The Air Force's Combat Aircraft: A Future Holding onto the Past

A Monograph

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America's AF has adopted a strategy that reduces and then modernizes its remaining legacy fleet of combat aircraft. The strategy attempts to free up the necessary funding required to procure a modernized AF with all stealth bombers and fighters. It has been plagued with setbacks because of production delays and cost overruns. The newly attained stealth aircraft have also fallen short of their projected and required mission capable rates and drastically exceeded their estimated cost per flying hour. While the AF attempts to explain away the costs as temporary or as costs that will dissolve when maintenance practices are developed and matured, the history of stealth aircraft reveals differently. It reveals instead that stealth aircraft cost drastically more per flying hour than do their predecessors. Given the history of how America's combat AF has fought to gain air superiority and provide support to the forces on the ground, it needs to procure a mixed stealth and legacy combat force capable of gaining air superiority at an acceptable cost. This total stealth and legacy force make-up should be sized to gain air superiority over the future battlefield, thus enabling a modernized legacy fleet to sustain air dominance over its enemies while achieving its nation's objectives. This solution will prove itself affordable while allowing the AF to continue its investments toward a stronger future.

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Abstract

THE AIR FORCE'S COMBAT AIRCRAFT: A FUTURE HOLDING ONTO THE PAST by Col Gordon P. Greaney, USAF, 39 pages.

Since the great losses of fighter and bomber aircraft in WWII, America's Air Force (AF) has made great strides in increasing the survivability of its aircraft over the contested airspace of its enemies. Since DESERT STORM these advances have been played out in the media for the world to see, and these same advances have not gone unnoticed by its adversaries. America's AF knows this and has remained at the forefront of research, development and technology, striving to keep the advantage it has attained over its adversaries. Advantage, however, often comes at a high monetary cost and requires balancing of resources within the overall defense budget. Should America's AF invest in replacing its legacy fleet of combat fighters and bombers in their entirety with a fleet of stealth configured aircraft? This monograph provides insight toward answering this question with a historical perspective of air power in combat, a review of advances in anti-aircraft capabilities, and a way forward that survives budgetary constraints and enemy advances.

The historical perspective reviews how America's AF has gained air superiority, the cost the AF paid in losses while achieving it and the benefits, once achieved. The framework for this analysis begins in WWII and reviews America's wars involving air power to its present day conflicts over the skies of Iraq and Afghanistan. In WWII, gaining air superiority was shown to be achieved at great losses of aircraft and aircrew. Once achieved, though, the benefits of this superiority reaped gains in the land war throughout Europe. Similar gains are achieved in the wars that followed with increasingly lesser cost to America's aircraft and greater gain to the forces on the ground. America's AF achieved technological advances preceding each of these wars but continued to leverage its legacy aircraft against the advantages made in its leading edge bombers and fighters. It was these advantages that allowed the AF to survive its enemy's anti-aircraft advances in capabilities.

America's adversaries have not remained unchallenged by its advances in technology. Countries like Russia and China view America as a possible threat or a nation with undue influence, so they continue to develop new technologies aimed at thwarting America's newest generation of aircraft. They are also improving their legacy anti-aircraft capabilities that give them a greater chance of survival with increased capability at detecting and shooting down opposition aircraft. There also exists a trend in the exportation of these anti-aircraft capabilities throughout nations that are emerging as moderate powers on the world scene such as Iran and India. These improvements, along with the proliferation, have caused America's AF to adapt a procurement strategy that replaces its legacy combat aircraft with modern stealth aircraft.

America's AF has adopted a strategy that reduces and then modernizes its remaining legacy fleet of combat aircraft. The strategy attempts to free up the necessary funding required to procure a modernized AF with all stealth bombers and fighters. It has been plagued with setbacks because of production delays and cost overruns. The newly attained stealth aircraft have also fallen short of their projected and required mission capable rates and drastically exceeded their estimated cost per flying hour. While the AF attempts to explain away the costs as temporary or as costs that will dissolve when maintenance practices are developed and matured, the history of stealth aircraft reveals differently. It reveals instead that stealth aircraft cost drastically more per flying hour than do their predecessors.

Given the history of how America's combat AF has fought to gain air superiority and provide support to the forces on the ground, it needs to procure a mixed stealth and legacy combat force capable of gaining air superiority at an acceptable cost. This total stealth and legacy force make-up should be sized to gain air superiority over the future battlefield, thus enabling a modernized legacy fleet to sustain air dominance over its enemies while achieving its nation's objectives. This solution will prove itself affordable while allowing the AF to continue its investments toward a stronger future.

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INTRODUCTION AND OVERVIEW

Since the great losses of fighter and bomber aircraft in WWII, America's Air Force (AF) has made great strides in increasing the survivability of its aircraft over the contested airspace of the nation's enemies. America's adversaries, however, have not remained idle. They, too, have advanced their technology and increased their ability to track and target aircraft in the skies over their territory. It was the adversarial increases in capability during the Cold War years that led America's AF to invest heavily in stealth technology to counter this threat. As a result, early stealth aircraft played a major role in the opening hours of OPERATION DESERT STORM and paved the way for less survivable aircraft to endure against the Soviet-designed Iraqi integrated air defenses.[1] The observed success resulted in an AF procurement strategy to replace all of its aging combat aircraft with an improved variant of stealth when these aged planes reached their end-of-service life.[2] This raises the question, does the United States Air Force (USAF) need to replace its legacy combat aircraft and procure only stealth configured combat aircraft in order to gain and maintain air superiority in a future Major Contingency Operation (MCO)?[3] To gain a better understanding of how to approach this question, there needs to first be an understanding of how combat aircraft have evolved since WWII and what drove those changes.

America's AF commonly refers to its fighter aircraft by the generation from which they originated beginning with the jet age. First generation are those that appeared late in WWII ranging from 1945 to 1955. A common jet aircraft from this era was the F-86 Sabre. These jets were subsonic aircraft with similar abilities as their piston engine counterparts. Second generation aircraft were from 1955 to 1960 and consisted of supersonic speed, higher ceilings and greater rates of climb. They also incorporated radar and air-to-air missile capability. Examples

[1] Warren Thompson, *F-117 Stealth Fighter Units of Operation Desert Storm* (New York: Osprey Publishing, 2007), 23-24.

[2] Combat Aircraft are defined in this monograph as manned/unmanned fighters and bombers.

[3] Air Superiority - That degree of dominance in the air battle of one force over another which permits the conduct of operations by the former and its related land, sea and air forces at a given time and place without prohibitive interference by the opposing force. U.S. Department of the Air Force, "Air Force Doctrine Document 2-1, 2000," (United States Air Force, January, 2000), 105.

of these aircraft are the F-100 Super Sabre, F-101 Voodoo, F-102 Delta Dagger, and the F-104 Starfighter. Third generation aircraft are marked by technological refinements with a push toward improved maneuverability and multi-role capabilities such as carrying out both air-to-air and ground attack missions. Their developmental time span was from 1960 to 1970 and included aircraft such as the F-4 Phantom that became popular during the Vietnam War. The fourth generation (4th Gen) includes more sophisticated avionics and weaponry brought on by advances in computers and systems integration, which spanned from 1970 to 1990. Increased agility and flexibility in mission roles are also typical attributes of 4th Gen and include aircraft such as the F-15 Eagle and F-16 Falcon. These same aircraft have also been recently modified with fifth generation (5th Gen) technology because of their extended procurement period combined with service life extensions to the older F-15s and F-16s.[4] These modified or newly procured legacy aircraft are loosely referred to as 4.5 generation and span from 1990 to 2000. 5th Gen aircraft are from 2000 and beyond and currently include only the F-22 Raptor and F-35 Lightning II. The attributes that characterize this generation of aircraft include highly advanced avionics and stealth sensory suites, giving the pilot a comprehensive view of the entire battle space. Also characterizing 5th Gen is a combination of stealth design and fuel efficient supersonic speeds. Most of these later changes came as a result of the lessons learned during the Vietnam War and were emplaced so America's aircraft could survive in the ongoing Cold War.[5]

The majority of U.S. aircraft lost in Vietnam were brought down as a result of enemy antiaircraft artillery (AAA).[6] This development or discovery drove a change in American tactics to fly above 15,000 feet whenever possible to stay above the maximum range of most AAA

[4] Boeing Company. "F-15E Radar Modernization Program Receives New Designation," Defensetalk.com, 2009, http://www.defencetalk.com/f-15e-radar-modernization-program-receives-new-designation-21992/ (accessed March 9, 2010).

[5] All references concerning the generation of aircraft, throughout this paper, are taken from the same source to provide consistency. Joe Yoon, "Fighter Generations," Aerospaceweb.org, 2000, http://www.aerospaceweb.org/question/history/q0182.shtml (accessed March 9, 2010).

[6] Michael E. Brown, Owen R. Cote, Sean N. Lynn-Jones, and Stephen E. Miller, *New Global Dangers: Changing Dimensions of International Security* (Harvard University: MIT Press, 2004), 23.

sites.[7] Higher flight ceilings, however, caused these same aircraft to enter the missile envelope of most radar guided surface-to-air missile (SAM) systems. A missile that is launched from a SAM site is then guided to its target by means of a radar guidance system. This system tracks the aircraft's movements and guides its missile to an intercept point. These SAMs were the leading cause of aircraft losses above 15,000 feet in Vietnam.[8] In response, engineers developed electronic counter measures against the SAM's radar detection and tracking ability but learned that the most effective means of surviving is to remain undetected. Since that would not always be plausible, the next best option was to prevent detection from directing effective anti-access measures against an aircraft.

The requirement for American aircraft to survive against SAMs in the Cold War, combined with the lessons learned from Vietnam and reaffirmed in DESERT STORM, helped lay the foundation for where the nation's AF would spend its resources on its next generation of aircraft. Modern aircraft needed the ability to survive against the Soviet made SAMs, therefore, airplanes such as the F-117 Nighthawk and the B-2 Spirit went on the drawing board and into production. The AF procured 59 mission capable F-117's by July 1990 before closing the production line. The B-2 stealth bomber went into production and was going to replace the B-52 Stratofortress but never realized its original force size as a result of the Cold War ending in December, 1991.[9] The country's long range bombers were no longer required to penetrate deep into the SAM defended Soviet Union, and President George H.W. Bush announced in January, 1992 the reduction of B-2 stealth bombers from the original plan of 132 to only 20 as part of the

[7] Federation of American Scientists, "Anti-Aircraft Artillery," fas.org, 1994, http://www.fas.org/man/dod-101/sys/land/row/aaa.htm (accessed March 9, 2010).

[8] Michael E. Brown, Owen R. Cote, Sean N. Lynn-Jones, and Stephen E. Miller, *New Global Dangers: Changing Dimensions of International Security* (Harvard University: MIT Press, 2004), 22.

[9] David Halberstam, *War in a Time of Peace: Bush, Clinton and the Generals* (New York: Simon & Schuster, 2001), 12-13.

'peace dividend.'[10] The requirement for stealth never went away, however, as evidenced by the AF's procurement strategy over the 18 years that followed.

Since the mid-to-late 1990s, the AF has been in the process of procuring 5th Gen aircraft to replace its aging fleet of fighters, the first of these being the F-22 to replace the F-15. Again, as with the B-2, the original plan to replace all F-15s with F-22s was reduced.[11] The AF could not afford to maintain and modernize its legacy fleet, sustain the current force size (personnel) and procure 5th Gen aircraft before legacy aircraft would reach their end-of-service life.[12] A new strategy had to be adopted that retained a portion of the 4th Gen fighters to complement the newly procured stealth aircraft until stealth numbers reached an acceptable level allowing for the legacy fighters to retire. This strategy, while delayed because of budget constraints, will result in an eventual replacement of 4th Gen aircraft by 5th Gen stealth aircraft.[13]

The USAF needs to procure 5th Gen combat aircraft only in numbers that will allow air superiority to be attained and enable flight operations of modernized 4th Gen combat aircraft to sustain air superiority. Currently the USAF is attempting to procure an all 5th Gen fighter and bomber force against an ever decreasing amount of resources available.[14] To achieve this objective, the AF is conducting a "recapitalize and modernize" approach.[15] This approach takes near term risk by retiring legacy aircraft in greater numbers than required for two nearly simultaneous conventional campaigns while selectively reinforcing deterrence against opportunistic acts of aggression.[16] A portion of the savings from this approach is then applied to the procurement of 5th Gen aircraft attained across and beyond the Future Years Defense Plan

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[10] Global Security, "Weapons of Mass Destruction: B-2 Production," Globalsecurity.org, http://www.globalsecurity.org/wmd/systems/b-2-production.htm (accessed March 9, 2010).

[11] Global Security, "F-22 Raptor History," Globalsecurity.org, http://www.globalsecurity.org/military/systems/aircraft/f-22-history.htm (accessed March 9, 2010).

[12] Ibid.

[13] Department of the Air Force, *Fiscal Year 2010 Air Force Posture Statement*, May 2009, Statement of: Secretary of the Air Force, Michael B. Donley and Chief of Staff of the Air Force, Gen. Norton A Schwartz, (Washington, DC, 2009), 4.

[14] Ibid., 5.

[15] Global Security, "Top Air Force Generals Address Airman's Concerns," Globalsecurity.org, http://www.globalsecurity.org/military/library/news/2007/09/mil-070926-afpn06.htm (accessed March 9, 2010).

[16] Office of the Secretary of Defense, *Quadrennial Defense Review Report: February, 2006* (Washington, DC, 2006), 38.

(FYDP). This strategy is based on procuring aircraft that possess the ability to access areas defended by advanced surface-to-air missile systems. Another portion of the savings goes toward enhancements and service life extension programs (SLEPs) to maintain and modernize the current 4th Gen aircraft until their eventual replacement. [17] Since this strategy does not procure legacy aircraft, it will result in a short term mix of both 4th and 5th Gen aircraft until the 4th Gen reach their new extended end-of-service life. It also makes the assumption the AF will not be receiving an increase to its Total Obligation Authority (TOA) to procure 5th Gen aircraft while maintaining its current force structure of 4th Gen aircraft.

METHODOLOGY

> *Anyone who has to fight, even with the most modern weapons, against an enemy in complete command of the air, fights like a savage against modern European troops, under the same handicaps and with the same chances of success.*
>
> Erwin Rommel

Since the end of WWII, America's AF has increased its ability to survive and operate over the skies of its enemies, but retaining this advantage requires an ever vigilant process of modernizing its legacy fleet and procuring a future generation of combat aircraft. This monograph examines three areas that support this type of modernization approach and procurement strategy. These areas include a historical perspective on how combat aircraft have been used in conflicts dating back to WWII, the advancement of technology towards thwarting air power and its freedom to maneuver, and the current reduction and procurement strategy in the USAF's fighter and bomber fleet size.

The first of these three areas will examine historical references from WWII to present-day conflicts. While there were no stealth aircraft in these earlier conflicts, the data provides the cost of gaining air superiority and reveals the survivability rate once that price was paid. In later wars, historical data reveals where stealth aircraft were used to gain access into high threat

[17] Department of the Air Force. *Fiscal Year 2010 Air Force Posture Statement, May 2009*. Statement of: Secretary of the Air Force, Michael B. Donley and Chief of Staff of the Air Force, Gen. Norton A Schwartz, (Washington, DC, 2009), 4-5.

environments and then allowed for continued operations of less survivable aircraft to operate and sustain air superiority. Historical accounts also confirm that the majority of follow-on air strikes are accomplished by the less survivable aircraft in America's recent conflicts.

The second area of evidence reviews the increasing counter-air threat through modernization programs to legacy systems, the introduction of advanced technology towards thwarting air power and its freedom to maneuver, and the proliferation of these systems. It will also assess the current USAF ability to survive and operate against these threats without stealth capability. For the purposes of keeping this monograph unclassified, only unclassified sources such as *Jane's Defense Weekly*, *Gulflink*, and *Sinodefense* are referenced. These sources will also be referenced when discussing and evaluating the survivability of America's newly acquired stealth fighter aircraft to include the proposed next generation bomber.

The final area reviewed is the USAF's reduction of 4th Gen aircraft and its procurement of 5th Gen aircraft. Information is taken from historical budgets that have been presented to the Department of Defense (DoD) along with published articles from senior Air Force leaders. Budget material related to reductions is obtained from the Air Force Financial Management and Comptroller web pages. Fleet management plans are obtained from multiple sources to include articles quoting the former Chief of Staff of the Air Force (CSAF), General T. Michael Moseley, and the current CSAF, General Norton A. Schwartz. Moseley listed his top three priorities of which the third was "recapitalizing and modernizing" the aging fleet and equipment.[18] General Schwartz has alluded that he will continue this course as stated in his confirmation hearing.[19] Also examined are the costs and mission capable (MC) rates of stealth aircraft because they provide relevancy toward maintaining an all stealth fleet as opposed to one mixed with a larger and less expensive legacy fleet.

[18] Defense Talk. "Air Force Focused on Three Priorities," Defensetalk.com, 2006, http://www.defencetalk.com/air-force-focused-on-three-priorities-8639/ (accessed March 9, 2010)

[19] Department of the Air Force, *Advance Questions for General Norton A. Schwartz: USAF Nominee for the Position of Chief of Staff of the USAF* (Washington, DC, 2008), 18.

Using these three areas, this monograph addresses what the future makeup of the USAF's combat fleet should be in order to gain air superiority and allow for continued operations of its less survivable but equally-capable aircraft. Gaining insight into the historical use of combat aircraft along with projected threats to the survivability of future, more advanced aircraft will help better determine an AF procurement strategy.[20] This insight begins with a review of past military history to present day execution of air operations.

HISTORICAL PERSPECTIVE

> *The future battle on the ground will be preceded by battle in the air. This will determine which of the contestants has to suffer operational and tactical disadvantages and be forced throughout the battle into adoption compromise solutions.*
>
> Erwin Rommel

Many historians refer to WWII as the war when air power first came of age.[21] Post-WWI visionaries such as Giulio Douhet, Billy Mitchell and Sir Hugh Trenchard saw aircraft as being able to revolutionize warfare. Douhet asserted that an air force that could achieve command of the air by bombing the enemy air arm into extinction would doom its enemy to perpetual bombardment.[22] Thus, command of the air meant victory. What was not adequately foreseen was the inaccuracy of weapons dropped from high altitudes while under attack and the enemy's ability to thwart airpower with AAA and fighters. Hence, the bomber did not always get through as predicted by early theorists, a fact later learned through experience such as when the German Luftwaffe attacked Britain in 1940.

The Germans needed control of the skies over both the English Channel and southern Britain if they were going to make a successful landing on the south coast of England, but the Royal Air Force Fighter Command denied them this domain. By October 1940, the Battle of Britain had been decided in the defense's favor, and the Luftwaffe resorted to a night bombing

[20] This insight will not advocate a total force size and makeup of 5th Gen vs. 4th Gen aircraft but instead provide support for a mix of the two.

[21] Henry H. Arnold and John W. Huston, A*merican Airpower Comes of Age* (Alabama: Air University Press, 2002), 218.

[22] Giulio Douhet and Dino Farrari, *The Command of the Air* (Washington D.C.: Air Force History and Museums Program, 1998), 3.

offensive for which it had never been trained. This victory was the defensive cornerstone upon which the whole subsequent successful Allied offensive in Europe was built and which gave it crucial relevance leading up to the events of June 1944.[23]

Because the integrity of Britain was maintained in 1940, a base was assured for operations over Europe, and America's 8th AF took up residence and applied its daylight precision bombing techniques to attacks on Germany. Thus Allied air superiority, so crucial to the success of Normandy landings, was gradually built up from 1940 onward with American escort, long-range fighters taking their toll on Luftwaffe defensive fighter strength.[24] U.S. operational losses rose to a peak in 1944 at 11,618 aircraft as Allied forces prepared to cross the English Channel in June of that year.[25] This was the largest loss of American aircraft in a single year and only includes those lost in the European theater. Achieving air superiority had come at a great cost and was still in question by the planners as Operation Overlord began.[26]

Air Chief Marshal Sir Arthur Tedder was Deputy Supreme Allied Commander under General Eisenhower, and he was also the air commander. He stated in one of his lectures after the war the following:

> There was an element of the unknown prior to the landings in Normandy, in spite of the fact that since 1940 Allied superiority had gradually extended from British coast, over the coastal sea routes, across to the shores of Europe and finally to some extent over parts of Europe itself. How unknown was the degree of air superiority we had attained is shown by the fact that prior to D-day it was estimated Luftwaffe would carry out 600 and 700 sorties per day over the area of the landings; whereas in fact they were unable to maintain a daily average of more than 200.[27]

The air attacks leading up to the Normandy invasion focused on disruption to enemy lines of communication along with enemy aircraft and the airfields they could operate out of in defense of the invading force. By D-Day, the Strategic Air Forces together with the Tactical Air Forces

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[23] Humphrey Wynn, and Susan Young, *Prelude to Overlord* (California: Presidio Press, 1984), 12.
[24] Ibid.
[25] John Ellis, *World War II: A Statistical Survey: The Essential Facts and Figures for All* (New York: Facts on File, Inc, 1993), 258-259.
[26] Humphrey Wynn, and Susan Young, *Prelude to Overlord* (California: Presidio Press, 1984), 12-13.
[27] A quote from Air Chief Marshal, Sir Arthur Tedder Humphrey. Wynn, and Susan Young, *Prelude to Overlord* (California: Presidio Press, 1984), 13.

had so successfully performed their mission of disrupting enemy communications that there was a chronic shortage of locomotives and cars, repair facilities were inadequate, coal stocks were reduced to a six day supply, and 74 bridges and tunnels leading to the battle area were impassable. The communications chaos thus produced fatal effects upon the enemy's attempts at reinforcement of the threatened areas after the allied landings. As far as the destruction of the enemy airfields during the pre-Overlord air offensive, it was summed up by the German Air Historical Branch when they stated:

> The systematic destruction of the ground organization of the Luftwaffe, especially of the fighter airfields, was very effective just before and during the start of the invasion. Hardly a single airfield, of those intended for fighter operations, is still serviceable. The outstanding factor both before and during the invasion was the overwhelming air superiority of the enemy.[28]

The cost to the Allies, in gaining such success during the pre-Overlord air offensive, can be gauged from the heavy losses they sustained from April 1 to June 5, 1944. The Allied Expeditionary Air Force lost 376 aircraft; Bomber Command lost 523 aircraft; and 8th Air Force lost 1,054 aircraft for a total of 1,953 aircraft lost.[29]

Until mid-1944 allied fighter aircraft could not escort the bombers all the way to their targets because of range limitations, and this left bomber aircrews reliant on their own defenses against the attacking Luftwaffe fighters.[30] This changed when 8th Air Force fighters, such as the P-51 Mustang, escorted their bombers during daylight raids and played a crucial part in the eventual Allied liberation of Europe by establishing windows of air superiority over the skies of Germany.[31] Allied aircraft losses continued to decrease, and by May 1945 America's operational losses for the year totaled 3,631.[32]

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[28] Wynn, and Susan Young, *Prelude to Overlord* (California: Presidio Press, 1984), 101.
[29] Ibid., 98-102.
[30] Jeffery R Barnett, *Future War: An Assessment of Aerospace Campaigns in 2010* (Alabama: Air University Press Maxwell, AFB, 1996), 44.
[31] Humphrey Wynn, and Susan Young, *Prelude to Overlord* (California: Presidio Press, 1984), 102.
[32] John Ellis, *World War II: A Statistical Survey: The Essential Facts and Figures for All* (New York: Facts on File, Inc, 1993), 259.

Once air superiority began to be obtained, the air losses greatly declined. Gaining air superiority was the key to success, but the cost was high, and the lessons learned drive one to conclude that future aircraft need the ability to gain air superiority early and without great cost to air assets. Just a few short years later these theories would again be put to task in the advent of the jet age over Korea.

The Korean War was no different than the one previously fought with regard for the need to gain air superiority. It did, however, see the transition in America's AF from piston driven aircraft into the jet age. At the onset of the war, the majority of America's aircraft in the inventory were still piston-driven.[33] The U.S. had a formidable air armada in the area of Japan that included 375 F-80 Shooting Star jet fighters, 30 F-82 Twin Mustang fighters, 32 B-26 Marauder light bombers and 30 B-29 Super Fortresses. While these aircraft may have already been out-dated, they were still able to create lasting destruction to Korea's military infrastructure in a mere matter of months because of the easily obtained air superiority.[34] North Korea's air force was modeled after the Soviet Unions and in early 1950 consisted of 2,200 personnel and approximately 210 aircraft. Their aircraft consisted of 93 Il-10 Ilyushin fighters, 79 Yak-9P Yakovlev attack aircraft and roughly 40 to 50 trainers, transport and liaison aircraft.[35]

The war began with the invasion from the North on June 25, 1950. The first retaliatory air strike to take place north of the 38 parallel was an 18-plane effort by B-26s of the 3rd Bomb Wing against the main Pyongyang military airfield. Within a few days, the North Korean Air Force (NKAF) ceased to be an effective force and was capable only of nuisance-type raids. "With little effort, the Far East Air Force (FEAF) had gained air superiority."[36] The FEAF leadership later estimated that air superiority was won by July 20 and air supremacy by the end of August

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[33] Stanley Sandler, *The Korean War: No Victors, No Vanquished* (Kentucky: The University Press of Kentucky), 172.

[34] Hugh Deane, *The Korean War 1945-1953,* (California: China Books and Periodicals, Inc, 1999), 145.

[35] Gordan L. Rottman, *Korean War Order of Battle: United States, United Nations, and Communist Ground, Naval, and Air Forces, 1950-1953,* (Connecticut: Praeger Publishers, 2002), 170.

[36] William T. Y'Blood, "7th Air Force: The Korean Air War," 7th Air Force Library Factsheet, http:// www.af.pacaf .af.mil/library/factsheets/factsheet.asp?id=7103 (accessed March 9, 2010).

that same year.[37] Although gaining air superiority and supremacy proved relatively easy at the onset, maintaining it proved to be more grueling.[38]

The early success was short-lived, and by November of that year MiG-15s were introduced into theater by the Soviet Union. Initially, these aircraft were all crewed by Russian pilots but were later augmented by Russian-trained North Korean pilots. The Mig-15s destroyed several B-29s, forcing the bombers to resort to night operations. America responded with its new jet fighter, the F-86 and began to escort the bombers on their missions. They were few in number as the FEAF had only 89 F-86A fighters by June 1951 and increased to only 132 F-86E/F fighter-bombers and 165 F-86E/F fighter-interceptors by July 1953. These were not enough to maintain air superiority for all combat missions flown, and the B-29 forces suffered considerable losses when escorts were not available. The FEAF lost 1,466 planes out of a total of 1,986 United Nations aircraft destroyed. Of the total lost, 963 were as a result of combat. AAA claimed 816 aircraft, of which the majority was flying ground attack missions, while 147 were lost in air-to-air combat.[39] The higher combat losses came as a result of temporarily losing air superiority combined with missions that required aircraft to fly inside the effective range of enemy AAA. Air superiority, combined with the ability to deliver munitions without flying into the threat radius of AAA, would have significantly reduced the number of overall losses. As America's AF closed out the air war over Korea, it applied lessons learned and invested in further transformation of its fighter and bomber forces. This continued transformation came about as it entered into the Cold War with Russia and faced its next challenge over the skies of Vietnam.

Aviators in the Vietnam War also experienced advances in technology designed to deny aircraft the freedom of the skies. America's pilots were expected to face radar guided missiles

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[37] Ibid.

[38] Air Supremacy - The complete dominance of the air power of one side's air forces over the other side's, during a military campaign. It is the most favorable state of control of the air. It is defined by NATO and the United States Department of Defense as "that degree of air superiority wherein the opposing air force is incapable of effective interference." NATO Standardization Agency, *NATO Glossary of Terms and Definitions*, North Atlantic Treaty Organization 2010, 2-A-11.

[39] William T. Y'Blood, "7th Air Force: The Korean Air War," 7th Air Force Library Factsheet, http:// www.af.pacaf .af.mil/library/factsheets/factsheet.asp?id=7103 (accessed March 9, 2010).

launched from the ground, air-to-air missiles launched from advanced fighters, and radar guided AAA. America's bombers, with the advent of jet engines, were able to fly above most of the AAA but now faced this new SAM threat introduced by the Soviet Union. These SAMs claimed almost half of the thirty losses of the high-flying B-52s with the other losses being attributed to operational causes. While air-to-air missiles, surface-to-air missiles, and the radars that guide them were perceived to be the greatest threat going into Vietnam, none of them achieved their projected success rates. In the end, AAA achieved the highest kill ratio accounting for the greatest loss of fixed-wing aircraft. Aircraft that engaged forces on the ground and within close proximity received return fire with whatever weapon the enemy had. If an aircraft flew inside the range of these weapons, statistically, it stood a greater chance of getting shot down than inside the weapon engagement zone (WEZ) of radar guided missiles. [40]

Some of the lessons derived from the losses in Vietnam taught America that its aircraft needed to be able to accurately strike the enemy without flying into the enemy's effective WEZ. It also revealed the capabilities that America would face in an all out war against its Cold War adversary, Soviet Russia. Against this rival, the engagement zone was more complex and provided a larger array of weapons that could effectively engage aircraft at all altitudes. In order to survive in this environment, an aircraft had to apply multiple defensive characteristics. Some of these characteristics relied on providing electronic countermeasures that thwarted the enemy's ability to track and engage the aircraft it detected or deceptively lead radar-guided missiles and AAA astray.[41] One of these defensive characteristics is to remain unseen by radar. It was during the mid-1970's, with the bitter experiences of the Vietnam War very much in the minds of senior U.S. military officers and politicians alike, that thoughts turned to ways of designing an aircraft whose surface could absorb probing radar beams or deflect them in such a way that there would

[40] James F. Dunnigan and Albert A. Nofi, *Dirty Little Secrets of the Vietnam War* (New York: St. Martin's Press, 2000), 108-109.

[41] Jacob Van Staaveren, *Gradual Failure: The Air War Over North Vietnam 1955-1966* (Washington D.C.: Air Force History and Museum Program, 2002), 116.

be little or no radar reflectivity.[42] This capability would expose the most heavily defended targets to air attacks, especially at night. Thus the concept of stealth technology was born, and the end results were to be dramatic when applied in the skies over Iraq.

America's aviators realized the first fruits of stealth technology during DESERT STORM as the successful application of this new technology came to bear against the Iraqi air defenses. In 1991, the USAF employed a squadron of aircraft that had the ability to engage targets with precision from medium to high altitudes and remain unseen by enemy sensors.[43] The F-117 stealth fighter was the first weapon to be used during the opening hours of military operations whose goal was to blind the enemy by destroying command, control, and radar. Despite Iraq's long and debilitating war with Iran, it was considered in 1990 to have the world's fourth largest military. Assets included 7,000 radar-guided missiles, 9,000 infrared (IR) missiles, 7,000 antiaircraft guns and 800 fighter aircraft. It was also known by Coalition war planners that the Soviet Union had spent nearly $235 billion on perfecting an integrated air defense system for the Iraqis, who had sufficient funds available to acquire such technology. As a result, Baghdad had become one of the world's best defended cities by 1990.[44]

The Operational Order (OPORD) for the first night of DESERT STORM stated that its offensive operations would focus on five theater objectives of which one was to, "gain and maintain air superiority." Phase I of this plan stated:

> strategic air campaign will be initiated to attack Iraq's strategic air defenses; aircraft/airfields; strategic chemical, biological and nuclear capability; leadership targets; command and control systems; Republican Guard forces; telecommunications facilities; and key elements of the national infrastructure, such as critical LOCs, electric grids, petroleum storage, and military production facilities.[45]

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[42] Warren Thompson, *F-117 Stealth Fighter Units of Operation Desert Storm* (New York: Osprey Publishing, 2007), 6.

[43] Precision - Defined as having the accuracy of less than or equal to 3 meters circular error probability

[44] Warren Thompson, *F-117 Stealth Fighter Units of Operation Desert Storm* (New York: Osprey Publishing, 2007), 6, 27.

[45] Federation of American Scientists, "Operation Desert Storm: Evaluation of the Air Campaign," fas.org. 1997, http://www.fas.org/man/gao/nsiad97134/app_05.htm (accessed March 9, 2010).

The planners understood that destroying Iraq's strategic air defenses, aircraft, and command and control systems were paramount to gaining air superiority in the early days of the war. The air campaign leveraged cruise missiles and stealth technology to open the doors for continued operations of less survivable aircraft to achieve the objectives leading up to Phase IV of the OPLAN entitled, "The Ground Offensive."[46]

The USAF lost only 14 aircraft after flying more than 29,300 combat sorties, or .048 percent against an enemy with overwhelming SAM's and AAA. SAMs accounted for 11 USAF aircraft shot down and AAA accounted for three. Of the 11 surface-to-air kills, seven were attributed to heat-seeking missiles, three to radar guided, and one still contested.[47] The Iraqi Air Force, however, did not achieve a single air-to-air kill against coalition forces, and they lost 36 of their own aircraft to USAF F-15Cs.[48] The tide had turned for America's AF in this war. All previous wars discussed resulted in AAA having the most kills against USAF aircraft, but the radar-guided and heat-seeking SAMs now replaced AAA as the new number one threat to aircraft.

Analysis of the aircraft losses suggests an effective use of stealth aircraft, stand-off weapons, and air-to-air capability early on in the endeavor to gain air superiority. Stealth technology provided protection against both radar-guided and heat-seeking SAMs and allowed F-117s to use precision weapons against Iraqi critical nodes. Stand-off weapons, directed at the integrated air defenses, blinded the Iraqi ground controllers and rendered them ineffective in aiding their own aircraft and SAM operators.[49] Superior fighters, combined with the destruction of enemy airfields, suppressed the threat of Iraqi interceptors. Flying high, fast, and at night reduced the risk of destruction by relatively small heat-seeking SAMs or AAA, and for aircraft

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[46] Ibid.

[47] United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington D.C.: Department of the Air Force, 2002), 1-2.

[48] Federation of American Scientists, "F-15 Eagle: Overview," fas.org http://www.fas.org/programs/ssp/man/uswpns/air/fighter/f15.html (accessed March 9, 2010).

[49] Department of Defense, *Final Report to Congress: Conduct of the Persian Gulf War* (Washington DC, 1992), 149.

that flew slow and low during daylight hours, flares and armor provided some protection against heat-seekers and AAA.[50] High-speed anti-radiation missiles (HARMs), electronic jamming, destruction of enemy command and control centers, dispensing chaff, and launching decoys countered larger radar-guided SAMs.[51] Flying unpredictably and using stand-off weapons and cruise missiles also reduced manned aircraft losses.[52] In all, the USAF conducted modern operations born out of the lessons learned from the past and did so very successfully. These more recent lessons learned over Iraq combined with lessons reaffirmed from previous air wars were what the USAF planners and executors brought with them into the skies over Kosovo.

Between March 24 and June 9, 1999, North Atlantic Treaty Organization (NATO), led by the United States, conducted an air war against Yugoslavia in an effort to halt and reverse the continuing human rights abuses that were being committed against the citizens of its Kosovo province by Yugoslavia's elected president, Slobodan Milosevic.[53] NATO's strategy was based on the gradual application of military force, which received considerable criticism from military strategists and others despite the fact that it ultimately did compel Yugoslavia's withdrawal at zero cost in NATO lives.

The military operation, named ALLIED FORCE, was planned to be prosecuted in five phases where the first of these, Phase 0, was the deployment of air assets into the European theater and the second, Phase 1, was to establish air superiority over Kosovo.[54] Phase 2 allowed for air strikes against military targets in Kosovo and against Yugoslav forces south of 44 degrees north latitude, to include Yugoslavian territory south of Belgrade. Phase 3 expanded the air

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[50] United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington D.C.: Department of the Air Force, 2002), 11.

[51] The AGM-88 HARM (high-speed anti-radiation missile) is a supersonic air-to-surface tactical missile designed to seek and destroy enemy radar-equipped air defense systems. The AGM-88 can detect, attack and destroy a target with minimum aircrew input. Guidance is provided through reception of signals emitted from a ground-based threat radar. http://www.fas.org/man/dod-101/sys/smart/agm-88.htm (accessed March 9, 2010).

[52] United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington D.C.: Department of the Air Force, 2002), 1- 2.

[53] Benjamin S. Lambeth, *NATO's Air War for Kosovo: A strategic and Operational Assessment* (California: Rand, 2001), 1.

[54] Department of Defense, *Report to Congress: Kosovo/Operation Allied Force After-Action Report* (Washington DC, 2000), 7.

operations against a wider range of high-value military and security force targets throughout the Federal Republic of Yugoslavia, and Phase 4 redeployed forces as required. Within a few days of the start of the campaign, alliance aircraft were striking both strategic and tactical targets throughout Serbia, as well as working to suppress and disrupt its integrated air defense system.[55]

Similar to the War in Iraq, launches of air and sea-based cruise missiles and use of stealth aircraft knocked out the most dangerous and heavily defended command and control facilities. The F-117 was used against highly defended Belgrade along with the B-2 stealth bomber in its combat debut.[56] This made the skies over enemy territory safer for formations of non-stealth attack planes with HARM-carrying and radar-jamming escorts. As raids degraded the enemy's anti-access systems further, fewer escort sorties were needed. Suppression of enemy air defenses, however, was more problematic for NATO aircraft. This was due to enemy tactics, the complex terrain and the current limitations of these aircraft to defend against SAMs without additional suppression aircraft in their formation.[57]

While the threat posed by the Serbia's offensive air capability was eliminated in the first few days of the conflict, reducing Serbian defensive capabilities did not proceed as quickly.[58] The Serbs used Soviet-designed and supplied antiaircraft missiles and artillery like their Iraqi counterparts and they, too, had learned from the Iraq War.[59] Both missile types that shot down USAF airplanes over the former Yugoslavia had also destroyed USAF airplanes over Iraq. Although the hardware was basically the same, the Serbs, however, used different methods than

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[55] Ibid., 7-8.

[56] The B-2 was first used in the Kosovo War and flew from Whiteman, AFB MO to bomb selected targets in Belgrade. Each B-2 carried 16 GPS-guided bombs that can be addressed to hit a specific desired mean point of impact. Benjamin S. Lambeth, *NATO's Air War for Kosovo: A strategic and Operational Assessment* (California: Rand, 2001), 93.

[57] Richard Hallion, *Storm Over Iraq: Air Power and the Gulf War* (Washington DC: Smithsonian Institution Press, 1997), 64, 163.

[58] Ibid.

[59] Iraqi and Serbian forces launched a great variety of Soviet-designed SAMs at USAF aircraft, but only six types brought down any airplanes. The most successful of these was the SA-16 (NATO nickname: Gimlet), which destroyed four aircraft. A man-portable missile, it has the smallest warhead. Lacking much range, speed, or the ability to reach high altitude targets, the Gimlet brought down no fighters. SA-16s destroyed two A-10 close support airplanes, shot down an AC-130 propeller gunship, and forced an OA-10 to crash. United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington, DC: Department of the Air Force, 2002), 4- 5.

Iraq. The Iraqis used the systems as they were originally designed, sending radar signals constantly to the aircraft they intended to shoot down. This made successful targeting more likely but also rendered the systems more vulnerable to HARMs. The Serbs used the radar considerably less in the early part of an engagement, thus scoring fewer hits but preserving their air defense capability until the end of the hostilities.[60] This tactic enabled the Serbs to shoot down an F-16 and, more notably, an F-117 by a Soviet-made SA-3.[61] The F-117 was supposed to be almost invisible to enemy radar and infrared tracking systems, which was one of the characteristics that had made it so successful during the Iraq War. It was unofficially assessed that the Serbs managed to bring one down, however, by focusing on the aircraft's expected flight path and time overhead.[62]

During ALLIED FORCE, NATO aircraft flew approximately one-third the number of combat sorties (21,000) that were flown by coalition aircraft during DESERT STORM (69,000). However, the number of radar-guided SAMs launched by the Serbs was almost the same number as the number launched by the Iraqis during DESERT STORM. As a consequence, the average aircrew participating in ALLIED FORCE experienced a missile-launch rate three times that encountered by the average coalition aircrew during DESERT STORM. Despite the larger number of SAMs fired at NATO aircraft over Serbia and Kosovo, the Yugoslavs achieved a considerably lower success rate than did the Iraqis. Based on the ratio of combat losses to sorties, NATO aircrews in ALLIED FORCE were six times less likely to be shot down than coalition aircrews flying in DESERT STORM.[63]

Analysis of ALLIED FORCE, with regard to USAF aircraft and their ability to survive and operate over the skies of contested airspace, suggests that modern stealth technology

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[60] United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington, DC: Department of the Air Force, 2002), 3.

[61] The SA-3 is a very fast missile with a relatively large warhead. It is vulnerable to countermeasures because it is usually launched from a fixed position rather than a vehicle.

[62] United States Air Force Document, "AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002," (Washington D.C.: Department of the Air Force, 2002), 5.

[63] Department of Defense, *Report to Congress: Kosovo/Operation Allied Force After-Action Report* (Washington, DC, 2000), 65.

combined with packaged aircraft capabilities can together achieve air superiority rather quickly. Although the Yugoslav air defense systems were some of the most capable the U.S. has faced in combat so far, they do not represent the most advanced state-of-the-art SAM capabilities for sale on the international market. In future engagements against advanced SAMs, USAF aircraft will need the ability to have continuous, real-time, precision location of passive and active enemy systems to better achieve effective suppression and destruction of these systems. In order to gain air superiority, they will also need the ability to do this without getting shot down first by the very system they are targeting. While these lessons were still being applied, and research was being conducted on technology to bring about these futuristic advancements, America's AF entered into operations over Afghanistan and Iraq.[64]

U.S. military intervention in Afghanistan (ENDURING FREEDOM) began on October 7, 2001 and consisted of airstrikes on Taliban and Al Qaeda forces, coupled with targeting by U.S. special operations forces working with the Northern Alliance and other anti-Taliban forces.[65] Despite the weakness of Taliban air defenses, Central Command launched cruise and stealth attacks at the opening of Operation Enduring Freedom to assure that no friendly aircraft would be shot down.[66] Both B-2s and F-117s were again tasked to initiate air superiority in the initial operations over Afghanistan.[67] As a result of the combined tactics from 2001 to 2002, there were no USAF aircraft combat losses to enemy SAMs, AAA, or fighters. Air superiority was quickly gained using advanced cruise missiles and stealth and then maintained through continued operations of 4th Gen fighters and bombers. The ease with which air superiority was gained in Afghanistan would not be the case for Iraq in 2003.

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[64] Ibid.

[65] Congressional Research, *Report for Congress: Afghanistan: Current Issues and U.S. Policy* (Washington, DC: Library of Congress, 2002), 6.

[66] Central Command - U.S. unified area command established on January 1, 1983, and commanded by a U.S. four-star flag officer (USCINCCENT) from headquarters at MacDill Air Force Base in Tampa, Florida. USCINCCENT exercises operational command of all U.S. forces in Southwest Asia, the Middle East, and East Africa. http://www.answers.com/topic/u-s-central-command (accessed March 9, 2010).

[67] USAF United States Air Force Document, *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002* (Washington D.C.: Department of the Air Force, 2002), 9.

IRAQI FREEDOM opened up slightly different than DESERT STORM. While remaining air threats were still planned for early destruction, leadership proved to be higher on the priority list. The plan called for beginning with a short, air-only campaign followed by the ground invasion. Late-breaking evidence, however, gave rise to stronger concerns that the Iraqi regime would deliberately destroy its southern oil wells. As a result, the timing of the ground forces launch was moved ahead of the scheduled air campaign launch to prevent such an action. Once again, another late breaking intelligence update provided compelling information on Saddam Hussein's whereabouts at Dora Farms near Baghdad.[68] In the early hours of March 20, 2003, just as the ultimatum expired, a pair of F-117 fighters targeted the site.[69] This attack narrowly followed a barrage of Tomahawk missiles launched from ships at other key leadership sites in Baghdad.[70] The F-117s entered and exited untouched, and the missiles struck their targets to no avail. The air portion of the war subsequently reverted back to its original plan. The following day, March 21, 2003, brought the larger-scale "shock and awe" attacks on Iraqi command and control and other sites from both Air Force and Navy air assets.[71]

The initial Iraqi air threat consisted of an Integrated Air Defense System (IADS) incorporating early warning radars, visual observers, SAMs and fighter/attack aircraft. Overall operational capability of Iraqi aviation was low while the surface-to-air threat was assessed as medium to high.[72] Primary concerns were concentrated strategic SAMs around Baghdad and large numbers of un-located tactical SAMs and AAA throughout Iraq. Iraq had approximately

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[68] Catherine Dale, *Operational Iraqi Freedom: Strategies, Approaches, Results, and Issues for Congress* (Washington DC: Congressional Research Service, 2008), 41.

[69] The Administration's intent to take military action against Iraq was formally made public on March 17, 2003, when President Bush issued an ultimatum to Saddam Hussein and his sons to leave Iraq within 48 hours. "Their refusal to do so," he said, would "result in military conflict." President Bush Address to the Nation, March 17, 2003, available at http://georgewbush-whitehouse.archives.gov/news/releases/2003/03/20030319-17.html (accessed March 9, 2010).

[70] Catherine Dale, *Operational Iraqi Freedom: Strategies, Approaches, Results, and Issues for Congress* (Washington DC: Congressional Research Service, 2008), 41.

[71] Information from V Corps leaders and staff, 2003. The basic facts of the case, during the initial days of OIF, were extremely well-documented by the international press. For one clear account, see Romesh Ratnesar, "Awestruck," *Time*, March 23, 2003. See also Michael R. Gordon and General Bernard E. Trainor, *Cobra II: The Inside Story and the Invasion and Occupation of Iraq* New York: Vintage Books, 2006.

[72] Lt Gen T. Michael Moseley, *Operation Iraqi Freedom: By the Numbers* (United States Central Command Air Forces, 2003), 3.

325 aircraft, 210 SAMs, and over 150 early warning radars. Repeating the same strategy that has now played out multiple times since the first Iraq invasion, USAF stealth aircraft, combined with advanced cruise missiles, targeted the IADS first but only in areas where Iraq had the ability to deny air access. Air superiority had already been attained over much of Iraq as a result of the northern and southern no-fly zones established at the termination of DESERT STORM. During the opening days there were reported to be 1,660 SAM launches, 1,224 AAA events, 436 SAM emitters detected and 19 Surface-to-Surface Missile (SSM) launches.[73] In all, the USAF lost only a single A-10A Thunderbolt II in support of troops on the ground to a tactical SAM.[74]

Analysis of America's aircraft and its brief history since WWII reveals that these platforms have always been vulnerable to forms of enemy action, but this vulnerability has been waning over time with each new conflict. The enemy's anti-access weapons of destruction have ranged from antiaircraft artillery, aircraft with radar-aided guns and missiles, to multiple variants of radar-guided SAMs. In spite of the rise in enemy capabilities, USAF aircraft and aircrew have increasingly had greater success in gaining air superiority over the skies of their opponents with fewer and fewer combat losses. This success is due in large part to the introduction of survivable, stealth aircraft with precision capability, but these aircraft did not always work alone. The success was also attributed to 4th Gen aircraft fitted with modern electronic countermeasure suites, expendables to increase their survivability, and precision weapons capability.

Upgrades to 4th Gen aircraft have included internal (on-board) enhancements enabling them to defeat threats electronically or external capabilities in the form of strap-on pods. Expendables, such as chaff, flares, and towed decoys, have been modified or added to increase 4th Gen aircraft chances of survival while inside the WEZ of enemy missiles and AAA. Modernized avionics and munitions, such as advanced airborne radars and precision weapons, have also been

[73] Ibid.

[74] Tactical SAM – For the purpose of this monograph a Tactical SAM is defined as a short range, line-of-sight SAM often hand-held or shoulder launched but with the capability of being mounted on tracked or wheeled vehicles.

fitted. These modifications have allowed USAF 4th Gen aircraft a greater ability to survive against anti-access threats and, on occasion, effectively strike targets using advanced munitions without having to enter into the enemy's range of fire.

Newer aircraft, such as the F-22 and F-35, have been transformed in their design and capability specifications to make them less vulnerable to advanced technology and futuristic capabilities that seek to deny them access. The AF is also reviewing options for fielding survivable long-range surveillance and strike aircraft as part of a comprehensive, phased plan to modernize the bomber force.[75] These capabilities, combined with tactics that use land and sea-launched cruise missiles, will continue to allow air superiority to be gained and maintained with limited loss to USAF assets. Once air superiority is tentatively gained, the AF can introduce its legacy aircraft to finish the endeavor and pave the way for all follow-on air missions. This is a strategy that relies on the continued advancement and procurement of aircraft that are capable of surviving future threats, and history has revealed that the enemy will continue to develop those future threats.

ANTI-ACCESS THREATS

> *To conquer the command of the air means victory; to be beaten in the air means defeat and acceptance of whatever terms the enemy may be pleased to impose.*
>
> Giulio Douhet

History has shown that the advancement in technology towards thwarting air power and its freedom of movement will continue to pose a credible threat to the future of America's combat aircraft. Surface and ground-based systems such as SAMs and AAA are two capabilities that are evolving to establish themselves as a formidable menace to current and future combat aircraft. U.S. air forces in future conflicts will encounter integrated air defenses of far greater sophistication and lethality than those fielded by adversaries of the 1990s. Department of Defense (DoD) forecasts that proliferation of modern SAMs by countries such as Russia, China,

[75] Office of the Secretary of Defense, *Quadrennial Defense Review Report: February 2010* (Washington, DC, 2010), 33.

and others will pose growing challenges for U.S. military operations worldwide. A third area of improvement comes in the form of an aircraft itself. [76]

America is not the only country developing and procuring advanced fighters capable of presenting serious threats to an enemy striving to gain or maintain air superiority.[77] DoD's 2006 Quadrennial Defense Review (QDR) envisaged such threats from "robust regional adversaries" early in the 21st Century and from "heavily-armed theater-level 'peer' competitors or major powers" by about 2014.[78] These forecasted threats are beginning to materialize across the globe as America's near-peers produce these capabilities for sale in the open market. These capabilities exist in the form of advanced SAMs, AAA, and aircraft.

There currently exists a modernization to the Soviet SAM system known as the Almaz S-300 Series, or more commonly referred to by its North Atlantic Treaty Organization (NATO) name, the SA-10C Grumble. This system poses a significant threat to America's 4th Gen fleet as it is assessed of being capable of defeating aircraft, strategic cruise missiles, tactical battlefield ballistic missiles, and other targets with a reflection surface up to 0.02 square meters.[79] This is slightly larger than a bird that has an average radar cross section of 0.01 square meters. It can also engage targets flying at speeds up to 2,800 meters per second in massive enemy air raids with heavy clutter and severe Electronic Counter Measure (ECM) environments.[80] Russia, however, was not satisfied to let America's air power go unchallenged in the 21st Century and has been busy, developing follow on missile systems to the SA-10C.

Between 1995 and 1997, the next generation of S-300 series SAMs yielded the S-300PMU2 Favorit which NATO designated the SA-10E. It was later re-designated as the SA-20

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[76] Office of the Secretary of Defense, *Quadrennial Defense Review Report: February 2010* (Washington, DC, 2010), 31-32.

[77] Ibid., 31.

[78] Office of the Secretary of Defense, *Quadrennial Defense Review Report: February 2006* (Washington, DC, 2010), 75.

[79] Kopp, Carlo. Dr., "Air Power Australia: Almaz S-300 Series," Australia's Independent Defense Think Tank, http://www.ausairpower.net/APA-Grumble-Gargoyle.html#mozTocId122631 (accessed March 13, 2010).

[80] Global Security, "Military: S-300PMU1 SA-20 Gargoyle," Globalsecurity.org, http://www.global security.org /military/world/russia/s-300pmu1.htm (accessed March 13, 2010).

Gargoyle. Key improvements included the missile's range from 81 miles out to 108 miles, a new variant of the transport erector launcher (TEL) giving the ability to "shoot and scoot," and a radar that can be ready to move in only five minutes from full operation.[81] In January 1999, the Russian Air Force formally announced that it had developed a new air defense system known as the S-400 or SA-21 Triumph.[82] This system is yet again an S-300 series that has been upgraded. Changes include increased missile range out to 120 miles, additional lighter weight missiles to counter low flying targets, and improved radar and trans-loader vehicles.[83]

In February 2004, Russia announced that state tests of the S-400 had been completed and that the system was finally ready for production. Between 2003 and 2004, China spent approximately $500 million on future S-400 systems, and in addition to China, Russia has offered the S-400 to the United Arab Emirates, once in 2002 and again in 2004. There is also speculation that Iran, a potential nuclear power, is currently seeking to acquire its own batch of S-400 missiles. The advanced capabilities of these SAMs, combined with their proliferation, reaffirm the USAF requirements to maintain the ability to gain air superiority if they are to survive in the skies over future conflicts.[84] These advanced SAMs, however, are not the only threats being made available in the open market.

The Man Portable Air Defense System (MANPADS) is another highly effective weapon class that has been proliferated worldwide. Typically containing an IR seeker, the missile offers little opportunity for a warning before impacts, which are often lethal.[85] They are mostly effective at low to medium altitudes and at short ranges. There are many variants of MANPADS that exist today, and most of America's combat aircraft have countermeasures capable of

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[81] Kopp, Carlo. Dr., "Air Power Australia: Almaz S-300 Series," Australia's Independent Defense Think Tank, http://www.ausairpower.net/APA-Grumble-Gargoyle.html#mozTocId122631 (accessed March 13, 2010).

[82] Claremont Institute, "Missile Defense Systems: S-400 SA-20 Triumf," MissileThreat.com http://www.missilethreat.com/missiledefensesystems/id.52/system_detail.asp (accessed March 13, 2010).

[83] Kopp, Carlo. Dr., "Air Power Australia: Almaz S-300 Series," Australia's Independent Defense Think Tank, http://www.ausairpower.net/APA-Grumble-Gargoyle.html#mozTocId122631 (accessed March 13, 2010).

[84] Claremont Institute, "Missile Defense Systems: S-400 SA-20 Triumf," MissileThreat.com http://www.missilethreat.com/missiledefensesystems/id.52/system_detail.asp (accessed March 13, 2010).

[85] IR Seeker – Defined as Infrared Seeker that has a passive missile guidance system which uses the emission from a target of electromagnetic radiation in the infrared part of the spectrum to track it.

defeating these during a detected or known missile launch. Once again, however, improvements to MANPADS have been an ongoing process. As recently as 2004, the Russian army developed a new MANPADS named the Igla-S or sometimes called the "Igla-Super."[86] It is known in western countries by its NATO name, the SA-24 Grinch, and is much more sophisticated and efficient in countering air threats than its predecessor, the SA-18 Grouse. This enhanced system is assessed to have two to three times improvement in combat effectiveness, compared with baseline Igla or SA-18 versions, especially when used against cruise missiles and small-size air targets. It is fitted with a new warhead with a larger High Explosive (HE) charge and enhanced fragmenting, laser impact/proximity fuse, and improved homing system. This homing system features an improved homing device providing higher accuracy and increased killing range out to 6 kilometers. As the earlier systems, the SA-24 can be prepared for launch within 13 seconds. It can engage large and small low-flying targets, including Unmanned Aerial Vehicles (UAVs) and cruise missiles, intercepting at closing speeds as fast as 400 m/sec (head on) or 320 m/sec (in tail chase). The SA-24 entered production in 2004 for the Russian Army and also for export.[87] Wherever there are MANPADS, AAA will also exist in great numbers.

Antiaircraft artillery is a general term for guns that can elevate to high angles and shoot accurately at aircraft using visual, electro-optical, or radar guidance. In most advanced nations, dated AAA pieces are largely being replaced with SAMs, although there remains interest in hybrid AAA-SAM systems. The hybrid systems have combined AAA with MANPADS in an attempt to increase their effectiveness. Even in today's advanced, technological warfare, these dated weapons provide a real threat to aircraft flying within their reach. During ALLIED FORCE, ENDURING FREEDOM and IRAQI FREEDOM, the AAA posed a serious enough threat below 15,000 feet that planners restricted aircraft from flying below this altitude unless

[86] Global Security, "Military: 9K338 9M342 Igla-S/SA-24 Grinch," Globalsecurity.org, http://www.globalsecurity.org/military/world/russia/9k338.htm (accessed March 13, 2010).

[87] "Igla-S, Igla-1," Defense Update: International, Online Defense Magazine, http://defense-update.com/products/s/sa-18.htm (accessed March 13, 2010).

requirements met predetermined special instructions (SPINS).[88] To gain a better understanding of why AAA still poses a threat even to stealth aircraft, this monograph will review some of the more recent improvements being made.

The ZSU 23-4 Shilka is a Russian made, fully integrated, self-propelled antiaircraft system with four liquid-cooled 23 millimeter automatic cannons mounted on the front of a large, flat, armored turret.[89] It has the capability to acquire and track low-flying aircraft targets with an effective range of 2,500 meters. It is also capable of firing on the move because of its integrated radar/gun stabilization system. The high frequency operation of the Gun Dish radar emits a very narrow beam that provides for excellent aircraft tracking while being difficult to detect or evade. However, such a frequency also dictates a limited range, which can be compensated for by linking the system to other long-range acquisition radar in the area. On newer variants, the radar is capable of being used independently in the search mode, whereas on previous versions it had been slaved to the gun tubes. In 1985, a modified ZSU 23-4M was seen with protrusions on the right and left sides of the Gun Dish radar dome and vanes down its center. The vanes are side-lobe clutter-reducing devices, and the protrusions are Identification Friend or Foe (IFF) receivers. Electronic target acquisition, tracking, and ranging are automated, and an onboard computer determines super-elevation and azimuth lead. The most significant changes in late production versions of the ZSU 23-4 have included a major change to the air cooling supply system as well

[88] SPINS are provided through the Air Tasking order and provide operational and tactical direction at appropriate levels of detail. They can be very explicit when forces operate from different bases and multi-component or composite missions are tasked. By contrast, less detail is required when missions are tasked to a single component or base. U.S. Department of the Air Force, *Air Force Doctrine Document 2-1, 2000* (United States Air Force, January, 2000), 49-50, 54.

[89] Christopher Foss, "Europe: More firepower for ZSU-23-4 SPAAG," Jane's: Defense Weekly, http://www4.janes.com/subscribe/jdw/doc_view.jsp?K2DocKey=/content1/janesdata/mags/jdw/history/jdw99/jdw04074.htm@current&Prod_Name=JDW&QueryText=%3CAND%3E(%3COR%3E((%5B80%5DSA-18+%3CIN%3E+body)%2C+(%5B100%5D+(%5B100%5DSA-18+%3CIN%3E+title)+%3CAND%3E+(%5B100%5DSA-18+%3CIN%3E+body)))) (accessed March 13, 2010).

as the radio and electronic systems of the vehicle. These changes have improved the overall reliability of a dated piece of AAA but it remains limited to its effective range.[90]

Another formidable AAA system is the Russian made 2S6 Tunguska. It is an integrated air defense system armed with 30 millimeter cannons and SA-19 surface-to-air missiles. The cannons used in the 2S6 are mounted in pairs with the right cannon having the appearance of being slightly to the rear of the left cannon and is provided with a muzzle velocity measuring system. Although the maximum vertical range of the weapons is estimated around 5000 meters, the maximum effective antiaircraft range is around 3000 meters.[91] There are also four SA-19 missiles mounted on each side of a turret with the twin 30 millimeter cannons and have an independent elevation which indicates a fire-and-forget type system.[92] There are at least two types of roof-mounted optical sights, the earlier system being somewhat similar to that of the older ZSU-23-4 system. The second arrangement is believed to be a new design and incorporates a day/night capability. One of the roof sights is assessed to be used with the SA-19 SAMs. A laser rangefinder is assessed to be incorporated as well, as the system also includes an IFF interrogator which interacts with the Khrom-Nikel (Odd Rods) IFF system found on Soviet combat aircraft.[93] This hybrid AAA/SAM is slightly more formidable than the ZSU-23-4 when its characteristics are compared. Like the ZSU-23-4, it also remains limited in its max effective range and will most likely only prevent aircraft from flying below predetermined altitudes developed in SPINS. Russia, however, is not the only manufacturer of AAA and SAM hybrid systems. China has also entered into the production and improvement of their AAA pieces.

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[90] "ZSU 23-4 Self-Propelled Antiaircraft Gun," Military Equipment of the Former USSR: Air Defense, http://www.gulflink.osd.mil/irfna/irfna_refs/n28en030/airdef.html#zsu23-4 (accessed March 13, 2010).

[91] Ibid.

[92] The SA-19 missile is a two-stage command-guided missile. The missile system is composed of the fire control unit, launcher, missile tracker, and the canistered missile, and is supported by the direct-view optics (DVO) and the HOT SHOT target tracking and acquisition radars onboard the 2S6M. Typical reaction time is 8-12 seconds. Global Security, "9M111 / SA-19 GRISON," Globalsecurity.org, http://www.globalsecurity.org/military/world/russia/sa-19.htm (accessed March 13, 2010).

[93] "ZSU 23-4 Self-Propelled Antiaircraft Gun," Military Equipment of the Former USSR: Air Defense, http://www.gulflink.osd.mil/irfna/irfna_refs/n28en030/airdef.html#zsu23-4 (accessed March 13, 2010).

The China Northern Industries Group Corporation revealed a seven-barreled 30 millimeter close-in weapon system during the 2005 Intentional Defense Exhibition in Abu Dhabi. This new weapon system, debuting as the LuDun-2000 (LD-2000), was specifically aimed for the export market. The LD-2000 features a seven-barreled remotely controlled 30mm cannon turret mounted on the rear of an 8X8 heavy-duty wheeled chassis truck. It has two ammunition boxes each holding 500 rounds of ammunition of which one magazine typically holds armor piercing rounds and the other high explosives. The seven-barreled 30mm cannon has a maximum cyclic rate of fire of 4,600~5,800 rounds/min and a maximum range of 3,000 meters. The tracking radar is mounted on the roof of the cannon turret, along with a day/thermal sighting system, which also incorporates a laser rangefinder. The weapon system is designed to use as stand-alone or to provide point air defense for high-value strategic targets against aircraft and cruise missiles. It can also be deployed as a part of a multi-layer air defense system comprising surface-to-air missiles and anti-aircraft artillery weapons.[94] Like the 2S6, this model also has an improved version that integrates SAM capabilities. The LD-2000 has a model that was introduced in 2006 incorporating the TY-90 SAM.[95] It carries six of these, three mounted on each side of the cannon turret with an assessed operating range out to 6 kilometers.[96] While not as widely proliferated as the previous two Russian variants, the LuDun-2000 remains a credible threat in the low altitude arena against aircraft it can see visually or with its radar. While these improvements provide a greater threat to China's enemies from the skies, they also fully understand that SAMs and AAA are not enough to defend itself from an invading American force. Because of this, they have also invested in another area to engage enemy aircraft in the air domain.

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[94] "LD-2000 Close-In Weapons System," Sinodefence.com, http://www.sinodefence.com/army/antiaircraft/ld2000.asp (accessed March 13, 2010).

[95] The TY-90 missile was originally designed as an IR-homing short-range air-to-air missile but has been modified to use as a standalone surface-to-air missile system as a part of the LuDun-2000 defense system. "TY-90 (Yitian) Surface-to-Air Missile," Sinodefence.com, http://www.sinodefence.com/army/surfacetoairmissile/ty90.asp (accessed March 13, 2010).

[96] "LD-2000 Close-In Weapons System," Sinodefence.com, http://www.sinodefence.com/army/antiaircraft/ld2000.asp (accessed March 13, 2010).

The third area that poses a threat to America's gaining of air superiority is the opposing force's fighter aircraft. USAF doctrine calls for a Counterair mission, which consists of operations to attain and maintain a desired degree of air superiority by the destruction or neutralization of enemy air forces. Both offensive and defensive actions are involved. Offensive Counterair (OCA) deals with aggressively neutralizing enemy forces in-flight or the supporting infrastructure on the ground, while the latter describes reactively engaging enemy aerospace forces which have already launched on an offensive mission.[97] To project an OCA front, a country's Air Force must survive the air-to-air engagement with opposing fighters. America's adversaries have not remained latent in their fighter advancements and many of these improvements have taken place over the past 20 years. Similar to the discussion on SAMs and AAA, this monograph will limit its review to the more recent developments regarding fighter aircraft.

In 1992, China became the first Non-Commonwealth of Independent States country to operate the Russian made Sukhoi fighter, designated Su-27 Flanker. The Su-27 was originally designed to go against 4th Gen fighters such as the F-15 Eagle and is assessed to be a formidable fighter capable of challenging air superiority. In 1995, Russia agreed in principle to allow China to build the Su-27SK single-seat fighter in China under license.[98] Then in 1996, the Sukhoi Company and Shenyang Aircraft Corporation (SAC) entered into a contract for the co-production of 200 Su-27SK fighters renamed the Jian-11 (J-11). This partnership did not go well, and China stopped the production of aircraft at around 100 total. In mid-2002, SAC unveiled its intention to build an upgraded multirole version of the J-11 by revealing a mock-up aircraft carrying various types of air-to-air and air-to-surface missiles. Russian sources also confirmed that SAC was pursuing a multirole variant of the J-11, designated J-11B, with much greater Chinese-made

[97] U.S. Department of the Air Force, *Air Force Doctrine Document 2-1, 2000* (United States Air Force, January, 2000), 8-9.

[98] "Su-27SK/UBK Air Superiority Fighter Aircraft," Sinodefence.com, http://www.sinodefence.com /airforce/fighter/su27.asp (accessed March 13, 2010).

content. There has also been speculation that Shenyang is currently developing a two-seater version of the J-11B, possibly designated J-11BS. The aircraft was to be similar to the Su-27UBK fighter-trainer but fitted with Chinese-made power-plant, avionics, and weapon suite. The Su-27 was already a formidable air-to-air fighter, and with upgrades helping it achieve parity with America's modernized F-15 Eagle, it will remain a threat to air superiority unless confronted with 5th Gen capabilities.[99]

The Sukhoi Su-30M Flanker-C is a Russian made multi-role two-seater fighter, broadly comparable to the American F-15E Strike Eagle multi-role fighter/bomber. The Su-30MKI is the export version of the aircraft and is equipped with thrust vectoring for combat agility and maneuverability. The aircraft is armed with precision anti-surface missiles and has a stand-off launch range of 120 kilometers. The Su-30M is capable of engaging two airborne targets simultaneously and can be armed with up to six medium-range air-to-air missiles and two short range IR missiles. The air-to-surface missile fits include four anti-radiation missiles, six laser-guided short-range missiles or six short-range anti-surface missiles with television controlled homing.[100] This aircraft, like the Su-27SK/J-11 variants, is also being exported to other nations looking to increase their air force capabilities.

The Indian Air Force ordered 40 of these aircraft in 1996 and an additional ten aircraft in 1998. The first 18 they received were upgraded in 2006 to the MKI standard. First deliveries of ten Su-30MKI aircraft (thrust vectoring/phased array radar) took place in September 2002 with final deliveries completed in December 2004. In 2003, Malaysia ordered 18 Su-30MKM aircraft (fitted with laser designator) and the first two were delivered in May 2007 and 8 more by March 2008. Also in 2003, Indonesia ordered two Su-30MKK aircraft. A further three Su-30MK2 aircraft were ordered in August 2007. In March 2006, Algeria placed an order for 28 Su-30MKA

[99] "Jian-11 Multirole Fighter Aircraft," Sinodefence.com, http://www.sinodefence.com/airforce/fighter/j11.asp (accessed March 13, 2010).

[100] "Su-30MK Multi-Role Two-Seater Fighter Aircraft, Russia," Airforce-technology.com, http://www.airforce-technology.com/projects/su_30mk/ (accessed March 13, 2010).

aircraft, with the first being delivered in December 2007. In July 2006, Venezuela placed a contract for 24 Su-30MKI aircraft. The first eight were delivered in May 2007 and deliveries concluded in August 2008.[101]

The Su-30MKI has advanced characteristics not commonly associated with 4th Gen aircraft, such as thrust vectoring, but it falls short of achieving 5th Gen characteristics that also include stealth. It does, however, remain a threat to America's 4th Gen air superiority aircraft and opposing forces stationed on the ground.

One of the most advanced non-stealth fighters made in Russia is the latest version of the Su-35. The Su-35BM is an advanced capability multi-role air superiority fighter that was also developed from the Su-27. The aircraft has a maximum speed of Mach 2.25, is capable of pulling in excess of nine times the force of gravity (+9g), and is equipped with a high-capability weapon systems that contributes to the aircraft's exceptional dog-fighting capability. The aircraft will enter service with the Russian Air Force in 2010, and Sukhoi has announced that it will be available for export deliveries that same year. The aircraft has 12 hard-points for carrying external weapons and stores and carries a mix of air-to-air and air-to ground medium and long-range missiles. The Su-35 can be armed with a range of guided bombs, including TV-guided, satellite-guided and laser-guided bombs.[102]

One of the more interesting characteristics of this aircraft is its X-band multimode phased array Irbis-E radar. The radar is said to be able to detect low-observable and stealth aircraft, unmanned air vehicles and missiles with a radar cross section of 0.01 meters squared at ranges out to 90 kilometers. It is also assessed to detect and track up to 30 airborne targets with a radar cross section (RCS) of three meters squared at ranges of 400 kilometers using track-while-scan mode. The infrared search and track fire control system includes an infrared sensor, laser rangefinder, target designator and television camera. The laser rangefinder has a five meter CEP

[101] Ibid.

[102] "Su-35 Multirole Air Superiority Fighter Aircraft, Russia," Airforce-technology.com, http://www.airforce-technology.com/projects/su-35/ (accessed March 13, 2010).

(circular error probability) to a maximum range of 20 kilometers against airborne targets and 30 kilometers against ground targets.[103] If the Su-35 is truly capable of detecting stealth aircraft, then it does pose a threat to America's ability to dominate in the air-to-air role. Detection is not enough by itself though; it will also need the ability to maintain a track for an effective missile launch. It will, in addition, be required to out maneuver 5th Gen aircraft in an air-to-air engagement if it is to survive the close in fight.

The DoD estimation of future threats has proven an accurate forecast upon review of advances in counter-air technology and the proliferation of that technology. In response, America's AF has been attempting to stay out front with the procurement of 5th Gen stealth aircraft capable of surviving in this forecasted environment. The brief history of air power since WWII has revealed three outcomes. The first was that heavy losses to aircraft and aircrew resulted when trying to achieve military objectives without air superiority and without superior aircraft capable of surviving enemy counter-air. This was most prevalent during WWII. Second, as witnessed in the skies over Korea, was that air superiority could be lost when an enemy introduced a more capable counter-air threat. It took the introduction of an equally-capable American fighter to provide only windows of air superiority for the remainder of that war. Finally, an outcome that has been noticeable in America's more recent conflicts, is where its AF faced credible counter-air threats and applied superior technology to survive. It was the technological advancements that neutralized the counter-air capability and allowed for less superior aircraft to fly continued operations in support of Combatant Commander's objectives while preventing its enemy from reemerging as a credible threat. Air superiority gained early provides America's leadership the ability to use air power as an effective tool to aid in achieving the overall campaign objectives. Superior air power allows those leaders to achieve this without great loss to its combat airframes and crew.

[103] Ibid.

RECAPITALIZATION & MODERNIZATION

Quantity has a quality all its own
Joseph Stalin

Because of the advancements made in counter-air technology and its application to AAA, SAMs, and fighter aircraft, America's AF has been attempting to modernize and replace its aging fleet of combat aircraft.[104] These replacement aircraft, referred to as 5th Gen, are designed to survive and operate in future high-threat environments with their stealth, flight characteristics, advanced communications and smart weapons capabilities. 5th Gen aircraft also come at a higher cost per unit when compared to the purchase of a new modernized 4th Gen aircraft.[105] This higher purchasing price, combined with the increasing cost of maintaining a legacy 4th Gen fleet, has led the AF to adopt a new budgeting strategy.

The AF's new budgeting strategy is one that relies on "recapitalization and modernization."[106] This strategy has three steps and is based on taking a defined acceptable risk in the near term by retiring legacy aircraft before their replacements, 5th Gen aircraft, are procured. The first step in this process calls for a substantial reduction of 4th Gen fighter aircraft in the near years of the FYDP to generate savings.[107] The second step uses a portion of the savings from the aircraft reductions to modernize the remaining smaller fleet with advanced capabilities in weapons, communication technology and SLEPs. The premise is based on a smaller, more capable 4th Gen fleet being able to manage multiple MCOs in the same fashion as the larger, less capable 4th Gen fleet. In theory, the increase comes as a result of better MC rates and increased lethality and survivability.[108] The third step combines the remainder of the savings

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[104] "F-22A Raptor Advanced Tactical Fighter Aircraft, USA," Airforce-technology.com, http://www.airforce-technology.com/projects/f22/ (accessed March 13, 2010).
[105] United States Government Accountability Office, *GAO-09-303: Joint Strike Fighter* (Washington DC: Government Accountability Office, 2009), 2.
[106] SSgt Todd C. Lopez, "Air Force Focused on Three Priorities," Official Web Site: U.S. Air Force, 2000, http://www.af.mil/news/story.asp?id=123027010 (accessed March 13, 2010).
[107] Department of Defense, *Quadrennial Defense Review Report: February 2010* (Washington DC, 2010), xi.
[108] Department of the Air Force, *Advance Questions for General Norton A. Schwartz: USAF Nominee for the Position of Chief of Staff of the USAF* (Washington, DC, 2008), 18.

with available procurement dollars toward the purchase of the 5th Gen replacement fleet.[109] This fleet will eventually grow to replace all the 4th Gen aircraft as they age out across and beyond the FYDP.[110] The end result of this strategy returns USAF combat aircraft to the determined size defined by the 2006 QDR Surge requirements to conduct and win a conventional campaign.[111]

The premise behind replacing 4th Gen with 5th Gen aircraft is based on the forecast of America's adversaries being able to defend their airspace with advanced capabilities competent in denying 4th Gen aircraft survivable access. As reviewed in Anti-Access Threats, this premise is based on solid evidence. What it does not take into account is the historical record that shows no requirement for superior survival ability beyond the initial destruction of the enemy's anti-access air defenses. It also does not take into account the monetary cost of procuring and maintaining an entire combat air force of 5th Gen stealth aircraft.

America's Air Force has been working towards replacing its superior fighter, the F-15 Eagle, with the world's most advanced fighter, the F-22 Raptor. The AF has also argued that it needs 381 F-22s to be able to dominate the skies at the start of any major war and clear the way for other U.S. and allied warplanes.[112] Nevertheless, current war budgeting priorities have out-weighed the high procurement costs of an aircraft that contributes little to, in what Secretary of Defense Robert Gates said, "fight the wars we are in today and the scenarios we are most likely to face in the years ahead. . . ." [113] This has resulted in the termination of further F-22 buys beyond

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[109] SSgt Todd C. Lopez, "Air Force Focused on Three Priorities." The Official Web Site of the U.S. Air Force, http://www.af.mil/news/story.asp?id=123027010 (accessed October 8, 2009).

[110] Department of the Air Force, *Advance Questions for General Norton A. Schwartz: USAF Nominee for the Position of Chief of Staff of the USAF* (Washington, DC, 2008), 18.

[111] Surge – wage two nearly simultaneous conventional campaigns (or one conventional campaign if already engaged in a large-scale, long-duration irregular campaign), while selectively reinforcing deterrence against opportunistic acts of aggression. Be prepared in one of the two campaigns to remove a hostile regime, destroy its military capacity and set conditions for the transition to, or for the restoration of, civil society. Office of the Secretary of Defense, *Quadrennial Defense Review Report: February, 2006* (Washington, DC, 2006), 38.

[112] Jim Wolf, "U.S. Fighter Plane Needs Major Upgrades-Arms Buyer," Reuters.com, 2008, http://www.reuters.com/article/idUSN2035135720081120?sp=true (accessed March 13, 2010).

[113] Norman Polmar, "Secretary Gates and the F-22 Raptor," Defensetech.org, 2010, http://defensetech.org/2009/04/15/secretary-gates-and-the-f-22-raptor/ (accessed March 13, 2010).

187 and places the average unit flyaway cost at about $350 million per aircraft.[114] Since the AF has to make do with only 187, it has budgeted an additional $8 billion dollars across the FYDP to upgrade the earlier F-22 models to equal the ones currently coming off the production line.[115] These additional costs have not been added into the flyaway cost since they are only forecast to be spent over the next five years.

Maintenance cost and mission capable rates of the F-22 have also fallen below original expectations. Lockheed Martin, maker of the F-22, said in a recent statement that the MC rate "has improved from 62 percent to 68 percent from 2004-2009."[116] However, as of June 2009, Air Combat Command (ACC) was reporting only a 62.9 percent MC rate.[117] A large contributor to the low MC rates among stealth aircraft is their low observable (LO) capability. This LO capability was one of the key justifications for the F-22 to achieve an air-superiority advantage. When fully operational, LO suppresses the F-22's visual signature, radar signature, infrared signature, electromagnetic emissions, and sound.[118] Currently, it is the LO that makes up over half of all maintenance hours spent on the F-22's. This has contributed significantly to the overall operating cost. According to the USAF, the variable cost per flying hour of the F-22 in 2008 has been $49,808. This total adds in the contractor support costs along with appropriate government costs. It is a stark comparison with the F-15C that totaled $17,465 per flying hour during that same year.[119]

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[114] Jeff Smith, *Response to F-22 Washington Post Article by Jeff Smith* (Washington, DC: Department of the Air Force, 2009), 2.

[115] Jim Wolf, "U.S. Fighter Plane Needs Major Upgrades-Arms Buyer," Reuters.com, 2008, http://www.reuters.com/article/idUSN2035135720081120?sp=true (accessed March 13, 2010).

[116] John A Tirpak, "The F-22, Bagel and a Smear," Airforce-magazine.com, 2009, http://www.airforce-magazine.com/DRArchive/Pages/2009/July%202009/July%2013%202009/TheF-22,BagelandaSmear.aspx (accessed March 13, 2010).

[117] Michael C. Sirak, "Raptor Rising," Airforce-magazine.com, 2009, http://www.airforce-magazine.com/DRArchive/Pages/2009/June%202009/June%2030%202009/RaptorRising.aspx (accessed March 13, 2010).

[118] Project on Government Oversight, "High-Maintenance F-22 Stealth Features Keeping It in the Shop," POGO.org, 2009, http://www.pogo.org/pogo-files/alerts/national-security/ns-f22-20090220.html (accessed March 13, 2010).

[119] Jeff Smith, *Response to F-22 Washington Post Article by Jeff Smith* (Washington, DC: Department of the Air Force, 2009), 1.

The F-22 was declared fully operation by ACC in 2005 and, despite all the early setbacks, has been improving in each of the troubled areas previously mentioned and is expected to meet the original design specifications the AF required.[120] But if it follows the path of all previous stealth aircraft, it will continue to remain more expensive to operate. While these aircraft are clearly needed to remove anti-access threats, they can be offset with newly procured 4th Gen aircraft. Boeing currently has unveiled an F-15SE Silent Eagle and is marketing it towards foreign sales with the advertisement of meeting cost-effective stealth technology. It is a single seat dual capable aircraft with the ability to match the current payloads of the F-15C and E models.[121] Compared to the F-22s cost, Boeing advertises the flyaway cost of an F-15SE Silent Eagle at about $100 million, including some spares and additional maintenance gear.[122] In America's AF, this aircraft would bring with it commonality and familiarity among both aircrew and maintenance personnel. These characteristics are often translated into significantly cheaper operating costs relative to full-up stealth aircraft and allow for a proven weapon system to perform continued operations once access into enemy territory is gained.

To aid in gaining air superiority, America's DoD planned on offsetting the "less-than-required F-22 procurements" by advancing the production and purchases of the F-35 Joint Strike Fighter. This advanced procurement would also allow the Air Force to start retiring its older F-16s, which the F-35 is supposed to replace. The program, which is by far the Pentagon's largest, is expected to cost nearly $300 billion if all of the 2,456 planes are purchased in the next 25 years. The F-35, which also has stealth features to avoid radar, was meant to focus more on attacking ground targets, whereas the F-22, in contrast, was originally designed for the air-to-air role. They currently are capable of doing both. Three versions were created that build off of the same design. This concept was supposed to make it more affordable while meeting the separate

[120] Ibid., 1-5.

[121] Boeing, "Boeing Unveils New International F-15 Configuration: The F-15SE," Boeing.com, 2009, http://www.boeing.com/news/releases/2009/q1/090317a_nr.html (accessed March 13, 2010).

[122] "Stealth Eagles?" Airforce-magazine.com, 2009, http://www.airforce-magazine.com/DRArchive/Pages/2009/March%202009/March%2018%202009/StealthEagles.aspx (accessed March 13, 2010).

needs of the Air Force, Navy and Marine Corp. The overall cost was also going to be reduced by making less-capable versions of the F-35 available to America's allied nations. In all, eight allied nations have invested in the program and are expected to buy hundreds of additional planes. The projected costs of the F-35 program have also risen from the originally speculated $200 billion to an estimated $298.8 billion resulting in a fly away cost for each F-35 at $122 million per copy.[123]

Stealth aircraft do not come cheap and they only get more expensive when increased size and range are required. America has not developed a new long range bomber since the B-2, and its procurement was cut short of its original expected buy. The Air Force was on track to gain its next long-range bomber, but it appears that the high cost and production delays of both the F-22 and the F-35 have impacted this goal. Prior to the 2006 QDR, the Air Force had indicated that its current bomber fleet would suffice until 2037, when advanced technologies, such as hypersonic cruise vehicles, would potentially reach maturity and be incorporated into follow-on bomber aircraft. The Office of the Secretary of Defense (OSD), responding to the Air Force's desire to retire 38 B-52Hs and, concerned about the Air Force's ability to successfully execute long-range bombing missions in the future, accelerated Air Force plans for fielding a new aircraft by almost 20 years, to 2018. [124] In 2006, the Commander of ACC stated that the Air Force is looking to get a "next generation" long-range bomber by 2018.[125] More recently, the current CSAF, General Schwartz, stated that these bombers, "could be part of the inventory as early as 2018, though likely later."[126] The 2010 QDR only directs the military to expand future long-range strike capabilities while maintaining and modernizing the current fleet of 144 long range bombers.[127]

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[123] Christopher Drew, "Gates Tries to Get F-35 Program Back on Course," Nytimes.com, 2010, http://www.nytimes.com/2010/02/03/business/03fighter.html (accessed March 13, 2010).

[124] Anthony Murch, *CRS Report for Congress: The Next Generation Bomber: Background, Oversight Issues, and Options for Congress* (Washington, DC, Congressional Research Service, 2008), Introduction.

[125] SSgt. C. Todd Lopez, "Air Force Will Get New Bomber, Upgrades to Fighters," AF.mil, 2006, http://www.af.mil/information/transcripts/story.asp?storyID=123028140 (accessed March 13, 2010).

[126] Maj. Patricia Traynor, "Deterrence is Not a Fading Concept, CSAF says," AF.mil, 2008, http://www.af.mil/news/story.asp?id=123126954&page=2 (accessed March 13, 2010).

[127] Office of the Secretary of Defense, *Quadrennial Defense Review Report: February 2010* (Washington, DC, 2010), ix.

America's Air Force is headed in a direction that will combine its 4th Gen fighter and bomber fleets with limited procurements of 5th Gen stealth aircraft for at least the next fifteen to twenty years. The legacy 4th Gen fleet will need SLEPs and technology upgrades to increase their service life and keep them relevant in the future fight while maintaining a fleet size that is commensurate with OSD and current QDR guidance. As the legacy aircraft age out beyond their extensions, the Air Force will again be faced with the dilemma of sizing the force. It will need to choose between a total combat force with superior stealth technology on all its aircraft or a mix of less survivable, less costly aircraft with the superior generation of their day.

CONCLUSION

The form of control most often practiced by aerospace forces today is air superiority, which enables friendly forces to use the air medium for military purposes while denying the enemy effective use of the same.[128] Today, and in the future, the proper employment of America's aerospace power will remain essential for its success within this air medium. To conduct that employment successfully, America will need aircraft capable of surviving and destroying the modern threats that seek to deny them access over its enemy's sovereign airspace.

Since the Wright Brothers first flew at Kitty Hawk, the airplane has continually advanced as an instrument of military and national power.[129] Planners in WWII were some of the first to apply relevant advances in aircraft against asserted air power theories. Two negative aspects stood out early: the bombers did not always get through, and when they did, the results were not always the destruction of their intended target. If Allied planners were going to prove or disprove their strategic theories on airpower, they would have to apply it in a fashion where air superiority was gained first. America also learned that if air power theory was going to survive at all, it could not be gained at such great losses in the future.

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[128] U.S. Department of the Air Force, *Air Force Doctrine Document 2-1, 2000* (United States Air Force, January, 2000), 4.

[129] Ibid.

Later wars bore out these lessons learned as America and Russia pitted their aircraft against each other, competing for dominance of the skies in wars conducted over proxy states' airspace. America continued to make advances in both aircraft designs and the ability to deliver accurate weapons while Russia introduced its own new aircraft, antiaircraft AAA and SAMs. It was not until DESERT STORM, though, that America's air power achieved superior results executing tactics aimed at gaining air superiority. Once it was gained through the aid of advanced stealth technology, the air assets were then able to focus the bulk of their efforts towards achieving the Combatant Commander's objectives. This similar strategy also played out in ALLIED FORCE, ENDURING FREEDOM, and IRAQI FREEDOM and continues to be maintained in the latter two operations today. The USAF has learned that when using technology that is superior to its enemy's ability to deny them access, that air superiority can be quickly gained and at a limited cost to its own aircraft.

America's enemies have learned that their anti-access capabilities need to keep up with the advances in stealth technology to prevent similar courses of action occurring against them. As a result, Russia has developed multiple advances towards its older anti-access equipment and then made these capabilities available on the open market. As discussed earlier, countries such as Iran, China and India have taken steps towards procuring Russia's most advanced fighters and SAMs, with other countries projected to do the same. China has also re-engineered some of this technology and gone into production for itself. As DoD's projected proliferation of these modern threats begin to materialize, America's AF has become focused on procuring an all stealth fighter and bomber force.

America's AF needs to remain focused on its past successes and how it has obtained air superiority. It started off WWII with lesser-capable aircraft which resulted in high loss rates against enemy counter-air. As advances were made in design, capability and sheer production, America was able to gain air superiority. In Korea, America entered aircraft that were one generation shy of the jet age and achieved early success but then quickly paid a heavy cost in

losses when Russian jet technology entered the war. Not until America countered with its own jet technology did it achieve limited air superiority again. In Vietnam, AF aircraft faced SAMs and somewhat equally advanced fighters but most often lost aircraft flying inside AAA trying to achieve effective target destruction. The answer to this threat came in the form of precision weapons that could be delivered from altitudes above most AAA's effective range. This accuracy was first achieved during DESERT STORM when precision weapons were delivered by equally impressive stealth F-117s. Totally counter to WWII, this war was fought with advanced aircraft being used first and then followed by earlier generation aircraft with less survivability and less accurate weapons capability. This tactic was used across the next three operations with advances in both stealth and accuracy of weapons. In all, the legacy aircraft continued to carry out the preponderance of weapons delivered after air superiority was gained.

It is clear from the history of America's success at gaining air superiority that technologically advanced aircraft will be needed to gain the early advantage in future wars. It is also clear that America's enemies will endeavor to advance their ability to produce anti-access threats capable of reaching parity with them. As seen with the high procurement and operating cost of 5th Gen aircraft, owning an entire combat force made up of these aircraft can become prohibitive when trying to maintain a force size capable of two simultaneous MCOs. An alternative approach that procures not only 5th Gen, but also modernized versions of 4th Gen and modification upgrades to it legacy 4th Gen aircraft, is a more feasible approach. It is an approach that allows for air superiority to be gained with 5th Gen aircraft, continued operations to be flown with modernized 4th Gen aircraft, and a total combat force that is sustainable within the confines of the AF's TOA. The USAF needs to procure 5th Gen combat aircraft only in numbers that will allow air superiority to be attained and enable flight operations of modernized 4th Gen combat aircraft to sustain air superiority.

BIBLIOGRAPHY

Auslin, Michael. "These Fighter Numbers Don't Add Up." American.com. http://www.american.com/archive/2009/july/these-fighter-numbers-dont-add-up (accessed March 16, 2010).

Barnett, Jeffery R. *Future War: An Assessment of Aerospace Campaigns in 2010.* Alabama: Air University Press Maxwell, AFB, 1996.

Beason, J. Douglass Dr. and Dr. Mark Lewis. "The War Fighter's Need for Science and Technology." Air & Space Power Journal. http://www.airpower.maxwell.af.mil/ airchronicles/ apj/apj05/win05/beason.html (accessed March 16, 2010).

"Bistatic Radar Sets." Radartutorial.eu. http://www.radartutorial.eu/05.bistatic/bs04.en.html (accessed March 16, 2010).

Boeing. "Boeing Unveils New International F-15 Configuration: The F-15SE." Boeing.com, 2009. http://www.boeing.com/news/releases/2009/q1/090317a_nr.html (accessed March 16, 2010).

Boeing Company. "F-15E Radar Modernization Program Receives New Designation." Defensetalk.com, 2009. http://www.defencetalk.com/f-15e-radar-modernization-program-receives-new-designation-21992/ (accessed March 16, 2010).

Boot, Max. *War Made New: Technology, Warfare, and the Course of History*. New York: Penguin Group (USA) Inc., 2006.

Brown, Michael E., Owen R. Cote, Sean N. Lynn-Jones, and Stephen E. Miller. *New Global Dangers: Changing Dimensions of International Security.* Harvard University: MIT Press, 2004.

Claremont Institute. "Missile Defense Systems: S-400 SA-20 Triumf." MissileThreat.com http://www.missilethreat.com/missiledefensesystems/id.52/system_detail.asp (assessed March 13, 2010).

Codevilla, Angelo and Paul Seabury. *A New Edition of a Classic Work of War Ends and Means; 2nd Ed*. Dulles: Potomac Books; Inc., 2006.

Congressional Research. "Report for Congress: Afghanistan: Current Issues and U.S. Policy." Washington DC: Library of Congress, 2002.

Dale, Catherine. *Operational Iraqi Freedom: Strategies, Approaches, Results, and Issues for Congress.* Washington DC: Congressional Research Service, 2008.

Deane, Hugh. *The Korean War 1945-1953.* California: China Books and Periodicals, Inc., 1999.

Defense Talk. "Air Force Focused on Three Priorities." Defensetalk.com 2006. http://www. defencetalk.com/air-force-focused-on-three-priorities-8639/ (assessed March 9, 2010)

Defense Talk. "B-2 Spirit Exceeds Mission Standard." Defensetalk.com. http://www. defencetalk.com/b-2-spirit-exceeds-mission-standard-7843/ (accessed March 16, 2009).

Department of Defense. *Final Report to Congress: Conduct of the Persian Gulf War*. Washington DC, 1992.

Department of Defense. *Report to Congress: Kosovo/Operation Allied Force After-Action Report.* Washington DC, 2000.

Department of the Air Force. *Advance Questions for General Norton A. Schwartz: USAF Nominee for the Position of Chief of Staff of the USAF*. Washington, DC, 2008.

Department of the Air Force. *Fiscal Year 2010 Air Force Posture Statement, May 2009. Statement of: Secretary of the Air Force, Michael B. Donley and Chief of Staff of the Air Force, Gen. Norton A Schwartz*. United States Air Force, 2009.

Douhet, Giulio and Dino Farrari. *The Command of the Air*. Washington, DC: Air Force History and Museums Program, 1998.

Drew, Christopher. "Gates Tries to Get F-35 Program Back on Course." Nytimes.com. http://www.nytimes.com/2010/02/03/business/03fighter.html (assessed March 13, 2010).

Dunnigan, James F. *F-22 Has a Fatal Skin Disease.* Strategypage.com. http://www.strategypage.com/dls/articles/F-22-Has-A-Fatal-Skin-Disease-7-25-2009.asp (assessed March 16, 2010).

Dunnigan, James F. and Albert A. Nofi. *Dirty Little Secrets of the Vietnam War*. New York: St. Martin's Press, 2000.

Ellis, John. *World War II: A Statistical Survey: The Essential Facts and Figures for All.* New York: Facts on File, Inc, 1993.

"F-22A Raptor Advanced Tactical Fighter Aircraft, USA." Airforce-technology.com. http://www.airforce-technology.com/projects/f22/ (assessed March 13, 2010).

Federation of American Scientists. "Anti-Aircraft Artillery." fas.org. http://www.fas.org/man/dod-101/sys/land/row/aaa.htm (assessed March 16, 2010).

Federation of American Scientists. "B-2 Bomber: Cost and Operational Issues." fas.org. http://www.fas.org/man/gao/nsiad97181.htm (assessed March 16, 2010).

Federation of American Scientists. "VI – Stealth Aircraft: Eagles Among Sparrows?" fas.org. http://www.fas.org/spp/aircraft/part06.htm#N_61_ (assessed March 16, 2010).

Federation of American Scientists. "Tactical Aircraft: F-15 Replacement Is Premature as Currently Planned." Fas.org. http://www.fas.org/man/gao/gao94118.htm (assessed March 16, 2010).

Federation of American Scientists. "Operation Desert Storm: Evaluation of the Air Campaign." fas.org. http://www.fas.org/man/gao/nsiad97134/app_05.htm (assessed March 9, 2010)

Federation of American Scientists. "F-15 Eagle: Overview." fas.org. http://www.fas.org/programs /ssp/man/uswpns/air/fighter/f15.html (assessed March 9, 2010).

Finlan, Alastair. *Essential Histories: War and Conflict in modern Times, The Gulf War of 1991*. New York: The Rosen Publishing Group, 2009.

Foss, Christopher. "Europe: More firepower for ZSU-23-4 SPAAG." Jane's: Defense Weekly. http://www4.janes.com/subscribe/jdw/doc_view.jsp?K2DocKey=/content1/janesdata/mags/jdw/history/jdw99/jdw04074.htm@current&Prod_Name=JDW&QueryText=%3CAND%3E(%3COR%3E((%5B80%5DSA-18+%3CIN%3E+body)%2C+(%5B100%5D+(%5B100%5DSA-18+%3CIN%3E+title)+%3CAND%3E+(%5B100%5DSA-18+%3CIN%3E+body)))) (assessed March 13, 2010).

GAO-09-303. *JOINT STRIKE FIGHTER: Accelerating Procurement before Completing Development Increases the Government's Financial Risk*. Washington D.C. General Accounting office, 2009.

Defense Intelligence Agency. *Future Soviet Threat to US Air Breathing Reconnaissance Platforms (U).* http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB74/U2-47.pdf (assessed March 13, 2010).

Gerstein, Daniel M. *Securing America's Future: National Strategy in the Information Age*. Westport: Greenwood Publishing Group, Inc., 2005.

Global Security. "F-22 Raptor History." Globalsecurity.org. http://www.globalsecurity.org/military/systems/aircraft/f-22-history.htm (assessed March 16, 2010).

Global Security. "Weapons of Mass Destruction: B-2 Production." Globalsecurity.org. http://www.globalsecurity.org/wmd/systems/b-2-production.htm (assessed March 16, 2010).

Global Security. "Top Air Force Generals Address Airman's Concerns." Globalsecurity.org. http:// www.globalsecurity.org/military/library/news/2007/09/mil-070926-afpn06.htm (assessed March 9, 2010)

Global Security. "Military: S-300PMU1 SA-20 Gargoyle." Globalsecurity.org, http://www.global security.org /military/world/russia/s-300pmu1.htm (assessed March 13, 2010).

Global Security. "Military: 9K338 9M342 Igla-S/SA-24 Grinch." Globalsecurity.org. http://www. globalsecurity.org/military/world/russia/9k338.htm (assessed March 13, 2010).

Global Security. "9M111 / SA-19 GRISON." Globalsecurity.org. http://www.globalsecurity.org/military/world/russia/sa-19.htm (assessed March 13, 2010).

Goure, Daniel and Christopher M. Szara. *Air and Space Power in the New Millennium.* Washington DC: Center for Strategic & International Studies, 1997.

Halberstam, David. *War in a Time of Peace: Bush, Clinton and the Generals.* New York: Simon & Schuster, 2001.

Hallion, Richard. *Storm Over Iraq: Air Power and the Gulf War*. Washington DC: Smithsonian Institution Press, 1997.

Head, William and Earl H. Tilford Jr. *The Eagle in the Desert: Looking Back on U.S. Involvement in the Persian Gulf War*. Westport: Praeger Publishers, 1996.

"Igla-S, Igla-1." Defense Update: International, Online Defense Magazine. http://defense-update.com/products/s/sa-18.htm (assessed March 13, 2010).

"Jian-11 Multirole Fighter Aircraft." Sinodefence.com. http://www.sinodefence.com/airforce/fighter/j11.asp (assessed March 13, 2010).

Kopp, Carlo. Dr. "Air Power Australia: Almaz S-300 Series." Ausairpower.net. Australia's Independent Defense Think Tank. http://www.ausairpower.net/APA-Grumble-Gargoyle.html#mozTocId122631 (assessed March 13, 2010).

Lambeth, Benjamin S. *The Transformation of American Air Power*. New York: Cornell University Press, 2000.

Lambeth, Benjamin S. *NATO's Air War for Kosovo: A Strategic and Operational Assessment.* California: Rand, 2001.

"LD-2000 Close-In Weapons System." Sinodefence.com. http://www.sinodefence.com/army/antiaircraft/ld2000.asp (assessed March 13, 2010).

Lopez, C. Todd SSgt. "Air Force Will Get New Bomber, Upgrades to Fighters." AF.mil, 2006. http://www.af.mil/information/transcripts/story.asp?storyID=123028140 (assessed March 13, 2010).

Lopez, Todd C. SSgt. "Air Force Focused on Three Priorities." AF.mil, 2006. http://www.af.mil/news/story.asp?id=123027010 (assessed March 13, 2010).

Mahnken, Thomas G. *Technology and the American Way of War Since 1945*. West Sussex: Columbia University Press, 2008.

Massachusetts Institute of Technology. "Stealth Warplanes: They can run, but they can't hide." Mit.edu. http://www.mit.edu/~thistle/v12/2/stealth.html (accessed March 16, 2010).

NATO Standardization Agency. *NATO Glossary of Terms and Definitions*. North Atlantic Treaty Organization, March 2010.

United States Central Command Air Forces. *Operation Iraqi Freedom: By the Numbers. (April 2003)*, by Lt Gen. T. Michael Moseley, 2003.

Congressional Research Service. *CRS Report for Congress: The Next Generation Bomber: Background, Oversight Issues, and Options for Congres*, Anthony Murch. Washington, DC, 2008.

Office of the Secretary of Defense. *Quadrennial Defense Review Report: February, 2006.* Washington, DC, 2006.

Office of the Secretary of Defense. *Quadrennial Defense Review Report: February 2010.* Washington, DC, 2010.

Polmar, Norman. "Secretary Gates and the F-22 Raptor." Defensetech.org, 2010. http://defensetech. org/2009/04/15/secretary-gates-and-the-f-22-raptor/ (assessed March 13, 2010).

Project on Government Oversight. "High-Maintenance F-22 Stealth Features Keeping It in the Shop." POGO.org, 2009. http://www.pogo.org/pogo-files/alerts/national-security/ns-f22-20090220.html (assessed March 13, 2010).

Owens, William and Ed Offley. *Lifting the Fog of War.* Baltimore: The John Hopkins University Press, 2001.

Parker, Geoffrey. *Cambridge Illustrated History: Warfare*. Cambridge: Cambridge University Press, 1995.

Richardson, Doug. *Stealth Warplanes: Deception, Evasion, and Concealment.* Oscoda: MBI Publishing Company, 2001.

Rottman, Gordan L. *Korean War Order of Battle: United States, United Nations, and Communist Ground, Naval, and Air Forces, 1950-1953*. Connecticut: Praeger Publishers, 2002.

Sandler, Stanley. *The Korean War: No victors, No Vanquished*. Kentucky: The University Press of Kentucky, 1999.

Scully, Megan. "Air Force poised to make F-22 request." GovernmentExecutive.com. http://www.govexec.com/dailyfed/0209/021709cdpm1.htm (accessed March 16,2010).

Sirak, Michael C. "Raptor Rising." Airforce-magazine.com. http://www.airforce-magazine.com/DRArchive/Pages/2009/June%202009/June%2030%202009/RaptorRising.aspx (assessed March 13, 2010).

Siuru, William D. and John D. Busic. *Future Flight: The Next Generation of Aircraft Technology 2nd Ed.* Blue Ridge Summit: Tab Books, 1994.

Department of the Air Force. *Response to F-22 Washington Post Article (July, 2009),* by Jeff Smith. Washington, DC: Department of the Air Force, 2009.

Snow, Donald M. and Dennis M. Drew. *From Lexington to Desert Storm and Beyond: War and Politics in the American Experience 2nd Ed.* Armonk: M. E. Sharp, Inc., 2000.

"Stealth Eagles?" Airforce-magazine.com, 2009. http://www.airforce-magazine.com/DRArchive/Pages/2009/March%202009/March%2018%202009/StealthEagles.aspx (assessed March 13, 2010).

"Su-27SK/UBK Air Superiority Fighter Aircraft." Sinodefence.com. http://www.sinodefence.com /airforce/fighter/su27.asp (assessed March 13, 2010).

"Su-30MK Multi-Role Two-Seater Fighter Aircraft, Russia." Airforce-technology.com. http://www.airforce-technology.com/projects/su_30mk/ (assessed March 13, 2010).

"Su-35 Multirole Air Superiority Fighter Aircraft, Russia." Airforce-technology.com. http://www.airforce-technology.com/projects/su-35/ (assessed March 13, 2010).

Sweetman, Bill. "Aviation Week's VTI: Radical and Cheap Anti-Stealth Radar." Military.com. http://www.military.com/features/0,15240,157743,00.html (accessed September 21, 2009).

Thompson, Warren. *F-117 Stealth Fighter Units of Operation Desert Storm.* New York: Osprey Publishing, 2007.

Tirpak, John A. "The F-22, Bagel and a Smear." Airforce-magazine.com, 2009. http://www.airforce-magazine.com/DRArchive/Pages/2009/July%202009/July%2013%202009/TheF-22,BagelandaSmear.aspx (assessed March 13, 2010).

Traynor, Patricia Maj. "Deterrence is Not a Fading Concept, CSAF says." AF.mil, 2008. http://www.af.mil/news/story.asp?id=123126954&page=2 (assessed March 13, 2010).

Trimble, Stephen. "The DEW Line: Infamous JSF report precedes "abrupt departure" for RAND analyst." Flightglobal.com. http://www.flightglobal.com/blogs/the-dewline/2008/10/infamous-jsf-report-precedes-a.html (assessed March 16, 2010).

Turdoslavich, William. *The Jack Ryan Agenda: Policy and Politics in the Novel of Tom Clancy.* New York: Tom Doherty Associates, LLC, 2005.

"TY-90 (Yitian) Surface-to-Air Missile." Sinodefence.com. http://www.sinodefence.com/army/surfacetoairmissile/ty90.asp (assessed March 13, 2010).

United States Air Force Document. *AFD-070912-043: Executive Summary: USAF Manned Aircraft Combat Losses 1990-2002.* Washington D.C.: Department of the Air Force, 2002. www.afhra.af.mil/shared/media/document/AFD-070912-043.pdf (assessed March 9, 2010).

United States Government Accountability Office. *GAO-09-303: Joint Strike Fighter.* Washington DC: Government Accountability Office, 2009

U.S. Department of the Air Force. *Air Force Doctrine Document 2-1, (January, 2000).* United States Air Force.

Van Staaveren, Jacob. *Gradual Failure: The Air War Over North Vietnam 1955-1966.* Washington DC: Air Force History and Museum Program, 2002.

Weiner, Tim. "The $2 Billion Stealth Bomber Can't Go Out in the Rain." Nytimes.com. http://www.nytimes.com/1997/08/23/world/the-2-billion-stealth-bomber-can-t-go-out-in-the-rain.html (assessed March 16, 2010).

Wolf, Jim. "U.S. Fighter Plane Needs Major Upgrades-Arms Buyer." Reuters.com. http://www.reuters.com/article/idUSN2035135720081120?sp=true (assessed March 13, 2010).

Wynn, Humphrey and Susan Young. *Prelude to Overlord.* California: Presidio Press, 1984.

Y'Blood, William T. "7th Air Force: The Korean Air War." 7af.pacaf.af.mil, 7th Air Force Library Factsheet, http://www.7af.pacaf.af.mil/ library/factsheets/factsheet.asp?id=7103 (assessed March 9, 2010).

Yoon, Joe. "Fighter Generations." Aerospaceweb.org. http://www.aerospaceweb.org/question/history/ q0182.shtml (assessed March 9, 2010)

"ZSU 23-4 Self-Propelled Antiaircraft Gun." Military Equipment of the Former USSR: Air Defense. Gulflink.osd.mil. http://www.gulflink.osd.mil/irfna/irfna_refs/n28en030/airdef.html#zsu23-4 (assessed March 13, 2010).