AU/ACSC/0530/97-03

THE PILOTLESS AIR FORCE?

A LOOK AT REPLACING HUMAN OPERATORS WITH ADVANCED TECHNOLOGY

A Research Paper

Presented To

The Research Department

Air Command and Staff College

In Partial Fulfillment of the Graduation Requirements of ACSC

by

Major Robert C. Nolan II

March 1997

Disclaimer

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government or the Department of Defense.

Contents

Preface

This project takes a limited look at the future of unmanned aerial vehicle (UAV) operations within the US Air Force. I choose this topic because it is relevant to today's military and there seems to be some increasing debate over the value of manned aircraft. During the time I spent gathering material for this effort I was surprised by the emotions that this subject raises. Also surprising was the limited understanding of what aircraft and airmen really do for the Air Force. I have attempted to conduct this effort without prejudice and focused on the concept that the Air Force serves the nation, not individuals seeking to accomplish personal goals.

I would like to thank Major Charles Manzione, my ACSC Faculty Research Advisor, for his guidance and assistance. I would also like to thank Col John Warden, USAF, Retired, and Dr. Lewis Ware, ACSC Faculty, for discussing this subject. In addition, I would like to thank my friends at Lockheed-Martin for being very candid about a subject that may be very sensitive to their profit margin.

Abstract

Today, there are several concepts that are threatening Billy Mitchell's vision of airmen. New technology and operational concepts are threatening the existence of the human aircraft operator. Looming on the horizon are unmanned aerial vehicles, spaced based weapons, and information architectures. This research effort is limited in scope. It focuses specifically on the UAV issue and explores the possibility that airmen will be replaced by unmanned vehicles in the next twenty years.

On the one hand, UAVs offer distinct advantages over manned aircraft. UAVs will save lives and money. UAVs are not constrained by the physiological limits of the human operator. In addition, they eliminate tough political situations that arise when airmen are shot down over unfriendly territory.

On the other hand, even with advanced unmanned technology, airmen still provide the Air Force with the indispensable qualities of flexibility and adaptability. These qualities, fueled by initiative and experience, are absolutely necessary to deal with the friction inherent in war.

Rapid advances in technology will produce man-in-the-loop and autonomous UAVs that will serve as force multipliers. Man-in-the-loop systems are vulnerable to communications jamming while autonomous systems do not provide the flexibility required or present a moral dilemma. Manned combat aircraft will be required to deal

with uncertainty and chaos. UAVs will increase the requirements for highly trained airmen.

The Air Force must exploit the advantages offered by the UAV. UAVs will play a significant role in future operations. However, as a warfighting institution, the Air Force must not forget the significant contribution of the human operator. The UAV is a force multiplier and nothing more. This technology will augment, not replace, the human operator. Airmen are critical to the functioning of the Air Force and they will continue to be well into the next century. To maintain the asymmetric advantage that air power gives our nation, skilled, cunning operators will be required to handle the uncertainty of war.

Material for this effort was gathered through the Air University Library, the ACSC curriculum, and interviews.

Chapter 1

Introduction

The destinies of all people will be controlled by airpower.

—William Mitchell, *Winged Defense*

Unmanned aerial vehicles (UAVs) will play a significant role in future operations and the US Air Force must exploit every advantage offered by UAV technology. However, as a warfighting institution, the Air Force must not forget the significant contribution of the human operator. The UAV is a force multiplier and nothing more. UAV technology can not replace the human operator. UAVs will actually increase the requirements for skilled airmen. Airmen are critical to the functioning of the Air Force and they will continue to be well into the next century. To maintain the asymmetric advantage that air power gives our nation, skilled, cunning human operators will be required to handle the uncertainty of war. The UAV debate was born in WWI but new technology has recently nurtured the argument.

World War I introduced the airplane, manned and unmanned, to the world as a military technology. Manned aircraft were capable of numerous combat duties and became a glamorous weapon of war. Unmanned aircraft were experimental, never achieved any measure of success, and thus were always behind the scenes.

Over the following decades, the manned aircraft flourished as the unmanned aircraft had relatively few advocates. The technology to conduct combat operations from the air matured rapidly. However, the concept of air operations lagged behind aircraft development. Many military leaders failed to foresee the aircraft's strategic value or the vital nature of the battlespace that it laid at their feet. The aircraft threatened the very existence of long established US military organizations. The aircraft was central to Billy Mitchell's vision of future war. He envisioned the aircraft as a device to eliminate trench warfare and return maneuver to the battlefield. He saw aircraft as the future and purveyor of modern combat operations.[1]

The backbone of Mitchell's vision lay in the independent use of airpower to achieve strategic military objectives. His concept of an independent Air Force revolved around a corps of specially trained individuals that he referred to as Knights-of-the-Air. Mitchell's Knights or airmen were elite. They were the sole harbingers of a quality that he referred to as airmindedness. They alone saw the capabilities of airpower: speed, flexibility, and most critically its unique perspective.[2] Mitchell's airmen were operators. They were the pilots and observers (navigators) of World War I. They possessed physical courage and they alone had the capacity to lead an independent air arm. Fifty years after the establishment of the US Air Force, Mitchell's concept of airmen is undergoing some strain.

As Air Force members we look back at Mitchell and view an institutional hero. An individual who had the moral courage to stand for a vision in which he believed. Today there are several concepts that are threatening Mitchell's Knights-of-the-Air. Some, such as Carl Builder, have argued that airmen are actually destroying the Air Force.[3] New technologies and operational concepts are challenging the existence of airmen. Looming on the horizon are unmanned aerial vehicles that will have the capability to carry the fight to the enemy, while airpower theorists such as John Warden, suggest that space based weapons will quickly replace combat aircraft.[4] Like the argument of Mitchell's day this topic is charged with emotion. Airmen are seen as arrogant in their stance supporting outdated technologies and concepts of warfare: fighting for unnecessary, expensive aircraft like the F-22 and the Joint Strike Fighter. Proponents of second or third order institutional change view UAVs, space based weapons, and information architectures as key to the institutional future of the Air Force. These individuals are viewed as misguided and jealous by the aviation community. They are unaware of the true capabilities and talents required to conduct combat operations from the air, jealous of institutional leadership and tired of playing second fiddle to airmen.

This research effort is limited in scope. Current international agreements prohibit space based weapons and our information metasystem is only a concept, so this essay will focus specifically on the UAV issue and explore the possibility that airmen will be replaced by unmanned vehicles in the next twenty years. This essay presents arguments for and against UAVs. Advantages in new technology are explored in an attempt to draw conclusions about the future of airmen and the Air Force. This effort examines this issue within an institutional framework, without prejudice, and it is mindful that the real mission of the Air Force is to serve the nation.

Notes

[1]William Mitchell, *Winged Defense* (New York, N.Y.: Dover Publications, 1988), 159

Notes

Roger Burlingame, *General Billy Mitchell, Champion of Air Defense* (New York, N.Y.: McGraw-Hill Book Company, 1952), 67-68.

[2]Mitchell, vii.

[3]Carl Builder, *The Icarus Syndrome* (New Brunswick, C.N.: Transaction Publishers, 1996), 179-188.

[4]Col John Warden (Retired), interview with author, 20 Dec 1996.

Chapter 2

The Case for Unmanned Aerial Combat Vehicles

We are heading to a future where combat aircraft will be pilotless drones.

—Ben Rich, *Skunk Works*

In 1982, the Israeli Air Force overran Syrian defenses in the Bekaa Valley and destroyed the Syrian Air Force in one of the largest air battles since WWII. Key to that victory were small unmanned aircraft used to deceive and destroy the Syrian integrated air defense system.[1] This incident focused world wide military attention on the UAV issue.[2]

The principal argument for UAVs is that they save lives. Henry C. Yuen, TRW futurist researcher believes that one of the foremost objectives in the development of new weaponry should be the total elimination of human risk.[3] Weapons and equipment that face destruction at the enemy's hand should be unmanned. Unmanned aircraft could be used in any situation. They could fly into extensive defense networks, with no regard for human life and the consequences thereof. The protection of human life has become a paramount concern for US NCA, as public opinion and increased media dissemination play a key role in military operations and thus political and diplomatic endeavors. The Gulf War laid this foundation and set the standard for modern combat operations.[4] The expectations produced by these operations may be unrealistic.

While low casualties are desirable, the expectation that losses will be minimal on a fluid battlefield may inhibit the future use of force as an instrument of national power. The desire to limit casualties may be an American center of gravity. The late Gen Mohammed Farah Aidid undermined US political objectives in Somalia while inflicting less than 2 dozen US casualties.[5] The importance of saving human life has become critical to the success of US military operations. UAVs will save lives. In August of 1995, a Predator UAV was completing a reconnaissance mission in Bosnia when it was shot down in the same area where US Air Force Captain Scott O'Grady was downed two months earlier. The Predator served as a loyal soldier and hardly a mention of its shoot down was noticeable in the world press.[6]

There may be a greatly added political benefit to these life saving drone aircraft. When they are shot down or fall from the sky they have little impact on the world's political fabric. From the Cold War to the Gulf War, the capture of American airmen has inflamed public debate over war and peace.

The shoot down of Francis Gary Powers over the Soviet Union is probably history's prime example. Two weeks before a scheduled Paris summit meeting, between President Eisenhower and Premier Khrushchev, Francis Gary Powers's U-2 was shot down over Sverdlovsk, USSR. Since 1959, the personal relationship between Eisenhower and Khrushchev was becoming quiet warm. In that year the Soviet leader visited the US as a guest of the Eisenhowers and toured the country to the nation's delight. On Sunday, 1 May 1960, while working for the CIA, Francis Gary Powers would change that relationship forever and put the world on the brink of Nuclear war. After Powers was shot down, Eisenhower was informed that the aircraft was completely destroyed and that the pilot was dead. The Eisenhower administration released a cover story that a NASA high altitude research aircraft strayed off course and was lost over the Soviet Union. Two days later Khrushchev accused the American government of lying and stated that "we have the remnants of the plane, and we also have the pilot, who is quite alive."[7] The Eisenhower administration was in a state of shock. Eisenhower decided to go to the Paris summit anyway and hoped that he and Khrushchev could resolve the situation. At the Paris summit, Khrushchev publicly humiliated President Eisenhower and refused to talk to him until he apologized for the U-2 overflights and punished those in the US government that were responsible. Eisenhower refused, the summit meeting broke up and US forces were placed on world wide alert. Later that week President Eisenhower went on television and explained to the American people what had happened in Paris. He also outlined the basics of the U-2 program. For the first time in US history an American president publicly admitted that the US was involved in spying. The incident was diffused somewhat when Henry Cabot Lodge rebutted Soviet complaints about U-2 spying when he released and provided the UN Security Council information about Soviet efforts to spy on the US. In 1962, the Kennedy administration traded Soviet spy Rudolf Abel for Francis Gary Powers's freedom.[8]

Francis Gary Powers was not the last American airman to cause political turmoil. Hanoi used American flyers as bargaining chips and instruments of propaganda in its negotiations with the Nixon administration.[9] Syria's capture of Lt. Goodman, a naval aviator, attacking a pro-Syrian Lebanese faction—and his subsequent release to the Reverend Jesse Jackson—helped to dissuade the Reagan administration from further military strikes in Lebanon in 1983.[10] Most recently, during the Gulf War, diplomatic arguments over the rescue of an American F-15E aircrew, downed in Iraq, threatened to divide the delicate coalition arrayed against Saddam Hussein.[11]

Unarguably, UAVs would avoid all of these problems and save money in the process.[12] Taking the human being out of the aircraft allows a significant reduction in developmental and operational costs. When aircraft were first developed little thought was given to what is now called the pilot-vehicle-interface. In today's complex and demanding environment, cockpit design and pilot life support systems consume a considerable amount of total resources available. It will cost approximately $17 billion to design and implement the F-22's advanced pilot-vehicle-interface. Almost 30 percent of the total F-22 program cost is invested in the pilot alone.[13] Operational costs may go much higher. The cost of flight training for a single US fighter pilot is now estimated at $2 million.[14] That's just initial training cost. The maintenance cost of two thousand actively flying F-16 pilots is close to $1 billion per year.[15] Removing the human operator results in a significant dollar savings and consumes less design resources. Time in development is also reduced as an expensive interface becomes unnecessary.

Eliminating the cockpit, life support systems, and pilot leads to another great advantage: size and weight reduction. Aircraft performance is severely limited by aircraft size and weight.[16] Removing the pilot and his or her supporting architecture produces a corresponding increase in aircraft performance.[17] Also, the unmanned aircraft will not be limited by the physiological barriers that nature has placed upon the pilot. The UAV would be G force limited by structural engineering, not the ability of the pilot's heart to provide his head with blood under the strain.[18] Endurance becomes limited only by fuel supply, not the pilot's bladder, physical comfort or exhaustion level. Regardless of the altitude, a UAV will not require oxygen or expensive pressure suit equipment to prevent the blood from boiling due to the partial pressure of oxygen. UAV performance, unlike the pilot's, will not degrade as a function of time as caused by fatigue. These concepts have been demonstrated in NASA's HIMAT unmanned research vehicle. This experimental UAV is capable of achieving acceleration levels that would kill the human pilot.[19] The UAV with reduced size and increased performance will also have a corresponding reduction in signature and thus is more survivable. [20]

Saving lives, reducing cost, and improving performance are strong motives for removing the human from the cockpit. The aftershocks from the shoot down of Francis Gary Powers led to the development of a highly classified drone aircraft during the height of the cold war. Kelly Johnson, designer of the SR-71 and the U-2, was a proponent of unmanned aircraft. He saw pilotless aircraft of all forms as making his job easier and providing a safer means of implementing national policy.[21] In 1963, under the code name of TAGBOARD, Lockheed's famed Skunk Works, developed a trisonic, air launched, unmanned reconnaissance vehicle. The D-21 was designed to fly over hostile territory, above ninety thousand feet, at Mach 3.3+, and take pictures. The vehicle was entirely autonomous and once launched it would fly a preprogrammed flight path, take its photos, eject the camera and film package, which would be recovered by a C-130 aircraft equipped with the Mid-Air Recovery System. The drone would then self-destruct in its unpowered descent. The original plan called for high speed launches from the SR-71. The combination was similar to the way the space shuttle is carried piggy back by a 747. After a fatal accident during flight testing, the B-52 become the operational launch platform. D-21s were used for a short time to penetrate China and fly highly classified reconnaissance missions.[22]

The most successful UAV to date has been the cruise missile.[23] The cruise missile is nothing more than an unmanned aircraft on a one-way mission.[24] The cruise missile has its origins in WWI and WWII. During WWI an unmanned aircraft carrying an explosive device was designed. The device was called the Bug and it was designed by the Sperry Company.[25] The unmanned aircraft flew using a gyroscope based autopilot and an altitude hold system. The Bug was launched from a track and was set to fall on its target after flying a specific heading for a specific amount of time. The Bug provided all the benefits of UAVs: its use did not threaten the life of a pilot; when they were dying at an unprecedented rate, and the cost was low at four hundred dollars to put three hundred pounds of explosive over a target.[26] The war ended before the Bug could be brought to bear on Germany.[27] In WWII the Bug concept was resurrected but it did not have the range to reach Germany from the British Isles.[28]

The Allies did not take advantage of this concept but the Germans did. They built the V-1 Buzz Bomb. The V-1 was another predecessor of the cruise missile.[29]

The modern day cruise missile is not unlike its ancestors. It flies a pre-planned program to its target where it explodes. Their major difference is how they find their way to the target. The Bug and the V-1 were programmed to fall on their target at a set time. Timing was based on rate and distance to target.[30] When the clock ran out of predicted flight time, the engine would shutoff and the vehicle would fall on its target and explode.[31] This method was not very accurate. The cruise missile relies on an inertial navigation system upgraded throughout the flight by comparing memorized topographical maps with actual areas of the earth's surface and recently improved with Global Positioning System updates.[32]

Like the cruise missile, the Predator UAV has been combat tested. Recently acquired by the Air Force, the Predator is a $3 million reconnaissance aircraft that is currently undergoing operational testing in Bosnia.[33] The aircraft is capable of flying at twenty-five thousand feet for up to 50-hours. The aircraft is remotely controlled and relays its video, radar, infrared or elint information to a line-of-sight ground station or to overhead satellites. The Predator embodies all the benefits of the UAV: it eliminates the need for humans to perform high risk or mundane intelligence gathering missions, it is relatively inexpensive, and the aircraft can far outperform any human with its 50-hour endurance.[34]

The benefits of UAVs are highly desirable and as the preceding examples show, have already been effectively demonstrated. If lives and money can be saved, with a corresponding increase in mission effectiveness, unmanned vehicles will become an essential warfighting tool. In regard to these issues, UAVs will greatly serve the national interest. The only question left to ask is do airmen provide the nation anything that UAV technology can not?

Notes

[1]Benjamin Cooling, *Air Superiority* (Washington, D.C.: Center for Air Force History, 1994), 598-601.

[2]Michael Gordon and General Bernard E. Trainor, *The General's War* (New York, N.Y.: Little, Brown and Company, 1995), 112.

Interestingly enough the IAF used UAVs in 1973 to attack Egyptian SAMs along the Suez Canal. But this drew little attention from the world.

[3]Alvin and Heidi Toffler, *War and Anti-War* (New York, N.Y.: Little, Brown and Company, 1993), 109-110.

[4]Gordon, 469-470.

Notes

[5]Ibid.

[6]Captain Scott O'Grady with Jeff Coplan, *Return with Honor* (New York, N.Y.: Doubleday, 1995), 22.

David Fulghum, "Two Predators Destroyed in Bosnia," *Aviation Week and Space Technology* 143, Iss 8 (August 1995): 24-25.

[7]Michael Beschloss, *Mayday, Eisenhower, Khrushchev and the U-2 Affair* (New York, N.Y.: Harper & Row Publishers, 1986), 59.

[8]Ibid., The material for this section was taken from Beschloss's comprehensive volume on the U-2 incident.

[9]Paul Seabury and Angelo Codevilla, *War Ends and Means* (New York, N.Y.: Basic Books, 1989), 230-233, 246-248.

[10]Gordon, 249.

[11]Ibid, 254-263.

[12]Steven Shaker and Alan Wise, *War Without Men* (New York, N.Y.: Pergamon-Brassey's, 1988), 4.

[13]Lt Col Patrick Duffy, interview with author, 16 Dec 1996. Lt Col Patrick Duffy is the F-22 Avionics IPT team chief. Actual breakdown of program costs is classified, so only an estimate can be given.

[14]Gordon, 75.

[15]2000 F-16 pilots flying the ACC requirement of 215 hours per year at 2000 dollars a sortie.

[16]Ray Whitford, *Design For Air Combat* (London, England: Jane's Publishing, 1987), 38.

[17]Bill Gunston and Mike Spick, *Modern Air Combat* (New York, N.Y.: Crescent Books, 1983), 28-29.

[18]Shaker, 104.

[19]Ibid.

[20]Ibid., xi.

[21]Ben Rich and Leo Janis, *Skunk Works* (Boston, M.A.: Little, Brown and Company, 1994), 22.

[22]Paul Crickmore, *Lockheed SR-71, The Secret Missions Exposed* (London, England: Osprey Aviation, 1993), 36-41. This section takes its information from Paul Crickmore's detailed description of the D-21 drone program. In the late 1970s the D-21 Drone almost became Lockheed's proposal for the stealth fighter but it was replaced with the all new F-117 design at the last minute.

[23]Shaker, 35.

[24]Ibid.

[25]Ibid., 22.

[26]Builder, 157-161.

[27]Shaker, 22.

[28]Builder, 157-161.

[29]Shaker, 30.

[30]Builder, 157-161.

Notes

[31]Shaker, 27.

[32]Bernard Blake, *Janes Weapon Systems 1988-1989* (Alexandria, V.A.: Janes Information Group, 1988), 721. The latest versions of the cruise missile use a TV camera to compare the target area with a memorized picture for an advertised CEP of 10M. As a member of the 39th Flight Test Squadron at Eglin AFB, from 1993 to 1996, I was directly involved in the testing of cruise missiles with GPS integrated navigation capabilities.

[33]David Fulghum, "Unmanned 'Spies' To Tune In Bosnia," *Aviation Week and Space Technology* 144, Iss 18 (April 1996): 58-59.

Fulghum, "Tier 2 UAV Aborts First Test Flight," *Aviation Week & Space Technology* 141, Iss 2 (July 1994): 22.

[34]David Fulghum, "USAF Pursues Stealthy UAV to Improve Reconnaissance," *Aviation Week & Space Technology* 140, Iss 3 (January 1994): 44-46.

Fulghum, "New UAV Force Forms at Nellis," *Aviation Week & Space Technology* 143, Iss 5 (July 1995): 20-22.

Fulghum, "Army Pushes Missiles For UAV Use," *Aviation Week & Space Technology* 143, Iss: 9 (Aug 1995): 23.

Fulghum, "Air Force Prepares New UAV Acquisitions & Operations," *Aviation Week & Space Technology* 143, Iss: 22 (November 1995): 52-54. Predator performance information was taken from the preceding four articles written between 1994 and 1995.

Chapter 3

The Case for Manned Combat Aircraft

> *I have too often seen the tide of battle turn around the high action of a few unhelped men to believe that the final problem of the battlefield can ever be solved by the machine.*
>
> —S.L.A. Marshall
> *Men Against Fire*

> *There is no substitute for a tactically devious human mind in a modern airplane.*
>
> —Carlo Kopp
> Airpower Journal

The use of unmanned systems to perform hazardous or monotonous tasks is not new. Boeing's Randy Harrison, design engineer of the DarkStar UAV, recently stated that soldiers, sailors and airmen would eventually all be replaced on the battlefield. This revolution is inevitable. It is "part of the great American tradition of substituting technology for human beings."[1]

From the Chief of Staff of the Air Force down, the benefits of Intelligence, Surveillance, and Reconnaissance (ISR) UAVs have been accepted, but UAVs have not yet been enlisted to perform traditional combat roles.[2] The principal opponent to combat UAVs are the airmen that these vehicles are supposed to remove from harms way.[3] Carl Builder asserts that the US Air Force has been ill served by airmen and that their unwillingness to accept replacement by robots is rooted in selfish unprofessional behavior:

love of flying and aircraft and/or the desire for a better airline afterlife.[4] To Builder and others, airmen have become the cavalry officers of the late twentieth century. The problem is that many outside the military aviation community do not adequately understand the real role of manned combat aircraft. If the sole function of combat aircraft was to fly to a pre-planned target and deliver ordinance there would be little need for airmen. Airmen contribute much more. The human element provides the system with its very basis for existence. Men and women, in combat aircraft, give us the flexibility to adapt to rapidly changing circumstances and the ability to exploit these changes. Flexibility and adaptability are human qualities. These qualities are synonymous with airpower. Nothing is as flexible and adaptable as the human being.

Are flexibility and adaptability still required of today's precise computer aided weapon systems? Clausewitz's concept of friction provides the answer to this question. Friction has an overarching effect on combat operations. It is the only constant in war. A very critical component of this debate is a concept brought to light by Dupuy, Ware, and Watts.[5] The American viewpoint of war is narrow and deterministic.[6] Americans historically ignore the very human nature of war. War is nothing more than an engineering problem. The enemy is viewed as a system to be dismantled.[7] War is an equation to be solved, quickly, and efficiently.[8] Underlying this philosophy is the arrogant view that American war is frictionless. The cornerstone to these beliefs is the total disregard of the enemy as a thinking opponent.[9] Technology can help in this respect, but it has not eliminated Clauswitz's concept of friction and thus flexibility and adaptability are still essential.[10] The human element remains the critical factor that leads to success in war and in the exploitation of technology.[11]

Even when employing our best technology friction has been a factor. During the Gulf War, with satellites, AWACS, JSTARS, and a complicated C4I network, the US military allowed the entire Hammurabi Division of the Iraqi Republican Guard to escape with its heavy weapons and command element intact.[12] The Iraqi causeway over the Euphrates river was not destroyed or even targeted before the last hours of the war.[13] Friction was a major element in the first information war and played a major role in the failure to totally meet our military objectives.

Using the Gulf War as the standard, Clausewitz's friction will be present and technology will never totally eliminate it. Flexibility and adaptability are as critical today to the conduct of military operations as they were yesterday. This concept is not foreign to the Israeli Air Force, the first air force to bring operational use of UAVs to the world's attention.[14] The ability to see through friction and the inability to totally eliminate it is fundamental to the Israeli military and their operational use of UAVs.[15] The Israeli Air Force has adopted many German operational concepts from WWII. The Israeli Air Force continues to train pilots as innovative warriors. They rely on the ideas outlined in the German Field Service Regulations of 1933:

> Situations in war are of unlimited variety. They change often and suddenly and only rarely are from the first discernible. Incalculable elements are often of great influence. The independent will of the enemy is pitted against ours. Friction and mistakes are of everyday occurrence.[16]

Even though they pioneered the use of UAVs in combat, the Israeli Air Force sees UAVs as nothing more than a force enhancement device and a complement to manned combat aircraft.[17] The Chief of Staff of the Israeli Air Force stated that "the secret weapon of the Israeli Air Force is highly trained people—war is characterized by great uncertainty and the only system capable of the flexibility we require is the human pilot."[18] As stated in AFM 1-1, technology only helps people to win wars.[19]

Our reliance on technology has given us great combat advantages but we must realize that technology can also fail. Take the Gulf War case of Maj Don Watrous. While engaged in combat with an Iraqi MiG-23 he fired three radar guided missiles. The rocket motors on the first two missiles failed to fire. These missiles fell harmlessly to earth while the third missile failed to guide. The MiG was escaping into Iranian airspace when Major Watrous elected to overspeed his F-15 and fired his last radar missile. The MiG was finally destroyed but Major Watrous shot $1.2 million worth of radar missiles and ripped off a portion of his left wing in the process.[20] Like the Vietnam War, where over fifty percent of all radar missiles failed, the Gulf War had its share of technology failures.[21] When technology does fail, what is left? Recently, General Reimer, the US Army chief of staff, answered this question when he stated that "when technology fails nothing can match the flexibility of disciplined, well trained soldiers."[22]

The reality of friction underlines the current need for human initiative, flexibility and adaptability. These qualities are essential now and they were critical when aircraft were first invented. Only humans had the sensor, fusion, and control capabilities to fly them. Flight control engineers refer to the pilot as an adaptive controller.[23] In this capacity, the pilot is a simple system that interprets various streams of information feedback and makes corrective inputs to keep the aircraft flying in the right direction at the desired altitude. The pilot does do this. However, the combat pilot's task is much greater. Not only must the pilot control the aircraft but he or she must make tactical decisions in a three dimensional environment based on the situation. The presented situation is rarely static and shaping its fluid nature is the pilot's responsibility. As a decision maker the pilot uses his training and experience to respond to new situations. His or her ability to make the correct decisions is the essence of the pilot's task. In the flying community this ability is often discussed in terms of aggressiveness.[24] Initiative, flexibility, adaptability and experience are key attributes that airmen bring the Air Force in its combat role. These characteristics are critical to a strategic air arm.

Flexibility, initiative, and adaptability are critical elements of airpower. These qualities are not inherent in aircraft types (machines) they are human in nature. To illustrate these concepts several combat examples are presented. In these examples an airman, in the true sense of Billy Mitchell's vision, acted in a manner that is unique to humans. The examples presented are singular only to aerial combat. If we were living in an age where unmanned combat aircraft were the norm there would be no need to save the lives of men or women engaged in aerial activities. Those types of examples, regardless of heroics, do not serve to illustrate the value of manned combat aircraft.

The first example occurred in WWI during an air superiority mission over Cambrai. One of Oswald Boelcke's squadrons was flying captured French airplanes. Lieutenant Sholto Douglas realized that several French made Spad-7s were working in concert with several German Fokker Monoplanes. These aircraft were destroying Douglas's squadron one by one. He quickly concluded that the Spads were being flown by German pilots. Under his leadership, Douglas's squadron reversed the course of the battle and helped to restore allied local air superiority. Sholto Douglas went on to become Marshal of the Royal Air Force.[25] This example is especially relevant today when the latest generation fighter aircraft are being sold to any nation able to purchase them. The US has sold F-16s to 18 nations.[26] The French have sold Mirage 2000s and F-1s.[27] Both the French and the Iraqis were flying the F-1 during the Gulf War.[28] The Russians are selling MiG-29s and Su-27s.[29] Currently, NATO forces fly both the F-15 and the MiG-29.[30] A UAV with the most advanced electronic identification equipment may not be able to identify friend or foe. As in the example from WWI, a human operator may be required to actually see hostile intent. Even today with increased beyond visual range engagement capability, visual engagements are required to prevent fratricide and the proliferation of modern combat aircraft to numerous nations may only increase this requirement and the reliance on highly trained airmen.

The second example is one of leadership, driven by experience, from an airman, Gen James H. Doolittle. He led the one way mission to bomb Tokyo early in WWII and flew combat missions in every major WWII theater.[31] As the Northwest African Strategic Air Force Commander Doolittle instituted a policy of close fighter escort for all bombing missions. During these missions, escort fighters were ordered not to leave the bombers. Early in 1943, Doolittle instructed General Arnold and Eaker that "close fighter escort was critical to bomber success."[32] General Eaker failed to see this critical need and was later reassigned because of his lack of vision.[33] Once General Doolittle became the Eighth Air Force Commander, he saw the need to change escort tactics. He allowed escort aircraft to pursue German fighter aircraft wherever they could be found and he allowed escort aircraft to attack German targets independent of Eighth Air Force Bombers.[34] This single act greatly contributed to gaining air superiority over Germany during WWII and had a direct positive impact on the success of Operation Overlord and the final defeat of Hitler's Germany.[35] While being interviewed following WWII, General Doolittle commented that he based this critical decision on his experience as an airman and that if he had not flown combat missions over Europe he would not have realized the critical need to update escort tactics.[36] This example shows the importance of experience and initiative. General Doolittle made these decisions despite the opposing views of many of his contemporaries.[37] He had learned a critical lesson and he learned it in combat. How will unmanned combat aircraft assimilate information and decide that tactics need to be changed? This example shows that the requirements of war are not static. What works today may not work tomorrow. Once the need is seen to change tactics how will unmanned combat aircraft make that change or even see the need for a change? Airmen have been using their experience and training to adapt to new situations and teach others how to do the same since aircraft were first flown. This ability is the cornerstone of flexibility and is an essential element of a true airpower nation.

The last examples are both from Desert Storm. They both demonstrate the inherent flexibility and versatility of the manned combat aircraft. During the Gulf War, Capt Ron Garan was leading an eight ship of F-16 aircraft on a pre-planned strike in Iraq. The initial target was a rebuilt bridge over the Euphrates river. Starting his dive to deliver his weapons, Captain Garan noticed something that was not in the premission briefing intelligence photos. He quickly broke off his attack and directed his flight members into a holding pattern. He informed airborne command elements that a large amount of heavy bridge building equipment was positioned along the banks of the river and some of it was being driven away. He redirected his flights' efforts and quickly established separate targets for each aircraft. Once retargeted, the flight destroyed the bridge, four heavy lift cranes, one dozen bulldozers, several dump trucks, and four armored personnel carriers.

The attack was accomplished just after sunrise. The Iraqis were moving the equipment to a safe location when they were caught off guard. Captain Garan's quick decisions, initiative, and flexibility wiped out a significant amount of Iraqi heavy repair capability.[38] The ability to quickly assess the military situation and retarget will be a necessary UAV capability. How will UAVs make these decisions that are made easily by human operators?

Capt Landis Cook was leading a fourship of A-10 aircraft on a pre-planned armed reconnaissance mission in southern Iraq. Shortly after entering his area of responsibility, JSTARS controllers directed his flight to an area containing a tank formation. The vehicles were moving northwest toward US forces involved in the early hours of the ground offensive. Captain Cook was ordered to destroy these tanks as they presented a threat to the coalition east flank. The tanks were moving at a high rate of speed and kicking up considerable dust so Captain Cook decided to visually identify the targets before attacking. He directed his flight to hold while he flew directly over the tanks at low altitude. On this pass Captain Cook viewed a large Union Jack flying from the lead tank in the formation and he quickly identified the vehicles as British Challengers. He relayed this information to JSTARS. Airborne command elements informed Captain Cook that there were no British Units located within his kill box and that he had clearance to destroy these Iraqi tanks. Captain Cook relayed to JSTARS and to AWACS controllers that he had visually identified these vehicles as British and that his flight would ensure their safety until JSTARS could confirm their identity. Several minutes later, JSTARS controllers confirmed that the tanks were indeed British. Captain Cook's ability to quickly assess this situation, disregarding his clearance to fire and reliance on his own judgment, prevented a possible catastrophic fratricide incident.[39] An autonomous or remotely controlled UAV may not have handled the situation in the same manner.

In each case presented, an airman displayed the ability to think independently of preplanned objectives with a focus on what was best for the tactical situation at hand. The human qualities of flexibility and adaptability supported by initiative, imagination, and experience were critical to the success of these endeavors and have demonstrated their vital contribution to the true nature of airpower. In combat, the ability to adapt to changing and sometimes very unexpected circumstances is essential. UAV advocates think in terms of what Clausewitz called war on paper or absolute war. When airmen go to war its real war. It is unlikely that the friction of war will ever be eliminated, therefore to adequately serve our nation combat UAVs will have to exhibit human qualities.

Notes

[1]Phil Patton, "Robots With The Right Stuff," *Wired* 4, Iss 3 (March 1996): 215.

[2]Peter Grier, "Dark Star and its Friends," *Air Force Magazine* 79, Iss: 7 (July 1996): 40-41.

[3]Steven Shaker and Alan Wise, *War Without Men* (New York, N.Y.: Pergamon-Brassey's, 1988), 170-171.

[4]Carl Builder, *The Icarus Syndrome* (New Brunswick, C.N.: Transaction Publishers, 1996), 179-188.

[5]Colonel T.N Dupuy, *A Genius For War, The German Army And General Staff 1807-1945* (Falls Church, V.A.: NOVA Publications, 1977), 300-307. In his work Col Dupuy establishes a basis for German operational and tactical success through their ability to handle the fog and friction of war through superior training and a focus on individual initiative.

Lewis Ware, "Some Observations of the Enemy as a System," *War Theory Course Book, Air Command and Staff College 1996*, 334-338. Dr. Ware presents the case that US warfare focus on the opponent as a system removes the thinking enemy and disregards the frictional element of warfare.

Barry Watts, *The Foundations of U.S. Air Doctrine, The Problem of Friction in War* (Maxwell AFB, AL.: Air University Press, 1984), 17-23, 60-72. Watts examines US WWII air planning and concludes that our planning assumed that war was nothing more than an engineering problem and that friction was disregarded.

Notes

[6]Watts, 17-23, 60-72.

[7]Ware, 334-338.

[8]Watts, 17-23, 60-72.

[9]Ware, 334-338.

[10]Dupuy, 300-307.

[11]Alvin and Heidi Toffler, *War and Anti-War* (New York, N.Y.: Little, Brown and Company, 1993), 75.

[12]Michael Gordon and General Bernard Trainor, *The Generals' War* (New York, N.Y.: Little, Brown and Company, 1995), 421-422.

[13]Ibid., 429.

[14]Ibid., 112.

[15]Lon Nordeen, *Fighters Over Israel* (New York, N.Y.: Orion Books, 1990), 168-179.

[16]Watts, 114.

[17]Shaker, 32-34.

[18]Nordeen, 1.

[19]Air Force Manual (AFM) 1-1, *Basic Aerospace Doctrine of the United States Air Force*, vol. 1, March 1992, 18.

[20]Maj Don Watrous, interview with Author, 1996. Major Watrous is currently a student at the Indian Intermediate Staff College. I served two years with Major Watrous in the 46th Test Wing.

[21]Walter Boyne, *Phantom In Combat* (Washington, D.C.: Smithsonian Institution Press, 1985), 76-80, 163. An analysis of the most successful air battles of the Vietnam War showed that at least 3 missiles were required for each MiG shot down. The two missile salvo is a technique taught to US fighter pilots to increase their chances of a kill because of unreliable missile technology.

[22]General Reimer, Commandant's Lecture Series, USAF Air Command and Staff College, Maxwell AFB, AL., Sept 1996. Permission to use quote from General's Office, 28 Feb 1997.

[23]Department of Defense, *Military Standard 1797A*, *Flying Qualities of Piloted Aircraft* (Washington D.C.: January 1990), 239. An adaptive controller is a signal gain and time delay combined with a lead and lag filter. This element represents the pilot in basic flight control models.

[24]Aggressiveness is the measure of the quickness and appropriateness of decisions made by the pilot. It was a graded element in undergraduate pilot training and fighter training programs until the early 1990s when it was replaced with the graded areas of airmanship, judgment, and safety.

[25]Sholto Douglas, *Combat and Command* (New York, N.Y.: Simon and Schuster, 1963), 83-101.

[26]*Code One*, Lockheed Martin Tactical Aircraft Systems, Vol 10, No 3 (July 1995), 34.

[27]William Green and Gordon Swanborough, *Observers Guide to Military Aircraft* (New York, N.Y.: Acro Publishing, 1982), 16-17. The French have sold the Mirage 2000

to Egypt, India, Jordan, and the UAE. They have sold the F-1 to Greece, Kuwait, Iraq, Libya, Jordan, South Africa, Spain, Ecuador, and Qatar.

[28]Gordon, 104.

[29]Bill Gunston, *The Osprey Encyclopedia of Russian Aircraft* (London, England: Osprey Aerospace, 1995), 226 and 365. The Russians have sold the MiG-29 to Bulgaria, Cuba, East Germany, India, Iran, Iraq, North Korea, and Yugoslavia. They have sold the Su-27 to China.

[30]Ibid, 226. The German Luftwaffe continues to fly 24 MiG-29s purchased by East Germany. These aircraft were kept in the inventory, after the reunification of Germany, because of their surprising performance and weapons capabilities.

[31]Carroll Glines, *The Doolittle Raid, America's Daring First Strike at Japan* (West Chester, P.A.: Schiffer Military History, 1991), 16. Gen Hap Arnold chose Jimmy Doolittle to lead this mission because of his superior airmanship and leadership ability as well as his aeronautical engineering background. Arnold referred to Doolittle as *the master of the calculated risk*.

[32]James Doolittle with Carroll Glines, *I Could Never Be So Lucky Again* (New York, N.Y.: Bantam Books, 1991), 374-383.

[33]Stephen McFarland and Wesley Phillips Newton, *To Command The Sky* (Washington, D.C.: Smithsonian Institution Press, 1991), 144-149.

[34]Doolittle, 374-383.

[35]Ibid.

[36]Ibid.

[37]Ibid.

[38]Maj Ron Garan, interview with author, 16 Dec 96. Major Garan is currently a student at the US. Navy Test Pilot School.

[39]Maj Landis Cook, interview with author, 31 Nov 96. Major Cook is currently an A-10 instructor pilot with the 422nd TES at Nellis AFB, NV.

Chapter 4

The Future

> *It is common place in human affairs that men continue to labor on major undertakings a long time after the ideas upon which these efforts were based have become obsolete.*
>
> —Fred Ikle, Every War Must End

The technology required to conduct unmanned combat operations within the atmosphere is very near. The computational power of computers is multiplied 4,000 times every decade and by 2015 10 gigabytes of memory will fit on a crystal smaller than a sugar cube.[1] Jeffrey Barnett predicts in *Future War* that autonomous weapons using artificial intelligence supported by automatic target recognition algorithms employing multispectral sensors will rule the battlespace. Barnett backs his conclusion with data that predicts that in the next 20 years data fusion rates will be 10,000 times faster and more accurate than they are now and data storage capabilities will be at least 1,000 times greater.[2] These capabilities are predicted to produce computers that mimic thought and maybe even think for themselves with some level of self awareness.[3] This increase in computational power may provide the human qualities of flexibility and adaptability to all types of UAVs.

There are two categories of unmanned aircraft: Man-in-the-loop (MITL) and autonomous. MITL systems have some type of human operational interface.[4] The aircraft is airborne and humans control it from the ground. Predator is an example of this UAV category. On the other hand, autonomous systems takeoff and fly with no human interaction.[5] Autonomous UAVs are further subdivided into programmable or independent systems. Programmable systems fly a pre-planned profile based on a preset software program. Truly autonomous (independent) platforms make the decisions required to complete their mission.[6] DarkStar and the cruise missile are autonomous UAVs.[7]

Both types of UAVs offer unique benefits and have unique support requirements. MITL systems currently offer a greater degree of adaptability as mid-mission inputs allow course, altitude, and/or target flexibility.[8] MITL systems use data-link to communicate with a ground station or relay control signals through satellite systems.[9] Some unusual difficulties have surfaced while operating MITL systems. Mr. Douglas Shane, of Scaled Composite Technologies, states that "direct control of unmanned aircraft inflight has had some surprising results."[10] Originally MITL UAV operations were viewed as relatively stress free. These aircraft were viewed and still are viewed by many as quasi-airplanes. No direct flight experience was required to operate them and anyone with computer knowledge would be able to "fly" MITL UAVs.[11] Experience has shed new light on the conduct of these operations. MITL direct control unmanned aircraft do not provide the ground operators with the same level of cues and feedback that a manned aircraft provides to its pilot.[12] This lack of situational awareness has led Mr. Shane to comment that "direct control drone operations are surprisingly stressful."[13] During the development of the Raptor UAV, the engineering control team was monitoring a flight that had proceeded into its second 30-hour period. While monitoring the system an aircraft emergency occurred. The engineers flying the aircraft knew that something was very wrong but they could not keep up with the changing data on their screens and had no direct flight experience to rely upon. They failed to realize that the aircraft had rolled onto its back due to a flight control malfunction and flown into the ground. Minutes after the aircraft had impacted the earth the engineers still believed that the aircraft was in its orbit and what they had experienced was a data telemetry failure.[14] The Raptor test team was so effected by this accident that they cut a hole into the top of their second UAV, added a set of cockpit controls, and completed the test phase of their program with a test pilot in the aircraft.[15] Scaled Composite learned what others have been learning as ISR UAVs become more common. Airmen are required to operate these systems to prevent high accident rates.[16] Mitchell's airmindedness is critical even to the operation of unmanned systems. The Raptor accident also taught Scaled Composite that more people are required to support MITL UAVs as opposed to manned aircraft.[17] Due to the lack of inflight feedback cues, several people are required in the ground station to safely monitor the aircraft. Scaled Composite recommends all MITL drone aircraft be controlled by a trained pilot and that his flight crew consist of at least two other people to monitor airborne systems and that high fidelity simulators are required to provide UAV crew proficiency.[18] The Air Force has agreed with these concepts in theory. Predator operations starting at Nellis Air Force Base, in the 11th Reconnaissance Squadron, will be controlled by a trained pilot or Weapons Systems Officer.[19] These individuals will be supported by at least two crewmen to monitor other than primary flight control systems.[20]

Another major problem associated with MITL UAVs is that some type of signal must go from ground station to aircraft or from ground station to satellite to aircraft. This limits UAV operations as the telemetry signals for each aircraft/ground station must be unique and satellite bandwidth availability does not allow large numbers of UAV aircraft to operate at the same time.[21] The requirement for data link transmissions to operate MITL UAVs creates another difficulty.

Data link or radio control transmissions create a vulnerability. An adversary could jam or engage these signals or take command of the aircraft or at least intercept the downlink to determine what we are observing.[22] Existing high power microwave or EMP technology already presents a significant threat to data link operations.[23] A data link controlled robot has already been turned on its operator. While disarming a bomb with an explosives ordinance disposal robot, the bomber successfully jammed the police signal and sent his own signal to drive the robot directly at the officers controlling the device.[24] Alvin Toffler believes that any device controlled with radio frequency signals will be vulnerable to this type of interference and to think that our adversaries would not take advantage of this is dangerous.[25] The problem with MITL UAVs or any remotely controlled weapon is that they depend on vulnerable communications.[26] These communication systems link humans to a less intelligent, but highly responsive mechanical system. If these links breakdown, or are disrupted, or sabotaged or, worse yet, manipulated by the enemy, the UAV becomes useless or potentially self destructive.

Like MITL UAVs, autonomous systems have their own problems and benefits. Independent UAVs will be different from the programmable cruise missile in that a cruise missile is preprogrammed to fly to a point in space. The missile carries out a set of if/then statements.[27] Independent UAVs will have the ability to think.[28] They are built around a complicated set of subsystems: sensors, control and analysis software, and pattern recognition capabilities.[29] The largest benefit is that this type of system does not require a vulnerable line of sight support infrastructure of hardware or personnel. Traditional aircraft maintenance systems will be required but once the system is airborne it will be on its own, free to carry out its specific mission. Independent combat UAVs will need to have what has been referred to as "wetware" or some type of machine intelligence to carry on all of the manned missions that occur today such as armed reconnaissance or air-to-air operations.[30] Such a technology would produce combat drones capable of thinking for themselves or at least mimicking thought. Such artificial life or A-life systems are very near. Many A-life research programs are funded through weapons research by the US government.[31] A-life systems are programmed with some level of basic knowledge, turned on, and then left to learn for themselves.[32] Combat UAVs with A-life technology would adapt to the surrounding environment much the same as humans learn and would continue to learn until they are turned off or destroyed. Such weapon systems present more of a moral dilemma than a technological design problem.[33] An unmanned fighter aircraft operating on A-life technology may develop a self-awareness. This type of system may evolve and develop the capacity for independent behavior.[34] Doyne Farmer, a former Los Alamos physicist working on A-life systems, was recently quoted as saying "once self-aware war machines are in place, even if we change our mind, dismantling them may become impossible, they may literally be out of control."[35] Human Beings fight out of loyalty to comrades and nation. What will motivate an intelligent machine?"

If technology does produce a "wetware" type of machine intelligence, another problem is that the machine may not learn the right lessons. These machines will function based on software designed by humans and even the best computer engineer will not be able to foresee every circumstance.[36] Autonomous systems will at least start their lives with the tactical knowledge of their programmers. What if this knowledge is wrong? The old computer programmer's axiom of "garbage-in, garbage-out" may yield another vital problem with these type of systems.[37] Even the best software designers can and do make mistakes.[38]

A prime example of these difficulties was displayed during the second flight of the DarkStar ISR UAV. The DarkStar was not programmed to handle a takeoff abort. If the engine failed on takeoff, the designers had postulated that the aircraft would glide straight ahead and either land on the runway or crash past the runway's departure end. They did not foresee any other possible takeoff problems. While the DarkStar was taking off, it became airborne on its nose wheel first and started a porpoising motion. It finally bounced into the air early, stalled and crashed onto the runway.[39] After the accident, Richard Karl, the DarkStar Lockheed-Martin Skunk Works program manager stated "the pilot would have known to chop the throttle once the aircraft started to wheelbarrow. We try to dream up every possibility, but there's always one that gets away."[40] In this case the "one that got away" cost one hundred million dollars.[41]

Computer programming cannot be perfect. The main problem with programmed or independent autonomous UAVs will be their inherent inability to cope with error, surprise and chance—Clausewitz's friction.[42] Because the human mind is so flexible, learning may occur very fast and tactical learning and the spread of that knowledge can occur quickly. Autonomous UAVs may find it difficult to adapt tactically to various situations and disseminate that information to other autonomous systems. The adaptability and flexibility of the human mind may be hard to replace or at least more trustworthy for the time being.[43] Mr. Dane Hancock of Lockheed-Martin's Tactical Aircraft Systems has stated that:

> Preplanned drone operations are easy and hardware is not a problem for autonomous decision making UAVs. Software is the key stepping stone for UAV development. Where do we start the baseline for problem solving? We can teach a system to learn but it needs an experience database upon which to judge and make future assessments. With the availability of sensor equipment we can flood a system with information, but unlike a highly trained pilot or one with a great deal of experience, we rarely know what piece of information is essential at a given time. The situational awareness of the pilot, even when incomplete, is almost impossible to duplicate within a machine. DarkStar is a prime example.[44]

Independent UAVs may also present a political problem. Thinking, self-aware robot combat aircraft may violate the Geneva Accords.[45] Armed independent UAVs will present significant diplomatic difficulties as nations decide that they do not want these aircraft operating in their airspace. Downed pilots may represent limited political risk when compared to overflights of armed unmanned aircraft.

The last war is not like the next war. Therefore, the Air Force must expend its limited resources preparing for the next war. MITL systems are vulnerable to exploitation and jamming. Independent autonomous UAVs may present a moral or political dilemma and their programming may not be flexible enough to handle the rigors of combat. Can these difficulties be overcome by focusing on programmable cruise missile type systems?

Many believe that the US Air Force has not applied the correct level of effort to cruise missile technology, including Carl Builder who believes that pilots have drawn attention away from this unmanned weapon.[46] Senior US Navy leadership has stated that cruise missiles are a cheap aircraft replacement.[47] Statements such as these show a lack of understanding of the nature and purpose of the cruise missile. The cruise missile, like the

WWI Bug, is a derivative of the manned aircraft.[48] It is an excellent weapon for attacking highly defended, soft, fixed targets. However, the programmable cruise missile is not very flexible. A cruise missile equipped with a conventional warhead is not a hard target penetrator.[49] The warhead is an airburst weapon with a relatively small yield.[50] Like the German V-1 of WWII this weapon can be defeated by anti-air artillery, airborne interceptors, and barrage balloon netting.[51] From June 1944 until March 1945, 10,500 V-1s were launched against England only 2,500 penetrated the British air defense network.[52] In WWII thin fishing nets suspended below barrage balloons and hung from 200 to 300 foot poles were used to "catch" low flying V-1s, before they reached their high value targets. Modern day cruise missiles approach their targets at an above ground altitude of 100 to 200 feet to maximize blast effectiveness and diminish warning time of height finding radars.[53] A relatively inexpensive net hung some distance from a high value soft target may foil the $1.2 million cruise missile.[54] Who would ring high value targets with fishing net? During WWII, the US sealed harbor facilities with 1.5 inch thick steel anti-submarine netting. In Boston alone, some of this netting went to a depth of 500 feet and covered over 10 miles of harbor access.[55] Low-tech netting, unaffected by stealth technology, could easily present the high-tech cruise missile with a problem.

The Chief of Staff of the Air Force, General Fogleman understands the limitations and flexibility problems inherent in the cruise missile. General Fogleman recently stated " we need to understand the role of cruise missiles. [The cruise missile is] a weapon that is good at getting some guy's attention but you are not going to sustain an air campaign with them."[56] To increase the capability of the cruise missile it must have a hard target penetrating warhead. A hard target penetrating capability requires a heavier missile. A heavier weapon would require an increase in lift. Suddenly, the missile has entered the vicious cycle of aerodynamic design: more weight requires a greater lifting surface and larger control surfaces these in turn produce more drag and now the missile needs a larger engine and the cycle continues.[57] The desire to give the cruise missile multiple target or re-attack capability yields the same effect. For true autonomy add a human operator and the cruise missile becomes the F-16 and if stealth characteristics are required it becomes an F-117.

The vulnerabilities presented by MITL UAVs, the inherent inflexibility of programmable systems, and the risks associated with independent autonomous UAVs present some large difficulties. These problems do not totally outweigh the benefits of UAVs. They do however, present considerable arguments, when combined with the chaos and uncertainty of war, to continue manned flight operations. The human operator or airman will be required in several future roles. This does not lead to the demise of the UAV. The UAV represents a significant force multiplier and UAV technology should be exploited for all missions, including the most complex, as a complement for manned systems. UAVs should be used in the following areas:

1. When the lethality of the airspace to be penetrated is too great for manned aircraft. Small inexpensive, non-stealthy UAVs could shut down the enemy integrated air defense system. Manned aircraft could then attack in aircraft carrying the larger ordinance to destroy critical interdiction targets or conduct armed reconnaissance.

2. When the airspace to be penetrated is too politically risky for manned aircraft. Low observable UAVs could carry on ISR missions in the pre-hostilities phase of a conflict with little risk of downed airmen influencing the diplomatic process.

3. When the airspace to be penetrated is too toxic for human operators. UAVs could perform all missions in nuclear, biological, and/or chemical environments.

4. When lower priority missions could be performed by UAVs to free highly skilled airmen to handle higher priority tasks. Preplanned stationary targets could be destroyed by UAVs while manned aircraft are used to hunt for mobile weapons of mass destruction.

5. When overall mission effectiveness can be increased with UAVs. UAVs could be used to provide constant battlespace surveillance or constant command and control radio link. UAV assets could improve mission effectiveness in any situation where overhead assets are required around the clock or mission requirements exceed human physiological limitations.

At some point in the future UAV and manned aircraft technology may be melted into the same airframe. This "composite airframe" could be manned or unmanned depending on mission requirements. General Fogleman has speculated that later versions of the Joint Strike Fighter (JSF) may be unmanned.[58] Perhaps, the JSF will be our first manned/unmanned composite airframe.

Regardless of airframe type, UAV operations will expand the role of airmen. As more unmanned vehicles are pressed into service airmen will be required to lend their unique expertise (airmindedness) to the teams operating these aircraft. MITL systems will require trained pilots to conduct combat operations and programmable and independent systems will require airmen to aid the designers and software engineers with software baselines and tactical updates. A Predator UAV has already been destroyed because its non-aircrew operators did not understand the tactical implications of orbiting a single point at low altitude for an extended period of time. The US Army's Hunter UAV program was canceled due to extremely high accident rates caused by non-aircrew operators.[59] UAVs will fly within federal airspace and will have to follow the FAA airspace rules and procedures.[60] As UAVs become too large to travel in transport aircraft, they will fly to their theaters and be required to conform with international airspace regulations. Airmen already understand these procedures and they understand the consequences when they are not followed. Airmen will provide the following to a force employing UAVs:

1. Provide airmindedness and leadership for the control of MITL UAV operations. Design mission specific training programs to introduce the concept of airmanship and airmindedness to non-flying control room personnel. Introduce and train control room personnel in crew resource management procedures to provide ground controllers that will function as a team in stressful situations.

2. Airmen will become the specialists for specific UAV airframe capabilities and limitations.

3. Assist in the development of high fidelity simulators to provide realistic training for MITL UAV crews.

4. Assist design and software engineers in the baselining of software for programmable and independent autonomous UAVs. Provide autonomous UAV development teams with the knowledge necessary to conduct developmental and operational UAV flights.

5. Assist design and software engineers with updating tactics in the software baseline of programmable and independent UAVs.

5. Advise staffs how to employ UAVs in a manner consistent with mission requirements and the tactical situation at hand.

Airpower gives the United States an asymmetric advantage over every nation on Earth. This advantage is not created by technology but by highly trained men and women. Airmen provide the flexibility and adaptability that is synonymous with airpower. UAVs will play a large role in our future but airmen will be required to ensure that UAVs are employed correctly and manned aircraft will be vital for dealing with the uncertainties of war. US forces must not forget that we face thinking enemies and that a peer competitor will eventually challenge our dominance. Cooperation and unity of effort will be essential to the successful integration of UAVs, for any mission, into our force structure. UAV advocates must understand that UAVs are aircraft and that the Air Force is full of people with developmental and operational experience that can be useful in any UAV program—this includes airmen. UAV opponents—including airmen—must understand that UAVs are a critical part of our future. UAVs will be an essential force multiplier and will enhance each Air Force core competency and thus make the nation stronger.

Notes

[1]John Petersen, *The Road to 2015* (Corte Madera, C.A.: Waite Group Press, 1994), 30.

[2]Jeffery Barnett, *Future War* (Maxwell AFB, A.L.: Air University Press, 1996), 1.

[3]Petersen, 31-32.

[4]Steven Shaker and Alan Wise, *War Without Men* (New York, N.Y.: Pergamon-Brassey's, 1988), 7.

[5]Ibid.

[6]Ibid.

[7]Steven Ashley, "Robot Spy Planes Peer Over Horizon," *Mechanical Engineering* 118, Iss: 3 (March 1996): 85-86.

[8]Peter Grier, "DarkStar and Its Friends," *Air Force Magazine* 79, Iss: 7 (July, 1996): 40-45.

Notes

[9]David Fulghum, "Air Force Prepares New UAV Acquisitions & Operations," *Aviation Week & Space Technology* 143, Iss.: 22 (November 1995): 52-54.

[10]Douglas Shane, "The Role of the Test Pilot in UAV Development," *Society of Experimental Test Pilots 1996 Report To the Aerospace Profession* (September 1996), 245.

[11]Ibid.

[12]Ibid.

[13]Ibid.

[14]Ibid., 241.

[15]Ibid., 243.

[16]David Fulghum, "Air Force Prepares New UAV Acquisitions & Operations," *Aviation Week & Space Technology* 143, Iss: 22 (November 1995): 54.

[17]Shane, 245.

[18]Ibid.

[19]David Fulghum, "Unmanned 'Spies' To Tune In Bosnia," *Aviation Week & Space Technology* 144, Iss 18 (April 1996): 58.

[20]Maj Phil Pearson, interview with author, 18 December 1996. Major Pearson is the operations officer of the 11th RS Nellis AFB, NV.

[21]Steven Ashley, "Robot spy planes peer over horizon," *Mechanical Engineering* 118, Iss: 3 (March 1996): 86.

[22]Alvin and Heidi Toffler, *War and Anti-War* (New York, N.Y.: Little, Brown and Company, 1993), 114.

[23]Ibid., 265.

[24]Ibid., 114.

[25]Ibid.

[26]Shaker, 169.

[27]Ibid., 7.

[28]Toffler, 114-115.

[29]Shaker, 8.

[30]Phil Patton, "Robots With The Right Stuff," *Wired* 4, Iss: 3 (March 1996): 149.

[31]Toffler, 117.

[32]Ibid.

[33]Ibid., 116.

[34]Shaker, 171.

[35]Toffler, 117.

[36]Ibid., 116.

[37]"New Technologies and War-Fighting Capabilities," *Air Power Journal* X, no.3 (Fall 1996): 113.

[38]Shaker, 174.

[39]Michael Dornheim, "DarkStar Destroyed On Second Flight," *Aviation Week & Space Technology* 144, Iss: 18 (April 1996): 24-25.

[40]Ibid., 25.

Notes

[41]Maj Dan Morin, interview with author, 5 March 1997. Major Morin was involved in the crash investigation process while stationed at Edwards AFB, CA.

[42]Toffler,117.

[43]Ibid., 116-117.

[44]Mr. Dane Hancock, interview with author, 16 Dec 1996. Mr. Hancock is a senior vice president of engineering and development with Lockheed Martin.

[45]Shaker, 171.

[46]Carl Builder, *The Icarus Syndrome* (New Brunswick, C.N.: Transaction Publishers, 1996), 215.

[47]US Navy Capabilities Lecture, Operational Structures Course, USAF Air Command and Staff College, Maxwell AFB, AL., 20 November 1996.

[48]Shaker, 21.

[49]Duncan Lennox, *Janes Strategic Weapon Systems 1990* (Alexandria VA: Janes Information Group, 1990), BGM-109.

[50]Ibid.

[51]Shaker, 28.

[52]Ibid.

[53]Lennox, BGM-109.

[54]John Tirpak, "First Force," *Air Force Magazine* 79, no. 9 (September 1996): 38. In the 1960s and 70s the Soviets reportedly built 300 ft tall fences across valley openings that led to critical targets. The belief was that low flying US bombers would impact the fence or be forced to climb into a missile engagement zone. Not a high-tech solution but it might have caused US bomber crews some anxious moments.

[55]Dudley Knox, *A History Of The United States Navy* (New York, N.Y.: G.P. Putnam's Sons, 1948), 452. After the US declared war on Germany, the US east coast was prime hunting ground for German Submarines. Submarine nets, mines, and local citizen patrols helped to keep US harbors clear until industry could produce more fighting ships. I had the opportunity to see the remains of the WWII Boston Harbor submarine nets. The nets sit in huge rusting rolls on George's Island. George's Island sits in the middle of Boston Harbor and some of the submarine net control facilities were located there.

[56]Tirpak, 38.

[57]Ray Whitford, *Design For Air Combat* (London, England: Jane's Publishing, 1987), 38. Any aerodynamic design is a compromise between weight, size, and capabilities.

[58]Tirpak, 41.

[59]David Fulghum, "Two Predators Destroyed In Bosnia," *Aviation Week & Space Technology* 143, Iss 8 (August 1995): 24-25.

Peter Grier, "DarkStar and Its Friends," *Air Force Magazine* 79, Iss 7 (July 1996): 42.

[60]David Fulghum, "Predator To Make Debut Over War-Torn Bosnia," *Aviation Week & Space Technology* 143, Iss 2 (July 1995): 48.

Chapter 5

Conclusion

People are the decisive factor in war.

—Air Force Manual 1-1

The Air Force must exploit the advantages offered by the UAV. UAVs will play a significant role in future operations. However, as a warfighting institution, the Air Force must not forget the significant contribution of the human operator. The Air Force cannot ignore the true nature of war. Warfare is a contest between thinking entities and by its nature it will be characterized by uncertainty, fog, and friction. No matter how good the computer programmers are or the artificial intelligence becomes there is no substitute for the human brain. No matter what high technology provides us with, airpower is highly trained people not airborne or space born platforms. The UAV is a force multiplier and nothing more. Billy Mitchell's airmen are critical to the functioning of the US Air Force and they will continue to be well into the next century.

The vulnerabilities presented by MITL UAVs, the inherent inflexibility of programmable systems, and the risks associated with independent autonomous UAVs present some large difficulties. These problems do not totally outweigh the benefits of UAVs. They do however, present considerable obstacles, when combined with the chaos and uncertainty of war, to continue manned flight operations. Airmen will be required in several future roles. The UAV, however, represents a significant force multiplier and UAV technology should be exploited for all missions, including the most complex, as a complement for manned systems. UAVs should be used in the following areas:

1. When the lethality of the airspace to be penetrated is too great for manned aircraft.
2. When the airspace to be penetrated is too politically risky for manned aircraft.
3. When the airspace to be penetrated is too toxic for human operators.
4. When lower priority missions could be performed by UAVs to free highly skilled airmen to handle higher priority tasks.
5. When overall mission effectiveness could be improved with UAVs.

UAV operations will expand the role of airmen. As more unmanned vehicles are pressed into service, airmen will be required to lend their unique expertise (airmindedness) to operating these aircraft. Airmen will provide the following to a force employing UAVs:

1. Provide airmindedness and leadership to the control of MITL UAV operations.
2. Become specialists for specific UAV airframe capabilities and limitations.
3. Assist in the development of high fidelity simulators to provide realistic training for MITL UAV crews.
4. Assist design and software engineers in the baselining of software for programmable and independent autonomous UAVs.
5. Assist design and software engineers with updating tactics in the software baseline of programmable and independent autonomous UAVs.
6. Advise staffs on employment of UAVs in a manner consistent with mission requirements and the tactical situation at hand.

Airpower currently gives the United States an asymmetric military advantage over every nation on Earth. This advantage is not created by technology but by highly trained men and women. Airmen provide the flexibility and adaptability that is synonymous with airpower. UAVs will play a large role in our future but airmen will be required to ensure that UAVs are employed correctly and manned aircraft will be vital for dealing with the uncertainties of war. US forces must not forget that we face thinking enemies and that a peer competitor will eventually challenge our dominance. Cooperation and unity of effort will be essential to the successful integration of UAVs. UAV advocates must understand that UAVs are aircraft and that the Air Force is full of people with developmental and operational experience that can be useful in any UAV program—this includes airmen. UAV opponents—including airmen—must understand that UAVs are a vital part of our future. UAVs will be an essential force multiplier and will enhance all Air Force core competencies and thus make the nation stronger. To maintain our asymmetric advantage, skilled, cunning operators will be required to handle the uncertainty of war.

Bibliography

Books

Barnett, Jeffery R. *Future War*. Maxwell AFB, AL.: Air University Press, 1996.

Beschloss, Michael R. *Mayday, Eisenhower, Khrushchev and the U-2 Affair*. New York, N.Y.: Harper & Row Publishers, 1986.

Blake, Bernard. *Janes Weapon Systems 1988-1989*. Alexandria VA: Janes Information Group, 1988.

Builder, Carl H. *The Icarus Syndrome*. New Brunswick, C.N.: Transaction Publishers, 1996.

Burlingame, Roger. *General Billy Mitchell, Champion of Air Defense*. New York, N.Y.: McCraw-Hill Book Company, 1952.

Crickmore, Paul F. *Lockheed SR-71, The Secret Missions Exposed*. London, England: Osprey Aerospace, 1993.

Doolittle, James, with Carroll Glines. *I Could Never Be So Lucky Again. N*ew York, N.Y.: Bantam Books, 1991.

Dupuy, Colonel T.N. *A Genius For War, The German Army And General Staff 1807-1945*. Falls Church, VA: NOVA Publications, 1977.

Glines, Carroll. *The Doolittle Raid, America's Daring First Strike at Japan.* West Chester, P.A: Schiffer Military History, 1991.

Green, William and Gordon Swanborough. *Observers Guide to Military Aircraft.* New York, N.Y.: Acro Publishing, 1982.

Gordon, Michael R., and General Bernard E. Trainor. *The General's War*. New York, N.Y.: Little, Brown and Company, 1995.

Gunston, Bill, and Mike Spick. *Modern Air Combat*. New York, N.Y.: Crescent Books, 1983.

Gunston, Bill. *The Osprey Encyclopedia of Russian Aircraft.* London, England: Osprey Aerospace, 1995.

Ikle, Fred Charles. *Every War Must End*. New York, N.Y.: Columbia University Press, 1991.

Knox, Dudley W. *A History Of The United States Navy.* New York, N.Y.: G.P. Putnam's and Sons, 1948.

Marshall, Samuel L. A. *Men Against Fire: The Problem of Battle Command in Future War*. New York, N.Y.: Morrow Publishing, 1947.

Lennox, Duncan, *Janes Strategic Weapons Systems 1990.* Alexandria V.A.: Janes Information Group, 1990.

McFarland, Stephen L., and Wesley Phillips Newton. *To Command The Sky*. Washington, D.C.: Smithsonian Institution Press, 1991.

Mitchell, William. *Winged Defense.* New York, N.Y.: Dover Publications, Inc., 1925.
Nordeen, Lon. *Fighters Over Israel*. New York, N.Y.: Orion Books, 1990.
O'Grady, Captain Scott, and Jeff Coplon. *Return With Honor*. New York, N.Y.: Doubleday, 1995.
Petersen, John L. *The Road to 2015*. Corte Madera, C.A.: Waite Group Press, 1994.
Rich, Ben R., and Leo Janis. *Skunk Works*. Boston M.A.: Little, Brown and Company, 1994.
Shaker, Steven and Alan Wise. *War Without Men.* New York, N.Y.: Pergamon-Brassey's, 1988.
Toffler, Alvin and Heidi Toffler. *War and Anti-War*. New York, N.Y.: Little, Brown and Company, 1993.
Watts, Barry B. *The Foundations of US Air Doctrine, The Problem of Friction in War*. Maxwell AFB, AL.: Air University Press, 1984.
Whitford, Ray. *Design For Air Combat.* London, England: Jane's Publishing, 1987.

Periodicals

Ashley, Steven. "Robot spy planes peer over horizon." *Mechanical Engineering* 118, Iss: 3 (March 1996): 84-89.
Code One. Lockheed Martin Tactical Aircraft Systems. Vol. 10, No 3 (July 1995)
: 34.
Cunningham, Ann Marie. "Unmanned Flying Vehicles." *Technology Review* 94, Iss: 3 (April 1991): 16-17.
"Dark Star." *Air Progress* 57, Iss: 7 (September 1995): 47-50.
Dornheim, Michael A. "DarkStar Destroyed On Second Flight." *Aviation Week & Space Technology* 144, Iss: 18 (April 1996): 24-25.
Fulghum, David A. "Gulf War Successes Push UAVs Into Military Doctrine Forefront." *Aviation Week & Space Technology* 135, Iss: 23 (December 1991): 38-40.
Fulghum, David A. "Tier 2 UAV Aborts First Test Flight." *Aviation Week & Space Technology* 141, Iss 2 (July 1994): 22.
Fulghum, David A. "USAF Pursues Stealthy UAV to Improve Reconnaissance." *Aviation Week & Space Technology* 140, Iss 3 (January 1994): 44-46.
Fulghum, David A. "New UAV Force Forms at Nellis." *Aviation Week & Space Technology* 143, Iss 5 (July 1995): 20-22.
Fulghum, David A. "Army Pushes Missiles For UAV Use." *Aviation Week & Space Technology* 143, Iss: 9 (Aug 1995): 23.
Fulghum, David A. "Air Force Prepares New UAV Acquisitions & Operations." *Aviation Week & Space Technology* 143, Iss: 22 (November 1995): 52-54.
Fulghum, David A. "Global Hawk UAV May Fly Early." *Aviation Week & Space Technology* 144, Iss: 18 (April 1996): 24-26.
Fulghum, David A. "Unmanned 'Spies' To Tune In Bosnia." Aviation Week & Space Technology 144, Iss 18 (April 1996): 58.
Grier, Peter. "Dark Star and its Friends." *Air Force Magazine*: 79, Iss: 7 (July 1996): 40-45.
"New Technologies and War-Fighting Capabilities." *Air Power Journal* X, no.3 (Fall 1996): 111-114.

Patton, Phil. “Robots With The Right Stuff.” *Wired* 4, Iss: 3 (March 1996): 148-152.
Shane, Douglas B. “The Role of the Test Pilot in UAV Development.” *SETP 1996 Report To the Aerospace Profession* (September 1996): 234-246.
Smith, Bruce A. “Thinking it Through.” *Aviation Week & Space Technology* 144, Iss: 11 (March 1996): 17.
Sweetman, Bill. “Drones: Invented and forgotten.” *Popular Science* 245, Iss: 3 (September 1994): 34-36.
Tirpak, John A. “First Force.” *Air Force Magazine* 79, no. 9 (September 1996): 34-41.
“UAV Force Concept.” *Aviation Week & Space Technology* 143, Iss: 2 (July 1995): 42-43.
“UAV Roles Defined.” *Aviation Week & Space Technology* 141, Iss: 2 (July 1994): 20-22.

Manuals

Air Force Manual (AFM) 1-1. *Basic Aerospace Doctrine of The United States Air Force*. 2 vols., March 1992.
Department of Defense (DOD) Military Standard 1797A. *Flying Qualities of Piloted Aircraft.* Washington D.C.: January 1990.
Ware, Lewis B. “Some Observations of the Enemy as a System.” *War Theory Course Book, Air Command and Staff College 1996*: 334-338.

Reports

Air Force Center For Studies and Analysis (US) *ALCM vs B-1 Against Imprecisely Located Targets*. Washington, D.C. 19 January 1982.
Air Launched Cruise Missile Shows Promise But Problems Could Result in Operational Limitations. MASAD, U.S. General Accounting Office. 26 February 1982.
Air Force Wright Aeronautical Labs. *An Analysis of Cruise Missile Survivability Against Advanced Air-to-Air Missiles*. AFWAL-TR Air Force Wright Aeronautical Labs. May 1984.

Lectures

US Navy Capabilities Lecture, Operational Structures Course, USAF Air Command and Staff College, Maxwell AFB, AL., 20 November 1996.
Reimer, Gen Dennis J., Commandant’s Lecture Series, USAF Air Command and Staff College, Maxwell AFB, AL., Sept 1996. Permission to use quote from General’s Office, 28 February 1997.