WILL THE BOMBER ALWAYS GET THROUGH?

THE AIR FORCE AND ITS RELIANCE ON TECHNOLOGY

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Major Tonnell was commissioned through the Reserve Officer Training Corps, Auburn University in 1987. He earned his wings from Undergraduate Pilot Training, Columbus AFB, Mississippi in 1989, graduating with distinction. Major Tonnell went on to fly the F-15A/C at Bitburg AB, where he was deployed to Operation DESERT STORM in 1991, Operation PROVIDE COMFORT in 1992, Operation DENY FLIGHT in 1993. In 1994, he was stationed at Tyndall AFB, Florida, where he instructed students at the F-15 Replacement Training Unit. During his tenure at Tyndall, Major Tonnell received F-15 Instructor of the Year for the 95th Fighter Squadron and Flight Commander of the Year for the 325th Fighter Wing. In 1995, Major Tonnell was selected for Squadron Officer School in residence where he was a Distinguished Graduate. In 1997, he spent a one-year remote assignment (non-flying) at Osan Air Base, South Korea, as Chief of Warfighter Requirements with Seventh Air Force. Following his Korea tour, Major Tonnell returned to the F-15 and was stationed at Elmendorf AFB, Alaska.

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After SAAS, Major Tonnell will assume the position Director of Operations at Eleventh Air Force's 611th Air Operations Squadron.

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ABSTRACT

This study analyses the inherent dangers of relying too heavily, or solely, on one panacea technology to prosecute war strategy at the expense of other, essential capabilities. The historically sound pillars of military success (the sword, the shield, and the support) have given victory to those who have used all three in a balanced, synergistic manner. When, due to over-reliance on a single technology, one of these pillars is relegated to a lesser status, or when one is marginalized, the pendulum of the advantage may swing to the enemy, or the enemy may successfully force a pendulum swing to his advantage.

Before and during World War II, the Air Corps' (and then Army Air Forces') unescorted, high-altitude, daylight precision bombing doctrine relied heavily on the B-17 weapons system to prosecute the industrial web strategy. This over-reliance on the B-17 weapons system technology slighted the shield pillar (long-range fighter escort) with devastating results as Germany was able to swing the pendulum of advantage in its favor.

The post-World War II era witnessed heavy reliance on the technology of nuclear weapons. This reliance resulted in a weakening of not only the shield pillar but also the conventional sword. Hence, when the Vietnam War began, the Air Force was ill prepared to engage in non-nuclear conflict as North Vietnam was able to swing the pendulum of advantage in its favor.

In 1989, the Air Force began using its newest technologically superior weapon – stealth. Used in three conflicts between 1989 and 1999, Air Force doctrinal thinking evolved from using the new weapon in solitude to packaging the weapon with other assets, thus balancing the pillars. While the F-117 shootdown over Serbia was a black eye for the USAF, it was not, in fact, due to over-reliance on the new technology.

Global Strike Task Force, the latest attempt at doctrinal evolution, has at its core technological superiority vis-à-vis stealth, intelligence gathering, and horizontal integration of ISR, space, and strike assets. While it does not rely too heavily on one panacea technology, it may, in fact, marginalize one of the essential pillars of success. Unless the concept is carefully scrutinized, the ability to properly create its future force structure may, again, catch the Air Force ill prepared for a fight it did not envision.

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Introduction

"The bomber will always get through..." So said Stanley Baldwin in 1932 in an address to Parliament.[1] What would induce someone to make such a broad, far-reaching statement? Perhaps he was influenced by "Billy" Mitchell's notion that "the shooting of airplanes out of the sky...is almost impossible of achievement"[2] or by his astounding demonstration of air power in the sinking of the *Ostfriesland* in 1921. Perhaps Baldwin's inspiration came from the writings and theories of Giulio Douhet in the early 1920s. After all, Douhet said, "Nothing man can do on the surface of the earth can interfere with a plane in flight."[3] Perhaps the motivation was closer to home. London had been bombed by German airships as early as 1915. The effect on the British people was devastating[4] and, even by 1932, no effective defense against attack from the air had been developed. Whatever the influence and however *macabre*, his statement reflected the belief, and the reality, that air attack could not be stopped and that British policy should be based on that assumption. Baldwin went on to say, "The only defence is in offence, which means that you have to kill more women and children more quickly than the enemy if you want to survive."[5]

While this statement may have seemed logical at the time, fundamental advances in other areas of aviation shortly proved this statement to be shortsighted. But still, much of the policy debate in England, France, and Germany before World War II centered on the

[1] Quoted in *Parliamentary Debates, House of Commons Volume 270,* First Session of the Thirty-Sixth Parliament of the United Kingdom of Great Britain and Northern Ireland, 1932, 270 H. C. Deb. 5s, 632
[2] William Mitchell, *Winged Defense* (New York: Dover Publications, Inc., 1988), 203
[3] Giulio Douhet, *The Command of the Air,* USAF Warrior Studies, eds. Richard H. Kohn and Joseph P. Harahan, trans. Dino Ferrari (Washington, D.C.: Office of Air Force History, 1983), 9
[4] James S. Corum, *The Luftwaffe, Creating the Operational Air War* (Lawrence, KS: University Press of Kansas, 1997), 24
[5] *Parliamentary Debates*, 632

assumption that any aggressor could bomb its enemy with impunity.[6] Proposals were offered (largely at the prodding of President Roosevelt) wherein countries agreed not to bomb enemy cities.

These proposals were ostensibly established to minimize civilian loss of life, but in reality they were most likely established out of fear of retaliation. If England bombed Germany, the British could expect indefensible retaliation – and vice versa. Hitler himself ordered that London be spared until just over one year into the war.[7] If the idea that bombers were impregnable was believed, then there was no sense in bringing attack on oneself. And the resulting timidity to aggressively employ bombers against enemy targets may have prolonged the war. The belief that the technological superiority of the bomber gave it the capacity to single-handedly conduct war-winning operations with impunity was, I surmise, an overestimation that would be realized soon enough.

It is interesting to note that it seems this over-confidence in, and reliance upon, technology was not limited to the Allies in World War II. Admittedly taking some literary license, but in no way distorting the meaning, one can rephrase Baldwin's infamous statement to fit today's vernacular. The idea that the bomber would always get through was directly related to the idea that the bomber was so technologically advanced for its time that nothing could negate its advantage. A more current version of Baldwin's statement might read; the technological superiority of the bomber will enable it to always overcome any defenses we might be able to forge against it and, hence, it will always be able to successfully deliver its ordnance and complete its mission. Has the United States Air Force ever fallen into the same fallacious snare that Baldwin did? In this paper I will attempt to answer the questions, "Does

[6] George H. Quester, *Deterrence Before Hiroshima, The Air Power Background of Modern Strategy* (New Brunswick, NJ: Transaction, Inc., 1986), 106
[7] Alan J. Levine, *The Strategic Bombing of Germany, 1940-1945* (Westport, CT: Praeger, 1992), 26

the Air Force rely too heavily on its technological prowess by depending on one panacea technology to achieve success with regard to desired objectives? Is this reliance to the detriment of other, traditionally required capabilities?"

Background and Significance of this Work

For thousands of years mankind has relearned the lessons of combat. Time and again, concepts of warfare have been tested, violated, retried, and proven.

The Pillars

I believe the three basics of warfare that have emerged are the sword, the shield, and the support.

As I define them:

1) The "*sword.*" The "sword" consists of the offensive means with which to strike an enemy.
2) The "*shield.*" The "shield" consists of the defensive means to protect the sword, or sword-bearer.
3) The "*support.*" The "support" consists of the items and processes required to sustain the soldier so that he may continue to be an effective fighter.

The ancient Greek phalanx had its hoplites' thrusting spears as the sword, its three-foot shields and tight formation as the shield, and its logistics trail as the support.[8]

The medieval knight had his battle-ax or lance as his sword. His shield consisted of a coat of mail, a helmet, and a shield. His esquire and groom comprised his support.[9]

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[8] F. E. Adcock, *The Greek and Macedonian Art of War* (London: University of California Press, 1957), 3

More recently, the Air Force strike package has as its sword the bomb-droppers. Its shield consists of escort and electronic warfare aircraft, and its support consists of early warning and tanker aircraft.

It seems that all three pillars have stood the test of time and have proven essential to successful combat operations. Improvements in any one pillar can give great advantage to the architect of that improvement.

The Pendulum

Warfighters strive to design new and better weapons with which to defeat adversaries. The more reliable, accurate, and lethal, the better. Almost without fail, better weapons emerge as new technology presents itself. But, as man's imagination and ingenuity have no bounds, this struggle has proven to be endless. The result is a continuous cyclical pattern of new weapons emerging only to be overshadowed by even better ones.

This trend is much like a pendulum. Whereas one weapon emerges that is technologically superior and the pendulum swings in favor of the side that owns it, the pendulum will invariably swing in the opposite direction as the opposing side takes measures to overcome the advantage. The time required for the pendulum to swing may be only days; or it may be months or decades. The motion of the pendulum is not always constant, but it is always consistent. Any advantage held will, in time, be overcome by some other entity who, in time, will lose that advantage to still another.

A highly technical advantage claimed by one side will eventually be overcome by the other. I presume three ways in which the advantage of a technologically superior weapon is overcome.

1) *Technology Falling Short of Promise*. The first is a function of the

[9] Michael Howard, *War in European History* (Oxford: Oxford University Press, 1976), 3

technology itself. A new weapon that shows great potential often falls well short of its promised capability.

2) *Low-Tech Tactics or High-Tech Counters*. The second is a function of enemy ingenuity. A technologically superior weapon can be overcome either by an enemy's own high-tech progress or by his own low-tech tactical solution.

3) *Contextual or Political Factors*. The third is a function of the situation or contextual factors of a conflict. One can overcome an adversary's advantage by managing or capitalizing upon the contextual factors inherent in a conflict; thereby minimizing or even rendering useless that advantage.

The chariot represented a quantum leap in war fighting technology. Its advantage of speed and mobility moved the pendulum in its favor and gave it preeminence for several hundred years.[10] But since the chariot was only effective when fighting on relatively flat and open terrain, an enemy could overcome its advantage by refusing battle in open fields and taking to the forest or hills. This is an example of forcing the enemy into a context where his advantage is rendered ineffective.

But the introduction of mounted cavalry along with the stirrup overcame the advantages of both the chariot and woodland fighting.[11] Cavalry could outmaneuver the chariot and cavalry could pursue the enemy into wooded areas. The age of the chariot came to an end as the pendulum swung once again. This is an example of overcoming an advantage through technical means (stirrup) and tactical means (cavalry).

Bribery overcame the protection afforded by China's Great Wall. The longbow and crossbow overcame the medieval knight's armor; the longbow and crossbow were overcome by gunpowder; the muzzle-loader by the breech-loader; the wooden fort by flaming projectiles; the stone

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[10] Martin van Creveld, *Technology and War, From 200 B.C. to the Present* (New York: The Free Press, 1989), 12

[11] Ibid., 14

fort by the cannon; the machine gun by mobile armor – the list is endless.

The Problem

It appears that, as new and improved weapons strengthen one of the pillars of the possessor, the pendulum may swing in his favor. This edge over the opponent lasts until the opponent swings the pendulum back in any of the three ways mentioned above. As long as the possessor did not rely too heavily, *or solely*, on that advantage, the opponent's negation of the advantage may only serve as irritation to the owner rather than his defeat.

But, when one of the three pillars is forsaken in deference to a technological advantage, disastrous results eventually occur. The support pillar might be discounted if victory seems imminent. Rommel was convinced that, despite his severe lack of supplies, his chance for victory would not present itself again. In spite of a distressed supply line, he pressed his attack on the Egyptian stronghold at El Alamein. As his essential supplies dwindled without replacement, his warfighting capacity quickly declined and he was soundly defeated.[12] The sword pillar might be overlooked if a defensive position is considered sufficient to defeat the enemy. The Germans, entrenched in their fortresses, forsook their offensive initiative on the Brittany peninsula during the Allied breakout from Normandy. If attacked, the German's plan sought to hold ground to delay the Allied offensive, thereby giving German reinforcements time to muster and perhaps defeat the Allies. But when Patton sent his 8th Corps to circumnavigate the fortresses, occupy the territory, and simply contain them, the Germans met with defeat.[13]

[12] Charles F. Marshall, *Discovering the Rommel Murder, The Life and Death of the Desert Fox* (Mechanicsburg, PA: Stackpole Books, 1994), 84
[13] Bradford J. Shwedo, *XIX Tactical Air Command and ULTRA: Patton's force enhancers in the 1944 campaign in France* (Maxwell AFB, AL: Air University Press, 2001), 40

The shield pillar might be marginalized if a force has such an advantage that it perceives the threat to its force as negligible. When Demosthenes landed at Pylos, the Spartans neglected the need for their shield – at least for a time – and delayed sending troops to meet the Athenians. The Spartans, ever-confident in their sword, thought "whenever they [Spartans] chose to take the field, the place would be immediately evacuated by the enemy [Demosthenes]".[14] The Athenian threat posed by Demosthenes was perceived as negligible and the Spartans did not put up their "shield" until the Athenians had already dug in and prepared for the fight. The Spartan's overconfidence in their own military might and their lack of regard for the shield caused them a humiliating surrender at their own back door.[15]

While there have been many reasons military forces may dismiss a pillar of success, reliance on one magical technology to effect victory has often been an impetus. While technology may yield temporary advantages, if the criticality of a pillar is minimized the enemy will in due time successfully overcome the advantage with perhaps severe consequences for the over-reliant aggressor. If the pillars are not neglected, enemy attempts to swing the pendulum will generally result in annoyance rather than annihilation. When a pillar is forsaken and no provisions made for the inevitable swing of the pendulum back in favor of the enemy, the cost can usually be counted in body bags.

Why the Fascination?

Fascination with technology may be part of the Air Force culture. The Air Force does indeed have a love affair with its airplanes, and

[14] Thucydides, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War*, ed. Robert B. Strassler (New York: The Free Press, 1996), 224
[15] Ibid., 244

rightly so.[16] For the USAF, the ultimate fighting capability is embodied in machines rather than in soldiers. The Air Force is the keeper "of the decisive instruments of war – the technological marvels of flight."[17] While the term "decisive" may or may not be too strong a word and is not debated here, the fact remains that Air Force potential rests largely on the capability of its technological wonders. But this fascination is not unique to the Air Force.

The "American Dream" is to become a successful, contributory, independent individual. The United States was built on the backs of people. There has been, and still is, a high value placed on the worth of the individual. The early pioneer days were treacherous and losing a single person of the colony (or family) had great effects on the success or failure of the group as a whole. The Constitution acknowledged that individuals had God-given rights that were for all mankind – an ideology largely alien to foreign governments of the time. So it only made sense to try to improve the situation of the individual so that the group, as a whole, would benefit. Improvements in medicine, agriculture, and science applied to the individual made his work easier, more efficient, and more productive. These same improvements – many technological in nature – also served to preserve individuals' lives. One could overcome great odds by using technologically advanced implements and one could save lives in the process.

Perhaps USAF reliance on technology sprouted from these early pioneer days. The Air Force, due to the relatively low cost of its aircraft, was able to incorporate the rapidly advancing technology into its airplanes in its pioneer days. These improvements not only made its operations easier, it made then more efficient and more productive. It also made them safer. As such, reliance on technology has been, and

[16] Carl Builder, *The Masks of War: American Military Styles in Strategy and Analysis* (Baltimore, MD: Johns Hopkins University Press, 1989), 195
[17] Ibid., 33

continues to be, greatly beneficial to Air Force operations, especially in time of war. When this balanced reliance on technology writ large becomes unbalanced, tragedy results. When a pillar is treated as insignificant – perhaps due to dogmatic reliance on a single, cure-all technology – the impending disaster follows the swinging pendulum.

Methods and Organization

This thesis investigates three case study examples of the US Air Force's doctrinal reliance on a single technology for prosecuting war operations at the expense of one or more of the essential pillars. Chapter 2 analyzes US bombing in World War II and the reliance on the technology of the high-altitude daylight bomber weapons system. The reliance on this technology, which proved less capable than promised, gave rise to results that were less than expected with high casualty rates. Chapter 3 examines the post-World War II era and the heavy reliance on nuclear weapons to carry out military strategy. When thrust into the Vietnam War, the Air Force was ill prepared to engage an enemy state whose political context forced a scenario wherein the efficacy of nuclear weapons was diminished to vestigial proportions. Chapter 4 explores the post-Vietnam era and the Air Force's eventual reliance on stealth technology which became manifest in the Gulf War and again in Kosovo. The Gulf War saw the use of single-ship stealth mission into highly defended target areas. Fortunately, the USAF was more circumspect in this era and eventually began to reincorporate the shield pillar by packaging stealth assets with more traditional shield assets. This balancing of the pillars, however, could not overcome the contextual, political factors that forced a pendulum swing. Chapter 5 looks at the current era and beyond with the new Global Strike Task Force concept. This concept, if not carefully scrutinized, may lead the Air Force back into the trap of minimizing the importance of the pillars through over-reliance on a single technology.

In order to investigate the sole reliance on a technology for strategy prosecution, evidence was gathered as much as possible from primary sources – those sources that actually either dictated the doctrine of the day or those sources that are indicative of the doctrine of the day. Air planner's statements and speeches, key personnel interviews, force structure documents, doctrine documents, and the like were consulted to establish the credibility of the assertions that 1) a single technology was indeed the focus of war-winning capabilities, 2) this resulted in a weakening of a pillar of success, and 3) enemy pendulum swinging actions were successful due to the devaluation of this pillar.

Chapter 2

World War II and Air Corps Reliance on Bomb, Bomber, and Bombsight Technology

> *Our strategic air plan is predicated on the fundamental fact that our bombers can fly deep into enemy territory, drop an effective load of bombs, and return to base without losses disproportionate to the damage accomplished.*
>
> --General Henry H. Arnold

The years between World War I and World War II brought drastic technological advances to the United States. The popular belief during this period was that technology was "changing the world".[18] Many factors, including standardized mass production, produced affordable, technologically advanced items for the general public including commercial radios, motion pictures, vacuum cleaners, toasters, washing machines, and refrigerators. Airplanes, too, were becoming accessible to the general public. The post-WWI drawdown turned a lot of air enthusiasts loose and carnival and barnstorm flying exposed many Americans to the technological marvels of flight. Airplanes seemed capable of the impossible. William Mitchell perpetuated this idea when, in July 1921, he sent the *Ostfriedland* to the ocean floor with airpower. Mitchell's ideas on the primacy of aircraft in general, and bombers in particular, for national defense purposes were widely known. Mitchell's own notes on bombardment were, according to Lawrence Kuter, "the basis of instruction in the Air Corps Tactical School from its inception"[19] and Mitchell's acolytes eventually rose to the top of Air Corps leadership.[20] By 1932, the Air Corps Tactical School (ACTS) had

[18] David R. Mets, *The Air Campaign, John Warden and the Classic Airpower Theorists* (Maxwell AFB, Ala: Air University Press, 1999), 6

[19] Quoted in Robert T. Finney, *History of the Air Corps Tactical School, 1920-1940*, USAF Historical Study 100 (Maxwell AFB, Ala: Air University Press, 1998), 57

[20] Mets, *The Air Campaign*, 44

explicitly adopted the concept of high altitude daylight precision bombardment to prosecute its emerging industrial web strategy,[21] and it was the ACTS that developed "strategic and tactical doctrines that would later guide air campaigns in World War II."[22]

The doctrine espoused by the ACTS and eventually the Air War Plans Division (AWPD) was established on a single, technologically superior capability – the heavy bomber weapons system. Three of the principles upon which Army Air Corps doctrine was built were:

1) The number one job of an air force is long-range bombardment.
2) Destruction of key targets in the enemy's interior can accelerate war termination.
3) This can be accomplished through high altitude daylight operations with precision bombsights.[23]

The first principle relied solely on the capabilities or promised capabilities of the long-range bomber. The second principle relied solely on the capabilities or promised capabilities of the bombs carried by the bomber. The third principle relied solely on the capabilities or promised capabilities of the Norden bombsight that delivered those bombs. This chapter will examine, in reverse order, these three capabilities, their relation to doctrinal decisions, and the actual performance under wartime conditions vis-à-vis their promised performance.

Norden Bombsight

Carl Norden was born in Holland, raised in Java, and schooled in Switzerland. He came to the United States in 1904 and worked with Lawrence Sperry at the Sperry Gyroscope Company as a consulting engineer in the mid 1900s. In 1913 he left the Sperry Company to set up his own business and began designing bombsights for the Navy in 1920.

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[21] Finney, 66
[22] Henry H. Arnold, *Global Mission* (New York, N.Y.: Harper & Brothers, 1949), 149
[23] Henry H. Arnold, *Report of the Commanding General of the Army Air Forces to the Secretary of War* (No Publisher Listed, January 1944), 2-3

By 1928, he had produced a reliable stabilized bombsight and secured contracts with the Navy.[24] Norden's company built the first synchronized bombsights and associated automatic flight control systems. Basically, the Norden bombsight communicated electronically with the aircraft's autopilot system to steady the aircraft during the bombing run. It was the bombardier's job to feed the aircraft's airspeed, wind speed and direction, altitude, and angle of drift into the Norden computer and then carefully place the aiming crosshairs over the target. Once all information had been entered and an aiming solution had been achieved, the bombardier released his bomb load.

Source: http://www.zocalo.net/~mgr/Norden/NordenBombsignt-0355.jpg

Figure 1. Norden M-9 Bombsight

The Norden bombsight was renowned for its accuracy and was held in strictest secrecy. In fact, all bombardiers had to sign an oath in which they promised to never let a bombsight fall into enemy hands. Major General Benjamin Foulois, Chief of the Army Air Corps in the early 1930s, stated that the Norden bombsight program was "the most

[24] Stephen L. McFarland, *America's Pursuit of Precision Bombing, 1910-1945* (Washington, D.C.: Smithsonian Institution Press, 1995), 5-30

important military secret project under development by the Air Corps."[25]

Norden Development

The Norden Company began development of a bombsight for the Navy long before World War II. By 1932 the project had come to the attention of airmen and the Air Corps Chief purchased 25 bombsights via Navy channels.[26] Army Major General H. A. Drum, Commanding General of HQ Hawaii Department, was so impressed with its capabilities that he requested, in 1935, enough Norden Mark XV sights to equip all bombers under his command.[27] In that same year Norden began production of the experimental Stabilized Bombing Approach Equipment (SBAE), which was the autopilot hardware used to stabilize the aircraft during the final phase of the bomb run.[28] The marriage of the bombsight and the SBAE proved to be a winning combination that greatly increased the accuracy of the bombsight. But by 1936 it was apparent that the procurement arrangements for the Air Corps were unsatisfactory. In order to maintain the strictest secrecy, control of – and access to – Norden contracts remained with the Navy. As such, Air Corps' official interaction with the Norden Company was nearly nonexistent. When only 100 of the 206 bombsights ordered by the Air Corps had arrived, and no definite delivery schedule could be obtained from the Navy, the Air Corps began to take measures to correct the procurement problems and the Sperry Gyroscope Company (an additional source of bombsights with which the Air Corps could interact directly) was tasked with building bombsights for the Air Corps.[29]

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[25] Quoted in Donald Sherman, "The Secret Weapon", *Air & Space* 9, no. 6 (February-March 1995), 79

[26] *Case History of Norden Bombsight and C-1 Automatic Pilot* (Historical Office, Air Technical Service Command, January 1945), p.2, 202.2-35 part 1 in USAF collection, Air Force Historical Research Agency (AFHRA)

[27] Ibid.

[28] Albert L. Pardini, *The Legendary Norden Bombsight* (Atglen, PA: Schiffer Publishing Ltd, 1999), 92

[29] *Case History of Norden*, 3-4

By December 1941 production schedules for bombers were exceeding those of both Sperry and Norden bombsights and in January 1942 the Navy finally agreed to allow the Army Air Forces (AAF)[30] direct oversight for the contracting and production of Norden sights.[31] The AAF established a contract with the Victor Adding Machine Company and the Norden Company established subcontractors to increase production. These actions attenuated but did not alleviate the bombsight shortage. In response, the AAF established priorities for bombsight distribution, thereby ensuring that all heavy bombers in the combat theater were fitted with Norden sights, and pairing medium bombers in the combat theater and all stateside bombers with the Sperry sight.[32] Even these measures did not rectify the shortage.

Since the AAF's preferred method of bombing was to have several aircraft release their bombs on the signal of a lead aircraft, it was not necessary that every bomber be fitted with a bombsight.[33] As such, in April 1944, the United States Strategic Air Forces in Europe requested that the next 1,000 B-17s be produced without bombsights and that, thereafter, every other B-17 be fitted with the Norden sight.[34] This course of action was the final solution to the shortage problem and actually resulted in a surplus of Norden sights. This was fortunate for the AAF because by 1943 it was determined that the Sperry sights were experiencing too many malfunctions for AAF requirements. In a memo to General H. H. "Hap" Arnold, the Chief of the Air Staff recommended canceling all Sperry contracts and fitting all AAF bombers exclusively

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[30] The Army Air Corps officially became the Army Air Forces on 20 June 1941

[31] Pardini, 100,110

[32] Ibid., 111-112

[33] This bombing method, known as salvo bombardment, dictated that all aircraft in a "box" release their bombs on signal from the lead aircraft. Due to the operational requirement to maintain radio silence, the most common signal used was the actual release of the bombs. Upon seeing the lead aircraft's bombs released, the other aircraft in the box also released their bomb load. The targeting errors inherent in this method will be discussed later.

[34] *Case History of Norden*, 13

with Norden sights.[35]

Between 1932 and the end of World War II, over 8,000 Norden bombsights had been made for the Navy and over 81,000 for the Army Air Forces at a cost of as much as $8,800 per unit.[36] The Norden bombsight was considered a huge success and continued to be the bombsight of choice for the Air Force well into the nuclear age.

The Pickle Barrel

What made the Norden bombsight so successful was its accuracy; accuracy in delivering the deadly tonnage of bombs dropped on German and Japanese targets. The accuracy of the bombsight was nearly legendary, even before it was tested in combat. The advanced technology of the bombsight drove the common belief, or at least the common claim, that the sight was accurate enough to deliver a bomb in a pickle barrel from high altitude. Just how this myth began is a myth in itself, but perhaps the earliest appearance of this claim was found in a 1939 issue of Time magazine. The 23 October issue stated "US aviators boast they can drop a bomb in a barrel from 18,000 feet."[37] Bombing results in a training environment seemed to support the claim. When the 19th Bombardment Group began training with the Norden sight they were placing their bombs within 520 feet of their target when dropped from 15,000 feet. By the end of 41 days of training, they were consistently placing them within 164 feet, a drastic improvement.[38] General "Hap" Arnold himself stated, "If airmen got to talking a little too confidently …about 'tossing it right in the pickle barrel'…our continued improvement

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[35] Maj Gen Barney M. Giles, Chief of Air Staff, memorandum to Gen Henry H. Arnold, Commanding General, Army Air Forces, subject: Sperry Bombsights, 21 October 1943, 28156-microfiche frame 8.5, AFHRA
[36] McFarland, 147-148
[37] "World War", *Time*, 23 October 1939, 33
[38] Arnold, *Global Mission*, 150

in bombing with the Norden sight may explain why."[39]

While this claim of accuracy may have been the popular belief, it was not meant to be a literal representation of the bombsight's actual capabilities. But its actual capabilities were apparently not too far from its claimed capabilities. In 1940 Theodore Barth, President of Carl Norden, Inc., privately stated that "we do not regard a 15-foot square 'sample'…as being a very difficult target to hit from an altitude of 30,000 feet" assuming the latest model of bombsight and autopilot were used. He declared, however, that even if the older models were used, they should "enable direct hits from 30,000 feet."[40] So pervasive was this belief that the Latin motto "Cupa fiat melior muriae; per Norden obibit" was embossed on napkins used in the Pickle Barrel Conference Club in the Norden headquarters building. A rough translation reads, "Let a pickle barrel be made in the future and it will perish at Norden's hand."[41]

As early as 1934, the Norden Company claimed a radial error of approximately five mils, which would translate to a 100-foot error when dropped from 20,000 feet.[42] Compared to the Sperry sight's 18-mil error – which would translate to a 360-foot miss – the Norden sight seemed far superior.[43] Supporting these claims by Norden were tests involving 80 bomb drops where half of the bombs landed within 75 feet of the target.[44] It seemed to Air Corps planners that the Norden sight was the perfect bombsight for their long-range bombers. Its accuracy was just too good to be true.

It must be pointed out that the impressive results from bombing test runs occurred in generally ideal conditions. Furthermore, the test bomb runs used procedures which would not be used in combat. Bombs were dropped from aircraft in train (one behind the other). One or two

[39] Ibid., 50
[40] Personal letter, Theodore Barth to Herbert Dargue, 7 February 1940, 168.7119-49, AFHRA
[41] Sherman, 86
[42] Personal letter, Theodore Barth to Herbert Dargue, 15 March 1934, 168.7119-49, AFHRA
[43] Personal letter, Theodore Barth to Herbert Dargue, 27 April 1937, 168.7119-49, AFHRA
[44] Sherman, 82

passes may have been made dropping 100 pound practice bombs to correct for deflection errors before the final run was accomplished.[45] Once the bombsights were employed under combat conditions, the AAF began to get a clearer understanding of the degree of accuracy the sight was, and was not, capable of providing. The pre-war pickle barrel myth "was quickly exploding."[46]

The reliability, and hence accuracy, of the Norden bombsight began to decline in 1943. It is thought that this was primarily due to production problems. Initially, each Norden sight was handmade to a high level of precision. But with the high demand for the bombsight and the resulting contracts and sub-contracts, problems ensued with mass production and the assembly line techniques. Tolerances were not up to standard, lubricant problems hampered standardization, and ball bearing shortages resulted in lowered quality standards.[47] Even though new inspection techniques and production procedures were called for, the bombsight never recovered and "the service would soon know the sight in use wasn't accurate enough to hit the pickle barrel."[48] More discussion concerning the accuracy of the bombsight and World War II bombing follows shortly.

Norden and Air Corps Doctrine

The remarkable, technologically advanced Norden bombsight played a significant role in the Air Corps' doctrinal development. Even though the Air Corps' dealings with the Norden Company were routed through Navy channels and, hence, virtually no official interaction existed between Norden and the Air Corps, the Norden Company had a direct influence on ACTS instructors and eventually World War II air

[45] Barth to Dargue, 7 February 1940
[46] Memoirs of Richard D. Hughes, no date, p.26, 520.056-234, AFHRA
[47] *Case History of Norden*, 11-12
[48] Col J. F. Phillips, Chief, Materiel Division, Washington, D.C., memorandum to Maj Gen O. P. Echols, AC/AS, Washington, D.C., subject: Sperry Bombsight, 25 August 1944, 202.2-35 part 1, AFHRA

planners.

Norden President Theodore Barth had a personal relationship with an Air Corps officer named Herbert Dargue and the two corresponded frequently. Between 1934 and 1938 Colonel Dargue was Assistant Commandant of the ACTS and in 1941 became Major General Dargue, Commander of First Air Force.[49] As early as 1934 Barth was trying to persuade the Air Corps, via Dargue, to buy Norden equipment. Barth was convinced that Norden bombsights would "outperform the Sperry system in every respect."[50] In 1937, Barth openly pleaded with Dargue to purchase Norden equipment, calling Sperry equipment "monuments to failure" explaining that Sperry's claims of accuracy were "fantastic predictions of performance."[51]

Again in 1937, Barth wrote to Dargue stating, "I believe it so important for the Air Corps to build its 'bombardment policy' around the M-1 [Norden] bombsight."[52] In response, Dargue wrote to Barth saying, "I have shown your letter to Lieutenant [Lawrence] Kuter."[53] In another letter Dargue told Barth that he had instructed Lt. Kuter (an instructor at the school) to incorporate the Norden bombsight capabilities into the ACTS curriculum.[54] Many instructors at the school in 1937 were convinced that the pinpoint accuracy required for high altitude, daylight precision bombing could be achieved by the Norden sight and the idea that this technological capability could be decisive in war was implied in ACTS concepts.[55] It should be remembered that the 1940 architects of World War II air doctrine (AWPD-1), except one, were instructors at the ACTS in 1936-37. The one exception, Kenneth Walker, had been an

[49] Arnold, *Report of the Commanding General*, 55
[50] Barth to Dargue, 15 March 1934
[51] Barth to Dargue, 27 April 1937
[52] Ibid.
[53] Personal letter, Herbert Dargue to Theodore Barth, 4 May 1937, 168.7119-49, AFHRA
[54] Personal letter, Herbert Dargue to Theodore Barth, 25 May 1936, 168.7119-49, AFHRA
[55] Finney, 71; and Mets, *The Air Campaign*, 46-47

instructor until 1933.[56]

In 1941 the framers of AWPD-1 received their charter. Using B-17 and Norden bombsight capabilities as a baseline, they developed strategy and future requirements for the coming war.[57] In other words, the technological capabilities, or better the promised technological capabilities, provided a foundation for strategic bombing doctrine during World War II. One of the earliest doctrine manuals for the Air Corps (FM 1-10) stated, "The destructive power of aerial bombardment is controlled largely by the accuracy of bomb placement. ...High altitude precision bombing requires a sight of great accuracy."[58] It is clear that air doctrine was established, in part, on the technological feasibility of the bombsight. But neither the Norden nor the Sperry bombsight would be effective unless the bombs it aimed were able to destroy the target upon impact.

The Bombs of World War II

A 1940 Air Corps briefing designed for an Army ground unit audience stated "accurate means of dropping bombs and the correct size of bomb are available to destroy any object...and neither altitude, nor poor visibility, will greatly influence the hitting probability."[59] The "accurate means" referred to the Norden bombsight. But the bombsight was not a weapon. It was only a means to deliver a weapon. The weapon that Air Corps doctrine rested upon was the gravity bomb.

At the outset of World War II, many types of bombs were available for use by the Air Corps but by far the most common was the demolition,

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[56] Finney, 104-107

[57] Hughes, 7; Richard D. Hughes worked in the Intelligence Group, Office of Chief of the Air Corps in June 1941. He and Malcolm Moss worked for Haywood Hansell during the drafting of AWPD-1 and had a great deal to do with target selection during the planning phase. He later moved up to become Assistant Chief of Staff to Ira Eaker, Commander, 8AF.

[58] Air Corps Field Manual (FM) 1-10, *Tactics and Technique of Air Attack* (Washington, D.C.: Government Printing Office, 1940), 22

[59] Air Corps Lecture, "Air Corps – Organization, Equipment, Missions, and Operations", Tactics Conference, 1939-1940, p.9, 248.2021 A-1, AFHRA

or general-purpose, bomb.[60] This bomb came in many sizes ranging from 100 to 4000 pounds.[61] During this period, approximately half the weight of most bombs consisted of explosive material and the rest was made up of casing and fragmentation material. For example, a bomb weighing 1000 pounds contained 556 pounds of explosives and a 500-pound bomb contained 256 pounds of explosives.[62] These bombs were capable of delivering damage that was, at the time, impressive. A 600-pound bomb, detonated with an instantaneous fuse, could create a crater five feet deep and 17 feet wide, displacing 17 cubic yards of soil. With a delayed fuse, that same bomb would produce a crater 10 feet deep and 37 feet wide, displacing 170 cubic yards of soil.[63]

Size Matters

To load a bomber with an arbitrarily selected size and number of bombs would most likely minimize the efficiency desired when striking targets deep in German territory. Air planners, taking into account expected accuracy of the bombsight, needed to be able to select the right size bomb and predict the right number of bombs required to cause the desired level of damage. If the bombs selected were too small, the desired effect would not be achieved and a second strike might be required, wasting both time and resources. If, on the other hand, the bombs selected were too big, the overkill would also be wasteful. Field Manual 1-10 instructed its reader that, "an objective against which large bombs should be used normally cannot be destroyed by a larger number of smaller bombs of equivalent, or even greater, weight."[64] Reinforcing this idea was a monograph from the Aviation Ordnance School that

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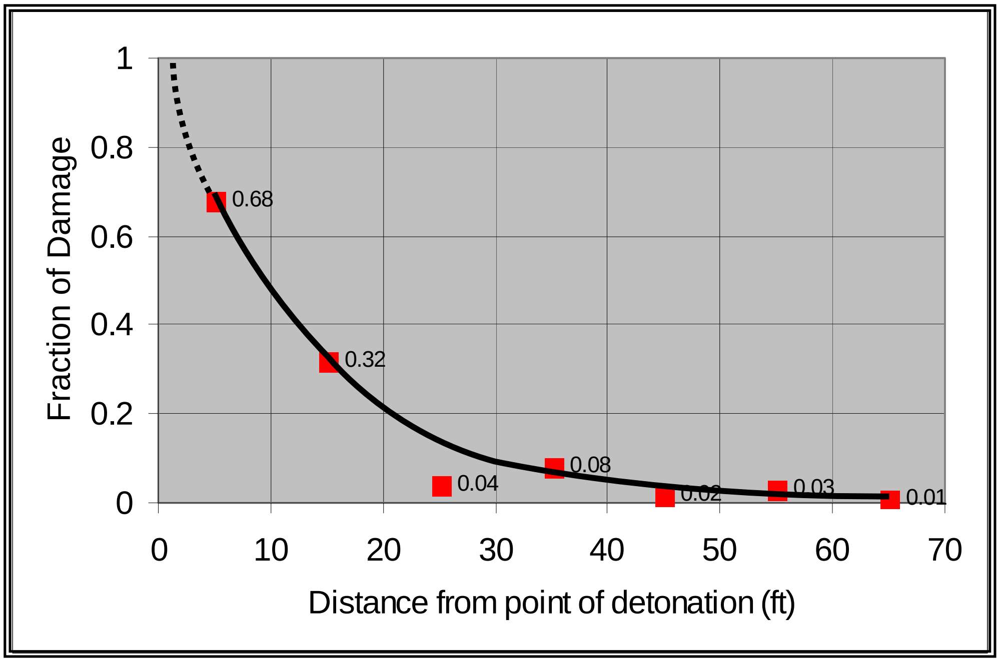
[60] USSBS, Physical Damage Division, *Physical Damage Division Report (ETO)* (Washington, D.C.: Government Printing Office, 1947), 2
[61] *Advanced Armament* (Orlando, FL: AAF School of Applied Tactics, October 1943), p.14, 248.222.22, AFHRA
[62] FM 1-10, 10
[63] Ibid., 13
[64] Ibid., 12

stated, “it is a costly error to use a proportionately large number of smaller bombs with the idea that the probability of the larger number of hits which would result would be more effective.”[65] Basically, the correct size bomb for a particular type of target was the smallest one that would achieve the desired level of damage.



Source: USSBS Physical Damage Division Report (ETO), Physical Damage Division, April 1947, page 72

Figure 2. Machine Tool Damage, European Theater – 500lb Bombs

The type of target was but one factor to contemplate when determining the correct size and number of bombs required to lay waste industrial web strategic targets. Target size and configuration, accuracy of the bombsight, payload capacity, and the estimated percentage of aircraft expected to actually reach the target were all taken into consideration.[66] Bombs obviously would have different effects on different targets, depending on the composition and construction of the

[65] The Ordnance School, Aberdeen Proving Ground, Maryland, “The Power and Effect of Airplane Bombs”, Report no. 1940-61, 1940, pp.8-9, 248.2209 A-2, AFHRA
[66] Operations Analysis Section, HQ AAF, “Estimation of Force Requirements”, Report no.C5-1886, 8 July 1944, p.3, 131.504C Vol. 3, AFHRA

target. A 600-pound bomb could put a 17-foot hole in a wall eight feet thick but might not have any effect on a 20-foot thick submarine pen roof.[67] Figure 2 shows how the effect on machine tools of a 500-pound bomb decreases with distance from point of detonation.

Once the correct size of bomb was tentatively determined, the number of bombs required to inflict the desired level of damage was determined. The term "saturation" was used to describe the percentage of the target area that will be affected in some way by the bombs dropped. For example, to inflict 50% saturation of a 10 million square foot factory, 613 500-pound bombs were required. When the desired amount of saturation was increased to 75%, the number of bombs required doubled to 1226 bombs.[68] Numbers, calculations, and predictions were used determine force requirements for war scenarios; and these were based on the technological capabilities demonstrated or promised by both the Norden sight and the explosives technology of the day.

Bombs and Air Corps Doctrine

In 1940, Muir Fairchild, considered by many to have been one of the "bomber mafia", was Director of the Department of Air Tactics and Strategy at the ACTS. Under Fairchild's tutelage, Major Ralph A. Snavely helped write the course material for the Bombardment Aviation course. His lecture – "Power and Effect of Demolition Bombs" – was taught at the school and attempted to instruct students in the finer points of bomb size selection. The school's belief in the capability of the bombs of the day was in line with the lecture's remark, "the demolition bomb has the power and effect to destroy the usefulness of any objective known to

[67] FM 1-10, 14

[68] 2nd & 3rd Operations Analysis Sections, Far East Air Forces, "Number of Aircraft Necessary for Proposed Military Operations", Report no.4, 15 August 1944, pp.2, 8, 131.504C Vol. 3, AFHRA

exist."[69] As if to drive the point home, Snavely went on to say, "the power of the demolition bomb imposes no limitation whatsoever upon the ability of bombardment aviation to destroy objectives, whatever, wherever they may be."[70] As was seen earlier, ACTS instruction and, eventually, doctrine was founded on the perceived capabilities of the Norden bombsight. Doctrine was further built on the perceived capabilities of the bombs that the sight would aim.

Throughout the Demolition Bomb course, the school taught students how to select the proper size bomb for the target in question. Students were led through various academic scenarios to practice bomb selection, and then the school answer was explained. For example, the ACTS answer to the best bomb size to destroy both aircraft on the ground and locomotives was the 100-pound demolition bomb. Interestingly, the school also believed that "a 100-pound bomb has the necessary power and effect to destroy...heavy factory buildings." These all had the caveat that the bomb(s) needed to land very close to their target (75 to 100 feet) to have the intended effect.[71]

But despite the wide range of bomb sizes available, and despite the bomb sizes recommended by the ACTS, the most common general-purpose demolition bomb used against Germany was the 500-pounder.[72] The United States Strategic Bombing Survey (USSBS) studied 50 bombing missions against European targets, assessing damage caused by nearly 18,000 bombs. Of these bombs, 80.36% (14,439) were 500-pound bombs.[73] While the 500-pound bomb could cause serious damage to a target, its lethal radius was only 60 to 90 feet.[74] Accurate placement

[69] Maj R. A. Snavely, "Power and Effect of Demolition Bombs, Part II" lecture, Air Corps Tactical School, Maxwell Field, AL, 17 May 1940, p.25, 248.2209 A-2, AFHRA
[70] Ibid.
[71] Maj R. A. Snavely, "Power and Effect of Demolition Bombs, Part I" lecture, Air Corps Tactical School, Maxwell Field, AL, 19 February 1940, pp. 11, 14, 23, 248.2209 A-2, AFHRA
[72] Mets, *The Air Campaign*, 39
[73] Percentages derived from USSBS, *Physical Damage Division Report (ETO)*, found at Table 1.-*Summary of high-explosive bomb damage on European Targets*
[74] Far East Air Forces, "Number of Aircraft Necessary for Proposed Military Operations", 3

was, indeed, essential. But even an accurately placed bomb was liable to be ineffective. A case in point was a two-foot miss by a 1,000-pound bomb dropped on a gun emplacement that caused no damage to its target.[75]

By mid-1944, there was enough wartime data to prompt Eighth Air Force's Operational Analysis Division to recalculate the bomb-sizing tables contained in "The Handbook for Bombardiers" [TM 1-251]. Using bomb damage assessments and actual sighting error information, the document suggested using this more correct information to determine bomb sizes required in combat. The recalculated numbers showed that more bombs were required to achieve desired levels of damage than doctrine had previously suggested.[76]

By war's end, over 1.5 million tons of bombs had been dropped in the European theater.[77] While this enormous amount was apparently enough to do the job, "an optimistic estimate is that five percent of the bombs which were dispatched to industrial targets caused either structural or superficial damage."[78] The Norden sight and the bombs, which were so fundamental to the high altitude, daylight precision bombing of targets deep within Germany, were not performing as promised.

The Bombers of World War II

In the years leading up to World War II, many factors influenced air planners. The very survival of the Air Corps depended greatly upon the ideas and capabilities it produced. The idea of strategic bombing is what gave the Air Corps its direction and the capabilities, mostly derived from the emerging technology of the time, gave it its credibility. As has

[75] USSBS, *Physical Damage Division Report (ETO),* 15
[76] HQ AAF, "Estimation of Force Requirements", 5
[77] Henry H. Arnold, *Third Report of the Commanding General of the Army Air Forces to the Secretary of War* (Baltimore: Schneidereith and Sons, 12 November 1945), 60
[78] USSBS, *Physical Damage Division Report (ETO),* 7

been shown, the idea of strategic bombing and the industrial web theory relied heavily on the technology of the weapons (bombs) that would cause the desired destruction and on the Norden bombsight that would accurately place those bombs on target. But neither of these technological marvels would be of any value if they could not be placed in a position where they could be employed. This was the job of the heavy bomber.

The Bomber Emerges

The interwar years saw the fledgling Air Corps struggle to find its feet. Questions of force structure, organization, mission, and budget plagued Air Corps leadership as they fought for legitimacy. During this period the Air Corps envisioned a balanced force with two main stanchions; a bomber force and a pursuit force.[79] The bomber force (or striking force) would deliver the weapons to the targets and the pursuit force would not only protect the US from enemy bombers, but also would protect the bombers from enemy fighters. According to then Captain Claire Chennault (an ACTS instructor), the pursuit fighter would be a "multi-seater with at least four gun stations so placed as to afford the maximum field [of fire] for each."[80] It would carry a crew of seven, 2000 pounds of ammunition, and fly 20 to 30 miles per hour faster than the bombers.[81]

Chennault was well aware of the technological challenge presented by these requirements. He was also well aware of the proclivity toward bombers at the ACTS. He thought it possible to build such a pursuit fighter, but he also thought that, if built, it would be an important but difficult task to prevent the bomber enthusiasts from transforming it into

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[79] Leonard Baker and Benjamin F. Cooling, "Developments and Lessons before World War II", in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin F. Cooling (Washington D.C.: US Government Printing Office, 1991), 48
[80] Claire Chennault, "Special Support for Bombardment", *US Air Services* XIX, no.1, January 1934, 19
[81] Ibid.

a bomber.[82] Yet even the early air enthusiasts who were not necessarily bomber enthusiasts were marveled by the technological capabilities of bombers. In the 1920s, Carl Spaatz was primarily involved with pursuit aircraft issues and had little involvement in the changing focus of the ACTS from pursuit to bomber.[83] But by 1929, when he took command of the 7th Bombardment Group, he thought the B-2 Condor "could penetrate enemy airspace with relative impunity" and he considered the B-9 "a precursor of things to come."[84]

The Air Corps Tactical School was a clearinghouse of sorts. Ideas were tested and evaluated and those that were considered feasible were adopted into the large body of accumulating concepts at the school. Those that were considered impractical, however, were discarded.[85] As time marched on, the technology of new bombers outpaced that of existing fighters and the fighters became increasingly "impractical". In 1933 an umpire for the air exercises at Wright Field declared, "due to increased speeds and limitless space, it is impossible for fighters to intercept bombers and therefore it is inconsistent with the employment of air force to develop fighters."[86] A bold and perhaps insular statement, it was indicative of the general attitude that was forthcoming.

This attitude, along with the influence of bomber theorists, drove the ACTS doctrine, and the Air Corps in general, toward emphasis on the bomber. Mitchell's influence has already been discussed, but the influence on the Air Corps of perhaps the greatest bomber advocate is unquestionable. Giulio Douhet spelled out his ideas on long-range bombing in the early 1920s. While the ACTS did not have a direct translation of Douhet's book until the early 1930s and while he was not referred to by name, his influence is evident. The instructors at the

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[82] Ibid.
[83] David R. Mets, *Master of Airpower; General Carl A. Spaatz* (Novato, CA: Presidio Press, 1988), 67
[84] Ibid., 79
[85] Finney, 58
[86] Ibid., 76

ACTS referred to Douhet as "the Italian authority" and many of their ideas mirrored his.[87] Douhet's suggestion that the bomber could not be stopped and that anti-aircraft artillery was ineffective against it was also at least implied by the ACTS.[88] Attaining control of the air through the use of bombers – vice fighters – was also common to both. Douhet proposed hitting the enemy "eggs in the nest", destroying enemy aircraft on the ground with long-range bombers.[89] This idea was incorporated into the doctrine over Europe, albeit with emphasis on enemy aircraft *production* vice the enemy aircraft proper.

In 1935, the embodiment of the strategic bombing theory – and of the anticipated technological capability – was unveiled when the B-17 rolled off the production line. Prior to the B-17, many fine bombers had been tested. But, as encouraging as they were in terms of technological capability, the ACTS cadre wanted more. The B-17 was what they had been waiting for. The B-17 propelled the bomber force to the forefront and the pursuit force to the rear. The new-found preeminence of the bomber only served to increase the emphasis on strategic bombing.

Even the bombers developed before the B-17 were technological wonders that outperformed the fighters of the day. In 1931 the B-9 was the first bomber that could outrun Air Corps fighters. In 1932 the B-10's overall performance made it the fastest and most powerful bomber in the world.[90] In 1933 these advances in bomber technology prompted Brigadier General Westover (Chief of the Air Corps) to announce, "no known agency can frustrate the accomplishment of a bombardment mission."[91] But the B-17 was unrivaled. It carried all its bombs internally, was aerodynamically clean, and its machine guns were

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[87] Ibid., 58
[88] Giulio Douhet, *The Command of the Air*, USAF Warrior Studies, eds. Richard H. Kohn and Joseph P. Harahan, trans. Dino Ferrari (Washington, D.C.: Office of Air Force History, 1983), 49, 55
[89] Ibid., 54
[90] Research Studies Institute, USAF Historical Division, *The Development of Air Doctrine in the Army Air Arm, 1917-1941*, USAF Historical Study no.89, p.46, 5-3414-8B, AFHRA
[91] Quoted in McFarland, 96

mounted to be fired from enclosures in the fuselage. Its 103-foot wingspan was nearly 30 feet more than the B-10. Its weight (35,000 pounds) was roughly four times that of the B-10. Its top speed (250 miles per hour) was a full 40 mph faster than the B-10 and its service ceiling was 30,000 feet.

But most importantly it could haul 2,500 pounds of bombs 2,260 miles, or it could haul 5,000 pounds of bombs 1,700 miles. It was truly "a long-range, self-defended, offensive terror of the skies – truly a flying fortress."[92] So important was the B-17 to the Air Corps that General Arnold dubbed it the "turning point in the course of air power."[93] Even so, the Air Corps was envisioning greater things from its bomber corps. Interestingly, the Air Corps could foresee bigger, faster, more lethal bombers but for some reason could not foresee bigger, faster, more lethal fighters. This mindset affected – limited – doctrinal development.

Bombers and Doctrine

Because of the preeminence of the bomber, and the insufficiency of the fighter, air doctrine was built around the technological capabilities – or perceived capabilities – of the bomber, particularly the B-17. The B-17 could overfly any anti-aircraft artillery lobbed at it and could outrun any fighter paired against it. High altitude, precision, daylight bombing was based on these perceived capabilities. "No barrier can be interposed to shield…against the airplane", said Major Fairchild. "Trying to protect from air attack would be a picture of chaos and confusion."[94] The ACTS "Air Force" lecture declared that the airplane might be "hampered by pursuit and antiaircraft, but there is no way known to insure against his

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[92] USAF Historical Division, *The Development of Air Doctrine in the Army Air Arm*, 46-47
[93] Arnold, *Global Mission*, 155
[94] Maj Muir S. Fairchild, "The Aim in War," lecture, Air Corps Tactical School, Maxwell Field, AL, 27 May 1940, 12, 49

dropping tons of bombs on any vital objective."[95]

Because of its perceived invulnerability, it was the perfect tool for the industrial web theory. The theory made sense only if there was a platform capable of carrying out the concept; and the bomber, according to Lieutenant Kenneth Walker, "is capable of reaching out and destroying an enemy's means for the prosecution of war, immediately upon declaration thereof."[96] The bombs were on hand, the bombsight was the best in the world, and the B-17, which "foreshadowed technically" air power's destiny[97], promised unmatched capabilities. In essence, the B-17 "was the focus of [ACTS] planning" because the idea of using daylight precision bombardment to cripple an enemy's industrial strength was "summed up by the great word 'B-17'".[98]

This doctrinal reliance on bomber technology translated into force structure requirements for the approaching world war. The emergence of the bomber as the consummate fighting platform resulted in a lack of emphasis on fighter technology. As such, circular reasoning held that since fighter technology was lagging, it could never catch up to that of the bomber. Hence, new technology was applied to the bomber, ensuring that the fighter did not advance technologically. The "General Air Force Principles" lecture at the ACTS stated that, "every dollar which goes into the building of auxiliary aviation and special types, which types are not essential for the efficient functioning of the striking force ["striking force" defined as bombardment and attack aircraft] can only occur at the expense of that air force's offensive power."[99] This emphasis on the bomber would soon affect the Air Corps' concept of operations, which became a key issue in the prosecution of the high altitude, precision,

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[95] Air Corps, "Air Force," lecture, Air Corps Tactical School, Maxwell Field, AL, 1934-1935, 4
[96] Kenneth N. Walker, "Bombardment Aviation, Bulwark of National Defense", *US Air Services* XVIII, no. 8, August 1933, 18
[97] Arnold, *Global Mission*, 157
[98] Ibid., 156, 259
[99] Air Corps, "General Air Force Principles," lecture, Air Corps Tactical School, Maxwell Field, AL, 1934-1935, 2-3

daylight bombing of Germany's industrial network.

Bomber Concept of Operations

On the eve of war, the Air Corps still believed that gaining control of the air was mandatory for successful operations.[100] The question was *how* to go about securing it. During the 1920s the task of gaining air superiority was given to the fighter aircraft, but in the late 1930s the fighter aircraft had lost some of their promise. The dilemma now was whether to take out the enemy airborne defenses with fighters via aerial combat or whether to take them out with bombers via long-range bombing.[101] A small contingent of fighter advocates at the ACTS fought for the former option, but – with the recent, and significant, technological advances of the bomber in mind – the ideas of these men were marginalized in favor of the latter option. According to the school, since "a powerful air attack once launched cannot be stopped, it is questionable whether control of the air can ever be achieved."[102] The bomber would not need a fighter escort to gain air superiority by clearing the path of enemy fighters since the enemy fighters would be unable to stop the bomber forces, with or without fighter escort.

The role of the fighter was seen as primarily a defensive, though relatively ineffective mission. Aerial combat was "incidental" and "indecisive" and even the evidence to the contrary, as later seen in the Battle of Britain, was seen as an anomaly.[103] The ACTS believed the technological superiority of American bombers rendered them invulnerable and, thus, aerial battles were precluded.

This notion swayed doctrine in favor of the second option in the Air Corps' dilemma. Bombers would be the vehicles through which air

[100] Finney, 56
[101] Ibid., 74-75
[102] Air Corps Lecture, "General Air Force Principles," 7
[103] Ibid.

superiority would be obtained. A "powerful counter offensive" was required to obtain security against air attack.[104] This counter offensive was the first order of business in conjunction with destruction of the enemy's industrial framework. The first step in this counter offensive was the destruction of the fighter industry to include assembly plants and steel factories.[105] Hence, the concept of gaining air superiority by engaging enemy forces in the air to protect friendly long-range strike aircraft gave way to the concept of gaining it by engaging enemy industry.

The ACTS air planners could not have anticipated the introduction of the heretofore unprecedented technological miracle called radar – and the deadly effect it had on air operations. Yet what they *could* predict, they did not. They had seen advances in both fighter and bomber technology, but for some reason were unable to anticipate technological improvements in either friendly or enemy air defenses, while at the same time they *were* able to envision advances in bomber technology. While it is true that the fighters of 1941 did not have the range to accompany the bombers of 1941, the belief was that the bomber would not need an escort; and this belief, at least in part, drove the priorities for technological development. Now the only problem facing air planners was the question of how to effectively engage enemy industry. The high-altitude, precision, daylight bombing doctrine was the answer.

The high-altitude, precision, daylight bombing doctrine obviously suggested bombing from high altitude. But what altitude was considered high? According to FM 1-10, "high" was defined as anywhere between 13,500 and 18,000 feet.[106] But as late as 1939, the ACTS advocated bombing from 6,000 feet in order to obtain maximum efficiency. From this altitude, one could expect a circular error of probability (CEP) of only

[104] Maj Muir S. Fairchild, "Foreign Developments in Antiaircraft Defense," lecture, Air Corps Tactical School, Maxwell Field, AL, 8 November 1939, p.3, 248.2021 A-1 Vol. 2, AFHRA
[105] Arnold, *Report of the Commanding General*, 47; and Hughes, 30
[106] FM 1-10, 48

70 feet. This meant that a full 50% of the bombs dropped could be expected to fall within 70 feet of the aimpoint, a reasonably good situation considering the 60 to 90 foot lethal radius of the 500 pound bomb.[107]

It was fairly apparent that bombing from 6,000 feet was not an option, assuming the enemy employed anti-aircraft artillery (AAA). Anti-aircraft fire was not expected to be much of an impediment to bombers. The ACTS had much the same view concerning the technological advances of AAA as it did concerning the technological advances of fighters in that neither was expected to develop significantly. In the 1920s AAA was seen as only a mild hindrance,[108] but still a hindrance to be avoided. If the bomber could outrun enemy fighter aircraft, what altitude was needed to over fly enemy AAA? The 1940 Air Corps Field Manual stated that, "the accuracy of antiaircraft artillery fire…is, in general, best at medium altitudes" where "medium" was defined as below 13,500 feet.[109] In a 1941 memorandum from the British Advanced Air Striking Force in France, the ACTS learned that AAA was "very unlikely to be dangerous" at 18,000 feet and – even at that altitude – if the first shot missed, it was "extremely unlikely" that subsequent shots would find their mark.[110] So, in the minds of air planners, 18,000 feet was as high as they would need to fly and, as such, could expect CEPs no greater than 210 feet.[111]

The technological advantages of the bomber, the ability to outrun or overfly threats were significant but not sufficient to mitigate attacks from those fighters that, through geometric positioning, would be able to

[107] Maj C. E. Thomas Jr., "Antiaircraft Defense-The Limited Aim," lecture, Air Corps Tactical School, Maxwell Field, AL, 9 November 1939, p.4, 248.2021 A-1 Vol. 2, AFHRA
[108] Finney, 62
[109] FM 1-10, 48-49
[110] Naval Attaché, London, memorandum no. 4 to Air Corps Tactical School, subject: Tactics in Avoidance of Long Range A. A. Fire, 24 June 1941, 248.2202 A-1, AFHRA
[111] Using the 70-foot miss distance from 6,000 feet altitude found in note #91, one can extrapolate a 210-foot miss distance from 18,000 feet altitude.

attack bombers. What was needed was a tactic to maximize the defensive firepower of the bombers.

The bomber formation was the answer. While a large formation was not suited to AAA defense, it did afford security against whatever fighters *were* able to intercept the bombers. The basis of this concept of operations was that "a very disciplined, tight formation with complementary and supporting machine gun fire and a very carefully worked-out tactic" would contain enough innate self-defense capability that enemy fighters would be destroyed before they could engage the bombers.[112]

During the course of the war, many different types of formations were employed in attempts to maximize defensive firepower, flexibility, maneuverability, and bombing accuracy. Typically, one formation was adopted until the enemy improved either his tactics or his technology to counter the advantages of the formation.[113] The first long-range strike into Europe by the Eighth Air Force on 17 August 1942, utilized a formation of two squadrons – made up of six aircraft each – flying wide apart.[114]

Over time, two factors increased the size of bomber formations. One was the need to increase the amount of bombs dropped on specific targets due to less than hoped for accuracy. The second was the growing aggressiveness of the Luftwaffe, which demanded more bombers per formation in an attempt to overwhelm enemy fighters with firepower. Formations grew from 12 aircraft in August 1942 to 18 the next month; from 36 aircraft to 54 in March 1943.[115]

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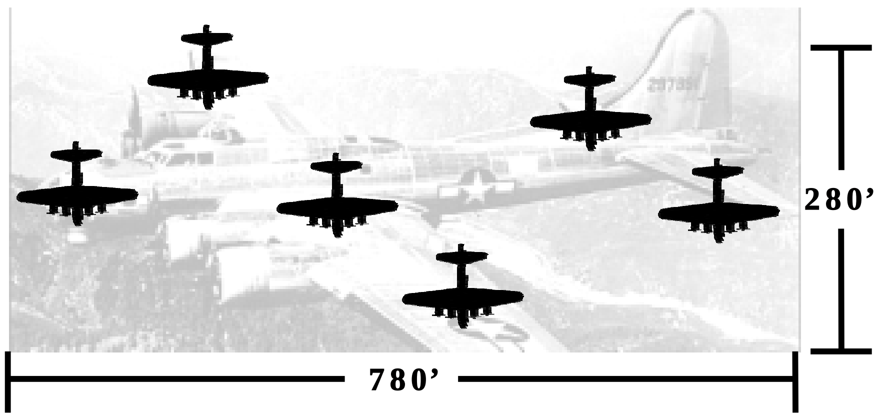
[112] Gen Hunter Harris, Jr., transcript of US Air Force Oral History Interview by Mr. Hugh N. Ahmann, 14-15 November 1974 and 1-2 March 1979, p.86, K239.0512-811, AFHRA

[113] Eighth Air Force and AAF Evaluation Board, "Eighth Air Force Tactical Development; August 1942-May 1945", May 1945, p.2, 520.04-11, AFHRA

[114] AAF Evaluation Board, "Eighth Air Force Tactical Development", 3

[115] Ibid., 6-18



Source: Eighth Air Force and AAF Evaluation Board, “Eighth Air Force Tactical Development; August 1942-May 1945”, May 1945, 4

Figure 3. Typical Bomber Squadron Formation

The actual dropping of bombs from such large formations was problematic. The spatial relationship within a formation prohibited each aircraft from lining up on the target individually. Hence, the “box” concept was developed. A box consisted of anywhere from three to 18 aircraft, but the most oft-used box size for the B-17 was 14 aircraft.[116] Within each box, one aircraft was designated as the lead. The lead aircraft carried the highest qualified bombardier whose job it was to line up on the target, feed flight data to the Norden bombsight, put the target in the cross-hairs, and release bombs. All other aircraft in the box would release their bomb load upon seeing the lead aircraft’s bombs begin their descent. This obviously induced some error in accuracy since this method “involves an uncontrolled delay which may result in large range errors.”[117] Many factors other than this contributed to accuracy errors. The air planners’ reliance on technology screened them from the realities of combat conditions and the bombers’ performance was indicative.

[116] USSBS, Bombing Accuracy Division, *Bombing Accuracy, USAAF Heavy and Medium Bombers in the ETO* (Washington, D.C.: Government Printing Office, 1947), 2, 10
[117] FM 1-10, 50

Bomber Performance

Bomber performance never did achieve the level anticipated. Reliance on the technological superiority of American equipment, along with the empirical data gathered on training missions, led air planners to expect a high degree of efficiency and accuracy. By 1938 training missions dropping over 200,000 bombs provided practical statistics suggesting a worst case CEP of 285 feet from 15,000 feet altitude.[118] Information such as this was translated into "Expected Error" tables, which were used by air planners to determine the number of bombs and bombers required to destroy targets. At 20,000 feet, for example, one could expect a CEP of 392 feet in 1940.[119] By 1943, after much operational experience had provided data on actual bombing accuracy, the expected error was raised to a worst-case CEP no greater than 425 feet when bombing from this altitude.[120] But even this number proved to be way off the mark. "Accuracy achieved during operational training in the US fell off considerably after groups began to bomb enemy targets under combat conditions."[121]

The reasons accuracy fell off were myriad. Besides the psychosomatic stress induced by overflying hostile terrain, weather, smoke and haze, AAA, bombing altitude, formation bombing, and enemy fighter activity had an enormous impact on accuracy.[122]

The factor having the greatest impact on accuracy was weather.[123] Bomber crews were trained to fly and bomb in the weather and air planners believed that "development of navigational aids [was] so accurate that enemy targets [could be] attacked by bombing through the

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[118] McFarland, 95
[119] FM 1-10, 70, 73
[120] Operations Analysis Section, IX Bomber Command, "Report on the Errors Affecting Bombing Accuracy", Report no.7, 29 July 1943, p.7, 131.504C Vol. 3, AFHRA
[121] AAF Evaluation Board, "Eighth Air Force Tactical Development", 62
[122] USSBS, *Physical Damage Division Report (ETO)*, 7; and AAF Evaluation Board, "Eighth Air Force Tactical Development", 62
[123] USSBS, *Bombing Accuracy*, 5

overcast."[124] Systems such as Gee-H, H2X, and Micro H were developed during the war to enhance accuracy when bombing in the weather; and bombing in the weather occurred quite often. As an example, 8th Bomber Command used weather-bombing techniques on 64% of the flying days between 1 September and 31 December 1944,[125] which represented 76% of the total bombing raids for that time period.[126] By the end of the war in Europe, the AAF admitted that "bombing through overcast by means of H2X, Gee-H, or Micro-H is accomplished by a tremendous loss of effectiveness."[127] In fact, the USSBS determined that accuracy when bombing with Micro-H and Gee-H through clouds was six times worse than when bombing visually in clear weather; and that accuracy when bombing with H2X through total overcast was 150 times worse than when bombing visually in clear weather.[128]

Accuracy results when encountering smoke were similarly dismal. Smoke screens generated by the enemy to mask his position degraded bombing accuracy by a full 75% compared to targets that had no smoke screen.[129] Smoke generated by friendly bombs on the target essentially served the same purpose as smoke generated by the enemy himself. "Smoke produced by the formations bombing first result[ed] in cutting the accuracy of later formations by at least one-half."[130]

Even if the weather was good, antiaircraft artillery served to reduce bombing effectiveness. Recall that, in 1940, AAA was not expected to be effective above 13,500 feet; and in 1941 it was not expected to be effective at 18,000 feet. But by the end of the war it was evident that the "accuracy of enemy antiaircraft fire normally required our [AAF]

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[124] Arnold, *Report of the Commanding General*, 51
[125] Headquarters Eighth Air Force Operational Analysis Section, "Report on Bombing Accuracy; 1 September 1944 to 31 December 1944", 20 April 1945, p.5, 520.56A, AFHRA
[126] *AAF Bombing Accuracy, Overseas/Continental, Report No.2* (No Publisher Listed, July 1945), p.16, 134.71-83, AFHRA
[127] Ibid., 4
[128] USSBS, *Bombing Accuracy*, 13
[129] *AAF Bombing Accuracy, Report No.2,* 21
[130] Ibid., 22

formations to bomb from heights around 25,000 feet."[131] In fact, the average altitude from which bombing occurred for B-17s was just over 21,500 feet; and when the altitude was increased, the accuracy decreased.[132] Eighth Bomber Command, during 1944 and 1945, was only able to place 14.2% of its bombs within 500 feet of its target aimpoints from 21,000 feet; and only 12.6% from 25,000 feet – and these statistics are for good visibility conditions.[133] Yes, the bomber was able to overfly much of the AAA – as predicted – but as enemy AAA technology and tactics overcame the bombers' advantage, the bombers were driven higher and higher which drove the accuracy lower and lower.

The formations, designed to defend bombers from those few enemy fighters that would be able to engage, relied upon rigid adherence to position within the formation to afford maximum coverage of defensive firepower. But once the enemy technology and tactics countered this defensive posture, "our losses for a long time averaged about four percent per mission."[134] Enemy fighters quickly gained the speed advantage (technologically) and learned to attack from a formation's vulnerable direction (tactically). Attacks on the bombers' tails accounted for 46% of all enemy fighter encounters and 44% of all bombers hit by enemy fighter fire.[135]

Bombing from a "box" presented problems as well. There was an inevitable delay in releasing bombs, for a majority of aircraft in the box, after the lead bombardier released his. This slight delay would cause range errors at the target. If an aircraft in the box were flying a heading just 3 degrees different than the lead at the time of bomb release, a 600-foot lateral deflection error at the target would occur. A speed differential

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[131] AAF Evaluation Board, "Eighth Air Force Tactical Development", 62
[132] USSBS, *Bombing Accuracy*, 10
[133] *AAF Bombing Accuracy, Report No.2*, 18
[134] Gen Hunter Harris, Jr., interview, 87
[135] Operational Research Section, HQ VII Bomber Command, memorandum to Col C. F. Bookwalter, Chief of Staff, A-4 Section, 2nd Bombardment Division, subject: Comments on Certain Proposed Modification to B-24 Aircraft, 8 January 1944, Appendix A, p.iii, 520-56B, AFHRA

of just six miles per hour would cause a 700-foot range error at the target.[136] Beyond this degradation in accuracy, the number of boxes tasked to strike a target had a large impact. "Accuracy achieved by the first three boxes over the target was more than twice as great as that of succeeding groups"[137], which is to say that, given the poor accuracy of the first three boxes, the accuracy of the succeeding boxes was twice as bad.

All the aforementioned factors affected bombing accuracy individually, but taken in the aggregate, they combined to produce drastic degradation of bombing accuracy. Even with operational empirical data, air planners continued to overestimate the capabilities of their equipment and underestimate the adverse effects of combat operations. The USSBS Bombing Accuracy Division examined in detail 194 bombing missions and determined that 121 had CEPs worse than expected.[138] Actual CEPs against synthetic oil targets turned out to be 38% worse than expected.[139]

Accuracy was generally better in the summer than in winter and accuracy actually improved during the latter months of the war. There may be several valid reasons for this improvement, but two reasons serve as a macabre reminder that an abiding faith in a single technology comes with a heavy price – Regensburg and Schweinfurt. On 17 August 1943 air superiority had not yet been achieved and Allied losses reflected this. The Regensburg and Schweinfurt raids underscored the reality that "too many had paid with their lives in disproving the Air Corps' pre-war theory that the Flying Fortress could defend itself, unaided, against enemy fighters."[140] A 16% loss rate costing over 600 lives was a stark wakeup call and proved too costly for air planners. The second

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[136] Headquarters Eighth Air Force Operational Analysis Section, "Report on Bombing Accuracy; 1 October 1943 to 1 March 1944", 12 April 1944, p.6, 520.56A, AFHRA

[137] *AAF Bombing Accuracy, Report No.2,* 4

[138] USSBS, *Bombing Accuracy,* 6

[139] Ibid., 7

[140] Hughes, 88

Schweinfurt raid on 14 October 1943 had nearly identical results.[141] Army Air Force top brass claimed great results[142] but even though the bombing accuracy was considered good for these raids, those further removed from the limelight considered the results disappointing.[143] The AAF never again ventured out from under the fighter escort umbrella and, fortunately, both the long-range fighter and air superiority were only months from becoming reality.

By the spring of 1944 long-range fighters became standard and "the Luftwaffe could not prevent [the AAF] from attacking any portion of the Reich"[144] – a claim that was also made by Muir Fairchild before the war.[145] After air superiority had been secured, bombing accuracy improved noticeably. In April of 1944, 8th Bomber Command was placing only 29% of its bombs within 1,000 feet of its aimpoints. With air superiority gained bombing missions were less hampered by enemy activity, fewer aircraft were lost, and fewer experienced bombardiers killed. The bombing accuracy steadily improved until, one year later, the number had risen to 59%.[146]

While accuracy improved toward the end of the war, fluctuations were common and the final results were still rather grim. According to the USSBS Bombing Accuracy Division, only 40.77% of B-17 bombs fell within 1,000 feet of their intended aimpoint.[147] Remembering that a CEP of 425 feet was considered worst-case in 1943, the USSBS results indicate that overall average CEPs were well outside 1,000 feet. Regarding synthetic oil targets, 19,029 tons of bombs dropped (or 15.4%)

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[141] Alan J. Levine, *The Strategic Bombing of Germany, 1940-1945* (Westport, CT: Praeger, 1992), 101, 105
[142] Arnold, *Report of the Commanding General,* 51
[143] Hughes, 35; and Levine, 106
[144] Henry H. Arnold, *Second Report of the Commanding General of the Army Air Forces to the Secretary of War* (No Publisher Listed, 27 February 1945), 9
[145] See footnote 77
[146] *AAF Bombing Accuracy, Report No.2,* 17
[147] USSBS, *Bombing Accuracy,* 10

landed within the oil plant fences.[148]

Bombing results demonstrated conclusively that the technological capabilities promised – in the combination of the Norden bombsight, the bombs it would direct, and the bombers that would deliver them – fell well short of expectations.

The Pillars and the Pendulum

Air planners prior to and during World War II relied on the technology of the day to the point where the "shield" pillar was marginalized. While this may have been justified, at least in their minds based on the existing threat technologies, they failed to anticipate the motion of the pendulum.

It has been shown that air doctrine used to execute the air strategy in World War II was nigh on fully reliant on the technological capabilities of the heavy bomber weapons system (the Norden bombsight, the bombs of the era, and the bomber itself). While air planners could foresee drastic improvements in bomber capabilities, they were unable, or disinclined, to project parallel improvements in fighter aircraft or AAA. Consequently, the belief that the bomber could out-fly or overfly all known threats became entrenched in air doctrine, which is to say dogmatic. The advances of the B-17, for example, proved to planners that no enemy fighter could catch the heavy bombers. Accordingly, the concept of escort fighters was marginalized to the point where advances in long-range fighter technology were neither pursued nor funded. The common line of thought was that since the bomber could get to the target unmolested, what could stop it from employing its Norden sight to drop its powerful bombs into the "pickle-barrel" of Germany's industrial might? No shield was required. No shield was provided.

[148] USSBS Oil Division Report, "Weapons Effectiveness and Bombing Techniques", no date, p.5, 248.222-15, AFHRA

Some have argued that, had the Air Corps realized the impact radar would have on air operations, it would have had to rely even more on technology to achieve success. This may be true. But surely air planners would *not* have relied solely on the bomber weapons system to prosecute its strategy, had they known that the enemy had available to it a high-tech counter to the heavy bomber's apparent impervious qualities. They would have, instead, realized the even-more critical importance of the shield. But this is counterfactual.

The pendulum did, indeed, swing, as it likely always will. In World War II, however, the AAF was not prepared to deal with the inevitable swing. In the first place, the technological facility, upon which were based air doctrine and tactics, fell well short of its promised capability. The bomber could not, in fact, operate with impunity over enemy territory. Enemy fighters and AAA proved to be an enormous obstacle. The Norden sight was not nearly as accurate as claimed and, as a result, the bombs' blast effect was minimized as they detonated beyond their lethal radii. In the second place, US technological advantage was countered by both the enemy's own high-tech progress and by his own low-tech tactical innovation. Technologically speaking, faster fighters, better armament, and longer range and more accurate AAA combined to take advantage of unescorted bombers frozen in formation. Tactically speaking, attacking formations from the nose, diving from above to disperse bombers, and simply turning on the smoke generators all combined to render ineffective much of the AAF's technological advantage. The pendulum swung and the Army Air Force was not ready.

The consequences speak for themselves. The lack of a shield as a result of reliance on one technology had grave effects. Perhaps the 18,000 American aircraft lost and 92,000 casualties[149] could have been

[149] Arnold, *Third Report of the Commanding General,* 34

reduced had the shield not been overlooked. And without a shield, the sword became much less effective.

Regarding the reliance on the promise of technology, Richard Hughes stated, "we were too naïve to introduce the question of our real capabilities."[150] The AAF was enamored of technology and wanted very much to believe it held the key to victory. In 1945, General James Doolitle said, "Basically, the trouble was we...talk[ed] about air power in terms of promise and prophecy instead of in terms of demonstration and experience."[151]

But the AAF was slow to learn its lesson. In 1944, General Arnold proclaimed, "we have proved that our pre-war plane designs and pre-war concepts of air strategy and tactics were sound."[152] Ten years later, Lt Gen Laurence Kuter admitted, "In World War II there was time in which we could learn, time in which we could correct unsound doctrine – and there was time to apply valid doctrine."[153] The pitfalls of employing doctrine based on one panacea technology should have been a lesson from this war, but the emergence of nuclear technology stifled the learning process.

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[150] Hughes, 9
[151] Quoted in Baker and Cooling, 45
[152] Arnold, *Report of the Commanding General*, 34
[153] Lt Gen Laurence S. Kuter, "American Air Doctrine" lecture, Squadron Officer School, Air Command and Staff College, Maxwell Field, AL, 9 November 1954, p.1, MU 38043.K97a, AFHRA

Chapter 3

Post-World War II Reliance on Nuclear Technology and its Impact in Vietnam

> *If, in putting Mr. de Seversky's ideas to the test, they prove well-founded we have saved some money; if they prove ill-founded we have lost the war and the nation.*
>
> --Hanson Baldwin

Hanson Baldwin was referring to the ideas put forward in Alexander de Seversky's 1942 book *Victory Through Air Power* in which de Seversky postulates that air power is decisive and that no other military branch can be effective unless air power first achieves air superiority. Baldwin points out in his article that Seversky makes several assumptions about the character of the next war which are unfounded and short-sighted. He then adds that, indeed, air power is crucial but that air power shares its place along side land and sea power as a viable addition with unique synergistic capabilities.[154] Baldwin's statement, while made in 1942, is as valid today as ever.

Baldwin suggests that total reliance on air power for the country's defense at the expense of the other services is a mistake. Extracting his idea to this paper, total reliance on a single technology for the country's defense at the expense of other, tested technologies is a mistake. Reliance on one technology to execute war strategy has, in the past, diminished our acknowledgement of the necessity to balance reliance on all three pillars of success. When one pillar was minimized, we left ourselves vulnerable to the swing of the pendulum.

If an idea sounds too good to be true, it probably is. But this is what happened between the Second World War and the Vietnam War.

[154] Hanson Baldwin, "Victory Through Air Power?", *Sea Power Magazine* 2, no. 6 (June 1942), 6

"Our national fascination with technology in the 1950s transferred to Vietnam in the 1960s."[155]

World War II through the Korean War

Shortly after the atomic bombs were dropped on Japan, a new set of beliefs about air power began to emerge. The war was over and the subsequent bombing survey (the United States Strategic Bombing Survey – USSBS) painted a relatively favorable picture of the efficacy of air power in bringing the war to an end. While many facets of military power were mentioned, the primacy of air power had the most decisive effect on ending the war; and the aspect of air power that was most vital to enemy capitulation was strategic air power. Paul Nitze, author of the USSBS *Summary Report*, wrote, "military defeats in the air, at sea and on the land, destruction of shipping by submarines and by air, and direct air attack with conventional as well as atomic bombs... jointly and cumulatively were responsible for Japan's disaster"[156]

Many naval and army officers, in trying to plead a case for their own decisiveness, and hence post-war budget dollars, used quotes like this and others to downplay the decisiveness of air power. Once the war was over, the drawdown began and money was tight. The Army Air Forces' leadership was not only trying to minimize the impact of drawdown and budget crunches, but was also trying to gain its independence from the Army. Surviving the drawdown while at the same time seceding from the Army was no easy task. But the latter was required to fulfill the former. In order to gain independence, it was crucial that the AAF demonstrate its value to the war effort and project that value to the future defense of the country. The same USSBS

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155 Dr. Earl H. Tilford, "The Revolution in Military Affairs: Prospects and Cautions", *Strategic Studies Institute*, June 1995, 19, on-line, Internet, 21 January 2002, available from http://carlisle-www.army.mil/usassi/ssipubs/pubs95/rmapros/ rmapros.htm

156 Paul Nitze, *The United States Strategic Bombing Surveys Summary Report* (Maxwell AFB, Ala: Air University Press, 1987), 106

Summary Report was oft quoted by air power advocates to support their claims to decisiveness and, hence, budget dollars and eventually independence. The famous early surrender theory proposed by Nitze gave airmen the ammunition they needed.

> Based on a detailed investigation of all the facts, and supported by the testimony of the surviving Japanese leaders involved, it is the Survey's opinion that certainly prior to 31 December 1945, and in all probability prior to 1 November 1945, Japan would have surrendered even if the atomic bombs had not been dropped, even if Russia had not entered the war, and even if no invasion had been planned or contemplated.[157]

Despite its drive for independence, the AAF actively advocated unifying all the services under one department. In 1944, General Henry H. Arnold promoted establishing a single war secretary with assistant secretaries in charge of the different services.[158] The AAF favored retaining ownership of but assigning tactical aircraft to Army units, thereby leaving the AAF primarily responsible for strategic air power.[159]

Bombers, Bombs, and Force Structure

The faith in the ACTS tenets, reliance on the technology of the bomber, and the emerging reliance on nuclear technology served to diminish the value of the AAF shield, giving tactical aircraft low priority between 1945 and 1950.[160] By the end of 1943, General George Marshall, anticipating drawdown after the war, said, "I think maintenance of sizeable ground expeditionary forces [is] probably

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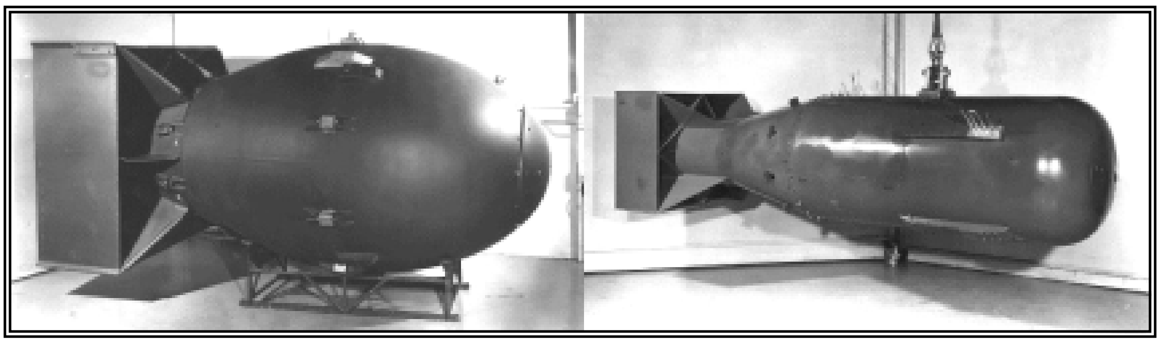
[157] Ibid., 107

[158] Robert F. Futrell, I*deas, Concepts, Doctrine, Basic Thinking in the United States Air Force, 1907-1960, Volume 1* (Maxwell AFB, Ala: Air University Press, 1989), 191

[159] Ibid.

[160] David MacIsaac, "Voices from the Central Blue: The Air Power Theorists," in *Makers of Modern Strategy, From Machiavelli to the Nuclear Age*, ed. Peter Paret (Princeton: Princeton University Press, 1986) 643

impractical...having air power will be the quickest remedy."[161] By 1946, the demobilization had intensified which prompted General Carl Spaatz to give priority to "the backbone of our Air Force – the long range bomber groups and their protective long-range fighter groups organized in our Strategic Air Command."[162] Two years after the war, and after the Air Force gained its independence, Air Force doctrine continued to be based on the principles of the Air Corps Tactical School's industrial web theory and its reliance on the strategic bomber.[163] "Strategic bombing concepts from the 1930s combined with the promises of atomic weapons formed the basis for airpower thinking."[164]



Source: http://www.atomicarchive.com/Photos/Photo9.shtml and http://www.atomicarchive.com/Photos/Photo5.shtml

Figure 4. The first two atomic weapons; FatMan and LittleBoy

With pressure to maintain fighting capability in the face of tight budgets, the Air Force relied more and more on its highly technical nuclear capability. Air Force Chief of Plans, General Lauris Norstad, a fan of tactical air power, stated that with the advent of the atomic bomb the tactical air force had become "as old fashioned as the Maginot

161 Quoted in Robert F. Futrell, "The Influence of the Air Power Concept on Air Force Planning: 1945-1962," in *Military Planning in the Twentieth Century*, ed. Lt Col Harry R. Borowski (Washington DC: Office of Air Force History, 1986), 256

162 Quoted in Futrell, "The Influence…," 257

163 Mark Clodfelter, *The Limits of Air Power, The American Bombing of North Vietnam* (New York: The Free Press, 1989), 11

164 Futrell, "The Influence…," 251

line."[165] Between 1945 and 1949 the atomic stockpile grew from just two bombs to 250 bombs[166], and by the middle of the Korean War the number had burgeoned to 832.[167] As early as 1947 the Air Force Directorate of Intelligence was developing nuclear war plans to defeat the new threat – the Soviet Union.[168]

This reliance translated into the shaping of the force structure. The AAF – and then Air Force – had to determine how best to support its doctrine with budget cuts looming ominously. By the end of World War II, the AAF had 22,393 bombers (very heavy, heavy, medium, and light) and 16,799 fighters in its inventory.[169] Just two years later, by the end of 1947, these numbers had dropped to 6,405 bombers and 6,053 fighters.[170] By 1948, the defense budget had reached its low point[171] and by the end of that year the Air Force had 3,875 bombers and 4,425 fighters. Yet even as the total number of bombers decreased, the total number of *heavy* and *very heavy* (i.e. strategic) bombers increased.[172]

By June 1950, the bombers that had actually increased in number since the end of World War II were the B-36, the B-45, and the B-50.[173] The B-36, contracted in 1941, came too late for the war but was modified to carry atomic weapons after the war.[174] The B-45 was the first jet

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165 Ibid., 257
166 Ibid.
167 Ibid., 262
168 Ibid., 259
169 *Army Air Forces Statistical Digest, World War II* (Washington DC: Office of Statistical Control, December 1945), 139, available at http://www.au.af.mil/au/afhra/ wwwroot/aafsd/aafsd_pdf/t084.pdf
170 *United States Air Force Statistical Digest, 1947* (Washington DC: Director of Statistical Services, 1948), 134
171 Colin S. Gray, "Strategy in the Nuclear Age: The United States, 1945-1991," in *The Making of Strategy, Rulers, States, and War*, ed. Williamson Murray, MacGregor Knox, and Alvin Bernstein (Cambridge: Cambridge University Press, 1995), 586
172 *United States Air Force Statistical Digest, 1948,* Vol 2 (Washington DC: Statistical Services, 1949), 22-29
173 Air Force Regulation (AFR) 5-24, *United States Air Force Statistical Digest, Jan 1949-Jun 1950* (Washington DC: Operations Statistics Division, 1950), 171-181
174 "B-36 Peacemaker", *Global Security.Org*, 23 Jan 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.globalsecurity.org/wmd/systems/b-36.htm

bomber to drop an atomic weapon (in a test scenario)[175] and the B-50 was a substantially modified version of the B-29.

On the fighter front, while we had a large number of World War II leftovers still in the inventory, the fighters whose numbers were increasing in the Air Force inventory were the F-80, the F-84, the F-86, and the F-94.[176] The F-80, a high-altitude interceptor, was designed to intercept and engage inbound bombers (as was its two seat version, the F-94).[177] The F-84's conventional air-to-ground role was modified to a nuclear role and it became the first USAF jet fighter capable of carrying a tactical atomic weapon.[178] The F-86, like the F-80, was designed to intercept and engage inbound bombers, but with an all-weather capability.[179]

By the beginning of the Korean War, the Air Force had fulfilled General Spaatz's notion of supporting the backbone of the Air Forces, the strategic bombing arm and the fighters to protect them. The capabilities that were beginning to atrophy were interdiction, close air support (CAS), and air superiority. The capabilities that were new and improved were strategic bombing and bomber intercept. But the Korean War forced the US into a scenario in which strategic nuclear bombing was not feasible and bomber intercept missions were not required. "In the summer of 1950, the Air Force was not prepared for an extended conventional air campaign in Korea."[180] Thus, the Air Force had to either forego the interdiction, CAS, and air superiority missions or make do with what platforms it had. Obviously, it did the latter and the fortunate fact that

[175] "B-45 Tornado U.S. Air Force Light Bomber", *Boeing, A Brief History*, 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.boeing.com/company offices/history/bna/b45.htm
[176] AFR 5-24, *Jan 1949-Jun 1950*, 171-181
[177] "Lockheed F-80 'Shooting Star'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.wpafb.af.mil/museum/ air_power/ap37.htm
[178] "Republic F-84 'Thunderjet'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.wpafb.af.mil/museum/ air_power/ap43.htm
[179] "North American F-86 'Sabre'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.wpafb.af.mil/museum/ air_power/ap40.htm
[180] Thomas C. Hone, "Korea", in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin F. Cooling (Washington DC: US Government Printing Office, 1991), 454

North Korean air defenses were less than formidable played a sizeable role in keeping the North Korean and Chinese fighters at bay. While nuclear weapons may have had some utility in deterring escalation, the political context brought to the war by North Korea and China swung the pendulum in their favor by denying US use of atomic weapons.

Korea Through Vietnam

The Korean War caught the US unprepared for conventional warfare. The Air Force's heavy reliance on nuclear weapons atrophied the capabilities of its shield pillar. The US performed well in the Korean conflict but returned to the nuclear panacea shortly after the armistice. The focus on nuclear weapons did, indeed, provide global, albeit tenuous, stability. But it again left the Air Force unprepared for non-nuclear conflict.

Korea and Lessons Lost

The nature of the Korean War necessarily put the focus of air power back on support of the ground troops.[181] Strategic bombing was not the focus of the war. Lt Gen George Stratemeyer, Far East Air Forces (FEAF) Commander, said on 15 September 1950, "Practically all of the major military industrial targets strategically important to the enemy forces and to their war potential have been neutralized."[182] As this was only two months into the war, the focus shifted early to support of ground troops as strategic targets became sparse. Even so, the Air Force never lost sight of its strategic nuclear bombing mission. The detonation of the first thermonuclear device emphasized the immeasurable power

[181] Major Robert J. Hamilton, "Green and Blue in the Wild Blue: An Examination of the Evolution of Army and Air Force Airpower Thinking and Doctrine Since the Vietnam War" (masters thesis, School of Advanced Airpower Studies, 1993), 6
[182] "Strategic Bombardment", *USAF Museum Website*, 7 Feb 2002, n.p., on-line, Internet, 21 Feb 2002, available from http://www.wpafb.af.mil/museum/history/ korea50/k50-3.htm

that could be delivered by strategic bombers and by mid-1953 the nuclear stockpile had topped 1,000 bombs.[183] Despite the war that was raging in Korea, General Vandenberg, Air Force Chief of Staff, stated that he could not sacrifice his deterrent capabilities in Europe to fully participate in the Korean War.[184] This suggests that the Air Force was so reliant on nuclear technology to deter (or repel) a Soviet invasion of Europe that it would withhold capabilities from an ongoing war. Add to this the fact that the Europeans favored more nuclear weapons and fewer conventional forces in Europe, and one can perhaps see why the reliance on nuclear technology outlasted the Korean experience.[185]

Despite this reliance and the resulting imbalanced force structure, there were some who saw the need for restructuring. One of these was Secretary of Defense (SecDef) Robert A. Lovett. Lovett was SecDef from 1951 to 1953 and made great strides to balance the USAF force structure both to accommodate the needs of the ongoing war and to meet future defense demands.[186] He recognized the attraction of – and reliance on – the relatively cheap nuclear "sword" and saw the dangers of foregoing the conventional "sword" and "shield" when he said, "There is no new, inexpensive, or magic way to win wars in the near future. We must be able to defend ourselves and to win battles with tested, available armaments…Any premature adoption of the most modern…weapons and devices could lead to possible disaster."[187] Despite his efforts, his successor, guided by Eisenhower's New Look program, would eventually put even more reliance on nuclear technology.

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[183] Futrell, "The Influence…," 263
[184] Futrell, *Ideas, Concepts…,* 301
[185] Futrell, "The Influence…," 263
[186] "Robert A. Lovett", *US Department of Defense Website*, 21 Feb 2002, n.p., on-line, Internet, 21 Feb 2002, available from http://www.defenselink.mil/specials/ secdef_histories/bios/lovett.htm
[187] Ibid.

At the close of the Korean War, Eisenhower vowed that the United States would never again become mired in a similar war.[188] With this implied as policy guidance, the Air Force took the vital lessons from the Korean War and failed to internalize them. The 1953 final report from the FEAF stated that because of the uniqueness of the Korean situation, crafting the future USAF force structure from the Korean model would be a fatal mistake.[189] The Korean War, it was decided, was a peculiar one and would not be repeated. The war did not generate post-war appraisals of air power capabilities because the performance of tactical air power was perceived as successful in its own right. What was not considered contextually was the fact that North Korea afforded a battlefield largely devoid of radar-guided surface to air threats, significant numbers of air-to-air threats, and that North Korean air forces, due to the inability to construct airbases close to the front, were unable to operate in close proximity to allied ground forces.[190]

After Korea, the United States continued its quest to maintain nuclear hegemony. Several assumptions were made about the post-Korean War global landscape: the military assumed that the President would give authority to use nuclear weapons; the use of nuclear weapons would be a military, vice political, decision; future wars would be fought against an industrial state; the US would maintain its nuclear superiority in the future; nuclear technology could trump an enemy's strategy; and nuclear technology that could successfully wage total war could also successfully wage limited war.[191] The Air Force was truly attempting to make the next war fit the current technology rather than making the current technology fit the next war.[192] But the next enemy was able to swing the pendulum once again away from the United States.

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[188] John Sbrega, "Southeast Asia", in *Case Studies in the Development of Close Air Support,* ed. Benjamin F. Cooling (Washington DC: Office of Air Force History, 1990), 411
[189] MacIsaac, 643
[190] Hone, "Korea", 497
[191] Futrell, "The Influence…," 269
[192] Ibid.

Post-Korean War

Throughout the 1950s, Air Force doctrine continued to emphasize the primacy of nuclear weapons delivered by strategic bombers.[193] The weight of Air Force strategy was designed to deter, and if necessary meet, an opponent in an all-out nuclear exchange. In January 1954, President Eisenhower unveiled his New Look policy that put greater reliance on nuclear technology. This policy also promoted strategic air power as the best means to deliver the weapons of mass destruction. Conventional forces were cut drastically and continental air defense against enemy strategic bombers was raised to a new level.[194] A key precept of this policy was that nuclear weapons would be used to fight both limited wars and general wars. Air Force Secretary Donald A. Quarles stated, "From now on, potential aggressors must reckon with the air-atomic power which can be brought to bear immediately in whatever strength, and against whatever targets."[195] The new Secretary of Defense, Charles Wilson, was unable or unwilling to carry on the efforts of his predecessor to balance the forces and reduce the reliance on nuclear weapons. Driven to action under the New Look policy, he stated, "We are depending on atomic weapons for the defense of the nation. Our basic defense policy is based on the use of such atomic weapons as would be militarily feasible and usable in a smaller war."[196]

Much of this reliance can be attributed to the shrinking budget. Nuclear technology gave the promise of vast capability at relatively inexpensive cost. By 1954 even the NATO allies had adopted US nuclear weapons as the primary offensive weapon in Europe since they would be

193 Dennis Drew, "Two Decades in the Air Power Wilderness: Do We Know Where We Are?" *Air University Review* 37, no. 6 (September-October 1986), 5
194 "Charles E. Wilson", *US Department of Defense Website*, 21 Feb 2002, n.p., on-line, Internet, 21 Feb 2002, available from http://www.defenselink.mil/specials/ secdef_histories/bios/wilson.htm
195 Quoted in Futrell, *Ideas, Concepts*, 452
196 Quoted in Drew, 5

financially unable to sustain large conventional forces.[197] The US military, faced with the tightening budget, agreed to budget cuts if they could be assured that they would actually get permission to use nuclear weapons during future crises.[198] This concern arose from Truman's reluctance to use them in the Korean War and foreshadowed the same issue in the Vietnam War. One of the results of this concern was the eventual rise of the tactical nuclear weapon. If the political leadership was unwilling to use nuclear weapons because of their overwhelming destructive ability, perhaps they would not be so circumspect to use low-yield nuclear weapons.

Kennedy and the Nuclear Dilemma

Until 1960, the Air Force continued to rely largely on nuclear technology to deter aggression or, if necessary, fight and win its nations wars. Even before John F. Kennedy was elected President, he showed some concern that nuclear reliance was no longer plausible. "The notion that the Free World can be protected simply by the threat of 'massive retaliation' is no longer tenable."[199] Although the idea had been entertained by Air Force personnel in positions of authority, this was the first time that the unbalanced pillars had been addressed at the highest political levels. Once in office, Kennedy put forth his Flexible Response policy that sought to increase conventional force capabilities in order to minimize the imbalance created by the reliance on nuclear technology. In 1964, Air Force Chief of Staff General John P. McConnell lamented, "We [USAF] did not even start doing anything about tactical aviation until about 1961 or 1962."[200] In the years prior to the Vietnam War, despite Kennedy's interest in non-nuclear forces, Air Force doctrine paid only lip

197 Futrell, "The Influence…", 264
198 Ibid.
199 Quoted in Futrell, "The Influence…", 267
200 Quoted in Sbrega, 411

service to tactical air power. Even General Curtis Lemay admitted, "Our basic doctrine has remained generally unchanged since that time [1935]."[201]

By 1956, the Air Force had been given full control of the emerging ballistic missile inventory. These missiles were assigned to the Strategic Air Command (SAC) and, since the strategic bomber and the ballistic missile were the only viable means of delivering nuclear weapons, SAC enjoyed priority regarding Air Force assets and budget dollars. By 1962, well over 3,000 aircraft were assigned to SAC – over 1,200 more than any other command.[202] Although several Air Force commands focused on non-nuclear issues, SAC's dominant position was evident in the Air Force budget. Between 1953 and 1960, "the Air Force . . . found itself spending huge sums to develop a variety of missile systems while at the same time purchasing ever more expensive bombers and fighters."[203] These bombers were designed to deliver nuclear weapons and the fighters were designed to intercept enemy strategic nuclear bombers. Doctrine, assets, and spending were all testaments to the abundant reliance on nuclear technology.

Still, the Kennedy administration pushed for a more balanced force. But it would take years before the bureaucratic machine that is the military would build a force structure to achieve that goal. Budgets would have to be radically altered and ideologies would have to be swayed. The Cuban Missile Crisis of 1962 served to widen the gap between political and Air Force ideology. Even though the success of the political-military strategy cannot be argued, the post-crisis perceptions were very different. The Secretary of Defense, Robert S. McNamara, acknowledged the efficacy of conventional forces in the successful

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[201] Quoted in Drew, 6

[202] AFR 5-24, *United States Air Force Statistical Digest, Fiscal Year 1962* (Washington DC: Directorate of Data Automation, 1962), 93

[203] *Congressional Quarterly Almanac, 1960*, Vol XVI (Washington, D.C.: Congressional Quarterly Service Inc., 1961), 374

outcome when he said, "non-nuclear forces were our sword, our nuclear forces were our shield."[204] He even went as far as to say that, "nuclear weapons serve no military purpose whatsoever. They are totally useless—except only to deter one's opponent from using them."[205] Contrast this with General LeMay's perception that the successful resolution of the crisis was due to the decisive superiority of strategic, nuclear power.[206] Granted, the most likely reason the Soviets did not march on Berlin in October 1962 was the massive American nuclear deterrent force in Europe. But funding a force structure based on its deterrent value leaves little warfighting capability if – or when – deterrence fails, especially if the contextual factors of the impending conflict rule out the use of this nuclear deterrent force.

The Air Force, it seems, still clung to its *raison d'etre*. Strategic air power was what gained the Air Force its independence, was what justified defense dollars, and nuclear bombs fit nicely with its doctrine.

Tactical Air Command and Force Structure

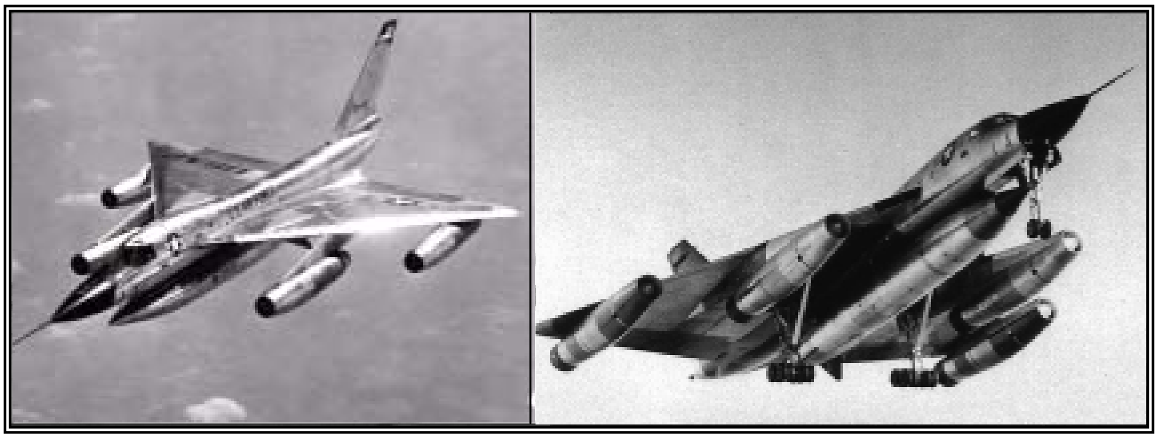
Two assumptions that were accepted after the Korean War were that future war would be geared toward the total destruction of the enemy, and that the enemy would be an industrial state.[207] But the Vietnam War proved both assumptions wrong. Basing its force structure on its nuclear-reliant doctrine and these assumptions, the Air Force was ill prepared for the type of warfare the contextual factors of Vietnam presented.

By the start of the Vietnam War, the most prominent bombers in the USAF inventory were the B-52, B-57, and B-58. The B-57, acquired in the 1950s, saw combat in Vietnam, but the B-52 was the primary

[204] Quoted in Futrell, "The Influence…", 268
[205] Ibid.
[206] Ibid.
[207] Hamilton, 21

bomber of the time. It served in Vietnam, but only as a means to deliver conventional bombs – a role for which it was not designed.

In 1957, General LeMay proposed combining SAC and Tactical Air Command (TAC).[208] Perhaps this threat of a "hostile" takeover, the limited defense dollars of the time, and the introduction of the tactical nuclear weapon prompted TAC to continue its procurement of tactical nuclear fighter-bombers. In 1956 General Otto P. Weyland (TAC commander) believed that "the most likely conflict in the immediate future will be the peripheral type. In this event it will be primarily a tactical air war."[209]



Source: http://www.xs4all.nl/~mvburen/b-58/gallery/01.htm and http://www.b-58hustler.com/

Figure 5. Convair B-58 *Hustler*

Under Weyland, TAC began a struggle to gain parity with SAC. But since budget dollars were so tied up in nuclear funding, he was only able to improve TAC's capabilities by creating a nuclear capability in its fighter-bombers. As a result, air superiority aircraft and those designed for CAS atrophied[210] as did tactical electronic warfare assets.[211]

[208] Futrell, "The Influence…", 266
[209] MacIsaac, 644
[210] Ibid. The fighter aircraft of the era (the Century-series fighters) were almost exclusively designed as either tactical nuclear fighters or bomber interceptors. Neither design was well-suited to the air superiority task of engaging fast, maneuverable enemy fighters

In mid-1964, the Air Force fighter inventory consisted almost exclusively of the Century Series fighters. The F-84 and F-86 were still around, but just one year into the war there were no operational F-84s and only 10 operational F-86s left on hand.[212] The F-4 did not show up in the Air Force inventory in large numbers until mid-1966,[213] and it was acquired from the Navy. Fortunately, the F-4 proved to be more successful than other USAF aircraft when forced to change roles from nuclear attack or bomber intercept to conventional attack or air superiority. So the Century Series fighters comprised the bulk of the inventory at the outset of the Vietnam War.

The F-101 was originally designed as a long-range bomber escort but was later converted for use as an air defense interceptor.[214] The F-102 was also designed as a strategic bomber interceptor[215] as was the F-104[216] and F-106.[217] The F-100 was actually designed as an aerial combat jet – an air superiority fighter – but was later redesignated as a fighter-bomber and performed primarily air to ground tasks in the Vietnam War.[218] It was the F-105 that carried out the bulk of bombing for the Air Force in the early stages of the Vietnam War.

The F-105 was designed around its bomb bay. It was designed to carry one nuclear weapon at high speed and low altitude; maneuverability and survivability were not an issue.[219] It flew 75 percent

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[211] Thomas C. Hone, "Southeast Asia", in *Case Studies in the Achievement of Air Superiority,* ed. Benjamin F. Cooling (Washington DC: US Government Printing Office, 1991), 509

[212] AFR 5-24, *United States Air Force Statistical Digest, Fiscal Year 1966* (Washington DC: Directorate of Data Automation, 1966), 123

[213] Ibid.

[214] "F-101 Voodoo Fighter", *Boeing, A Brief History*, 2002, n.p., on-line, Internet, 20 February 2002, available from http://www.boeing.com/companyoffices/history/ mdc/voodoo.htm

[215] "Convair F-102 'Delta Dagger'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 21 February 2002, available from http://www.wpafb.af.mil/museum/ research/fighter/f102.htm

[216] "Lockheed F-104C 'Starfighter'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 21 February 2002, available from http://www.wpafb.af.mil/museum/ research/fighter/f104c.htm

[217] "Convair F-106A 'Delta Dart'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 21 February 2002, available from http://www.wpafb.af.mil/museum/ research/fighter/f106a.htm

[218] "North American F-100 'Super Sabre'", *USAF Museum Website*, 7 February 2002, n.p., on-line, Internet, 21 February 2002, available from http://www.wpafb.af.mil/museum/research/fighter/f100c.htm

[219] Kenneth P. Werrell, "Did Technology Fail in Vietnam?" *Air Power Journal* (Spring 1998), 89

of the strike missions during Rolling Thunder and 397 of the 753 F-105s were lost during the war (a loss rate 15% higher than the F-4).[220] While well designed for its tactical nuclear mission, the F-105 lacked performance qualities for non-nuclear attack during the Vietnam War principally because it was forced into a situation where its primary mission could not be carried out. Air Force commanders and pilots showed outstanding flexibility taking less than adequate airframes and performing as well as they did, but the need for flexibility was driven by the Air Force's inattention to the shield and conventional sword.

Source: http://www.military.cz/usa/air/post_war/f105/for_a_mission.jpg and http://aircraftstories.free.fr/mono/f105/introduction/1.jpg

Figure 6. Republic F-105 *Thunderchief*

The Pillars and the Pendulum

After World War II, the Air Force struggled to find the niche that would guarantee its independence. Had it not been for the atomic bomb, it may have fully realized the importance of tactical air power in winning the war. Its vision of the next war – whether internally generated by USAF leadership or externally by civilian leadership – was that of a nuclear exchange. This vision, budget constraints, and its reliance on technology pushed it to develop doctrine essentially based on one

[220] Ibid.

panacea technology – nuclear weapons. Minimizing its shield, the Korean War caught the Air Force unprepared for conventional conflict. But for many of the same reasons, the USAF also lost the lessons of this war and maintained its reliance on one technology as a means of waging war. When the Vietnam War began, much of the Air Force's shield and conventional sword had atrophied. Its air superiority and electronic warfare capabilities had been lost on the strategic or tactical nuclear capabilities. While the civilian leadership did, indeed, put many constraints the Air Force, the Air Force also unwittingly put constraints on itself by its concentration on the nuclear sword and by its lack of concentration on other pillars of success.[221]

The Vietnam War indicates that sophisticated technology cannot successfully substitute for inept strategy and the Air Force learned the hard way that technological superiority can be overcome if and when the enemy can swing the pendulum in his favor. Nuclear weapons definitely achieved their promised capabilities. North Vietnamese low-tech tactics did not have devastating effects on air operations, but their high-tech surface-to-air counters did take advantage of both the lack of fighter maneuverability and of electronic warfare assets. The biggest factor, however, in the successful pendulum swing was the fact that use of America's panacea technology was diminished to vestigal proportions attributable to the political context of the conflict. Essentially, North Vietnam put the US in a situation wherein the wielding of nuclear might was neither possible nor practical.

While losing the war may not have been caused solely by reliance on nuclear technology, surely the atrophied shield and conventional sword played a part. Even after the war, the Air Force would continue to rely on nuclear technology to win the next war. The Air Force was not fighting the last war, as it is so often accused. It was fighting its version

[221] Ibid., 97

of the next war. It was fighting in a scenario based on assumptions that had twice been proven wrong, a scenario that would never be realized.

Chapter 4

Stealth: A Success Story

We will continue to offset capabilities the other guy may come up with to counter stealth.

--General Michael Ryan

Airborne electronic warfare…when coupled with stealth… technology, appears to be one of the most effective techniques for increasing aircraft and aircrew survivability in hostile environments.

--Congressional Research Service Report

Although many of the lessons of the Vietnam War were quickly forgotten, one lesson that stuck with Air Force planners concerned air defense. Many aircraft were downed by a new weapon the Soviets had developed – the surface-to-air missile. With its radar guiding the missile to its target, it proved a formidable foe for pilots. Many tactics were employed to dupe either the target-tracking radar or the missile itself. While some of these tactics were fairly effective, it became clear that as surface-to-air missile technology matured, many of these tactics would be rendered ineffective. Air planners needed a way to effectively avoid these missiles if the Air Force wartime mission was to be successful. Aircraft that could not survive the mission could not bring firepower to bear on enemy targets. Survivability, ever the basic requirement for combat, took on new dimensions.

Aircraft designers produced aircraft that flew faster than ever before and at very low altitudes. Aircraft designers produced aircraft that flew higher than ever before. But the missile threat could not be thwarted. Not long after the war, with the speed and altitude options exhausted, air planners sought a different approach. Air planners realized that if enemy surface to air missiles and their associated radars could find our aircraft, they could engage our aircraft. Perhaps the only course of action left to them was to attempt to deny the acquisition of our aircraft by enemy radar or missile. The seeds of the modern stealth aircraft were planted, and eventually came to fruition in the F-117 Nighthawk.

Beginnings of Stealth

Throughout history, as men have invented new technology and tactics to detect and destroy an adversary, the adversary has countered with new technology and tactics to defend itself. This game of deadly chess has always been with us. At times the players move slowly, with large, sometimes irregular pauses between moves. At times the play is rapid, especially in periods of war. But whether the play is slow or fast, the game is always on.

Detection

Finding the enemy has always provided consternation for warfighters. It can be utterly disquieting to know the enemy is looking for you, or may have already found you, while you still seek his position. Finding the enemy on the ground has always been problematic, but because of the physical limitations of geography, his ability to rapidly change his position – and thus avoid detection – has been rather limited. Finding enemy aircraft, on the other hand, presents a greater challenge to those who wish to protect their possessions from air attack. Aircraft have the inherent ability to rapidly change their position to avoid detection and the speed at which they can fly, in effect, compresses distance affording little time for detection. Nevertheless, militaries have, since the beginning of flight, spent time, effort, and money trying to detect threatening aircraft.

One of the earliest methods of detecting enemy aircraft was via spotting posts. Visual spotting posts were used extensively during both world wars. Detecting aircraft via audio spotting posts proved effective also because aircraft were often easier heard than seen. During World War I, pheasants – thought to have a heightened sense of hearing – were placed at listening posts in France to warn of approaching aircraft.[222] In England, audio detection formed an integral part of the defensive screen in and around London.[223] But not long before World War II, a new invention came along that revolutionized the way aircraft were detected.

In 1873, British physicist James Clerk Maxwell accurately predicted the propagation speed of electromagnetic waves. By 1886 German physicist Heinrich Hertz had detected radio waves and only 11 years later had demonstrated that radio waves could be reflected off of metal objects. By 1904, German engineer Christian Huelsmeyer patented a device through the Royal German Patent Office that used reflected radio waves as an aid to navigation on the Rhine River.[224] By 1935, Sir Robert Watson-Watt successfully demonstrated radio detection and ranging – now called radar – to Hugh C. T. Dowding who was, at the time, in charge of research and development for the British Air Ministry.[225] Five years hence, radar was able to spot aircraft approaching out to 100 miles.[226]

The efficacy of radar during, and since, World War II is evident. Radar changed the nature of air operations in that the enemy could now be seen (electronically)...without being seen (physically). No longer did one have to identify an adversary aircraft's location by using human senses since radar far out-distanced human eyes and ears. But finding the opponent was only the first step in defeating him.

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[222] Rebecca Grant, *The Radar Game, Understanding Stealth and Aircraft Survivability* (Arlington, Virginia: IRIS Independent Research, 1998), 2

[223] Ibid

[224] Alfred Price, *Instruments of Darkness* (New York: Charles Scribners & Sons, 1977), 38

[225] Thomas B. Buell, et. al., *The Second World War: Europe and the Mediterranean*, ed. Thomas E. Griess (Wayne, New Jersey: Avery Publishing Group Inc., 1989), 59

[226] Grant, iv

Destruction

Obviously, finding the enemy proves fruitless unless one can also engage or destroy him. As detection methods improved, the need for better destruction methods necessarily followed. Historically, the primary methods for militaries to destroy detected aircraft have been via antiaircraft artillery (AAA) and air defense fighters. The Krupp Company, as early as 1870, developed what is believed to be the first AAA – designed to take down enemy balloons.[227] By 1912, the first military aircraft had been downed by AAA.[228]

In World War II, the German air defense network – consisting of early warning radar for detection, and AAA and fighter defense for destruction – presented a formidable barrier for Allied air strikes. In fact, of the Allied aircraft lost to enemy activity, 42% fell to AAA while 37% fell to German fighters.[229] On the Pacific front, Allied fighter aircraft and AAA took down a full 86% of the 2,800 Kamikaze manned-missiles. Considering that the remaining 14% sank 34 ships and damaged 368 others, the Allied methods of destruction were quite effective in ensuring fleet survivability.[230] The last of the "AAA wars" – Korea – saw a dramatic change in percentages of aircraft destroyed by AAA and fighters. Communist fighters claimed just 12% of US aircraft downed while AAA claimed 88%.[231] The advent of the surface-to-air missile (SAM) in America's next war introduced a wholly new dimension into the destructive methods used by militaries against intruding aircraft.

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[227] Richard P. Hallion, "Air Power and Joint Forces: Air Power and Asymmetric Threats" lecture, 2000 Air Power Conference, Canberra, Australia, 8 May 2000, n.p., on-line, Internet, 13 May 2002, available from http://www.defence.gov.au/aerospacecentre/2000apc/Hallion.html

[228] Ibid.

[229] Kenneth P. Werrell, *Archie, Flak, AAA, and SAM: A Short Operational History of Ground-Based Air Defence* (Maxwell AFB, AL: Air University Press, 1988), 18-19

[230] Hallion, "Air Power and Joint Forces…"

[231] Werrell, 74-75

Defense

The earliest measures taken by airborne craft to defend themselves against destruction was altitude. Balloons hovering over or near the battlefield simply could not be accurately fired upon due to their vertical distance from the threat. Even in World War II, as was shown in Chapter Two, altitude played a major role in the defense of US bombers. Speed, armor, and self-contained defensive firepower also enhanced aircraft survivability. The British maximized the defensive survivability of their bomber force by electing to fly at night, drastically reducing the ability of the Germans to detect and destroy them.

None of these defenses, however, was able to adequately defend aircraft from the newest detection method in World War II – radar. As such, both the Allied and Axis powers put much time and effort into exploiting the other's radar systems in an attempt to determine new methods of defending against radar acquisition. Electronic countermeasures such as "Window" and "Carpet" were developed by Britain as a direct result of exploiting captured German radar sets.[232] By 1941, basically all of the fundamental forms of electronic countermeasures had been at least identified, if not deployed.[233]

By the time the Vietnam War began, the Soviet-Warsaw Pact had developed a model of air defense that effectively combined detection by radar with destruction by what was – in effect – lethal, high explosive, self-propelled, guided AAA, making the defense yet more problematic.[234] The integrated air defense system (IADS), which included the radar-

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[232] Grant, 12, 14. "Window" (a.k.a. chaff) were strips of metallic foil dropped from aircraft creating numerous false targets on enemy radar screens. "Carpet" was the codename for a device carried aboard aircraft that could electronically jam enemy radar. This was accomplished by transmitting signals back to an enemy radar on the same frequency as the enemy radar receiver, thereby masking the actual radar return (the aircraft) in a cloud of false returns (the jammer).

[233] Ralph Sanders, "Three-Dimensional Warfare: World War II", *Technology in Western Civilization Vol II*, ed. Melvin Kranzberg and Carroll W. Pursell, Jr. (New York: Oxford University Press, 1967), 574

[234] Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington, D.C.: Smithsonian Institution, 1992), 25

guided SAM, provided an exigent scenario for US air forces in Vietnam. While AAA was still a primary threat, never before had they grappled with such deadly accuracy from such a persistent weapon, one that could actually follow them as they maneuvered to defeat it. The American response to this new threat was to pair its bomb-dropping aircraft with radar-jamming/shooting aircraft into what became known as the strike package. But even this response was less effective than anticipated. In the Linebacker II campaign alone (a campaign in which B-52s were packaged with SAM-suppressing support aircraft), 1,285 SAMs were fired resulting in 18 downed aircraft (15 of them B-52s) while enemy fighters downed only two US aircraft.[235]

The subsequent 1973 Arab-Israeli War reinforced to US airmen the devastating capability of an effective IADS coupled with capable SAMs. In this short-lived war, the Israeli Defense Force lost over 100 aircraft, mostly in the first three days. Only five percent of these losses were to enemy fighters; the rest were lost to SAMs and AAA.[236] Indeed, SAM activity was responsible for nearly 54% of Israeli aircraft losses (even though a high percentage of SAM sites were eventually destroyed or effectively jammed).[237]

The successful performance of SAMs in both the Vietnam War and the 1973 Arab-Israeli War was enough to shock American air planners into seriously looking at innovative ways to neutralize highly integrated air defense systems. New methods for protecting the air fleet writ large were needed. With the coupling of early warning radar, target tracking radar, and the surface-to-air missile into a highly integrated defense system, defending friendly aircraft became the impetus for a turning point in the history of airpower.

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[235] Hallion, "Air Power and Joint Forces…"
[236] Robert F. Futrell, I*deas, Concepts, Doctrine, Basic Thinking in the United States Air Force, 1961-1984, Volume II* (Maxwell AFB, Ala: Air University Press, 1989), 485-6
[237] Futrell, 487

Stealth and F-117 Development

In 1941, British researchers proposed modifying aircraft to reduce their vulnerability to radar detection. Two years later, the German Gotha 229 (a Horten twin-engine flying wing) was produced using a combination of plywood and charcoal materials in its construction. This new aircraft effectively absorbed radar energy rendering it "stealthy".[238] While both ideas were nigh revolutionary, they both stagnated in various stages of theoretical debate during the war. Although the idea of designing aircraft to be resistant to radar acquisition had been around since World War II, design of a mature stealth aircraft would not begin until 30 years after war's end.

Only 10 years after World War II, the U-2 made its first test-flight, and one year later, in July 1956, it overflew the USSR for the first time. While the U-2 was easily tracked by Soviet radar, all attempts to engage the 74,000-foot target were made in vain.[239] But after Gary Powers was shot out of the sky, it became apparent that ultra-high altitude was not going to serve as a viable defense against Soviet SAMs. The answer seemed to lie in ultra-fast aircraft. By 1967, the SR-71 was operational.[240] This avant-garde aircraft combined terrific speed with what could be called first generation stealth characteristics.[241] Using specially designed fuselage fairings (which give it its distinct cobra-like appearance) and radar absorbent paint, the SR-71's radar cross section

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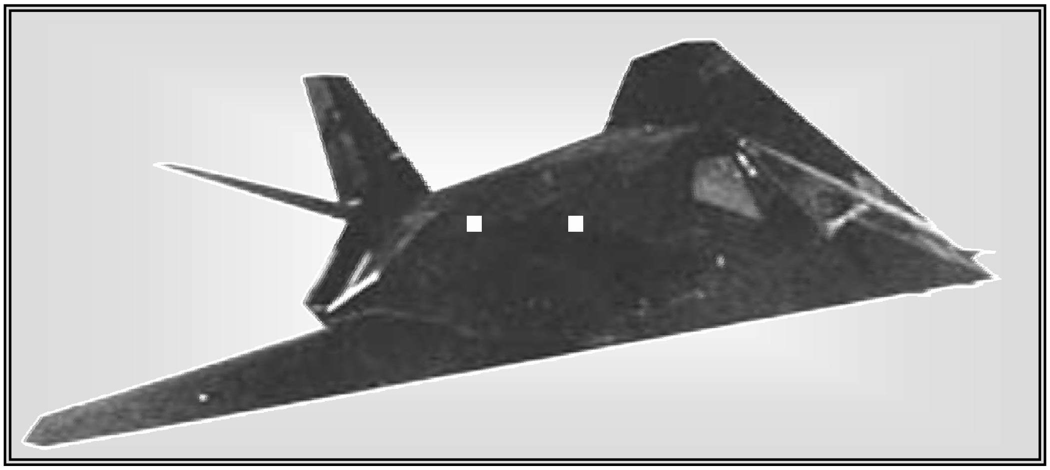
[238] Grant, 22

[239] Ben R. Rich and Leo Janos, *Skunk Works; A Personal Memoir of My Years at Lockheed* (Boston: Little, Brown and Company, 1994), 135, 146

[240] "The Oxcart Story", *Air Force Magazine* 77, No. 11, November 1994, 47

[241] Maj Gen Bruce Carlson, "DoD News Briefing: Stealth Fighters," *Defense Link*, 20 April 1999, n.p., on-line, Internet, 22 April 2002, available from http://www.defenselink.mil/news/Apr1999/…cont'd… t04211999_t420carl.html. Maj Gen Carlson, USAF Director of Operational Requirements in 1999, asserted that there have been four generations of stealth aircraft. The SR-71 was the first followed by the F-117 as the second. The third generation, the B-2, improved upon stealth characteristics of the F-117 while at the same time presenting an aerodynamically clean aircraft – something the F-117 was not. The fourth, and last generation, is the F-22, which improves upon the B-2 stealth characteristics while adding supersonic capability – a flight regime that, until the F-22, drastically reduced the efficacy of stealth design.

(RCS) was that of a Piper Cub.[242] The SR-71 afforded exceptional defense against Soviet SAM threats but was enormously expensive to operate and maintain.



Source: http://www.afa.org/magazine/June2001/0601stealth.html

Figure 7. First Picture of the F-117A Released by the Air Force (1988)

In 1975, four years after the last SR-71 was delivered, a Lockheed radar specialist highlighted to his peers a translated 1966 Russian technical paper by Pyotr Ufimstev that, in effect, outlined how one could calculate deflection angles and intensities of radar energy across the surface of objects with different shapes.[243] Thinking this might have some utility as a defensive measure against enemy IADS, an engineer at Lockheed (referred to as the "Skunk Works") had, in 1975, designed a working aircraft model to be used in the measurement of RCS based on Ufimstev's work.[244] The design and measuring of the test aircraft model was only possible because of relatively rapid advances in computer technology in the early to mid 1970s.[245]

[242] Rich and Janos, 197
[243] Ibid., 19-20
[244] Bill Sweetman and James C. Goodall, *Lockheed F-117A; Creation and Development of the Stealth Fighter* (Osceola, WI: Motorbrook International Publishers and Wholesalers Inc., 1990), 19
[245] John F. Guilmartin, "Technology and Strategy; What are the Limits?" in Sir Michael Howard and John F. Guilmartin, *Two Historian in Technology and Warfare* (Carlisle Barracks, PA: Strategic Studies Institute, 1994), 17

The Skunk Works' design of a low-observable aircraft began in earnest in 1976 under the code name "Have Blue", and the first Have Blue flight was made in early 1978.[246] The Air Force, also seeing future efficacy in its survivability characteristics, contracted with Lockheed for 100 aircraft in November of that same year (the number contracted was later reduced to a total of 64 aircraft).[247] Only 22 months elapsed from the time the contract was made until the first prototype F-117 rolled off the line. Nine months later, on 18 June 1981, the first F-117 prototype made its first flight.[248] A scant two years later, in October 1983, the first F-117 squadron achieved operational status.[249] The fact that the F-117 program used off-the-shelf parts to limit cost minimized the time required for design and production. The fact that it was built in utter secrecy, thus avoiding the typical bureaucratic acquisition and oversight process, also may have aided in the rapidity by which the F-117 program came to fruition, despite its $6.56 billion price tag.[250]

The F-117 program moved from developmental to operational purview in 1981 when the 4450th Tactical Group was identified as the Air Force organization that would eventually fly the F-117. Equipped with A-7Ds with which to train and use as a cover story, the 4450th continued training at Tonopah Test Range until 15 October 1982 when Major Al Whitley became the first USAF officer to fly the F-117. The F-117 continued under its umbrella of secrecy until 10 November 1988, when the Air Force publicly announced its existence. In October 1989, the 4450th was inactivated and F-117 flying operations were assumed by the 37th Tactical Fighter Wing.[251] This wing would be the first to employ

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246 Clayton K. S. Chun, *The Lockheed F-117A* (Santa Monica, CA: RAND, 1991), 1
247 Ibid.
248 Rich and Janos, 71, 85
249 Sweetman and Goodall, 70
250 Chun, 2-3
251 Harold P. Myers, "History and Lineage of the F-117A Stealth Fighter Organizations" (37th Tactical Fighter Wing Historian report, 1990), p. ii, K239.057-4 v. 30 in USAF collection, Air Force Historical Research Agency (AFHRA)

the F-117 in a combat scenario only two months later.

F-117 Characteristics

The ability of stealth technology in general, and the F-117 in particular, to fulfill its primary purpose – evading enemy IADS – is possible because of the unique design characteristics and innovative materials used. The F-117 exploits the visual, audio, thermal, and radar realms in order to minimize its susceptibility to detection.

Visually, the F-117 avoids detection by flying lights-out at night. Along with its flat-black paint scheme, the F-117 is virtually invisible to the naked eye, as its very narrow profile only enhances its visual elusiveness.

In the audio arena, the F-117 engines are buried in the fuselage and designed with diffused noise-suppressing engine nozzles. Its lack of supersonic capability eliminates the possibility of sonic booms and the high-pitched whines of its engines are difficult to hear.[252]

Thermally, the aircraft has no afterburner capability, limiting its heat signature. Ambient air is mixed with engine exhaust before it leaves the aircraft and its sawtooth trailing edges (aft of the engine nozzles) create shed vortices, further reducing its thermal signature.[253]

These design features are only complementary to its most crucial stealth characteristic – radar evasiveness. The faceted shape of the F-117 ensures that no two surfaces reflect the same radar wave simultaneously. Vertical surfaces (such as vertical stabilizers) are by far the most radar reflective surface on any aircraft, and the F-117 has no such surface. The underside of the aircraft is perfectly flat, ensuring that any radar that *can* find it must be directly below the aircraft.[254] The F-117 has virtually no protrusions and carries its weapons

[252] Chun, 6-7
[253] Grant, 29
[254] Chun, 5

internally, thereby reducing the amount of radar reflection and diffraction. To further reduce the diffraction, the intakes on the F-117 are covered with a fine grill-mesh whose gaps are smaller than the wavelengths of enemy radar.[255] Radar-absorbent material applied to the skin of the aircraft ensures that much of the leftover radar energy reflected or diffracted from the aircraft is absorb.[256] All these stealth design characteristics combine to give the F-117 an RCS of roughly .001 square meters, or approximately one ten-thousandth the RCS of a B-52.[257]

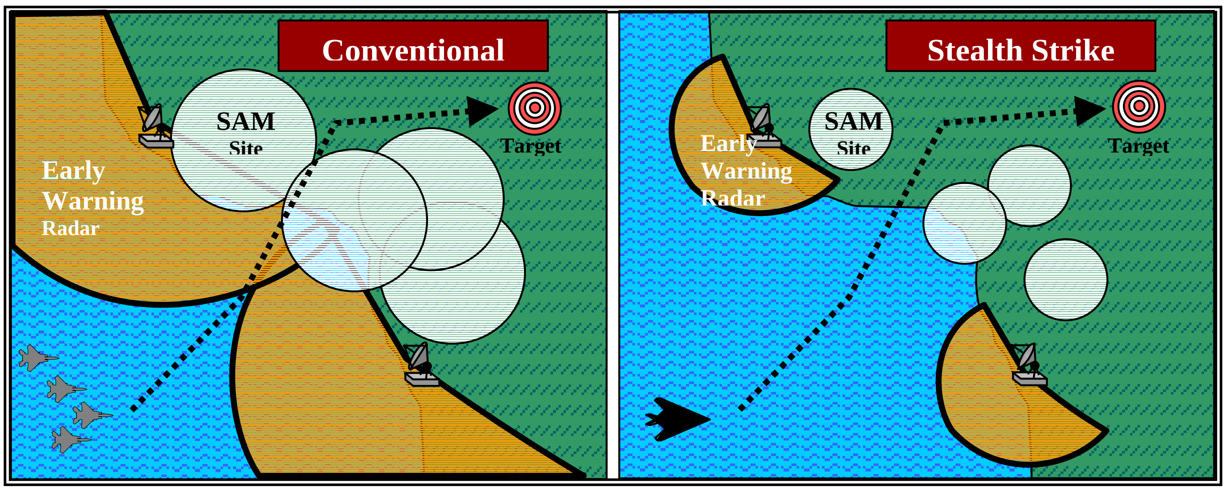
F-117 Doctrine

As the F-117 was developed under total secrecy and is, still, largely a classified system, any salient doctrinal documents pertaining to the F-117 are still classified beyond the level of this paper. What is available, however, is analysis of how the F-117 has been used in its short operational history. Since employment doctrine necessarily defines how the Air Force plans to accomplish its given task, one can infer the employment doctrine for the F-117 based on how the platform has been employed.

Avoiding enemy IADS when planning an air strike can be likened to "stepping around puddles of water."[258] Conventional, non-stealth aircrews plan their strike routes to avoid the SAM "puddles" to increase their chances of mission success and of making it home alive. If the puddles (or SAM threat rings) overlap, leaving no clear avenue of approach to the target, the conventional assets have historically had three options. The first is to accept the high risk of SAM engagement and expect losses. The second option is to create a strike package

[255] Grant, 26-27
[256] Ibid.
[257] Chun, 6
[258] Hallion, "Air Power and Joint Forces…"

consisting of electronic warfare and Suppression of Enemy Air Defense (SEAD) assets, which will reduce the risk somewhat. The third is to forego attacking the target, either abandoning it altogether or leaving its attack to some unmanned weapon – such as a cruise missile. Since the advent of stealth (in this case the F-117), a fourth option has emerged. Due to its ability to, in essence, shrink the puddles, the F-117 has the ability to create for itself a clear avenue of approach.



Source: Adapted from Rebecca Grant, *The Radar Game, Understanding Stealth and Aircraft Survivability*, (Arlington, Virginia: IRIS Independent Research, 1998), 37

Figure 8. Benefits of RCS Reduction in Air Strike Operations

The F-117's increased survivability, according to the original vision of air planners, would allow it to be employed in a high-threat area without the complex and sometimes cumbersome support packages required for conventional strike aircraft. The Squadron Commander of the 415th Tactical Fighter Squadron (TFS) – the first F-117 squadron deployed to Saudi Arabia in support of Desert Storm – equated F-117 capabilities with those envisioned by World War II air planners vis-à-vis the B-17 heavy bomber. The ability to hit targets deep within enemy territory and withdraw without taking losses had an irresistible pull on the Air Corps Tactical School (ACTS) cadre just as it did on the Gulf War air planners.[259] The ability to "sneak into places...avoid detection, and...kill targets" was made possible by stealth.[260]

The mantra of the F-117 community in the early days of stealth was, "We don't fly with USAF escort. We never have."[261] But the real "meat and potatoes" of the F-117 mission was "finding that 1,000-square-foot house in the middle of the city and... [hitting] the tool shed in the back yard."[262] Sounding very much like the ACTS concept of hitting the pickle barrel with unescorted, high-altitude B-17s, F-117 planners envisioned defeating enemy air defenses not by technologically superior physical means, but defeating enemy air defenses by technologically superior *meta*physical means. Rather than using the ACTS concept wherein the B-17 would physically overfly, outrun, or outgun the enemy defenses, the F-117 would simply transcend what was perceptible to the radar sensors, presenting a target seemingly without material form or substance. They would sufficiently shrink enemy radar detection ranges to create for themselves clear avenues of approach to their targets...and this they did.

The temptation to use this arguably revolutionary technology as the sole means upon which to rely for successfully achieving US strategic goals must have been compelling. This temptation, succumbed to by ACTS planners in World War II and air planners during the Cold War, would present itself again soon enough.

F-117 Employment

The F-117 has seen combat three times since becoming an operational system in 1983. While seven F-117s have been lost, only one has been to enemy fire.[263] Despite the attempts of anti-stealth

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[259] Lt Col Ralph W. Getchell, transcript of interview by TSgt Barry L. Spink and Hugh N. Ahmann, ed. and trans. Faye Davis, May 1992, p. 2, K239.0512-2047, AFHRA

[260] Ibid., 73
[261] Ibid.
[262] Ibid., 80
[263] Carlson, "DoD News Briefing: Stealth Fighters"

advocates to underrate its capabilities, its impressive combat record – with a high percentage of effective sorties, destroyed targets, and survivability – has drawn praise from all sectors of the Department of Defense. The manner in which the F-117 has been employed during these wartime operations reveals the level to which the Air Force has relied on the F-117's technological superiority to carry out its military strategy against its adversary. As in World War II, Air Force planners relied heavily – if not solely – on the F-117's technological prowess to engage strategic targets, believing that the aircraft's capabilities would keep it secure in the face of enemy fire. But unlike World War II, Air Force planners quickly realized the error in this line of reasoning *before* disaster forced them into acknowledging the essentiality of all three pillars of military success.

Operation Just Cause

In 1987, a former chief of staff of the Panamanian Defense Force (PDF) began overtly implicating Manuel Noriega in the 1983 death of former Panamanian dictator Brigadier General Torrijos. After Torrijos' death, Noriega took over the PDF, effectively becoming the dictator of Panama.[264] The internal Panamanian riots that followed these accusations prompted the chief of state, President Delvalle to relieve Noriega of his post at the PDF. In response, Noriega deposed Devalle and replaced him with one of his cronies.[265] The Panamanian people organized a national strike in reply to Noriega's actions, but Noriega unleashed his Dignity Battalions on the populace. After these forces brutalized the population, things settled down until mid-1989.[266]

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[264] Ronald H. Cole, *Operation Just Cause: The Planning and Execution of Joint Operations in Panama, February 1988 to January 1990* (Washington D.C.: Joint History Office of the Chairman of the Joint Chiefs of Staff, 1995), 6
[265] Notes, U.S. Southern Command briefing, subject: Operation Just Cause, "Rebirth of a Nation", no date, p. 1, K 464.335, AFHRA
[266] Ibid., 2

During 1988 and 1989, Noriega effectively obstructed the US ability to fully implement its rights under the 1977 Panama Canal Treaties. A total of 1,599 violations of those treaties occurred in these two years alone, increasing tension between the two states.[267] By this time, planning had already begun for direct action against the Panamanian dictator.[268]

In mid-1989, Noriega, in a show of cooperation, called for free presidential elections in Panama. When the Noriega-supported candidate lost, Noriega nullified the election (even 70% of the PDF voted for the opposition)[269] and unleashed his Dignity Battalions against the opposition, severely beating one of the candidates.[270] The ensuing riots and coup attempts amplified President Bush's concern over the safety of US citizens living in Panama, further straining relations between the two states.

On 15 December 1989, four US officers were stopped at a PDF roadblock. After PDF weapons were drawn, the car sped off as PDF guards fired. One soldier, Lt Robert Paz, USMC, was killed. An American couple that witnessed the event was detained, beaten, and molested.[271] Five days later, the full weight of American military might descended upon Panama.

On 20 December 1989, US forces initiated Operation Just Cause in Panama to safeguard American lives, restore democracy, protect the integrity of the Panama Canal Treaties, and to bring Noriega to justice.[272] The mission for the military was to "neutralize the PDF and

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[267] U.S. Southern Command briefing, subject: Operation Just Cause, "Rebirth of a Nation", no date, slide 6, K 464.335, AFHRA

[268] Lt Gen Peter T. Kempf, Commander, USSOUTHCOMAF, memorandum to Commander, Tactical Air Command, subject: Operation Just Cause After Action Report, 13 February 1990, p. 1, K464.335, AFHRA

[269] Minutes, Press conference with Lt Gen Carl L. Stiner (Commander, JTF South), 26 February 1990, p. 14, K-WG-37-Hi Vol 7, AFHRA

[270] Notes, "Rebirth of a Nation"

[271] Cole, *Operation Just Cause*, 27

[272] "Noriega Surrenders to US; Bush vows fair trial for ousted dictator", *The Atlanta Journal-Constitution*, 4 January 1990

other combatants...so as to protect US lives, property, and interests in Panama, and to assume full exercise of rights accorded by international law and the US-Panama treaties."[273] Eventually, about 24,000 US troops were directly involved in the operation[274], which was officially terminated on 31 January 1990.[275]

Source: http://www.rose-hulman.edu/~delacova/panama/panama10.gif

Figure 9. Noriega's Headquarters after Operation Just Cause.

This operation was the first time the F-117 performed under combat conditions. Prior to this operation, use of the F-117 was considered in 1983 (for the Grenada operation) and in 1986 (for Operation El Dorado Canyon in Libya). But Secretary of Defense, Caspar Weinberger, determined it was too soon to tip off the Soviets as to the existence of stealth aircraft in the US inventory.[276] Not only was this the first time the F-117 was used in combat, it was also the first

[273] U.S. Southern Command briefing, "Rebirth of a Nation", slide 18
[274] Minutes, Press conference with Pete Williams (Assistant Secretary of Defense for Public Affairs), 26 December 1989, n.p., K 417.01 v. 6, AFHRA
[275] Kempf memorandum, 1

[276] John A. Tirpak, "Two Decades of Stealth", *Air Force Magazine* 84, no. 6, June 2001, n. p., on-line, Internet, 1 May 2002, available from http://www.afa.org/magazine/June2001/0601stealth.html

time the F-117 had ever flown outside the continental US. Florida was as far away from Tonopah as the F-117 had ever flown. The combat operation for the F-117 was preceded by two exercises in which the aircraft flew from their home base to simulate attacks over Florida and returned. These exercises were in direct preparation for Just Cause and were designed to test the performance of the F-117 in a high humidity environment.[277]

The morning of 20 December 1989 began with a bang. In the opening moments of Operation Just Cause, multiple targets around Panama were attacked at precisely 0100 local.[278] Roughly 285 fixed-wing aircraft and 170 helicopters buzzed the skies over and near Panama.[279] At about 0020 local time, a group of F-117s crossed the western part of Panama, flying south toward the Pacific Ocean. Their flight path subsequently took them east and then back to the north to meet their Time Over Target (TOT). At 0100, two unescorted F-117s dropped one 2,000-pound bomb each at the Rio Hato airfield military complex, thus beginning Operation Just Cause.[280] Exactly three minutes after the F-117s attacked Rio Hato, Army Rangers dropped from C-130 aircraft to secure Rio Hato military complex.[281]

The precision-guided munitions from the F-117s impacted in an open field about 150 yards from the PDF's 6th and 7th Rifle Company barracks.[282] The intended purpose of this "error" was twofold. Intentionally missing the target would minimize casualties, but it would also serve to "disorient, …confuse, and frighten" the sleeping PDF soldiers in an attempt to pin them in their barracks as the Rangers airdropped onto the airfield.[283] The Rangers would then surround the

[277] Getchell interview, 4
[278] Notes, U.S. Southern Command briefing, "Rebirth of a Nation", 10
[279] Lt Gen Stiner Press Conference, 6
[280] Notes, U.S. Southern Command briefing, "Rebirth of a Nation", 12
[281] Lt Gen Stiner Press Conference, 6
[282] Cole, *Operation Just Cause,* 38
[283] Williams Press Conference

barracks and broadcast surrender propositions to the barracks' inhabitants, followed by direct action against them if no surrender came forthwith.[284]

Lieutenant General Carl A. Stiner, the Army general commanding the Joint Task Force, asked his air component commander, Lt Gen Peter T. Kempf, which Air Force system could ensure a 95 % chance that a target would *not* be hit, but instead *nearly* hit. General Kempf recommended the F-117.[285] Because Panama's air defense early warning systems were not robust, use of the F-117 was, at first, refused by senior leadership. But, once convinced of the technological superiority of the F-117's accuracy in delivering ordnance, the leadership ceded to Kempf's advice.[286] Hence, a total of six F-117s were used in Operation Just Cause, although only two engaged targets.[287]

It is commonly thought that, since Panama had a meager air defense system, stealth technology was not tested in this operation.[288] Perhaps the radar-evading facet of the F-117 was not tested, but surely the visual and audio aspects were. Approximately one hour prior to the commencement of operations, it became clear to General Stiner that the Panamanians knew of the attack.[289] As a consequence, at the time of the attack, the PDF soldiers at Rio Hato were not in their barracks, but in their defensive positions.[290] Their orders were to "Draw your weapons and get out on the airfield; start shooting when they come over."[291] The visual and audio aspects of the F-117's stealth design permitted it to

[284] Lt Gen Stiner Press Conference, 15
[285] Ibid.
[286] Cole, *Operation Just Cause,* 31,32
[287] Lt Gen Stiner Press Conference, 16
[288] Harold P. Myers, "Nighthawks over Iraq: A Chronology of the F-117A Stealth Fighter in Operations Desert Shield and Desert Storm," Special Report no. 37FW/HO-91-1 (Holloman AFB, NM: HQ 37 FW Office of History, 9 January 1992), 3
[289] Notes, U.S. Southern Command briefing, "Rebirth of a Nation", 14
[290] William T Y'Blood, "Peace is Not Always Peaceful," in *Winged Shield, Winged Defense: A History of the United States Air Force*, ed. Bernard C. Nalty (Washington D.C.: Air Force History and Museums Program, 1997), 436
[291] Cole, *Operation Just Cause,* 34

approach Rio Hato unseen and unheard. The fact that, only moments after the initial attack, the skies over Rio Hato were filled with AAA fire, shows that the PDF were indeed at the ready and that the stealthiness of the F-117 was effective.[292]

Fifteen days after it had begun, Manuel Noriega surrendered, emerging from the Vatican Embassy to face US soldiers, 20,000 anti-Noriega demonstrators, and, eventually, the US Justice System.[293]

Operation Desert Storm

In the late 1980s, unfolding events in the former Soviet Union and Warsaw Pact overshadowed, for the most part, events in Iraq. In 1988 most military minds guessed that Iraq would not – could not – be a threat to anyone as it licked its wounds from the recently ended Iran-Iraq War. Even so, the US had been keeping at least one eye on Iraq. Its propensity for using chemical weapons was cause for some concern, even if those weapons were used internally. In mid-July 1990, Iraqi dictator Saddam Hussein began publicly accusing neighboring Kuwait of oil over-production and even of stealing oil that rightfully belonged to Iraq. The US position on these accusations and clashes of interest between Iraq and Kuwait were addressed with Saddam Hussein by April Glaspie, US Ambassador to Iraq on 25 July 1990. In this meeting, the Ambassador told Saddam Hussein, on instructions from the State Department, that Iraq's "border differences" with the tiny sheikdom were of no concern to the US.[294]

It was during this time, on 21 July 1990, that US Central Command (USCENTCOM) was informed of an Iraqi armor division that had moved immediately north of the Kuwaiti border. Additionally,

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[292] History, Fourteenth Air Force, 1 January – 31 December 1989, Volume II, Document 9, K419.075-3 v. 2, AFHRA

[293] "Noriega Surrenders to US" article

[294] Dan Goodgame, "The Two George Bushes," *Time* 137 no. 1, 7 January 1991, n.p., on-line, Internet, 15 May 2002, available from http://www.time.com/time/poy2001/archive/1990.html

approximately 3,000 military vehicles had been spotted on roads between Baghdad and areas north of Kuwait.[295] Three days later, the Commander-in-Chief of USCENTCOM (USCINCCENT) assessed Iraqi strength along Kuwait's border was strong enough to successfully invade Kuwait.[296] By the end of July, there were roughly 80,000 combat troops and 20,000 combat support troops within 20 miles of the border.[297] Only five hours after USCENTCOM formally warned of an impending invasion, Iraqi forces pushed across the Kuwaiti border and continued toward the capital city.[298]

In the months that followed, many diplomatic attempts were made to resolve the situation, all of which failed. On 15 January 1991 President Bush released National Security Directive 54, which authorized "military actions designed to bring about Iraq's withdrawal from Kuwait" and laid out clear national and military objectives.[299] This directive also put forward military restrictions with regard to minimizing friendly casualties and enemy collateral damage.[300] Two days later, coalition forces attacked Iraqi units in Iraq and Kuwait. After 39 days of "the most lethal and intensive air attack[s] in history," the ground offensive began.[301] Lasting only 100 hours, the National Command Authority and USCINCCENT determined that Desert Storm's objectives had been met.[302]

During the deployment phase in 1990, the F-117s of the 415 TFS deployed to King Khalid Air Base, Saudi Arabia.[303] By 25 January 1991,

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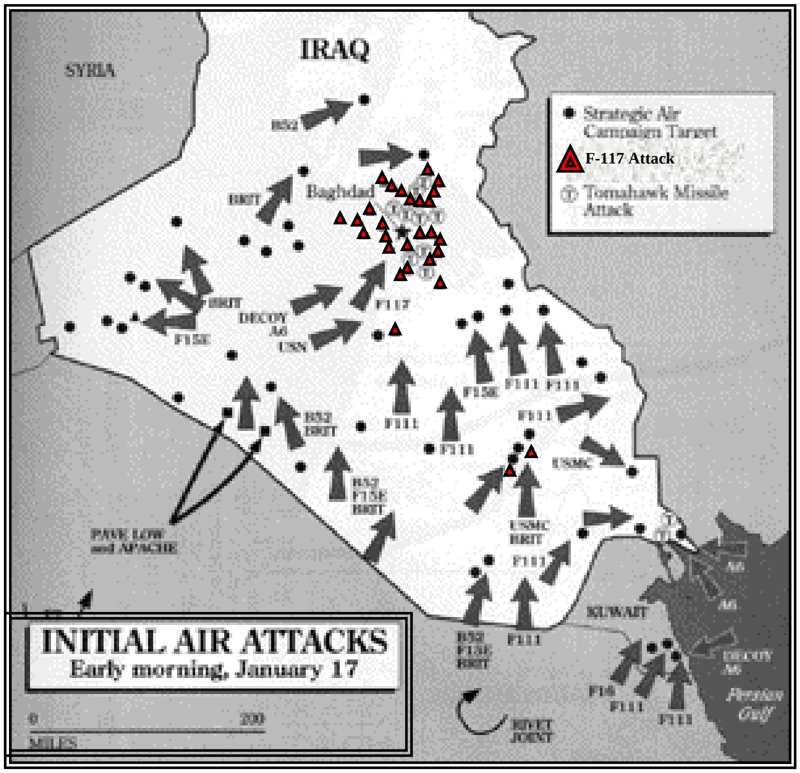
[295] Report of United States Central Command (USCENTCOM), "Operation Desert Shield/Desert Storm: Executive Summary," 11 July 1991, 3
[296] Ibid.
[297] Ibid.
[298] Ibid.
[299] National Security Directive 54, Responding to Iraqi Aggression in the Gulf, 15 January 1991, 2
[300] Ibid., 2-3
[301] USCENTCOM "Executive Summary", 11

[302] Ibid.
[303] Getchell interview, 26

after hostilities had begun, two squadrons of F-117s were parked in the best hardened aircraft shelters money could buy.[304]



Source: http://www.pbs.org/wgbh/pages/frontline/gulf/maps/3.html

Figure 10. Initial Air Strikes in Desert Storm

The first night of the war was a harrowing experience for F-117 pilots. Twenty-nine sorties were launched in three waves to attack 26 heavily-defended, high-value targets deep in the heart of the enemy IADS.[305] Roughly an 1800-mile round trip to the targets and back, the first wave launched at 0022 local to meet the 0251 and 0252 TOTs.[306] Central IADS command facilities were prime targets as were radar facilities. Communication nodes, such as telephone exchanges, communications satellite terminals, and television transmitters were also targets. Iraqi Air Force headquarters buildings and airfields were

[304] Myers, "Nighthawks over Iraq," 5, 7, 14
[305] Ibid., 3
[306] Getchell interview, 106-108

attacked on multiple waves, and presidential grounds and bunkers were hit with precision.[307]

The mission of the F-117 was to penetrate the very heavily defended areas in and around Baghdad and to employ precision-guided munitions autonomously.[308] The success of this first wave was essential. The F-117s, coupled with Navy Tomahawk missiles, had the task of degrading Iraqi IADS to such a degree that the air defense network of the enemy would not significantly degrade the follow-on strikes using conventional aircraft.

Due to the high density of SAMs and AAA around Baghdad, the Iraqi capital became the near-exclusive domain of the F-117s.[309] According to the commander of the 415 TFS, "We didn't have to worry about the SAMs because of the characteristics of the [F-117]."[310] This arrangement permitted the ever-scarce support aircraft (EF-111 Ravens, F-4G Wild Weasels, etc...) to concentrate on protecting the conventional non-stealth aircraft strike packages. In keeping with doctrine, the F-117s flew their strike missions unescorted, demonstrating that the aircraft "can operate and survive, alone, against very sophisticated and lethal defenses."[311] However, in a divergence from the tacit employment doctrine, air planners did, in fact, task aircraft such as the EF-111 electronic warfare (EW) asset to provide shield for the stealth strikes. These EW aircraft were not "packaged" with the F-117, but instead were tasked to be in the general geographic area when the strikes occurred. On occasion, the F-117 planners even requested EF-111 support.[312]

This acknowledgement that shield aircraft could be useful in protecting the F-117 prompted many to doubt the worth of the stealth

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[307] Myers, "Nighthawks over Iraq," 8-9
[308] Getchell interview, 1
[309] Ibid., 179
[310] Ibid., 193
[311] Lt Col Ralph Getchell, "Stealth in the Storm: Sorting the Facts from the Fiction," Research Report (Maxwell AFB, AL.: Air War College, 1992), 4
[312] Ibid.

aircraft. It was, after all, touted as having the ability to strike deep targets regardless of enemy defenses without any assisting shield aircraft. This capability seemingly justified the expense. After the war, stealth skeptics unjustly criticized stealth proponents, accusing them of "revising the war record" to rationalize the existence of the F-117.[313] The unsubstantiated belief that "significant numbers of F-117As *had* to be escorted by radar-jamming escort planes" made these skeptics question the efficacy of the F-117.[314] Was the superiority of US stealth technology good enough to justify its cost? Had the Air Force continued stealth development as a bid for budget dollars? The packaging of F-117s with support aircraft was seen as a failure of stealth technology, but in reality, it was anything but.

The air planners of the Gulf War saw EW support for the F-117 as a "good insurance" policy.[315] If an F-117 had a malfunction during a strike mission, the EF-111 would provide enough jamming of enemy IADS for the F-117 to escape to less-threatening airspace. If a bomb bay door jammed in the open position, much of the aircraft's stealth characteristics would be rendered ineffective due to the radar reflectivity of the open doors.[316] Additionally, this EW support was only requested, and given, when F-117s attacked the heavily defended areas in or near Baghdad, which was defended by an estimated 60 SAM batteries and roughly 1,800 AAA guns.[317]

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313 Rep. Andy Ireland, "The Real 'Stealth' is in the Tactics of Planes' Backers," *Christian Science Monitor*, 7 January 1992, 19

314 Ibid.
315 Getchell, "Stealth in the Storm," 2
316 Getchell interview, 156
317 Getchell, "Stealth in the Storm," 2

Source: http://home.freeuk.com/planefacts/patch/page5.htm

Figure 11. F-117 Patches from Desert Storm

Furthermore, the F-117 was never packaged – as some asserted – with these assets. The EF-111s were assigned an area to cover with radar jamming, not knowing where the F-117 strike would occur, or even *if* it would occur. In a strike package, if the EW assets cancel or abort their mission, the rest of the strike package likewise cancels. In the case of the F-117, "no provision was made to cancel the attack or even notify the attacking Stealth Fighters should the [EF-111s] be forced to abort their mission."[318] The Air Force realized that, while not required, using shield assets to aid in the protection of F-117s was a smart way to do business. A significant event, such as that experienced at Schweinfurt, was not required to convince air planners that reliance on a single technological solution for the prosecution of strategy could be a fatal proposition.

[318] Ibid.

Operation Allied Force

The ethnic *mélange* that characterizes the Balkan region has given rise to many cultural clashes in recent times. An orphan of the disbanded Austro-Hungarian Empire, Yugoslavia maintained relative internal serenity under Prime Minister Josip Tito until his death in 1980. Just over a decade later, the federation of six republics and two provinces began to violently fracture along ethnic lines. After several republics successfully gained independence from Yugoslavia, rumblings of a movement for independence led to violent clashes between Kosovars and Serbian authorities in the Kosovo province.

In early March 1998, President Milosevic launched a series of strikes into Kosovo to suppress the Kosovar insurgent movement (the Kosovo Liberation Army – KLA).[319] After it was learned that the civilian population of Kosovo was terrorized during these strikes, world attention once again turned to the Balkans. Diplomatic and economic pressures brought to bear against Milosevic seemed to have little effect, and in January 1999 – after more civilians were killed or mutilated in three towns in Kosovo – Joint Task Force Noble Anvil was created.[320]

In March of that same year, after peace talks proved fruitless, Yugoslavian forces launched a major offensive into Kosovo replete with crimes against humanity. By 23 March 1999, NATO Secretary General Solana had seen enough and ordered NATO's Supreme Allied Commander, Europe (General Clark) to initiate air operations to bring to an end the killing in Kosovo. Operation Allied Force began the following day. [321]

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[319] US General Accounting Office, *Kosovo Air Operations: Need to Maintain Alliance Cohesion Resulted in Doctrinal Departures*, Report to Congressional Requesters no. GAO-01-784 (Washington D.C.: General Accounting Office, July 2001), 18

[320] Ibid.

[321] Ibid., 18-19

Based on the threats of air strikes in 1998 and on the results of Operation Deliberate Force, NATO members believed the operation would be of short duration. Indeed, it may be because of this belief that NATO members were willing to participate in Allied Force.[322] The operation began with three Air Expeditionary Wings (AEWs) in eight locations. Seventy-eight days later, ten AEWs were providing combat power to Allied Force.[323] During those 78 days, approximately 900 NATO aircraft flew approximately 38,000 sorties. Serbian IADS fired 700 to 800 SAMs at NATO aircraft and two were downed; one of which was an F-117.[324] On 10 June 1999, Secretary General Solana called for suspension of hostilities and by 20 June, Yugoslavian forces had completely withdrawn from Kosovo.[325]

Surface-to-air missiles presented a constant threat to NATO airmen in Allied Force despite allied SEAD efforts. After the EF-111 and the F-4G (with their combined radar-jamming and radar destruction capabilities) were retired, the Air Force's capacity to conduct EW and SEAD operations was, in essence, retired with them.[326] The Air Force put its trust in the Navy's EA-6B to fill the gap left by the EF-111 retirement, but the EA-6B (considered a high-demand, low-density asset) is in short supply. The F-16CJ picked up the SEAD role left by the F-4G retirement, but this, too, is an aircraft in short supply. The US had only 48 F-16CJ and 30 EA-6B during Allied Force, along with a few German and Italian Tornados specially equipped to serve as EW assets.[327] These aircraft had to contend with the Serbian IADS, which had an estimated 22 SA-3 and SA-6 batteries plus multiple shoulder

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322 Ibid., 10

323 Lt Gen Michael C. Short, transcript of "End of Tour Report Interview" by Carol H. Parks, 23 March 2000, 9

324 Christopher Bolkcom, *Airborne Electronic Warfare: Issues for the 107th Congress*, Congressional Research Service Report RL30841 (Washington D.C.: Library of Congress, 9 February 2001), 5

325 US General Accounting Office, *Kosovo Air Operations*, 19

326 Kenneth S. Lambeth, *NATO's Air War for Kosovo: A Strategic and Operational Assessment* (Arlington, VA: RAND, 2001), 115

327 Ibid., 103

fired SA-7, -9/13, -14, -16, and –18 missiles in a country roughly the size of Kentucky.[328] Due to Serbian IADS tactics, US forces had enormous difficulty detecting and engaging SAMs whose operators minimized their radar emissions.[329]

Initially, NATO EW aircraft effectively jammed Serbian early warning radar. This forced the SAM operators to use their fire control radar, which, in turn, made them susceptible to F-16CJ attack. The Serbian countertactic to this was learned from their counterparts in Iraq in the eight years of Iraqi No-Fly Zone operations. The Serbian SAM operators simply minimized their radar emissions and dispersed themselves such that NATO aircraft could neither detect nor destroy them.[330] Serbian SAMs resorted to electro-optical guidance rather than radar guidance and sometimes fired at the trailing aircraft in strike packages in order to maximize the range between themselves and NATO SEAD aircraft.[331]

The radars in Serbia that were not under imminent attack could pass enough data, although inexact, to those SAM sites along the expected flight path of the strike package. Hence, SAM operators could take vague data from several radar sites and fuse it to minimize the time required to track and shoot allied aircraft. Minimizing the time for this process allowed the SAM to be fired and the radar shutdown before NATO SEAD aircraft could detect the radar emission. The result of these tactics was that enough enemy SAMs remained intact to drive NATO leadership to restrict friendly air operations to 15,000 feet or above.[332] Also a result was the fact that the Serbian SAM threat was persistent. Those SAMs that could be located by intelligence sources

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[328] Lambeth, 110 and Bolkcom, 7
[329] Bolkcom, 6
[330] Lambeth, 102-104, 111
[331] Ibid., 105, 115
[332] Michael C. Short, "An Airman's Lessons from Kosovo," in *From Manoeuvre Warfare to Kosovo?*, ed. John Andreas Olsen (Trondheim, Norway: Royal Norweigan Air Force Academy, 2001), 263

could be avoided, but those that could not be located could not be avoided.

On the fourth night of the war, 28 March 1999, the weather over the Balkans was not conducive to flying operations. Even so, the single F-117 tasked to attack targets in Serbia pressed toward his second assigned target of the evening. Approximately 28 miles northwest of Belgrade, the F-117 was shot down by enemy fire. The fire that took the aircraft down was a barrage of SAMs, probably the aging SA-3 system.[333] The undetected SAM battery responsible for the loss had not been located and, hence, did not appear on intelligence maps for air planners.[334]

Source: http://www.afa.org/magazine/June2001/0601stealth.html and http://www.fas.org/man/dod-101/sys/ac/f-117-nn4.jpg

Figure 12. F-117 Wreckage in Serbia

Several factors most likely led to the disaster. The Serbs most certainly obtained advance notice of the F-117 strike. Media coverage of Allied Force was heavy and the Serbs in all likelihood had spotters on the ground in Italy passing information to Serbian IADS operators. Further, according to General Clark, it was as "clear as the nose on your face" that information was being passed directly to Belgrade from Aviano

[333] Vince Crawley, "Air Force Secretary Advocates C-130s, Predators," *Defense Week,* 26 July 1999, 2
[334] Tirpak

Air Base (where the F-117s were based).[335] Hence, it is possible that Serbian IADS operators knew not only that an F-117 was taking off from Aviano, but also perhaps his route of flight or general target location. Add to this the fact that an early warning radar site located in Montenegro – politically off limits to US attack – was constantly providing information to the Serbian IADS network.[336] This advance knowledge made the F-117 rather predictable, but the fact that strike routes had been identical the preceding three nights only redoubled Serb awareness.[337]

Political constraints restricted the flight profile of the F-117. Crucial to its ability to minimize its RCS is the requirement that the F-117 approach enemy IADS at optimum aspect angles.[338] If the aircraft is required to maneuver or turn during its run on the target, the optimum attitude with respect to enemy radar is lost, thereby increasing its RCS. Restrictions on overflight of Bosnia (which were subsequently lifted) severely limited the ability of the F-117 to establish optimum RCS attitudes.[339] This was further complicated by the small volume of airspace in which the F-117 was operating. As the F-117 dropped its weapon on its first target of the evening, it became immediately visible to enemy radar systems as its bomb bay doors opened.[340] This most assuredly gave Serbian IADS operators a rough fix on his location. The compactness of airspace made the F-117 follow-on route of flight predictable.

In a definite departure from employment doctrine used in Panama, and in contrast to the procedures of early stealth days, F-117s not only had the aid of EW assets (as in Desert Storm), but were actually

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[335] Eric Rosenberg, "Clark Looks Back on Kosovo Conflict," *Defense Week*, 23 August 1999, 9
[336] Lambeth, 102-103
[337] Ibid., 118
[338] Grant, 30
[339] US General Accounting Office, *Kosovo Air Operations*, 13
[340] Lambeth, 118

packaged with them.[341] On the night in question, however, a tactical blunder positioned the EW assets too far from the F-117 to give it sufficient protection.

The Pillars and the Pendulum

In World War II, the AAF doctrine of unescorted, high-altitude, daylight precision bombing relied solely on the B-17 weapons system to execute its industrial web strategy in Europe. Not adequately heeding the shield pillar, the AAF sent its bombers into harm's way without the fighter protection it needed to effect higher survivability rates and acceptable loss rates. The AAF was not sufficiently prepared for the high- and low-tech counters to the technological superiority of the B-17 that eventually swung the pendulum in Germany's favor. Further, it did not envision the failure of this technology to live up to its anticipated potential. After some disastrous results in terms of poor performance and lives lost, the AAF altered its doctrine to account for these factors with favorable results.

Between World War II and Vietnam, Air Force doctrine relied largely on the technology of nuclear weapons and those aircraft that would deliver them to carry out its strategy. Not fully appreciating the need for the shield pillar, the fighter and electronic warfare assets of the Air Force lagged. For the most part, only strategic nuclear bombers, tactical nuclear fighters, and aircraft designed to intercept Soviet strategic nuclear bombers were funded and procured. The Air Force was not effectively prepared for a war whose political context minimized that technological superiority, allowing the pendulum to swing in favor of North Vietnam. Its force structure was not adequately prepared to engage in non-nuclear strike, fighter escort, or close air support

[341] Bolkcom, 5

missions. It adapted as best as it could, but the lesson was forgotten after the final defeat.

From Operation Just Cause to Operation Allied Force, the Air Force had the potential to base its doctrine solely on the technological superiority of stealth to carry out its strategy in those campaigns. The cost of the F-117 and the paucity of these aircraft perhaps prevented exclusive reliance on the technology, but the actions of air planners show a definite evolution in doctrinal thinking. In this case, realizing that reliance on this one technology could be disastrous, the shield was not forgotten. Witness the difference between "We don't fly with USAF escort. We never have"[342] with "We routinely package these airplanes with the suppression of enemy air defense [assets]."[343]

The fact that an F-117 could be shot down does not negate the advantage of stealth. It only shows that this advantage can be overcome. If Kosovo shows us that the Air Force can learn to diversify its reliance on technology, it also shows us how low-tech tactics can usurp high-tech advantage. Fortunately, the Air Force had anticipated this by evolving from a doctrine of solitary F-117 employment, to one of packaged F-117 employment. The loss of the F-117 was not necessarily due to a doctrinal failure or an over-reliance on a single technology; it was a tactical failure that was exacerbated by political constraints, externally generated circumstances, and low-tech innovative tactics.

General John P. Jumper (then Commander, Air Combat Command) was right when he said that F-117s "don't need escort jammers."[344] But this statement was clearly made assuming the IADS is the only enemy threat. If the geographical or political context of a conflict is also a threat (as was the case in Kosovo), overlooking the

[342] Getchell interview, 73
[343] Carlson, "DoD News Briefing: Stealth Fighters"
[344] Tirpak

potential effects of that threat can leave the way open to a pendulum swing.

Current Air Force Doctrine abounds with references to stealth. Refreshingly, it does not refer to stealth technology as the panacea weapons system. Mostly, stealth is referred to as a passive defense system,[345] or as one of many means to increase survivability when employing precision munitions.[346] In 1940, Major Muir Fairchild stated that "no barrier can be interposed to shield...against the airplane."[347] The ultimate airplane of the time – the B-17 – was described as "a long-range, self-defended, offensive terror of the skies – truly a flying fortress."[348] Perhaps in response to this precarious statement, Air Force Doctrine Document 2-1.2, *Strategic Attack* states, "when employing... stealth aircraft...which, similar to the bombers of the late 1930s, are presently seen as providing essentially their own air superiority, the... threat should be thoroughly analyzed. Appropriate supporting counterair, counterspace, and counter-information should be planned."[349]

In the case of stealth, the Air Force succeeded in adopting a radical technology into its concept of operations without yielding to the temptation of putting all its eggs in the stealth basket.

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[345] Air Force Doctrine Document (AFDD) 2-1.1 Draft, *Counterair Operations*, XX January 2002, 3
[346] AFDD 2-1.2, *Strategic Attack*, 20 May 1998, 20
[347] Major Muir S. Fairchild, "The Aim in War," lecture, Air Corps Tactical School, Maxwell Field, AL, 27 May 1940, 12, 49
[348] Research Studies Institute, USAF Historical Division, "The Development of Air Doctrine in the Army Air Arm, 1917-1941," USAF Historical Study no.89, p.46-47, 5-3414-8B, AFHRA
[349] AFDD 2.1-2, 25

Chapter 5

Technology: Implications for the Future

It is in time of peace that we must develop our technical equipment and train our personnel. We cannot do these things after the beginning of hostilities nor can we suddenly shift from one type of vital technical equipment to another after the fighting starts. Our leaders in peacetime should have sufficient imagination, vision, and experience to direct technical development and personnel training upon sound lines.

--Claire Chennault

The very systems that make military operations easier become themselves a target for counter-action.

--Richard Hallion

Technology is good, to be sure. It reduces casualties while expediting peaceful resolutions. But relying on one war-winning panacea technology is done at our own peril. Prosecuting wartime strategy with doctrine based wholly on a single, superior technology has, in times past, complicated efforts to win wars. Before the Air Force embraces – in toto – its future force structure with magical technology on which to base its doctrine, a look at history brings to light the dangers therein. This study demonstrates that the pendulum swing is certain (although not necessarily constant) and that, if one of the pillars of military success is neglected in deference to technology, adverse outcomes result when the pendulum *does* swing.

The World War II ACTS doctrine of unescorted, high-altitude, daylight bombardment was wrapped up in one technological marvel – the heavy bomber weapons system. This doctrinal reliance on one technology to carry out its industrial web strategy cost the AAF many aircraft and many more lives. With regard to the pillars, this reliance minimized the perceived need for the shield protection provided by escort fighters. The Germans countered with both high- and low-tech methods. Additionally, the Norden technology never fully realized its promised accuracy. As a result, the pendulum swung in Germany's favor until the AAF rectified the situation by embracing the shield and incorporating that shield into its operational doctrine.

Between World War II and Vietnam the Air Force's nuclear doctrine was also wrapped up in one technological marvel – the nuclear weapon. This doctrinal reliance on one technology to carry out the strategy *du jour* (assured destruction, massive retaliation, mutual assured destruction**,** etc.) left the Air Force poorly prepared for a non-nuclear war in Vietnam. With regard to the pillars, both the shield and the conventional sword were marginalized. Escort fighters and electronic warfare capabilities atrophied and nearly all bomber and fighter aircraft were designed specifically to deliver nuclear weapons.

While nuclear weapons definitely lived up to their full potential, political constraints put the US military in a position wherein its panacea nuclear technology could not be used. The Air Force had to fight a war with outdated conventional assets or adapt the nuclear assets to conventional roles. Because of this, the pendulum swung in favor of the North Vietnamese. While this reliance on nuclear weapons (and the resultant effect on the pillars of success) was not the only reason that war was lost, surely it played a significant role.

The successful deterrent role of nuclear weapons cannot be denied. The threat of their use was enough to prevent the Soviets from invading Europe or attacking America. The assumption that the deterrent and destructive qualities of nuclear weapons would render obsolete conventional war may have been the belief of the day, but the nature of the Korean War demonstrated that conventional, non-nuclear war was indeed possible in the nuclear age. The Vietnam War should have driven that point home to air planners.

The decade between 1989 and 1999 saw a strategic targeting doctrine that was initially wrapped up in one technological marvel –

stealth. But in this case, the doctrine evolved rather quickly from unescorted nighttime bombing to escorted nighttime bombing. With regard to the pillars, the shield was initially neglected, but then embraced before disaster forced the issue. Even though this pillar was embraced, Serbian low-tech tactics were able to swing the pendulum – at least for a time. Additionally, like the Vietnam scenario, the political context of Operation Allied Force reduced the efficacy of the F-117's stealth. While it did not prevent the use of the F-117, the political constraints dictated its tactics, prohibiting air planners from maximizing the stealth technology of the F-117. The resultant pendulum swing cost the Air Force one very expensive, very capable aircraft.

One downed aircraft seemingly pales in comparison to the huge losses sustained in WWII. We were, in World War II, involved in a total war with national survival at risk. But if tomorrow we again have to engage in total war for national survival, the fact remains that we have *far* fewer combat assets with which to engage the enemy now than we did in World War II. Because of this, it is evident that losing fewer aircraft could have as devastating an effect on current warfighting capabilities as losing many aircraft did in World War II. While a cost comparison may not take into account specific capabilities or numbers of lives lost, it can at least give some idea the impact losing aircraft can have on the ability of the Air Force to achieve success. A comparison of F-117 and B-17 sheds light on this impact. In 1943, B-17 unit cost was $230,000[350], equivalent to $2,214,913 dollars in 1991.[351] In 1991, F-117 unit cost was $45,000,000.[352] In terms of cost, losing one F-117 would have been equivalent to losing 20.3 B-17s. Because the F-117 is

[350] *Army Air Forces Statistical Digest, World War II*, (Washington DC: Office of Statistical Control, December 1945), 134

[351] This dollar equivalent was calculated using an Inflation Conversion Calculator available from Oregon State University (http://www.orst.edu/dept/pol_sci/fac/sahr/sahr.htm). The amount $2,214,913 represents roughly the average dollar equivalent found using 7 different on-line inflation conversion calculators.

[352] "USAF Factsheet: F-117A Nightawk," *Air Force News Online*, April 2002, n.p., on-line, Internet, 27 May 2002, available from http://www.af.mil/news/factsheets/F_117A_Nighthawk.html

so costly, hence scarce, it has a larger impact on total force structure if one is lost. For example, in 1943, there were 3,528 B-17s in service.[353] Losing 20.3 B-17s would equate to losing less than one-half of one percent of the total B-17 force structure. In 1991, there were 57 F-117s in operational service. Losing one F-117 equates to losing two percent of the total F-117 force structure (four times more than the B-17 loss). Now imagine losing six F-117s to enemy fire on one mission. Losing six aircraft to enemy fire seems relatively trivial, but in this case, more than 10% of the F-117 fleet would be gone. That is 10% of our ability to accomplish deep penetration strikes into high-threat areas.

Future Technology and Doctrine

How do these lessons impact the future of the Air Force? The Air Force is always in the process of trying to optimize its force structure to properly meet future challenges. During the early Cold War, its force structure was optimized for nuclear war. After Vietnam, this force structure shifted to favor meeting a large, more conventional adversary. Since the fall of the USSR, the Air Force has been trying to find its role in national defense. The monolithic Soviet threat is gone and the focus on winning large wars is dissipating. Desert Storm ostensibly steered the Air Force back toward that mindset, but the multitude of contingency and small war operations since then keeps tugging the Air Force leadership to reconsider the Air Force's role in national security, both at home and abroad. The events of 11 September 2001 underscore the complexity of the juncture at which the Air Force stands. But regardless of the role or roles the Air Force assumes in the coming years, the Air Force senior leadership realizes that many states currently (or will in the future) have robust anti-access and air defense capabilities. In fact, "potential U.S. regional adversaries spending on the

[353] *Army Air Forces Statistical Digest*, 138

order of only $15-20 billion over a decade in the global marketplace could develop robust theater-denial/disruption capabilities."[354] Whether large war, small war, or anti-terrorist strikes, the Air Force will most likely have to enter very hostile skies to achieve political ends.

The multitude of military operations in the decade of the 1990s taught the Air Force many lessons. Restrictive rules of engagement and high-level political involvement in the targeting process are likely for the foreseeable future.[355] Additionally, public demand for low collateral damage "is here to stay."[356] Tied in with this demand is the notion that "our enemies have...found that fighting the United States does not require a 'win.' Their objective simply could be not to lose. Shooting down a *single aircraft* [emphasis added] or sinking a single ship may be enough to turn the tide of public opinion, regardless of the raw numbers on the scoreboard."[357] Finally, the issue of access assurance will be an important factor in the future. Physically, the enemy may have advanced air defense and area denial weapons to inhibit US and allied entry into the theater. Politically, US and allied forces may be denied access to geographically strategic bases if the states in which these bases lie are unwilling to support US efforts.[358]

With these lessons in mind, the Air Force has been searching for the right force structure to maximize combat effectiveness given these constraints. Precision weapons with smaller warheads mitigate restrictive ROE and reduce collateral damage. Airframes with greater targeting capability allow airmen to attack more targets with fewer aircraft, reducing the number of airmen put at risk. More precise

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[354] Department of Defense, *Final Report of the Defense Science Board Task Force on Globalization and Security* (Washington D.C.: Office of the Under Secretary of Defense for Acquisition and Technology, December 1999), 25
[355] Gen John P. Jumper, "Global Strike Task Force: A Transforming Concept, Forged by Experience," *Aerospace Power Journal*, Spring 2001, 28
[356] Ibid.
[357] Ibid.
[358] Ibid.

intelligence will allow more precise targeting, which will reduce collateral damage and increase destructive potential. Stealth combined with precision weapons will mitigate the anti-access problem.[359]

These technologies are what the Air Force will rely upon when conducting operations in the future. The concept by which these technologies will be employed does not yet exist, but several potential doctrines are currently being examined in their embryonic stages. The most prevalent doctrine being espoused by Air Force leadership is the Global Strike Task Force (GSTF) model.

Global Strike Task Force

"Today, we stand on the brink of technological advances that can prompt a new concept of aerospace power employment," said General Jumper.[360] As early as 1998, the Global Strike Task Force concept was in the works as a solution to the impending anti-access threat.[361] The technologies previously discussed make GSTF feasible, but what makes GSTF possible is stealth.

Commonly referred to as the "kick-down-the-door" concept, GSTF is not envisioned as a war-winning scenario. Rather, it provides "a capacity to systematically destroy hundreds of targets, roll back enemy defenses, and clear the way for follow-on forces."[362] The GSTF relies on F-22s and B-2s from the two lead Air expeditionary forces to destroy the most critical targets in a one to three day bombing campaign. Initially, the F-22 and B-2 aircraft would operate from bases outside the lethal range of enemy theater ballistic missiles. From these bases, these aircraft conduct long-range strikes, skirting the edges of enemy SAM

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[359] Gen John P. Jumper, Commander, Air Combat Command, address to the Air Force Association 17th Annual Air Warfare Symposium, Orlando, FL, 15 February 2001, n.p., on-line, Internet, 13 May 2002, available from http://www.aef.org/pub/jumper2001.asp
[360] Jumper, "Global Strike Task Force," 25
[361] Ibid., 29
[362] Ibid., 31

threat rings, launching standoff weapons to destroy enemy air defense systems and strategic targets.[363] This series of strikes thus enable entry into the theater of more conventional forces by eliminating the anti-access threats.[364]

The stealthy nature of the F-22 coupled with its super-cruise capability essentially shrinks SAM threat rings, allowing it to deliver its standoff munitions deep within enemy territory (see Figure 13). The F-22 paves the way for follow-on forces (including the B-2) by establishing "local air superiority through the traditional 'sweep' role and through air-to-ground targeting of the enemy's air defense network."[365] As the F-22s exit enemy airspace, the B-2s then enter and conduct strikes using standoff munitions against enemy weapons of mass destruction, command and control facilities, critical manufacturing facilities, and the like.[366] In this scenario, the F-22 enables for the first time 24-hour stealth capability. Its presence and its capabilities allow other stealth assets (such as the F-117 and B-2) to conduct daylight operations.[367] Combining 52 F-22 and B-2 sorties with the promised small diameter bomb, the GSTF ostensibly could destroy around 400 targets in the first 24-hours of conflict – twice the number of targets and only a fraction of the sorties used on the first day of Desert Storm.[368] This, according to Jumper, provides "up-front mass, mostly against fixed targets."[369]

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[363] David A. Fulghum, "USAF Plans Rapid, All-Stealth Task Force," *Aviation Week & Space Technology Online*, 26 February 2001, n.p., on-line, Internet, 2 May 2002, available from http://www.aviationnow.com/content/ncof/ncfn08.htm

[364] Gen John P. Jumper, Chief of Staff, US Air Force address to the Air Force Association National Symposium, Orlando, FL, 14 February 2002, n.p., on-line, Internet, 13 May 2002, available from http://www.aef.org/pub/jump202.asp

[365] Jumper, "Global Strike Task Force," 30-31

[366] Jumper, address to the Air Warfare Symposium

[367] Master Sgt. Terry Somerville, "Global Strike Task Force: kicking down doors," *Air Combat Command News Service*, 10 August 2001, n.p., on-line, Internet, 2 May 2002, available from http://www2.acc.af.mil/accnews/aug01/01256.html

[368] Jumper, address to the Air Warfare Symposium

[369] Quoted in Fulghum, "USAF Plans Rapid, All-Stealth Task Force"

Source: Gen. John P. Jumper, Air Combat Command Briefing, subject: "Global Strike Task Force," 15 December 2000, slides 25 and 27

Figure 13. Stealth and SAM Rings

Once this up-front mass has finished its job, the less stealthy assets can enter enemy airspace. For example, the Joint Strike Fighter (with its golfball-size radar return) could begin carrying out attacks by the third or fourth day of the conflict with relative impunity.[370] Typical targets for these follow-on forces would be mobile targets or time critical targets that "crop up on short notice"[371] further giving the "bad guy...an excuse to quit."[372] The Global Strike Task Force here described purportedly mitigates both the physical access assurance issue – by destroying enemy anti-access systems – and political access assurance issue – by enabling operations from bases outside the operational theater which "reduces...constraints associated with basing restrictions."[373]

[370] Ibid.
[371] Jumper, address to the National Symposium
[372] Jumper, address to the Air Warfare Symposium
[373] Gen Larry D. Welch, "The Access Issue," *Air Force Magazine Online* 81 no.10, October 1998, n.p., on-line, Internet, 3 May 2002, available from http://www.afa.org/magazine/oct1998/1098access.html

Predictive Battlespace Awareness

Thus far, GSTF relies on stealth and small diameter standoff munitions technologies; technologies that are current or emerging. But GSTF also "relies on synergy between Intelligence, Surveillance, and Reconnaissance (ISR) assets" as well.[374] The future vision for ISR capability is the Multi-sensor Command and Control Aircraft (MC2A). Envisioned to combine the capabilities of many existing ISR platforms, the MC2A will be based on a wide-body civilian transport like the Boeing 767.[375] The ISR concept will coalesce the MC2A, unmanned aerial vehicles, and space assets in a constellation with horizontal, machine-level coordination in an attempt to provide Predictive Battlespace Awareness (PBA) for commanders and pilots.[376] This PBA will provide accurate targeting information for precision strikes.

Predictive Battlespace Awareness will purportedly provide commanders familiarity with "the patterns, the doctrine, the habit, the training of the enemy" in an attempt to get "inside the enemy's mind."[377] As General Jumper explains it, PBA gives an "understanding of the battle space in all four dimensions, the ability to anticipate the right move rather than simply react to enemy moves."[378] He describes the level of understanding required as "microscopic", at the "forensic-level", and "all-encompassing."[379]

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374 "Projecting Military Power in the 21st Century," *Northrop-Grumman Review Online*, Issue 1, 2001, n.p., on-line, Internet, 3 May 2002, available from http://www.northgrum.com/news/rev_mag/review12/access_page8.html

375 Glenn W. Goodman, Jr., "More Than Just Platforms & Sensors: US Air Force Pushes Integration of its ISR Assets," *Armed Forces Journal International Online* Vol.1, 2002, 26, on-line, Internet, 5 May 2002, available from http://www.afji.com/ISR/Mags/2002/Issue1/platforms.html

376 Jumper, "Global Strike Task Force," 30-31

377 Jumper, address to the Air Warfare Symposium

378 Somerville, "Global Strike Task Force: kicking down doors"

379 Somerville, "Global Strike Task Force: kicking down doors," and Jumper, "Global Strike Task Force," 30

Implications for the Future

The lessons from history suggest that marginalizing the pillars of sword, shield, or support due to over-reliance on a single panacea technology invites disaster. If a pillar goes unheeded and the Air Force is not prepared for it, a pendulum swing will result if the technology falls short of its promise, if the enemy employs high- or low-tech counters, or if the contextual framework of the conflict renders the cure-all technology inexpedient or impolitic. Applying these lessons to the future concept of Global Strike Task Force uncovers no smoking gun; but looking at each facet will bring to light some things to consider.

GSTF and the Pillars

Pillar of the Sword

It is hard to imagine any military neglecting the sword pillar, as it is the military's primary function to wield that sword. While GSTF does not neglect this pillar, it may, in fact, weaken that pillar somewhat. The GSTF construct "hinges on precision weapons and stealth capabilities inherent in the B-2 and F-22."[380] Essential to the successful employment of this doctrine is the small diameter bomb (SDB) because of its capabilities and because of the large capacity it facilitates, especially in the B-2.[381] The SDB program received roughly $12 million in the fiscal year (FY) 2001 budget and $40 million in the FY2002

[380] Jumper, "Global Strike Task Force," 30

[381] Boeing News Release, "Boeing Awarded Small Diameter Bomb Contract," 3 October 2001, n.p., on-line, Internet, 15 May 2002, available from http://www.boeing.com/news/releases/2001/q4/nr_011003b.html

budget.[382] The Air Force hopes to operationally deploy the SDB by 2006.[383]

The success of the SDB relies on the ability of its 250-pound warhead to do the work of a 1,000-pound warhead. Its small diameter will permit a multitude to be carried on fighters and bombers alike. While technology may make possible parity of the explosive charges, sheer weight (or lack of) may make penetrating hardened targets difficult, thus reducing destructive effects. Also, while never proven, shock effect surely has some value in combat, as evidenced by both North Vietnamese and Iraqi statements regarding demoralization when massive numbers of bombs were constantly exploding around them. While 250-pound SDBs may make air war more precise, they may also make air war more dainty, for lack of a better word. The days of thunderous terror raining from unseen B-52s inducing a sense of dread and hopelessness may be gone. Our sword may be sharper than ever before, but it may also be smaller than ever before. Rather than carrying a broadsword into battle, airmen may in the future be carrying very capable, very precise ice picks.

Pillar of the Shield

From an air-to-air perspective, the escort role of the shield is not clear. The GSTF model posits that F-22s enter enemy airspace and establish "local air superiority through the traditional 'sweep' role and through air-to-ground targeting of the enemy's air defense network."[384] After the F-22s complete their mission, the B-2s enter enemy airspace and attack strategic targets. Establishing even local air superiority with F-22s in a sweep role supposes a Mahanian air battle wherein all enemy

[382] Department of the Air Force, "RDT&E Descriptive Summaries For Fiscal Year 2002 Amended Budget Submission, Vol II," (Washington D.C.: Office of the Secretary of the Air Force, June 2001), 795
[383] Boeing News Release, "Boeing Awarded Small Diameter Bomb Contract."
[384] Jumper, "Global Strike Task Force," 30-31

fighters are destroyed. If this is, indeed, the GSTF concept – as it appears – the enemy need only ground its air fleet until the F-22s exit. Then, the B-2s essentially become new-millennial, unescorted, high-altitude, daylight B-17s. Stealthy or not, an enemy air force surely can acquire and engage a huge, black B-2 against a bright, blue sky. While GSTF does postulate using up to half of the F-22s in a defensive counter-air role protecting ISR assets orbiting far from enemy airspace[385], it does not address F-22s protecting B-2s in a close-escort role. An easy answer to this shortfall would be to simply re-task some of the F-22s from strike and/or sweep missions to B-2 escort missions. But this, in turn would diminish the striking capability envisioned in GSTF. Additionally, the F-22 cannot actively protect a non-maneuvering B-2 or F-117 from surface-to-air threats should an enemy with advanced anti-access SAMs detect the stealthy bombers during daylight operations.

The electronic warfare (EW) and SEAD assets that provide the shield for the sword-bearers are conspicuously absent from the GSTF construct. The doctrine presupposes that stealth technology will effectively shrink the SAM threat rings (Fig 13) such that F-22s and B-2s can attack targets from outside the lethal range of these threats. This was exactly the mindset of early F-117 planners.

The Air Force learned over a decade, however, that it was desirable to provide the EW/SEAD shield to the F-117. How many F-117s survived because of the application of this lesson is not known, but overlooking this shield in GSTF may bring to the forefront the requirement for EW/SEAD in a costly way. Losing even a single B-2 could "be enough to turn the tide of public opinion, regardless of the raw numbers on the scoreboard."[386] The impressive capability the B-2 brings to the fight is somewhat offset by its limited numbers. With a

[385] Jumper, address to the Air Warfare Symposium
[386] Jumper, "Global Strike Task Force"

mere 22 B-2s in active service[387], losing one or two could have devastating effects on US war-winning potential. Kosovo should have taught the Air Force that enemy counters to stealth and political constraints can result in diminishing the stealth advantage. Counters and constraints will be addressed later.

Current EW capabilities are resident only in the 1970's vintage EA-6B. Scheduled to retire in 2015, the EA-6B has been the workhorse of military EW operations since the EF-111 retirement.[388] Being few in number, EA-6Bs are considered high demand/low density assets and are typically conducting operations somewhere worldwide at any given time. In the FY2000 budget, the Navy was given $158 million for EA-6B upgrades to mitigate the signs of age and future budgets will grant even more.[389] The need for this EW asset is apparent. In 2000, an Airborne Electronic Attack Analysis of Alternatives commission was instigated to recommend follow-on options for the aging EA-6B. In December 2001, the commission recommended 27 options to replace the EA-6B, but the final decision on its replacement is scheduled for June 2002.[390]

The lack of EW assets for future operations is a concern for the government. No less than three governmental studies in the past two years have highlighted the need for development of next-generation EW capabilities. One report states that the Department of Defense "currently has too few jamming aircraft in its inventory to support more than one conflict simultaneously."[391] Another states, "The Department has identified the need for specific enhancements in its precision strike,

[387] John T. Correll, "Breakthrough Force," *Air Force Magazine Online* 84 no.4, April 2000, n.p., on-line, Internet, 3 May 2002, available from http://www.afa.org/magazine/editorial/04edit01.html
[388] David L. Rockwell, "Afghan Operations Underscore Value of Avionics Arsenal," *Aviation Week & Space Technology Online*, 12 March 2002, n.p., on-line, Internet, 15 May 2002, available from http://www.aviationnow.com/content/publication/awst/2002outlook/aw199.htm
[389] Department of Defense, *Report to Congress: Kosovo/Operation Allied Force After Action Report*, (Washington D.C.: Office of the Secretary of Defense, 31 January 2000), 3
[390] House Committee on Armed Services, *National Defense Authorization Act for Fiscal Year 2003*, 107th Cong., 2d sess., Report no. 107-436, 3 May 2002, 175
[391] Christopher Bolkcom, *Airborne Electronic Warfare: Issues for the 107th Congress*, Congressional Research Service Report RL30841 (Washington D.C.: Library of Congress, 9 February 2001), 5

electronic warfare, and intelligence, surveillance and reconnaissance (ISR) capabilities."[392] A third states, "We cannot move fast enough to replace the EA-6B."[393] The current trend is to replace the EA-6B with a modified version of the Navy's F-18 (designated the EA-18), but this "replacement" promises only marginal improvement as it uses the same jamming pods as the EA-6B.[394]

Despite the statements to the contrary, it seems that advances in next-generation EW capability are being marginalized in favor of redesignation of existing platforms. The EA-JSF (EW version of the Joint Strike Fighter) will not enter service ostensibly until 2013, assuming its projected timeline is not hampered by cost overruns or congressional interference. By then, the GSTF construct may have become doctrine; a doctrine without proper regard for the shield. General Michael Ryan, former Air Force Chief of Staff, stated that "The USAF believes that a combination of EW and low observables [stealth] are required to assure air superiority in the 21st century battlespace."[395] Apparently this belief was lost on GSTF.

Pillar of Support

Support assets are becoming increasingly important to Air Force operations. Nearly every air operation relies heavily on airborne warning, electronic eavesdropping, or air refueling. The MC2A platform mentioned earlier would presumably combine many of these capabilities into one, very capable platform. This platform would consolidate and perhaps simplify the network of air support assets needed for combat operations. It would also reduce the number of airborne support assets required since the previous functions of many aircraft could be done

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[392] Department of Defense, *Report to Congress*, 2
[393] House Committee on Armed Services, 585
[394] Rockwell
[395] Quoted in Bolkcom, 13

with only a few, or one. It would reduce the number of support aircraft requiring defensive protection and assemble the most critical support capabilities into one aircraft.

One critical ISR platform designed to replace the many existing platforms is, on a micro-level, like putting all the ISR eggs in one basket. Regardless of the MC2A's capabilities, if it is the only platform capable of performing ISR duties, it becomes an Achilles heel. General Jumper notes that "We have 160 airplanes at Tinker Air Force Base right now in some severe state of corrosion problems. It used to take us four or five months to put one of these airplanes through the depot. It takes us now more than year."[396] While he was referring to the effects of aging on the current tanker fleet, his point can be extended. If, for example, 160 MC2A aircraft are purchased to replace the aging ISR fleet, one flaw in design, one safety recall could conceivably ground the whole fleet simultaneously. It has happened before in large numbers, but the diversity of Air Force platforms at the time allowed the Air Force to continue its mission. Reliance for all ISR needs on this one, very capable platform may not be the smartest way to do business.

GSTF and the Pendulum

Technology Falling Short

Looking at the concept of GSTF vis-à-vis reliance on technology, it becomes evident that this emerging doctrine does not, in fact, rely solely on one panacea technology, but on technology writ large. While it remains to be seen if the "forensic" ability to predict enemy intentions will ever materialize, the lack of "microscopic" PBA will not spell the doom of GSTF. Hence, it seems a pendulum swing due to a technology's

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[396] Jumper, address to the National Symposium

inability to live up to promised capability will likely not occur in this regard.

Low-Tech Tactics or High-Tech Counters

In every war, men have innovated unique ways to overcome enemy advantages. In Kosovo, the Serb IADS operators displayed sophisticated integration and adaptive innovation to overcome the advantage of F-117 stealth characteristics. Unfortunately, low-tech tactical counters to high-tech advantages are generally unpredictable due to the dynamic, human innovative process. No amount of machine-based predictive battlespace awareness will be able to predict what the human mind can concoct. We should never assume that a technological advantage over the enemy cannot be countered simply because the enemy does not possess sophisticated technology.

To the cognitive mind, high-tech counters to high-tech advantages are much easier to contemplate. High-tech counters require advanced technology. Advanced enemy technology requires money, facilities, time to develop, and in some cases third party support. All of these requirements are more readily observable by human or electronic eyes and hence, more predictable.

The threat that sits squarely at the center of GSTF is that of advanced-technology missiles. Surface-to-surface missiles and surface-to-air missiles of next-generation design give the GSTF its task; create access where it does not exist.

The shootdown of the F-117 in Kosovo confirmed that stealth aircraft "become much more vulnerable when surprise is lost."[397] If GSTF relies solely on stealth technology to preclude SAM engagement,

[397] Bill Sweetman, "What's Next for 'Low Observables' Technology?" *Jane's Defence Weekly* 35, no.25, 20 June 2001, 59

we ourselves will be surprised when enemy high-tech counters enable SAM engagement. The Kosovo incident became worrisome to Secretary of Defense William Cohen and Joint Chiefs of Staff Chairman Gen Hugh Shelton. These men believed that the Serbian "air defense systems did not represent the state of the art. In the years ahead, we may face an adversary armed with state-of-the-art systems, and we need to prepare for that possibility now."[398]

Source: Federation of American Scientists, http://www.fas.org/nuke/guide/russia/airdef

Figure 14. SA-10 *Grumble*

The state-of-the-art systems they, and Gen Jumper, refer to are the so-called double digit SAM systems – the SA-10, -12, and –20 family of SAMs. The SA-20 is on the leading edge of the high-tech counters to US technology, including stealth. In its development stage, the SA-20 will be able to detect low-signature, stealth aircraft using a semiactive and active seeker on the missile itself. The missile will be capable of maneuvering at forces over 20 times that of gravity at an altitude of roughly 100,000 feet. Its lethal range is reported to be roughly 200 nautical miles, much farther than any SAM on the market today.[399]

[398] Quoted in Bolkcom, 7

[399] "S-400 SA-20 *Triumf*," *Federation of American Scientists Online*, 16 June 2000, n.p., on-line, Internet, 15 May 2002, available from http://www.fas.org/nuke/guide/russia/airdef/s-400.htm

Since this technology is still not widespread, the SA-10 (or "lesser" of the SAM threats) will be addressed.

The first SA-10 *Grumble* site became operational in 1980 and since 1996 the Russian military has been replacing all its older SAM systems with this missile system.[400] The system is being, or has been, exported to countries such as China and India.

The SA-10 *Grumble* is capable of handling multiple targets simultaneously, including low altitude and low signature targets, such as cruise missiles.[401] Each battery can engage up to six targets, launching two missiles against each with less than one second between launches.[402] With the exception of the Big Bird initial target detection radar, the whole SA-10 system is mobile and requires only five minutes to deploy once halted.[403] It can engage targets as high as 90,000 feet and as far away as approximately 50 miles.[404]

If the envisioned ISR capability of GSTF is able to locate the SA-10 *Grumble* fixed initial target detection radars, and the GSTF forces are able to destroy them, the SA-10 *Grumble* would be forced to operate in an autonomous mode, much like the SAMs in Serbia were in 1999. However, the next upgrade to the SA-10 (designated SA-10 *Favorit*) could engage targets as far away as 100 miles with its new mobile…and *autonomous*…radar system. This new system purportedly has an 80 to 93 percent probability of kill against targets with radar cross-sections equivalent to a Tomahawk cruise missile.[405]

The fact that a Tomahawk cruise missile is small and slender gives it inherent stealth characteristics. The radar cross-section of a Tomahawk missile is roughly five centimeters square, equivalent to the

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[400] "SA-10 *Grumble*," *Federation of American Scientists Online*, 30 June 2000, n.p., on-line, Internet, 15 May 2002, available from http://www.fas.org/nuke/guide/russia/airdef/s-300pmu.htm
[401] Ibid.
[402] Ibid.
[403] Ibid.
[404] Ibid.
[405] Ibid.

size of a ball less than two inches in diameter.[406] If the SA-10 *Favorit* can detect and engage a target this small with a high probability of kill, could it not also detect and engage an F-22 with a radar cross-section equivalent to the size of a ball approximately one inch in diameter?[407]

Stealth undoubtedly reduces the size of a SAM's lethal range, but considering that the SA-10 is a mobile system (and soon to be an autonomous mobile system), the ability of GSTF ISR systems to find and track the mobile SA-10 is problematic. Additionally, F-22 and B-2 aircraft launching standoff weapons in the first few days of the GSTF concept would be unable to target these mobile systems, even if their initial target location was known. If, as in the Kosovo shootdown, the SAM location is unknown and stealth aircraft inadvertently overfly the SAM location, the SA-10 has a high-tech capability to track and engage stealth aircraft. The results of such engagement would be devastating, especially if the stealth aircraft lacks the protective shield of EW/SEAD assets.

Contextual Factors

The owner of the GSTF idea stated that "Access challenges can take several forms, both political and physical."[408] According to the GSTF concept, the force structure, along with its technological capabilities should eliminate the physical anti-access issue. The political access challenge, vis-à-vis restricted basing privileges, should also be overcome by the GSTF concept by its inherent long-range strike capability. But what of other flavors of political constraints? In Vietnam, political contextual elements rendered our nuclear superiority ineffectual against North Vietnamese aggression. Again in Kosovo,

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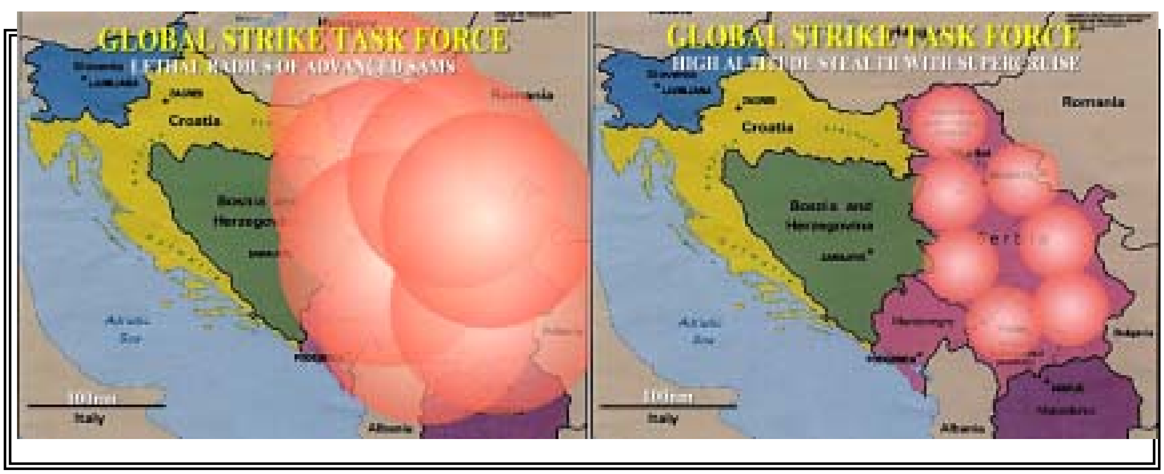
[406] "Key Technologies in Detail, Stealth Technology," *Centre for Defence and International Security Studies Online*, 1996, n.p., on-line, Internet, 3 May 2002, available from http://www.cdiss.org/cmtech2.htm

[407] Fulghum, "USAF Plans Rapid, All-Stealth Task Force"

[408] Jumper, address to the Air Warfare Symposium

political contextual elements prohibited the F-117 from optimizing its stealth characteristics. Airspace constraints, driven by political decisions, made predictable its flight path. Political constraints prohibited the US targeting of an early warning radar site in Montenegro – a site that most likely aided in the successful shootdown of the F-117.

Projecting the GSTF concept into a Kosovo-like scenario might produce very different results from an Iranian scenario (Fig 13). If one uses the same scale for threat rings in Figure 13 in a Kosovo scenario, the compactness of the enemy state reveals that next-generation SAMs – even when degraded by supercruise stealth at high altitude – offer a significant threat to friendly forces (Fig 15). Yes, the F-22's stealth provides "12 times more airspace than conventional aircraft in which to operate safely."[409] But in this scenario, as will be shown, that airspace is not exclusive.



Source: Adapted from Gen. John P. Jumper, Air Combat Command Briefing, subject: "Global Strike Task Force," 15 December 2000, slides 25 and 27

Figure 15. Stealth and SAM Rings – Small State Scenario

Considering that Serbia, in 1999, had an estimated 22 SAM batteries, it is not unreasonable to assume that the state could replace

[409] Fulghum, "USAF Plans Rapid, All-Stealth Task Force"

the 22 older SAM systems with seven next-generation double digit SAM systems. The point here is not that Serbia will be a threat in the future, but that geographical limitations imposed by political constraints can occur. In 1993, participants of Operation Deny Flight were prohibited from flying at supersonic speeds in Bosnian airspace. In 1986, the French government prohibited participants of Operation Eldorado Canyon from overflying France. In 2002, Pakistan prohibited offensive air operations from its territory into Afghanistan. If similar restrictions are imposed in a future Kosovo-like scenario, Figure 16 shows what effect political constraints could have on GSTF forces.

Given US history of political constraints, such a scenario depicted in Figure 16 is not unrealistic. In such a scenario, air operations are only possible from the north, west, and south. But operations from the west prohibit supersonic flight, thereby negating the advantage of supercruise entry into enemy airspace. Further, no offensive weapons release authority has been granted, so launching standoff weapons from outside SAM threat rings is not possible from the west. From the north, the supercruise advantage is intact, but again, launching standoff weapons as the GSTF construct dictates is not possible. Supersonic flight *is* authorized over Montenegro and Albania, as is offensive weapons release. But the early warning radar that is off-limits to destruction alerts the enemy to impending airstrikes, and perhaps passes information to Serbian IADS.

This feasible scenario shows that the technological advantages of stealth, supercruise, and standoff weapons may be diminished significantly depending on the context in which the GSTF finds itself. While victory in this scenario is still possible, it may involve GSTF F-22 and B-2 aircraft penetrating SAM rings to effectively launch their standoff munitions. Given that these next-generation SAM systems may be mobile systems, the targeting problem is further compounded. With the EW/SEAD shield perhaps absent, this combined political/high-tech counter to US technology may very well result in a pendulum swing, which may in turn result in the loss of US aircraft. Losing one B-2 equates to losing close to 5% of the total B-2 force structure. This could result in a lack of support at home for operations in a best-case scenario, or a military defeat in a worst-case scenario.

Source: Adapted from Gen. John P. Jumper, Air Combat Command Briefing, subject: "Global Strike Task Force," 15 December 2000, slide 27

Figure 16. Stealth and SAM Rings – Small State Scenario with Political Constraints

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Conclusion

The history of the Air Force is replete with lessons waiting to be learned and applied. The history recorded in these pages brings out the lessons of the dangers of over-reliance on one technology to win a war at the expense of one or more of the pillars of military success. When this happens, it leaves the Air Force unprepared to deal with the inevitable pendulum swing that puts the advantage in the enemy's court. Global Strike Task Force, while not totally reliant on one technology, may indeed slight a pillar of military success. This final chapter suggests that an adversary can force a pendulum swing whether by tactical or technological design, or by capitalizing upon limits imposed by the political or geographic contextual nature of the conflict. This ability to swing the pendulum may or may not be successful, depending on USAF readiness and ability to counter the attempt. If the shield pillar continues to be overlooked, it seems likely that an opponent, such as envisioned in GSTF, could succeed rather easily in swinging the pendulum. Further consideration of the need for – and the role of – EW assets in the future force structure of the USAF may, indeed, mitigate a pendulum swing.

Statements like "this [F-22] will be the airplane that nothing can touch"[410] and "the F-22 can get to any target in that battlespace to take out the threats that could...endanger follow-on forces"[411] seem to indicate that no shield is required. Granted, these statements may be hyperbolically made in order to secure the funding necessary for future stability of the programs involved, but they can also lead the Air Force into the trap of neglecting a time-honored pillar of military success in deference to this technology at our own peril.

[410] Jumper, address to the National Symposium
[411] Jumper, address to the Air Warfare Symposium

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