damage. These second-generation Hunters entered service sometime in late 2005 or early 2006. Over a year later, in September 2007, a Hunter system recorded its first kill. A scout team from the 25th Aviation Brigade spotted two enemy combatants setting up a roadside bomb. They called in a Hunter, which eliminated both bombers. Upon publication of the DOD's 2007 Unmanned Systems Roadmap, the Army's UAV inventory contained 54 Hunter vehicles.[7]

The second SR UAV in the military's inventory, the Pioneer, began the Long War as a Navy system, but soon showed its value with the Marine Corps. Pioneer continued to perform its basic ISR mission, with virtually no changes to the system. The only significant change was the addition of the MRS-2000 video receiver and terminal. Because of its compact size, the MRS-2000 added mobility to the Marines UAV capability. Previously, the video terminal for the Pioneer required a Humvee and three crew members to operate. Instead, the new receiver fit in a Soldier backpack. Initially there were only four video terminals. High demand led the Marines to order two more in July 2003. By the end of 2005, Pioneers had flown a total of 7,500 hours in Iraq. The Marine Corps continued to use the Pioneer, although the Shadow started replacing it in 2007.[8]

Following the cancellation of the Outrider system in 1999, the Army looked for a new replacement to provide tactical ISR at the brigade level. In December 1999, the Army selected the Shadow system, manufactured by AAI as its new UAV. About half the size of Hunter, the Shadow vehicle had a range of around 68 nautical miles and could stay aloft for up to six hours. The Shadow could be launched either from a runway, or via a catapult sys-


DOD photo, PFC Bradley J. Clark.

Figure 34. Shadow UAV Being Prepared for Flight.

tem (see Figure 34). In 2002, the Shadow entered full production. Each system contained four vehicles and two ground control stations. The Shadow deployed with the Army at the beginning of Operation IRAQI FREEDOM and quickly proved its worth. By June 2006, Shadow vehicles had flown a total of 84,000 hours, including 50,000 hours between August 2005 and the following June, an average of seven vehicles in the air around the clock. The Shadow was deployed at brigade level, with one in each Stryker brigade combat team and modular brigade.[9]

The Army used the One System Ground Control Station (GCS), designed by AAI for the Shadow system. Interoperability and commonality. increased due to its ability to work with multiple platfroms. From 2001 through 2005, the GCS was able to control modified Pioneer, Warrior, and Hunter UAVs, each of which had previously used its own GCS. The One System GCS met a DOD objective for a ground control station capable of controlling various UAVs in existence since the early 1990s.[10]. In 2004, the Marine Corps standardized the Shadow's GCS for use with the Pioneer. The following year, AAI received a contract from General Atomics to provide the GCS for the Army's Warrior UAV. As more units received the One System GCS, it was easier for an Army unit working adjacent to a Marine unit to "borrow" a Marine UAV and vice versa. In addition to providing a rapid response to quickly developing situations, this interoperability also decreased the amount of mission overlap that occurred when each service needed to deploy its own UAV.

Small UAVs

The growth of UAVs during the Long War was not limited to brigade and higher organizations. Small UAVs, such as AeroVironment's Raven and Dragon Eye, and Boeing's ScanEagle provided UAV support at battalion level or lower. The RQ-11 Raven (see Figure 35) evolved from the FQM-151A Pointer, described in the previous chapter. Briefly part of a program called Flashlite and later Pathfinder, the Raven entered LRIP in 2002. The system measured three feet long, with a wingspan of four and a half feet. The Raven fit into a suitcase and was hand launched. Once airborne, it transmited color video in real-time over a range of seven miles. Within four years the Army had used the Raven for 15,000 missions, under the operational control of company commanders. Its proven success led the Marine Corps to adopt the system in 2006.[11]

Slightly smaller than the Raven, the Dragon Eye first flew in 2000. The Marines acquired 40 systems in 2001. The Dragon Eye supported Marines at the company level and below. Even after acquiring Raven, the Ma-

US Army photo by SSG James Selesnick.

Figure 35. Hand Launched Raven UAV.

rines still retained the Dragon Eye as part of a new system, named Swift. Another small UAV tested by the Marine Corps was the ScanEagle. The ScanEagle's endurance far exceeded the Raven and Dragon Eye, both of which could only remain airborne for less than two hours. The ScanEagle could officially operate for up to 15 hours, although one system functioned for over 28 hours. The Navy also purchased several ScanEagle systems to assist in oil platform security. The Air Force also tested the system in 2007 for possible acquisition.[12]

Micro-UAVs

Although no micro-UAVs (sometimes called mini-UAVs) have entered full production, several systems were acquired via LRIP and deployed in support of the Long War. In 2004, the Army purchased 84 Tactical Mini-Unmanned Aerial Vehicles (TACMAV), which were developed by Applied Research Associates, for operation testing in Iraq and Afghanistan. Each system cost only $36,000. The TACMAV (see Figure 36) weighed less than a pound, measured just under 20 inches long, and had a 20-inch wingspan. It could fly for up to 25 minutes at a range of one-and-a-half nautical miles. The Army tested the TACMAV at the platoon and squad level. However, the results were not promising. Many units complained about the picture quality, lack of infrared capability, and the absence of grid coordinates on the terminal. After the initial tests, the Army rejected acquisition of the system.[13]

US Marine Corps photo.

Figure 36. Micro-UAV TACMAV.

AeroVironment, the producer of the Raven and the Dragon Eye, manufactured a more successful micro-UAV known as the Wasp. Smaller than the TACMAV at 11 inches long with a 16 inch wingspan, the Wasp possessed a similar range but had greater endurance and was able to stay aloft for up to an hour. The Wasp also used the same GCS that controlled the Raven and the Pointer. The Marines, Air Force, and Navy all demonstrated interest in the system.

UAV Systems in Afghanistan and Iraq Operations

Afghanistan

Following the attacks of 11 September 2001, al-Qaeda's haven in the mountains of Afghanistan became the first target in the War on Terrorism. In the ensuing Operation ENDURING FREEDOM, the United States relied heavily on Special Forces and precision aerial strikes to defeat the Taliban. Despite flying an average of only 200 sorties a day, Air Force crews engaged as many targets each day as it had when flying 3,000 daily missions during DESERT STORM. Among the factors that led to this increased efficiency, was the use of UAVs for target acquisition. Special Forces troops worked in conjunction with UAVs to monitor Taliban and al-Qaeda forces and decrease the sensor-to-shooter loop. Such integration of air and ground-based intelligence sources had a long history, going back to World War II when battle commanders regularly went aloft in liaison planes assigned to their units to confirm or verify intelligence reports. The live-video feeds of the Predator and Global Hawk gave the same capability to unit commanders without having to leave the ground. After a target was identified and engaged, UAVs performed battle damage assessments (BDA) to ascertain any requirement for additional strikes.[14]

Predators also played a vital role in ANACONDA the first unconventional American operation on Afghanistan. Predators performed two primary tasks: force protection and killer-scout operations. In a force protection mission, the UAV patrolled ahead of advancing forces and provided information about the enemy's location. In the killer-scout role, the Predator served as an airborne forward air controller (FAC). If necessary, force protection missions could change into killer-scout missions and provide targets for other aircraft or field artillery. Initially, some ground forward air controllers resisted coordinating with the UAV operators. But the Predator quickly proved its worth, and soon many ground FACs did not want to operate without UAV support. At Takur Ghar the tactical air control party (TACP) from the 1st Battalion 187th Infantry, of the 101st Airborne Division, received intelligence from higher level headquarters that enemy forces were gathering within his area of responsibility. Some hills obstructed the TACP's view and made it impossible for him to call for fire. An airborne FAC aboard an A-10 initially helped direct fire. Later, a Predator arrived on the scene and coordinated with the TACP, a pair of A-10s, and an AC-130. Fires were detected so well that the entire enemy force was destroyed before it could mount an attack on the infantry battalion.[15]

The Predator's ability to rapidly locate and identify targets made it possible to hit targets that previously would have escaped because of the delay in sensor-to-shooter. At times, however, this ability distracted from more important missions. One Predator operator described an incident in which a division commander, after viewing a Predator feed, ordered his air liaison officer to send aircraft to destroy a single truck seen delivering men and supplies on a battlefield, but the F-16s were unable to locate the truck. The air liaison officer wanted the planes to return to their close air support mission, but the ground commander wanted the truck destroyed. The F-16s continued to search for this one truck, reducing the close air support available to troops currently engaged with enemy forces. Video-feeds from UAVs have been described as seeing the world through a straw. Although the images acquired were remarkable, in this situation and in others it was easy to lose sight of the bigger picture in response to specific, yet limited, intelligence.[16]

When searching for a high-value target, however, this narrow focus can be extremely useful, particularly when hunting down Taliban and al-Qaeda leaders. Predator strikes routinely went after rich targets, sometimes engaging them even in the tribal regions of Pakistan. The number of attacks into Pakistan increased dramatically in the latter half of 2008. From January through the end of July, Predators fired five missiles at targets in Pakistan. In the three following months, they launched at least 18 missiles. Several attacks resulted in civilian casualties and a wave of negative publicity. One major success, however, was the elimination of Khalid Habib, a senior al-Qaeda operative, on 16 October. Additionally, analysts in the United States believed the Predator attacks forced the insurgents to retreat further from the Pakistan-Afghanistan border, complicating their insurgents' command and control. Although the Pakistani government regularly objects to the strikes as a violation of their sovereignty, American officials defended them as a matter of self-defense, since many attacks on US forces originated in Pakistan.[17]

Predator systems were also used to confirm and complement intelligence gathered from other sources. In early January 2007, elements of the 10th Mountain Division gathered signal intelligence indicating a pending attack on a newly established border post. As a result, UAVs were directed to observe areas within Pakistan where the attack was likely to originate. On 10 January, a Predator observed the assembly of enemy forces. A group of students was being armed and trained at a facility just inside Pakistan. The Predator continued to watch the enemy as they began to move toward the border post. Once they had moved far enough into Afghanistan where their location could not be disputed by the Pakistanis, the American forces fired on the raiding party. Using a variety of aerial and ground munitions, virtually the entire force was eliminated.[18]

Iraq

Despite a year of operational experience with the newest UAVs in Afghanistan and over a decade of research and development of interoperable systems, during the initial invasion of Iraq it remained difficult to share UAV gathered intelligence between the services. During the initial drive on Bagdad, the Global Broadcast System (GBS) distributed video from Air Force Predators and the Army Hunter systems. The Marines could view video over the GBS, but could not broadcast their own UAV intelligence from Pointer or Pioneer over the system. The Combined Forces Land Component Command (CFLCC) intelligence staff, headed by the C2, General James A. Marks, controlled UAV operations during the invasion. This overall direction facilitated the integration of UAV capabilities with other intelligence sources. At one point during the invasion, a human intelligence source reported a gathering of Fedayeen forces at a soccer stadium. CFLCC deployed a Hunter to verify the report. After confirming the report, field artillery and aerial fires eliminated the threat. Over the course of the next several years the services found ways to improve interoperability. However, it was often a case of working around problems rather than actually solving them, even then the situation was far from perfect.[19]

One example of this came in the lead-up to Operation AL FAJR, the joint Marine and Army operation to clear out Fallujah in November 2004. On 8 November, Camp Fallujah, which contained the command center for the Marine Expeditionary Force, began receiving mortar rounds which had been fired from inside a mosque courtyard. A Marine Pioneer located the target and the operator transferred the coordinates to the supporting field artillery unit. After making several adjustments, the artillery hit the courtyard but failed to suppress the mortar. At this point, the Marines received word that an armed Predator was in route. The Marine and Air Force operators still could not share images, so they used e-mail chat to transfer information. This approach took longer for the Predator to get on target, while mortar rounds continued to explode inside Camp Fallujah. The Marines finally got tired of waiting, and changed the mission from the Predator to a Marine AV-8B close support aircraft. The Pioneer operator gave targeting information via a voice link to the pilot, who then took out the insurgents and the mortar tube with a guided bomb. Fortunately in the end, the delay caused by inadequate communication capabilities between the Air Force and Marines was not detrimental to the mission. Had the AV-8B not been available ,however, the delay in getting the Predator on target could have resulted in serious consequences if the mortar gunner had been more proficient.[20]

Another incident from the same battle demonstrated that serious problems still remained with using UAVs in joint operations. Lieutenant General John F. Sattler requested that several mechanized units from the Army be sent to Fallujah to provide direct support to the Marines. In response, he received Task Force *2-2* from the 1st Infantry Division, and Task Force *2-7* from the 1st Cavalry Division. During the opening minutes of the attack, two of the Ravens from Task Force *2-2* crashed inside the city. Because of the timing, the unit had no other choice but to continue. Later, they discovered that the most likely cause of the crash was radio conflict from the adjacent Marine unit. In theory, standard frequency deconfliction conducted prior to the assault would have prevented this from happening. In this case, however, the deconfliction process never occurred and it resulted in the loss of two UAVs at the most inopportune time.[21]

From 2003 to 2008, proficiency with UAVs continued to improve. The battle for Sadr City in the spring of 2008 demonstrated how skilled the military had become at utilizing UAVs. Sadr City had long been used by Shia militia to launch rockets at the Green Zone, the government hub in downtown Baghdad. Iraqi Prime Minister Novri al-Maliki resisted attacking the area for over a year. Once he finally approved an operation to clear out insurgents from the district, UAVs played a critical role during the fight. The 3d Brigade Combat Team (BCT), 4th Infantry Division, had a Shadow platoon (comprising four Shadow systems), and each of its committed companys used a Raven UAV. However, in this fight the Predator played the most significant role. For the first time, a Predator was assigned to provide direct support to a BCT.

During the battle the brigade controlled all Shadow and Predator operations. Battalion commanders could request UAV support for a specific mission, which would generally be performed by a Shadow. UAV missions were generally assigned 24 to 48 hours in advance, although these could be adjusted. For example, following a rocket attack from inside the city, a Shadow would locate the insurgents responsible, often within 20-30 seconds. It would then follow the insurgents and eventually pass off the mission to an armed Predator, which could eliminate the target. This forced the insurgents to reorganize into smaller, less effective groups. If a company commander wanted to use his Raven, he requested a limited operational zone from the BCT, to eliminate air space conflicts.

The BCT's UAV fleet complemented manned aerial reconnaissance and ground reconnaissance missions. During the planning phase of a mission, UAVs provided critical intelligence information regarding the battlespace. As units prepared to engage the enemy, the tactical operations center could give them specific details in real-time, such as the location of insurgents, even before they made contact. The persistent stare of the Predator allowed the Army to develop a better understanding of the enemy's tactics. Rather than engage a single, small group of insurgents, the Predator could follow them and observe how they operated and moved. At one point after a rocket attack, a Predator trailed a group of insurgents all the way back to a building where the insurgent unit joined several other units for an after-action review. Sometimes, a Predator might follow a single enemy element for as long as 10 hours before engaging.[22]

The importance of the UAV operators and image analysts cannot be stressed enough. After the fight in Sadr City, the XO of the 3d BCT, Major John Gossart, praised their work:

> Seeing the ground from that vantage point, especially at night, takes training and practice to know what a cigarette or a weapon looks like. Knowing what to look for, what to cue off of, what is normal and what is not [is not easy]. When to move the bird and how to jump where the activity will happen, [and] not staying fixed on what the ground element can already see; our soldiers and leaders have become very good at this.[23]

The Challenges of UAV Operations in the Long War

The expansion of UAV use has sometimes led to heated discussions between the Army and Air Force personnel over who should control the unmanned aircraft. In 2007, the Air Force requested that the Secretary of Defense be the executive agent for military UAVs. The Pentagon denied the Air Force request and instead created a task force to manage all DOD UAVs. Despite such disputes, operationally the services continued to work together to support the nation's warfighters and doctrine writers from the Army and Air Force came together in 2008 to design a concept of operations for UAV employment in joint operations.[24]

The main item of contention was the Predator. Both services agreed that tactical-level UAVs, like the Raven, should be controlled by the Army (or Marine Corps) and strategic UAVs, such as Global Hawk, should be an Air Force asset. However, less clearcut was who should control the extended-range multi-purpose vehicles such as the Predator, that fall between the strategic and the tactical. In order to reduce costs and increase commonality and operability, the Pentagon instructed the Army and Air Force to merge these separate programs into a single program. Merging the development and acquisition programs might make the program more economically efficient, but it failed to answer the question of who controls the assets in theater.[25]

A second major challenge was a cronic shortage of pilots. In 2008, the Air Force created a new UAV pilot training program that took officers immediately out of initial pilot training. Previously, most Predator operators had other flight experience before entering the training program. These officers typically flew UAVs for approximately four years and then returned to their original career track. In addition to these temporary operators, the Air Force announced plans to develop a new career track focused entirely on unmanned flight operations. In the past some pilots had resisted UAV assignments because of the limited potential for promotion. This new track aimed to eliminate that problem. In addition to training more officers, the Air Force also used enlisted airmen to operate the sensors on board the Predator.[26]

The Future of UAVs

Despite the success of UAVs in Sadr City and elsewhere, their future remains unclear. The record levels of defense spending from 2003-2008 will nearly certainly decline in the years ahead. In the Army, the establishment in 2009 of the Army Brigade Combat Team Modernization Program will likely shape how UAVs are employed in that service. The proper balance between manned and unmanned aerial vehicles continues to be debated within the DOD and elsewhere. Questions about the effectiveness of UAVs against a technologically sophisticated opponent remain unanswered. The operational use of UAVs in Afghanistan and Iraq grew so rapidly that the long term costs of operating them is only beginning to become clear.

The Future Combat System

In 1999, Chief of Staff of the Army Eric Shinseki announced one of the largest transformation plans in the Army's history. His proposal aimed to make the Army more rapidly deployable. The Future Combat System (FCS) represented a major component of this plan. Over a period of 30 years, the FCS would replace a variety of major warfighting tools, including the M1 Abrams and the M2 Bradley, with an integrated system of UAVs, manned and unmanned ground vehicles, remote sensors, and an advanced network to manage battle space information. The FCS focused heavily on situational awareness, maneuverability, and information management, which its advocates argued would allow a smaller force to defeat a much larger enemy.[27]

The initial FCS design included four UAVs, each supporting a different element. The class I UAV provided RSTA at the platoon level. Classes II, III, and IV supported the company, battalion, and brigade level respectively. Each FCS equipped brigade would possess 200 UAVs. Critics of the FCS argued this would create an enormous airspace management problem. When General Peter Schoomaker replaced General Shinseki in 2003, he altered some aspects of the FCS program to get technology developed as part of the system into the hands of American forces fighting the Long War. The Army planned for three "spin-outs," each of which would deploy parts of the FCS alongside active brigades, the second of which included UAVs. Also in 2003, the Army selected Northrop Grumman's MQ-8 Fire Scout VTOL UAV as the class IV vehicle. The Fire Scout's vertical takeoffs and landings allowed to it operate from an unimproved runway. It lacked the endurance described by the FCS outline with only six hours over a target. The Navy also selected the Fire Scout to provide UAV support for surface ships, fulfilling a desire for a VTOL UAV that dated to the DASH program of the 1960s.[28]

In 2006, the Army selected the second UAV to become part of the FCS. They chose the Honeywell RQ-16 to be the class I vehicle. The RQ-16 micro air vehicle possessed a rather unique design. It generated lift via a propeller housed inside a duct. The vehicle weighs only sixteen pounds, possesses a range of six nautical miles, and flies for up to forty minutes per mission. Initially developed as part of a micro air vehicle ACTD, the Army purchased several systems to test with the 25th ID in 2004. The vehicle's performance in these tests helped insure its selection as part of the FCS.[29]

Because of budgetary concerns, the Army restructured the FCS program in 2007 and eliminated the class II and III UAVs. This decision also limited the potential air space management problems that the previous plan might have created by having so many UAVs operating. The elimination also reduced the amount of bandwidth required to transfer sensor data and vehicle control between ground stations and UAVs. Boeing, the lead contractor for the FCS, studied the bandwidth demands of the original plans for the FCS. Prior to the reduction of UAVs, the bandwidth required by the FCS was 10 times greater than what was expected to be available. Sensor data from the class III and IV UAVs alone comprised two-thirds of the FCS's bandwidth demand. Even after the elimination of the class II and III vehicles, concerns remained about the strain the FCS would put on the Army's information network.[30]

In may 2009 Army officials announced the cancelation of the FCS. However certain aspects of the program were to be incorporated into a new program, the Army Brigade Combat Team Modernization Program. Although at the time of this writing, the parameters of the BCT modernization program are still under development, it is clear that UAVs will be an important part of the program.

Challenges of the Future

The use of UAV supplied full-motion video has generated concern in some quarters that commanders have become addicted to it. One Air Force officer described this phenomenon as "Predator crack." A study by the Center for Army Lessons Learned (CALL) found that commanders in Iraq were occasionally hesitant to authorize a fire mission without full-motion video coverage of the target. Requiring a live video feed may help prevent the accidental targeting of civilian or friendly forces, a critical task in Iraq's operational environment. However, it does so at the expense of traditional methods of calling for fire. In a future conflict against a more technologically sophisticated opponent, constant full-motion video might not be as readily available. The constant use of full-motion video also puts tremendous strain on digital communications services. One of the key findings of the CALL study was the need to prioritize the use of full-motion video and only use it when necessary.[31]

In a report from 2005, the Congressional Research Service posed several questions about future UAV development. One of these, related to the growing dependence on UAVs, dealt with the effect of unmanned aircraft production on traditional aircraft production. The report questioned whether industry focus on unmanned vehicles would lead to a decline in manned aircraft development expertise, an area in which the United States traditionally holds a strong competitive advantage. During the Long War, many aircraft manufacturers have increased their research and development of UAVs at the expense of manned aircraft. A major question driving this debate is how soon UAVs can fill the role of combat aircraft, or whether they ever could. Proponents of UAVs argue that the Joint Strike Fighter is likely to be the last, manned fighter jet. Manned flight advocates believe that UAV technology is still too immature to completely replace manned fighters. While UAVs proved their capabilities against insurgents, who lacked sophisticated jamming and electronic warfare weapons, it remains unclear how effective they would be against an adversary with more advanced capabilities.[32]

Another potential problem is uncertainty over UAV long term operating costs. The rapid development and deployment of UAV systems precluded the examination of the logistical cost that normally happens whenever the military acquires a new system. Both Predator and Global Hawk skipped the system development and demonstration phase of acquisition, the series of tests which provide information regarding the maintenance requirements of new systems. The need to deploy UAVs to the field in order to support troops trumped the need for further testing. At one point, the Air Force offered to delay further Predator acquisition to perform these tests. However Congress rejected this offer. As a result of the rushed development, DOD is still determining the cost of maintaining UAV systems over an extended period of time.[33]

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Conclusion

> *So these systems [Unmanned Aerial Vehicles] have become very, very important. Now, it's a lot more complex than that because you have bandwidth issues. You have frequency issues. There is a limit to how many you can put in a certain airspace . . . again, because of communications issues and so forth. But, again, ISR is almost a pacing item for some of our units that are downrange. In other words, the key enabler for certain of our units that are downrange.*
>
> –General David Petraeus, Pentagon interview, 16 April 2008

Unmanned aerial vehicles represent one of the most significant weapons to emerge from the conflicts in Iraq and Afghanistan. No one can doubt the importance of UAVs in protecting the lives of US Soldiers. However, UAVs like the Predator, Shadow, and Raven did not emerge *ex nihilo* in 2001. Experiments with unmanned flight date to World War I. The Army used aerial reconnaissance separately from the Air Force dating to World War II, which predates the actual institutional separation of the Army and Air Force by several years. The last 90 years of manned aerial reconnaissance operations was a prelude to the organization and doctrine for the deployment of UAVs today. Knowledge of the history of both aerial reconnaissance and unmanned flight is helpful in determining the most effective employment of future UAVs.

Should UAVs continue to be spread throughout the services or consolidated under the Air Force? During World War II, the Army Air Force continually opposed the Army's liaison aircraft program. Recently, the air service has tried to gain complete control of UAV development and acquisition. In the past, the fiscal logic of research centralization has appealed to Congress. However, under the JPO the search for a few vehicles capable of performing all missions for all services proved far more expensive than allowing the individual services to develop their own UAVs. This latter approach has proved to be effective in facilitating interoperability and commonality. For example, after witnessing the effectiveness of the Army's Raven UAV, the Marines have begun to acquire it as well. The One

System Ground Control Station is also being used by the Marines after initially being an Army project.

Regardless of which service controls the DOD UAV program, it remains likely that the Army will continue to possess tactical UAVs in its organization. But how to most effectively organize these assets? In the extreme, two possibilities exist. Individual UAVs can either be assigned to individual units (company, battalion, brigade, division, corps), or pooled at a higher level and tasked out based on mission requirements. In the former model, each battalion might get a Shadow vehicle. In the latter, the brigade would have three or four vehicles which it could task as needed.

Historically, the latter approach has proven more effective as it optimized and prioritized the use of a limited number of systems. During World War II, even though each liaison plane received an assignment to a specific battalion, the division usually pooled these aircraft to ensure dawn-to-dusk coverage. Both Shadow and Predator have been used in this manner to provide continuous aerial reconnaissance. Assigning aircraft permanently to a single unit guarantees that the commander will always have an asset when he needs it, but it also increases the overall logistical burden on the unit and the Army as whole.

A slight variation to this approach was the organization of the 1st Aviation Brigade in Vietnam. The 1st Aviation Brigade functioned as a completely independent unit, providing logistical and maintenance support to numerous aviation groups, battalions, and squadrons. Its subordinate units were attached for various periods of time to ground units, with the brigade providing only administrative and logistical support.

Each of these models contains advantages and disadvantages, and the most effective solution is likely a combination of these approaches. During the fight for Sadr City each company had a Raven organic to its organization, although the units had to request airspace from the brigade to prevent collisions. The four available Shadow systems were pooled at the brigade level. Because of the importance of the fight, the 4th Infantry Division assigned Predator UAVs to the brigade as well. This mix of direct control, pooled assets, and tasked vehicles proved effective in the ensuing operation.

It is not good enough to simply acquire intelligence information. That information also has to be distributed to the users who need it. The net-centric approach makes it easy to simply broadcast full-motion video, but puts a tremendous strain on network resources. The Army needs to develop a way to ascertain who needs full-motion video, or when other methods could be used. Artillery observers are being underutilized as commanders prefer to use UAVs for targeting. A more traditional use of these forward observers and manned reconnaissance assets would place less strain on the network. The employment of UAVs and full-motion video should be need-driven, not capability-driven. Just because it is available does not mean it is always the proper tool to use. More effective application will guarantee that bandwidth and UAVs will continue to be available as required.

One challenge that has spanned the era of manned and unmanned aerial reconnaissance aircraft has been the difficulty in training pilots/operators and maintenance personnel. The suddenness of the United States' entry into World War I forced the American Expeditionary Force to rely on British and French trainers. The Army Air Force possessed a far greater training capacity at the start of World War II. However this did not necessarily translate into the ground forces receiving enough pilots to fly artillery liaison aircraft. Additionally, air and ground commanders disputed what the basic requirements should be for these pilots. The rapid increase of UAVs during the Long War resurrected similar issues. The number of UAV systems deployed increased so rapidly that none of the services had enough operators or mechanics. In this case, the military looked not to its allies but to private contractors to supplement service personnel. While this method provided a temporary fix it did not address the long-term problem. Operatonal requirements caused the expansion of training programs which added more cost to the expense of the short-term, contractor-based solution.

Historically the development of UAVs can be divided into three stages. During the first stage, which began in World War I and ended with Operation DESERT SHIELD, the military experimented and tested UAVs in a mostly theoretical fashion. The Lightning Bug's activity during the Vietnam War was a notable exception. The rest of the systems developed in this period helped formulate conceptions about the future of UAVs, but did little to provide any practical applications. The next phase, which lasted from DESERT STORM to the invasion of Afghanistan, may be categorized as "field testing," although some of these tests took place under actual combat situations. American military engagements in Iraq, Somalia, Bosnia, and Kosovo provided opportunities to augment the concepts developed over the previous six decades with actual battlefield experience. The performance of UAVs in this period varied greatly, not only from system to system, but also from conflict to conflict. Pioneers excelled in

Iraq, but struggled in Bosnia and Kosovo. During the Long War, the final stage of UAV development, the concepts and lessons of the earlier periods came to maturity. Although still being refined operationally, UAVs in Afghanistan and Iraq have proved decisive in their support of offensive, defensive, and stability operations.

Another theme is the ongoing contrast between specialization and efficiency and economy. In terms of mission performance, each service and branch possesses different requirements for its aerial observation platforms, manned or unmanned. During World War II, the Army Air Force needed fast, maneuverable planes to perform reconnaissance and conduct battle damage assessment deep in enemy territory. But, these planes flew too fast to effectively support the ground forces because they operated from far behind the front, a disconnect developed between the pilots and the ground forces. The Army Air Force was theoretically correct that using its aircraft for tactical reconnaissance and artillery adjustment would be more efficient and affordable. However, the slower less maneuverable liaison planes assigned to the ground units proved to be more adept at providing close range ISR.

The challenge of balancing mission performance with budgetary concerns is even more complicated in the era of the UAV. In theory, several UAVs could be developed to perform all the missions required by the services at every level of command. The JPO pursued this approach during the early 1990s. The hope was that by increasing interoperability and commonality there would be a reduction in the number of systems aircraft purchased, thereby saving money. However, the cost per unit of these aircraft became so expensive that it proved to be a less effective plan. On the other hand, acquiring low-cost specialized UAVs capable of performing only a few basic missions or supporting only a specific echelon would require a high inventory of vehicles. In addition to acquisition costs, the more varied systems that are purchased, the greater the logistical requirement. The challenge for DOD is finding the most efficient balance between these extremes.

The final question raised in this study is the proper balance between manned and unmanned aircraft. Critics of UAVs contend that against a more capable, conventional opponent, they will not be able to perform as effectively as they have in Afghanistan and Iraq. Proponents, on the other hand, think that the current operational environment will be the most likely type of conflict in the future. History cannot be used to determine how the next war will be fought. If anything, it shows that peacetime research and development never provides anything more than a base for war mobilization. The balloons of World War I, the liaison planes of World War II, and the aero-scout teams of Vietnam were all relatively undeveloped at the start of their respective conflicts. Moving forward, a broad research approach encompassing manned and unmanned aircraft will provide the best base to begin the next major conflict.

Over the last 90 years, the Army used a variety of vehicles to provide aerial reconnaissance. Technologically, a Raven flying around Sadr City appears worlds apart from a balloon floating over St. Mihiel. Their tasks, however, are remarkably similar. The field manual for balloon companies instructs observers to describe what they saw, without interpretation. Full-motion video now provides commanders exactly the same thing 92 years later. Determining intelligence requirements, gathering it and distributing the results to the field has been a consistent challenge for the Army's aerial reconnaissance program since the First World War. Although historical analysis cannot provide a clearcut template for the proper role and mix of UAVs and aerial reconnaissance, it does provide valuable insight for the way ahead.

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