

# **The Four Forces Airpower Theory**

**A Monograph  
by  
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## Abstract

THE FOUR FORCES AIRPOWER THEORY by MAJOR Brian P. O'Neill, USAF, 67 pages.

This monograph suggests an airpower theory that helps explain why airpower does not result in quick, clean, economical, “ideal” war. The genesis of this study comes from the observation that airpower advocates, from early personalities such as William Mitchell and Giulio Douhet, to present day U.S. Air Force leadership, forecast how newer and better airpower technology will almost certainly result in quick, decisive wars, but tend to underestimate the factors that work against airpower.

The earliest notions of ideal war came from a desire to avoid a repeat of the trench carnage during World War I. Airpower advocates seem to profess that the right airpower technology could almost bloodlessly force enemies to capitulate. Looking only at American wars since the advent of military airpower, it is clear that airpower has changed the character of war, but airpower does not and probably will not drive war to the point of “ideal.”

The novelty of this theory stems from the graphic analogy of the four forces that act upon an aircraft in flight. The theory suggests that technology is the “thrust” that propels airpower towards ideal war by generating the “lift” of improved effects. The “drag” of resource constraints and “weight” or “gravity” of enemy technology and counter-tactics work in opposition and drag airpower from ideal towards real war.

A review of three major airpower advocates, William Mitchell, Giulio Douhet, and John Warden, sets a foundation for how airpower advocates have developed ideas, concepts, and theory about airpower’s future capabilities. Three case studies, the B-17, free-fall nuclear bomb, and F-22A fighter, trace how airpower advocacy led to technology that would enable ideal war. In each case, application of the Four Forces theory demonstrates that while resource constraints and enemy technology and counter-tactics prevent ideal war, airpower technology improves the character of war as a whole.

## Table of Contents

Illustrations .....	iv
Introduction.....	1
Airpower Advocates .....	6
Giulio Douhet.....	7
William “Billy” Mitchell .....	10
John Warden .....	14
Case Studies.....	18
The Battleplane .....	18
Technology .....	22
Effects.....	23
Resources.....	26
Enemy Counter-tactics and Technology.....	28
Summary.....	31
The Atomic Bomb.....	32
Technology .....	34
Effects.....	35
Resources.....	36
Enemy Counter-tactics and Technology.....	38
Summary.....	40
The F-22A Raptor .....	41
Technology .....	45
Effects.....	48
Resources.....	49
Enemy Counter-tactics and Technology.....	54
Summary.....	57
Conclusions.....	58
BIBLIOGRAPHY.....	61

## Illustrations

Figure 1. The Forces Acting Upon an Airplane in Flight .....	3
Figure 2. Increased Thrust Results in Increased Lift and Increased Altitude .....	4
Figure 3. Graphical Depiction of the Four Forces Airpower Theory.....	5
Figure 4. Warden's Five Rings Model .....	16
Figure 5. The Four Forces Theory Applied to the B-17 .....	18
Figure 6. Four Forces Theory Applied to Free-fall Nuclear Bomb .....	33
Figure 7. Four Forces Theory Applied to the F-22A .....	42

## Introduction

Since the inception of powered, manned flight in 1903, airpower advocates have imagined airpower's developing ability to improve many aspects of war. Having witnessed the start of industrial era warfare from the American Civil War through World War I (WWI), the allure of more humane conflict seduced military minds. War had developed an insatiable appetite for lives and national resources. War decimated victorious and vanquished nations alike without even a semi-permanent outcome that would decisively prevent a rematch. War engulfed vast territory. War lasted years. Airpower seemed to promise a cure for the conditions of war. Airpower could reach past stagnant trench lines. Airpower could bomb anything the enemy held dear. Airpower seemed immune to the atrocities of the modern battlefield. Airpower even seemed to promise universal immunity from those atrocities. Airpower could change war into a clean, relatively bloodless "ideal war." These are the visions of airpower advocates. This monograph however, explains why airpower does not change war into the ideal that airpower advocates envision.

The term "ideal war" has a sort of clank to it. Arguably, the most ideal war is the absence of war. The use of the phrase "ideal war" in this monograph acknowledges that, while enduring peace would be the most desired situation, human history indicates that war will likely continue. If war cannot be eliminated, then the ideal war, the best case scenario, might be decisive war of short duration, cost, and casualty lists. This is the working concept of ideal war in this monograph.

Airpower advocates seek airpower's promised dominance by promoting ideas, theories, doctrine, and advances in technology. Even with its technologically advanced

air forces, America's wars fail to achieve "ideal" status in terms of brevity, economy, and decisiveness. Operation Desert Storm launched thousands of sorties to eject Iraq out of Kuwait in 1991. Few Americans and relatively few Iraqis died in this short conflict. Yet, Iraq capitulated only after the four-day ground invasion. Operation Allied Force took over ninety days to eject Serbian forces from Kosovo. Many believe that the threat of a ground invasion finally convinced Serbia to retrograde when airpower alone could not.<sup>1</sup> While airpower certainly played into policymaker decisions, it did not convince North Vietnam, North Korea, or the Axis powers in World War II (WWII) to surrender.

If asked to explain why the proletariat has not banded together to overthrow the bourgeoisie, a Marxist might answer to the effect "it just has not happened *yet*." The airpower advocate might answer the ideal war inquiry just the same. Many vocal airpower advocates believe that the underlying principles of airpower: flexibility, versatility, synergy, persistence, concentration, precision, and surprise are almost beyond reproach.<sup>2</sup> "These principles enabled by advanced technology can accomplish what land and sea power cannot, they just haven't *yet*!" claims the airpower advocate. This paper has a more thorough proposition. To discover the forces at work in the airpower-ideal war relationship, this paper proposes a different kind of airpower theory called the Four Forces of Flight. This theory does not suggest how to employ airpower, but suggests why airpower does not transform wars into ideal wars.

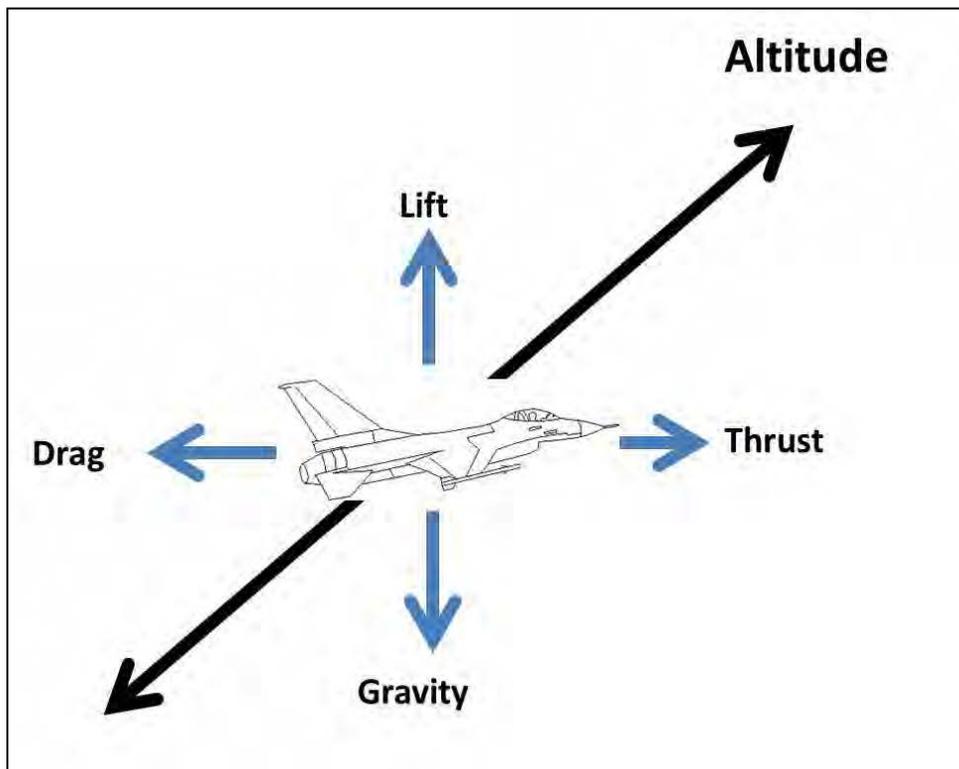
Familiarity with the basic physics of flight aids in understanding this theory. Four forces act upon an aircraft in flight (Figure 1). The force of engine thrust propels the

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<sup>1</sup> Benjamin S. Lambeth, *NATO's Air War for Kosovo: A Strategic and Operational Assessment* (Santa Monica, CA: RAND, 2001), 67-76.

<sup>2</sup> Headquarters United States Air Force, *Air Force Doctrine Document 1: Air Force Basic Doctrine*, (Washington DC: Government Printing Office, 2003), 27.

aircraft forward while generating the airflow over the wings, which then generates the upward force of lift. The force of drag opposes thrust while the force of gravity opposes lift. An airplane successfully flies when its engines develop sufficient thrust to both generate lift and overcome drag. The sleek, aerodynamic shape of the aircraft both maximizes its lift-generating capacity and minimizes its drag-creating capacity. Changes in the forces on an airplane affect the other forces as well as its velocity and altitude. Thus, lift increases as thrust increases. As lift increases, so does altitude. (See Figure 2) If the pilot uses the aircraft controls to hold altitude constant while increasing thrust, then velocity increases.<sup>3</sup> For the purposes of this monograph, the altitude increasing effect of thrust is the most important of these vectors.

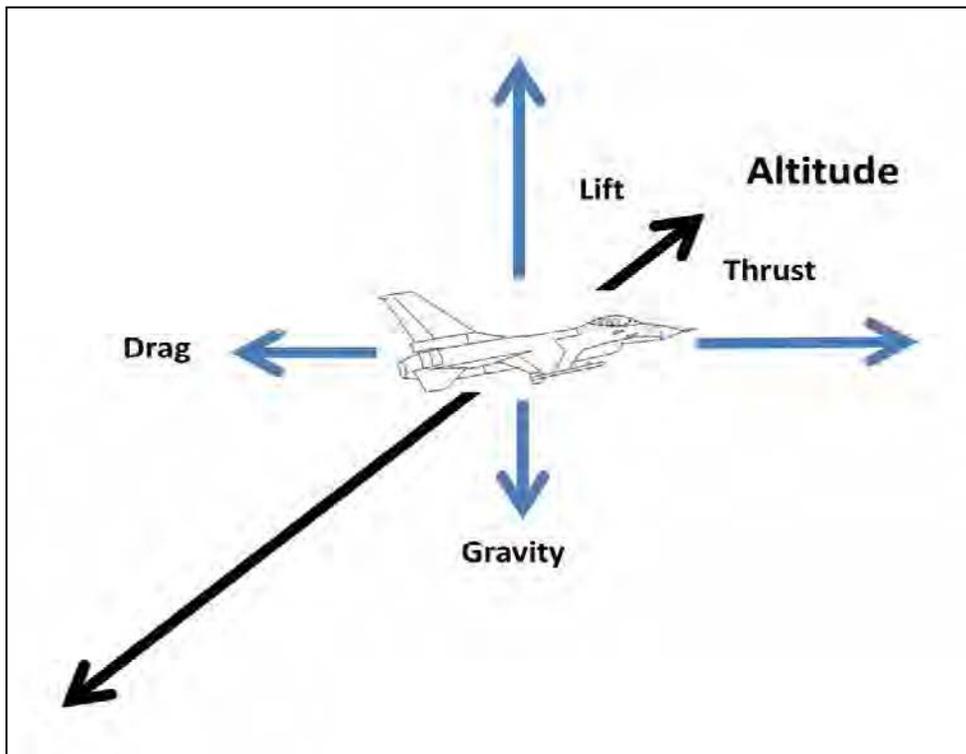


**Figure 1. The Forces Acting Upon an Airplane in Flight**

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<sup>3</sup> A complete discussion of aircraft operation and aerodynamics goes well beyond the scope of this monograph. For example, when velocity increases, a component of drag does too, however this does not generally prevent the aircraft from flying faster. For more information, see L. J. Clancy, *Aerodynamics* (London: Pitman, 1975).

The four forces of flight provide an ideal analogy for this airpower theory. Specifically, technology propels airpower towards ideal war by generating improved effects against the enemy. Airpower never creates ideal war because of the drag of resource constraints and the weight or gravity-like pull of enemy counter-tactics and technology. Figure 3 is a visual depiction of this theory. Sufficient thrust would seem capable of lifting an airplane to any altitude. Similarly, sufficient technology would seem capable of lifting airpower towards ideal war. As altitude increases, air eventually becomes too “thin” to support additional thrust and lift. In a more non-linear fashion, the context of war also limits airpower’s ability to achieve ideal war.



**Figure 2. Increased Thrust Results in Increased Lift and Increased Altitude**

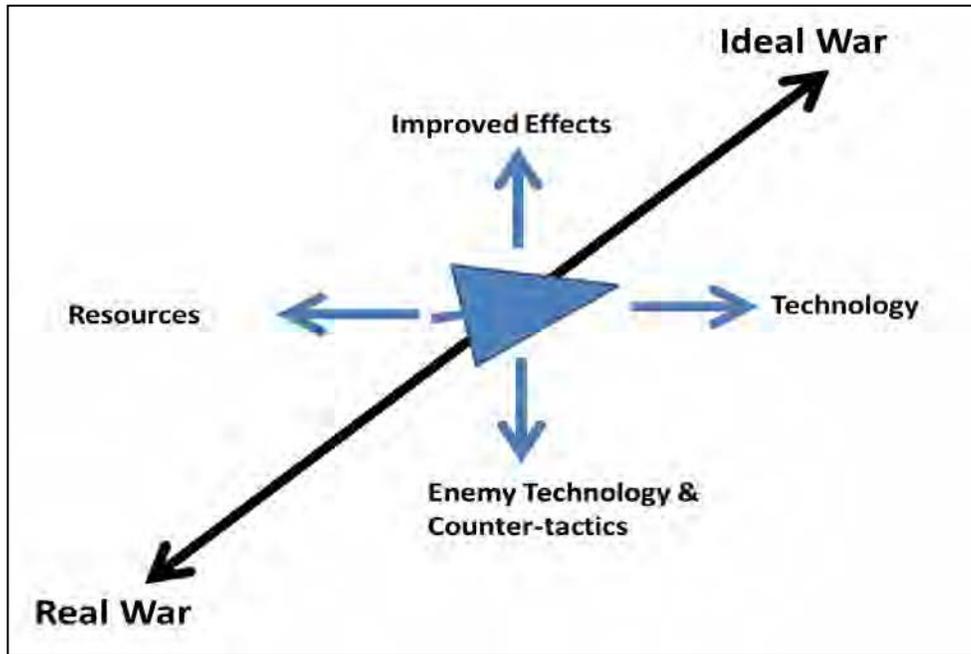


Figure 3. Graphical Depiction of the Four Forces Airpower Theory

Before proceeding, several important terms warrant definition. For this monograph, airpower consists of fighter, attack, bomber, and reconnaissance aircraft. Certainly, these platforms cannot do their jobs without the aid of ground support forces and mobility forces. However, airpower’s ground support and mobility forces do not conduct the direct opposition of wills that is war.<sup>4</sup> Space and cyberspace, while critical elements of modern airpower, remain outside this discussion for brevity and classification purposes.

To illustrate this theory, this monograph charts the following course. The Airpower Advocates section reviews the work of major airpower advocates in order to provide a foundation for the types of ideas, concepts, and theories that have shaped airpower technology. It also describes the research methodology that supports the theory. The research traces the effects of three airpower technologies compared to their

<sup>4</sup> Carl von Clausewitz, *On War*, ed. Michael Eliot Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 75.

advertised capabilities and then analyzes the effects of resource constraints and the enemy. Finally, synthesis of each airpower technology vis-à-vis the proposed theory finishes the evaluation.

The third section contains the case studies supporting the theory. Examining the B-17 as General Giulio Douhet's "Battleplane," the free-fall nuclear bomb as an extreme of strategic bombardment, and the F-22A, the monograph explores the analytical and predictive aspect of the Four Forces theory. The final section presents the conclusions and recommendations from this research.

### **Airpower Advocates**

The phrase, "In theory X, but in practice Y" can dilute the utility of the term theory. Common dictionary definitions of theory include "the analysis of a set of facts in their relation to one another," "abstract thought," and "a hypothesis assumed for the sake of argument or investigation."<sup>5</sup> With such varied conceptual backing, casual use of the word theory is unsurprising. Paul Reynolds presents a convincing argument that a proposition must meet stringent criteria in order to merit the title of theory. Reynolds suggests that a theory offers a "sense of understanding" and is part of scientific knowledge if it passes three tests. First, a theory should be abstract in that it is not specific to a time or location. Second, it should be intersubjective such that relevant scientists can agree upon its meanings and terms. Finally, a theory should be empirically relevant, or supported by observable findings.<sup>6</sup> Since the goals of science are to "provide typologies, explanations, predictions, and a sense of understanding," a useful theory

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<sup>5</sup> "Merriam-Webster.com," (Merriam-Webster, 2010).

<sup>6</sup> Paul D. Reynolds, *A Primer in Theory Construction* (Needham Heights, MA: Allyn and Bacon, 1971), 10-14.

needs to go beyond abstract thought.<sup>7</sup> This monograph demonstrates that the Four Forces airpower theory meets Reynolds' criteria and is not simply a set of related facts or an abstract thought. Reynolds construct provides a useful framework for building a new theory and holding it to a scientific standard. This is not to suggest that the ideas, concepts, and theories of airpower advocates in this monograph lack validity for failing to conform to a single definition of theory. Rather, Reynolds' model underpins the Four Forces theory as an organizing function and not just a rubric for all airpower concepts, ideas, and theories.

The Four Forces theory of airpower aims for similarity to Carl von Clausewitz's theory of war in that it describes the nature of airpower but does not embody concepts for how to employ airpower in all situations.<sup>8</sup>

## **Giulio Douhet**

Italian General Giulio Douhet (1869-1930) typically bills as the first airpower theorist. Douhet witnessed the carnage of WWI trench warfare and like many others, sought a way to avoid a repeat. An infantryman who never pinned on wings, Douhet wrote prolifically to describe his predictions on airpower's coming dominance including his 1921 and revised 1927 editions of *The Command of the Air*. Douhet felt that the Italian army squandered its airpower on ineffective ground combat-minded piecemeal missions during the 1911 war with the Ottoman Empire. He took his frustrations to pen and paper and began to call for an independent air force while describing how to win wars with it.

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<sup>7</sup> Ibid., 19.

<sup>8</sup> Clausewitz, 75-89. Clausewitz rejects the notion that battlefield success comes from a theory but demonstrates that knowing the nature of war via his theory is essential to war's conduct.

Douhet proposed several axioms for future airpower use, most of which were based on postulated future technological advances as opposed to demonstrated current capabilities. He recognized that aircraft could maneuver in three dimensions with increasing speed and extrapolated the idea that airplanes could then fly nearly any distance, height, or speed, “The airplane has complete freedom of action and direction; it can fly to and from any point of the compass in the shortest time- in a straight line- by any route deemed expedient.”<sup>9</sup> He proclaimed, “To conquer command of the air means victory; to be beaten in the air means defeat and acceptance of whatever terms the enemy may be pleased to impose.”<sup>10</sup> Douhet follows with two corollaries. First, a nation should always be prepared to gain command of the air by possessing, prior to war, the means to conquer command of the air by building an independent air force of correct and sufficient resources to do the job. Second and more intense, “All that a nation does to assure her own defense should have as its aim procuring for herself those means which, in case of war, are most effective for the conquest of the command of the air.”<sup>11</sup> While Douhet may sound narrow-minded, he was not just describing the benefits of airpower but also working to sway the public, civilian policymakers, and military leadership towards a wholly new line of thought regarding war.

Douhet laid a foundation for employment doctrine with several major tenets that while not a guarantee for war, have influenced airpower and warfare ever since. The first tenet included the combination of high explosive, incendiary, and gas bombs with the utility of the latter coming from its ability to prevent emergency responders from

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<sup>9</sup> Giulio Douhet, "The Command of the Air," in *Roots of Strategy Book 4*, ed. David Jablonski (Mechanicsburg, PA: Stackpole Books, 1999), 283.

<sup>10</sup> Ibid., 300-01.

<sup>11</sup> Ibid., 300.

assisting after an attack. Targeting has always been an essential element of airpower doctrine and Douhet felt that “In general, aerial offensives will be directed against such targets at peacetime industrial and commercial establishments; important buildings, private and public; transportation arteries and centers; and certain designated areas of civilian population as well.”<sup>12</sup> Douhet expanded on the topic of civilian population to convince his audience that the will of the population can be bombed to the point of popular revolt and subsequent government surrender. In effect, the calamity of WWI trenches, properly delivered to the civilian populations and governments, motivates a rapid capitulation. Douhet believed that defense against airpower was a fool’s errand, and bombers would easily reach and hit their targets every mission. As such, he called for the technological capacity of a “unit of bombardment” based on very hopeful calculations, that could destroy all within a 500-meter diameter without the need for a re-attack. To ensure delivery of unit of bombardment, the “Battleplane” came about in the 1927 version of his book. The Battleplane concept was a technological marvel capable of not only aerial combat, but bombing as well. While Douhet’s ideas were beyond reach at the time and did not advertise much of a downside to airpower, nations have been incorporating them ever since.

Douhet’s assertions appear to rest on the assumption that all future wars will be at least as total in their consumption of national resources as WWI. A summary of Douhet’s ideas is:

1. An independent air force is necessary for proper use of airpower.

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<sup>12</sup> Ibid., 294.

2. To conquer the command of the air for offensive operations equals victory. Ceding command of the air equals certain defeat.
3. Enemy vital centers of industry, transportation, and population are critical targets, with the latter being key to popular uprising and subsequent governmental failure.
4. Battleplanes dropping sufficient units of bombardment including explosive, incendiary, and gas bombs will always penetrate defenses rendering air defense worthless.

Douhet calls for the means to make ideal war through advanced airpower technology and pioneering doctrine. Even though ideal war through airpower remains out of reach, Douhet's work is the intellectual heritage of much of Air Force doctrine, and therefore much airpower success. Command of the air, now recognizable as air superiority, has become the first operational requirement for U.S. Combatant Commanders. Targeting methodology has grown more specific, however Douhet introduced analysis of critical target identification. Finally, the evolution of precisely controlled weapon effects demonstrates Douhet's influence on kinetic effects technology. Douhet sought brief, decisive war through airpower and his ideas have made strides in that direction even if they have not specifically made war ideal.

### **William "Billy" Mitchell**

A contemporary of Douhet, Brigadier General William "Billy" Mitchell began his U.S. Army career as a signal officer. Mitchell came to aviation late in his career, but like Douhet, quickly recognized not only its potential, but also its inefficient use by ground commanders. Mitchell also wrote and spoke prolifically about the need for an independent air force. His narrative followed a crescendo towards his court martial for

insubordination as he accused the War and Navy Departments of "almost treasonable administration of the national defense" in the wake of several air disasters.<sup>13</sup> Douhet had retired from the active roles during his most verbal years, but Mitchell still had to navigate professional boundaries, inter-service rivalry, and widespread isolationist sentiment. The latter required that Mitchell make most of his pitch for defensive rather than offensive airpower. The American isolationist mood resulted in much of his seminal book sounding as though it came from two sides of the same mouth. On the one hand, it argues as though defense of America is the goal, but the tactics presented required intercontinental attack against enemy targets, part of a decidedly offensive operation. This duplicity is present throughout Mitchell's work and seems to flow from the need to balance appeals to the public and Congress with slights against the Army and Navy.

Mitchell builds on Douhet in offering durable tenets of air doctrine. His most resounding call is for an independent air force since "So many erroneous doctrines have been enunciated about aviation by the older services that see in the development of air power the curtailment of their ancient prerogatives, privileges and authority, that we consider it time to challenge these proceedings and to make our views known."<sup>14</sup> Throughout his works, Mitchell adds other indictments of Army and Navy control over airpower including comparisons to other modern air forces, examples of employment efficiency stemming from centralized airpower control, and lengthy descriptions of the

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<sup>13</sup> James P. Tate, *The Army and its Air Corps: Army Policy Toward Aviation, 1919-1941* (Maxwell AFB, AL: Air University Press, 1998), 45.

<sup>14</sup> William Mitchell, "Winged Defense: The Development and Possibilities of Modern Air Power-- Economic and Military," in *Roots of Strategy Book 4*, ed. David Jablonsky (Mechanicsburg, PA: Stackpole Books, 1999), 422.

singular and superior nature of “the most highly organized individual fighting men that the world has ever seen.”<sup>15</sup>

Mitchell did not believe that bombers would be invincible, just invincible to ground attack. “The air is so vast and extends so far that the shooting of airplanes out of the sky, with cannon from the ground, is almost impossible of achievement, especially when planes are almost always protected by the clouds, by the glaring sun or the darkness.”<sup>16</sup> He deduced that an air force of two-thirds pursuit aircraft and one-third bombardment aircraft could achieve victory.<sup>17</sup> Mitchell takes multiple conflicting positions on the future shape of airpower depending on what constituency he is currently addressing. This is consistent with the reality that he was trying to devalue future contributions of the Army and Navy while convincing the public, Congress, and other national leaders of airpower’s promise. His recommended ratio of pursuit to bombardment aircraft is an acknowledgement that strategic bombardment of vital centers is necessary but he saw a need for aerial battle too since, “It was proved in the European war that the only effective defense against aerial attack is to whip the enemy’s air forces in air battles.”<sup>18</sup>

Mitchell’s final major tenet lines up with Douhet’s plan for targeting. “The air forces will strike immediately at the enemy’s manufacturing and food centers, railways, bridges, canals and harbors. The saving of lives, manpower and expenditures will be tremendous to the winning side. The losing side will have to accept without question the

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<sup>15</sup> Ibid., 499.

<sup>16</sup> Ibid., 502.

<sup>17</sup> Ibid., 511.

<sup>18</sup> Ibid., 502.

dominating conditions of its adversary, as he will stop entirely the manufacture of aircraft by the vanquished.”<sup>19</sup> He later expands to say, “...the hostile nation’s power to make war must be destroyed—this means the manufactories, the means of communication, the food products, even the farms, the fuel and oil and the place where people live and carry on their daily lives.”<sup>20</sup> So, while Mitchell does not dwell on the unpalatable notion that killing civilians will make other civilians overthrow their government, he does allow that making it risky and unpleasant to be a civilian in a hostile country will lead to degraded war-making capacity.

Mitchell does not focus on the specifics of technology such as units of bombardment or Battleplanes in his major work as Douhet did, but his major concepts are:

1. An independent air force, run by airmen, is a necessary component of airpower.
2. Strategic bombardment of vital industrial and population centers will eliminate the enemy’s ability to make war.
3. Defense against aircraft comes only from other aircraft, which enable air superiority, which in turn enables strategic bombardment.

Like Douhet, Mitchell did not foresee certain developments that would dampen airpower’s effects. Antiaircraft artillery and surface-to-air missiles continue to wreak havoc on aircraft. In other areas however, Mitchell’s foresight might have saved many Allied lives. His view that pursuit or fighter aircraft would be a vital component of air superiority not only endures today, but seems all but proven by the Allied success in the latter months of WWII in Europe.

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<sup>19</sup> Ibid., 427-28.

<sup>20</sup> Ibid., 489.

Often regarded as the “father” of the U.S. Air Force, Mitchell’s ideas remain prevalent alongside Douhet’s in modern doctrine. While he did not have the solution for ideal war, he contributed many ideas that carried airpower towards its critical roles in future wars.

## **John Warden**

Colonel (ret.) John A. Warden, came to prominence in the wake of Operation Desert Storm. Many credit him with development of the air campaign against Saddam Hussein’s regime in 1991. Warden retired from active duty in 1995 having leveled off at the rank of Colonel, but his influence on air power and strategic theory remains strong.

During his tenure as a student at the National War College, Warden wrote a thesis that the National Defense University eventually published as *The Air Campaign: Planning for Combat*. The book, updated in 2000, brings great clarity to the intersection of modern technology, airpower doctrine, and joint doctrine at the operational level of war.

Warden revisits the topic of “center of gravity” as the foundation for his book and the “five rings” system he developed. Warden wrote that centers of gravity exist not only at each level of war (grand strategic, strategic, operational, and tactical), but potentially at many points within a system at each level. As such, to affect a system like the political leadership of a nation, airpower would have to target all centers of gravity to alter the system.<sup>21</sup> Warden also developed his theory based on the assumption that individuals and organizations share certain qualities or functions being: leadership, energy conversion or

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<sup>21</sup> John A. Warden, *The Air Campaign: Planning for Combat* (Lincoln: ToExcel Press, 2000), 7.

production means, infrastructure, population, and fielded forces.<sup>22</sup> Warden visualizes these as five concentric rings with leadership in the center and military forces on the outside (Figure 4). Warden wrote that by viewing the enemy as systems within systems, airpower could target in parallel, the most critical centers of gravity within each system or ring to bring about strategic paralysis.<sup>23</sup> He went further to note that through intelligence gathering, it is possible to know if the enemy is “rational, irrational, fanatic, rigid, flexible, independent, innovative, determined, or doctrinaire” and to exploit those characteristics to predict enemy systems reactions to attack.<sup>24</sup> While physical destruction is often important, the *function* of system components is the true target.<sup>25</sup> Warden’s work on ideas of targeting systems in parallel to get at functions echoes into the twenty-first century in the form of “Effects Based Operations,” a joint operating concept championed by one of Warden’s Gulf War protégés, Lt Gen (ret.) David Deptula.<sup>26</sup> Although Warden’s seminal work emerged before the Persian Gulf War, it describes the air campaign approach during the war with great fidelity.

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<sup>22</sup> Ibid., 145.

<sup>23</sup> David S. Fadok, "John Boyd and John Warden: Air Power's Quest for Strategic Paralysis" (Research Paper, Air University, 1995), 1.

<sup>24</sup> Warden, 128.

<sup>25</sup> Ibid., 150.

<sup>26</sup> Lt Gen (ret.) David A. Deptula, "Effects Based Operations: Changes in the Nature of Warfare," ed. Aerospace Education Foundation (Arlington, VA: Aerospace Education Foundation, 2001).

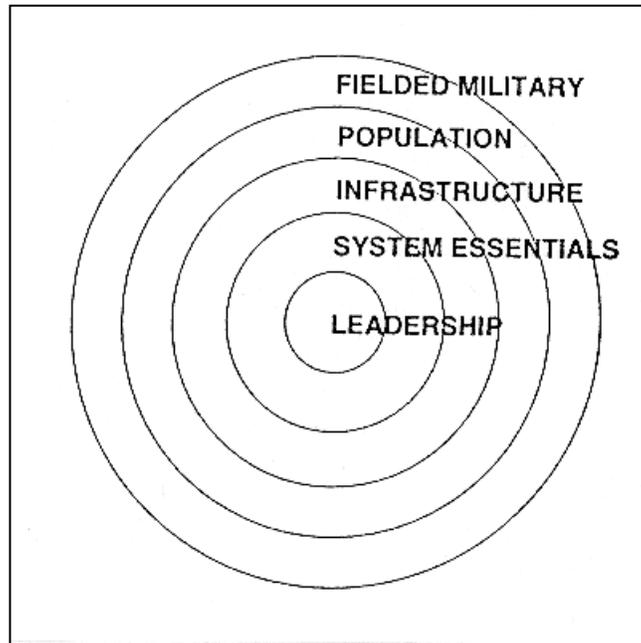


Figure 4. Warden's Five Rings Model

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Even though the five rings model is Warden's lasting signature, he clearly advocates for what he views as the proper priorities of air superiority, interdiction, and close air support. He states that, "Indeed, no nation enjoying air superiority has ever lost a war by the force of enemy arms" to unmistakably enjoin commanders not to parcel out airpower to interdiction or close air support prior to assuring enduring command of the air.<sup>28</sup> Warden's work summarizes as follows:

1. Air superiority is the *sine qua non* of an air campaign.
2. A five concentric ring model emanating from leadership, production means, infrastructure, population, outward towards military forces describes the enemy system of systems for airpower to target.

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<sup>27</sup> Col (ret.) John A. Warden III, "Air Theory for the Twenty-First Century" (Maxwell AFB, AL: Air University Press, 1995), 8.

<sup>28</sup> Warden, 129.

3. Airpower targets enemy systems in parallel, preferably prioritizing from the center of the five rings outward.<sup>29</sup> It targets functions, not just physical entities, through orchestration of precision weapons, stealth, and interdiction in lieu of CAS when possible.

Interestingly, Warden's work meets Reynolds' definition of theory. Whereas the Four Forces theory seeks to describe the nature of airpower, Warden prescribes a methodology for its employment. Each of his major tenets is abstract and intersubjective. The United States has not always faithfully employed airpower by attacking enemy systems in parallel, but this targeting scheme is visible from WWII to the present and especially in Operation Desert Storm. Empirical evidence in American wars since Desert Storm supports Warden's third tenet. Future wars will continue to test the durability of Warden's work as an airpower employment theory, especially against asymmetric threats. Like Douhet and Mitchell, Warden sought a better way of war through airpower. He built on the work of his predecessors, analyzed a great deal of historical airpower employment, and synthesized it into the framework of modern Air Force doctrine.

Douhet, Mitchell, and Warden form an incomplete list of important contributors to the realm of airpower ideas. However, they do represent the most prominent airpower advocates and theorists and thus build an understanding of both historical and modern airpower concepts. This understanding lays the foundation for the Four Forces theory. To demonstrate the explanatory and predictive utility of the Four Forces theory, the next section presents three case studies. Each case study illustrates the history of a

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<sup>29</sup> David R. Mets, *The Air Campaign: John Warden and the Classical Airpower Theorists* (Maxwell AFB, AL: Air University Press, 1998), 59.

technologically advanced airpower weapon system and applies the Four Forces theory. The result, while not ideal war, is an understanding of the contributions of each.

## Case Studies

### The Battleplane

The Boeing B-17 Flying Fortress was essentially Douhet's Battleplane. It was state of the art technology for its day, a critical component of the Allied victory, but not a singular key to ideal war. Figure 5 graphically depicts the application of the Four Forces theory to the B-17.

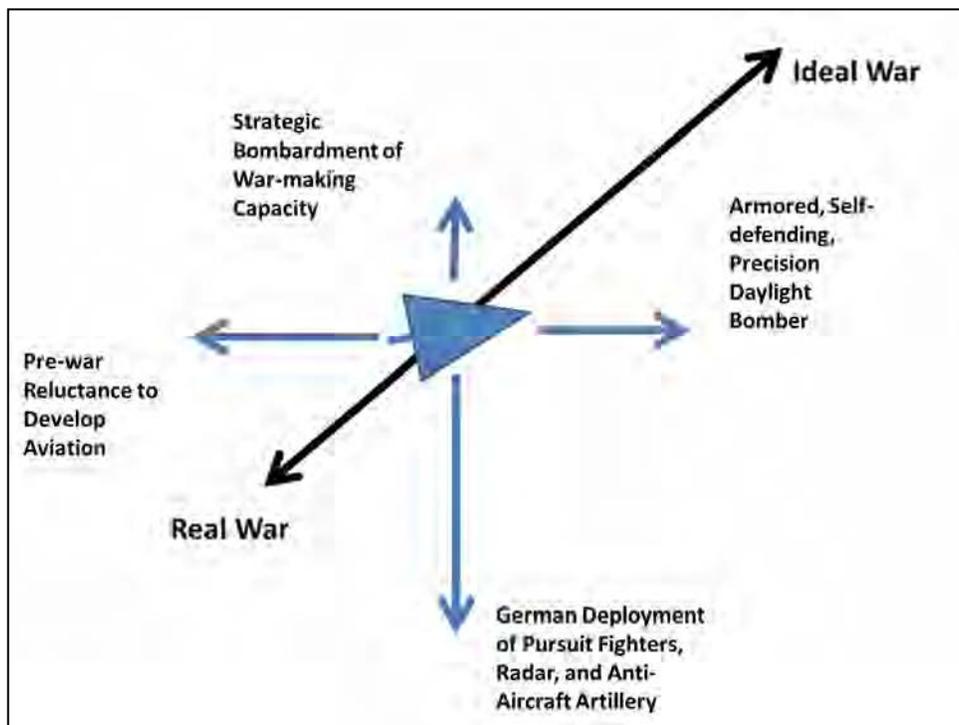


Figure 5. The Four Forces Theory Applied to the B-17

In *The Command of the Air*, Douhet arrives at the idea of a Battleplane from a series of deductions about speed, armament, armor, and agility.<sup>30</sup> These new heavy, multi-engine, and medium-speed Battleplanes would need the same defensive firepower, armor, radius, and speed as “combat” or pursuit planes. Douhet argues that an independent air force of Battleplanes would always fly in mutually supportive formations.<sup>31</sup> As such, each could carry less armor and defensive firepower because all would combine to have far greater ability to ward off attackers. The weight savings would allow these all-purpose craft to carry sufficient bombs to accomplish the mission. By merging combat planes and bombers into Battleplanes, independent air forces gain efficiency of single-phase operations with fewer aircraft.<sup>32</sup> Battleplanes needed to have modularity allowing the substitution of fuel, armor, bombs, and weaponry depending on the threat and range to targets.<sup>33</sup> Finally, Douhet calls for amphibious Battleplanes since air forces would have to conduct operations over land and sea. Should amphibious Battleplanes prove too technologically ambitious, he allows for identically capable land and sea versions.<sup>34</sup> The Battleplane was a tall order, but the Boeing Corporation essentially built it.

The interwar period proved ripe for the development of the Battleplane. Mitchell and other airpower advocates had kept the idea of airpower alive in the mind of the

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<sup>30</sup> Douhet, 115-17. He notes that a “combat plane,” which can be imagined as an escort fighter, needs to have a certain weight due to armament, defensive armor, and offensive weaponry. The combat plane needed a vague amount of speed in order to conduct an unlikely aerial battle and the radius of action to clear the way for a bomber. Douhet uses a reductionist mathematical model to determine that maximum efficiency comes from just adding bombing capacity to combat planes.

<sup>31</sup> *Ibid.*, 117.

<sup>32</sup> *Ibid.*, 118.

<sup>33</sup> *Ibid.*, 118-19.

<sup>34</sup> *Ibid.*, 119.

American public and government despite scant budgets and little desire to return to war. In 1934, however, the Army Air Corps requested a bomber to replace the Martin B-10 bomber. The new bomber needed to carry two thousand pounds of bombs at 200 miles per hour for a range of five thousand miles.<sup>35</sup> Prototypes of the future Flying Fortress trickled off the line throughout the next four years as setbacks and slim budgets cast doubt on the future of the B-17.<sup>36</sup>

As Germany began its rampage in Europe, America exported early B-17s to Great Britain to little tactical success. While British complaints led to improvements in the 0.3 and 0.5 inch guns, armor plating, and the widespread integration of the Norden bombsight in U.S. versions, the British declared the bomber unusable in September 1941.<sup>37</sup> Between losses to the Luftwaffe and inaccurate or dry bombing runs, the British swore off the B-17.

As Boeing evolved the B-17, the U.S. Army Air Corps Tactical School at Montgomery Field, Alabama evolved from the ideas of Mitchell and Douhet, the doctrine and tactics that future bombers would use. Two factions at the Air Corps Tactical School debated the primacy of bomber versus pursuit aircraft. The bomber camp won the debate, minimized the role of pursuit, and went on to author the WWII air campaign plan known as Air War Plans Division/1.<sup>38</sup>

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<sup>35</sup> Martin W. Bowman, *Combat Legend: B-17 Flying Fortress* (Shrewsbury, UK: Airlife Publishing Ltd, 2002), 5.

<sup>36</sup> *Ibid.*, 14.

<sup>37</sup> *Ibid.*, 16.

<sup>38</sup> Hugh G. Severs, "The Controversy Behind the Air Corps Tactical School's Strategic Bombardment Theory: An Analysis of the Bombardment Versus Pursuit Aviation Data Between 1930-1939" (Air University, 1997), 8. Severs explores what information was available to the Air Corps Tactical School in order to determine whether bombardment proponents ignored available information in coming to their conclusions. General Lawrence S. Kuter, "United States Air Force Oral History Interview," (Maxwell AFB, AL: Air Force Historical Research Agency, 1974), 112-13. Severs notes that upon reflection, General

Given that the planners came from “the bomber school,” Air War Plans Division/1’s emphasis on bomber requirements carries no surprise. The plan called for the buildup of a significant pursuit force, but buries several pages deep the tenet, “It is believed that the degree of reliability of conducting sustained offense of air operations would be greatly enhanced by development of an escort fighter.”<sup>39</sup>

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Kuter explains that strategic bombardment proponents at the Air Corps Tactical School closed their minds to the idea that unescorted bombers could be repulsed from the air or ground. Headquarters U.S. Army Air Forces, "AWPD/1 Munitions Requirements of The Army Air Forces", (Washington DC: 1941).

<sup>39</sup> Ibid., 12.

## Technology

From Air War Plans Division/1 and the work of the Air Corps Tactical School, the Army Air Corps clearly preferred that B-17 successors should also fight as Battleplanes. The B-29 Superfortress could have been the Battleplane if it were the most advanced and available bomber at the war's outset. The B-17 was available on December 7, 1941 and license production could increase the fleet quickly.<sup>40</sup> Technologically, the B-17 evolved quickly with the -F and -G variants numbering approximately 3400 and 8700 respectively. These later models had turbocharged engines, eleven or twelve .50 caliber guns, an 8,000 pound payload capacity, ceilings over 35,000 feet, top speeds over 300 miles per hour, and a combat configured range of approximately 1,800 nautical miles. With a crew of ten, the B-17 had six dedicated gunners. B-17 tactics called for mutually supportive formations that optimized both bomb impact patterns and defensive fires to and from the target. As such, multi-ship formations benefited from much more firepower than a single aircraft could alone provide, just as Douhet had forecast.

The concept of precision daylight bombing in WWII is very different from today's three-meter standards for satellite-guided weapons. With the Norden bombsight, experienced bombardiers claimed impacts within yards of desired impact points from altitudes over twenty thousand feet during training in 1940.<sup>41</sup> Crews bragged about dropping bombs into pickle barrels. This confidence did not completely spill over into the development of Air War Plans Division/1. The war planners assumed far more realistic figures including: 220 feet of "long-short" error and 275 feet of "left-right" error. For a

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<sup>40</sup> Bowman, 73. Boeing eventually licensed production of B-17s to Lockheed Vega and Douglas in order to meet production demand. Engineering updates often resulted in widely varied aircraft supposedly of the same design.

<sup>41</sup>Ibid., 15.

hypothetical 100 foot by 100 foot target, the single sortie statistical probability of a direct hit by any bomb from a series was .012 percent. This drove the need for 220 bombers to attack a target to ensure its destruction in one mission.<sup>42</sup>

Douhet and Mitchell called for precision strategic bombardment capability. The Air Corps and aircraft industry delivered what they could with the available time, funding, engineering, and aeronautical technology. The result was the B-17. It was an aircraft that, under combat conditions, needed 219 formation members to achieve a 90 percent probability of target destruction. Even if that is an uninspiring statistic by today's standards, it must be view in light of the fact that the Axis powers did not have any equivalent Battleplane.

## Effects

A certain amount of lore surrounds the B-17. It is one of the most prolifically produced combat aircraft ever and it was the workhorse of the European strategic bombing campaign. It starred in movies and television shows. However, it did not create ideal war. At face value, Mitchell and Douhet would have expected that the threat of bombing would cause enemies to evacuate their towns and cease all war-making production and that chaos would rule cities targeted by airpower.<sup>43</sup> The actual effects, while critical to the war's outcome, fell short of these predictions.

The Allies dropped 2.7 million tons of bombs on 1.4 million sorties on Axis targets in Europe. Towards the end of the war, President Truman directed a survey of

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<sup>42</sup> "AWPD/1 Munitions Requirements of The Army Air Forces."

<sup>43</sup> Mitchell, 433. Douhet, 20-23.

Allied bombing effects called The United States Strategic Bombing Survey.<sup>44</sup> A concise review of the survey reveals that bombing of German war-making and civilian economic targets killed three hundred thousand German civilians and wounded another 780,000. Bombing destroyed 3.6 million homes rendering as much as 20% of the population at least temporarily homeless.<sup>45</sup>

The Bombing Survey determined that on average, only 20% of bombs fell within 1000 feet of the intended target.<sup>46</sup> By comparison, modern standards for building destruction require direct hits to the structure to disable internal functions such as manufacture. When Allied bombing concentrated on specific target systems, the results reflected the bombing accuracy. Attacks on submarine facilities in 1943 accomplished little beyond harassment due to the twelve feet of concrete covering critical areas.<sup>47</sup> When the Allies concentrated on ball bearing and aircraft manufacturing, German industrial output dipped temporarily, but rebounded within months.<sup>48</sup> Interviews with German leaders and factory management exposed that, prior to the attacks, German industrial efficiency was low by Allied standards. Characterized by single shifts, shorter workweeks, and excess machinery, German industries rebounded quickly by optimizing remaining capacity.<sup>49</sup>

Strategic bombardment from B-17s and B-24s achieved the greatest effects against German oil and transportation industries. Over the course of an entire year, Allies

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<sup>44</sup> *The United States Strategic Bombing Surveys (European War) (Pacific War)*, ed. Air University Press (Maxwell AFB, AL: Air University Press, 1987).

<sup>45</sup> *Ibid.*, 5-6.

<sup>46</sup> *Ibid.*, 13.

<sup>47</sup> *Ibid.*, 14.

<sup>48</sup> *Ibid.*, 15-18.

<sup>49</sup> *Ibid.*, 15-19.

flew 6,552 sorties dropping 18,328 tons of bombs on the Leuna synthetic oil production complex. Germany successfully reconstituted some refinement capacity, but output eventually dwindled below 15% by May 1944. Output never recovered much above this level and German consumption exceeded production for the rest of the war. The Wehrmacht and Luftwaffe felt the fuel starvation sharply as Panzer divisions stopped in their tracks and replacement pilot training flight hours fell precipitously.<sup>50</sup> Attacks on German railways and inland river transportation also decimated German war-making capacity, but no single attack or industry caused a deathblow to Germany. In fact, many aspects of the German economy continued to grow throughout the war.<sup>51</sup> While not specifically part of the bombing plan, Allied attacks frequently overwhelmed medical and fire response capability after raids resulting in higher civilian casualty and property damage than planners expected.<sup>52</sup>

After nearly five years of service in the Royal Air Force and Army Air Corps (and later Army Air Forces), the technologically advanced Battleplane never dealt a decisive blow that could turn WWII into a quick, ideal war. Douhet, Mitchell, and others felt certain that strategic bombing from invincible bombers would quickly terrorize civilians until they idled economies if not overturned governments. Excess economic capacity and adaptable populations contributed, but perhaps the best explanation for the absence of ideal war in Germany is that, “The power of a police state over its people cannot be underestimated.”<sup>53</sup>

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<sup>50</sup> Ibid., 22-23.

<sup>51</sup> William R. Emmerson, "Operation Pointblank: A Tale of Bombers and Fighters," United States Air Force Academy, <http://www.usafa.edu/df/dfh/docs/Harmon04.doc> (accessed October 7).

<sup>52</sup> *The United States Strategic Bombing Surveys (European War) (Pacific War)*, 35.

<sup>53</sup> Ibid., 39.

## Resources

Technology provided only so much thrust to the Battleplane. The resultant lift, or effects, never attained ideal war altitude. Resource constraints provided one of two major opposing forces.

Looking only at 1945 and the nearly 13,000 B-17s that had rolled off of assembly lines, it is difficult to think of resource constraints as a major source of drag on the Battleplane concept. However, resource scarcity put friction against the B-17 prior to its appearance on the drawing board. After WWI, the Army cut aviation manning, equipment, and overall strength by ninety-five percent. Airpower suffered from a vacuum of doctrine and combat-proven tactics which muted its budget influence compared to ground Army and Navy needs.<sup>54</sup> Billy Mitchell and others worked to keep aviation in the public, Congressional, and General Staff spotlight, but many efforts were counterproductive. Lean Air Corps budgets continued throughout the 1930s as the Army and Navy perpetuated the narrative that airpower was only for support of ground and naval forces and needed only limited funding.

Despite the B-17's initial production troubles, the Air Corps determined to exhibit its capabilities as much as possible. Although it only had a mandate for homeland defense, the Air Corps demonstrated intercontinental reach in February 1938 with B-17 tours to South America and back.<sup>55</sup> During highly publicized air exercises on May 12, 1938, a formation of B-17s led by future Air Force Chief of Staff, Curtis Lemay, intercepted and targeted the Italian cruise liner *Rex* 725 miles from New York's coast

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<sup>54</sup> Phillip S. Meilinger, *The Paths of Heaven: The Evolution of Airpower Theory* (Maxwell AFB, AL: Air University Press, 1997), 185.

<sup>55</sup> Bowman, 11.

despite nearly prohibitive weather. This event once again demonstrated airpower's ability to conduct coastal and continental defense while flaunting naval vulnerability.<sup>56</sup> The Navy answered this challenge by demanding that the Army cease violations of its mandate for sea control. The Army Chief of Staff, General Malin Craig, who viewed any military element other than infantry as a supporting "nonstory," caved into Navy pressure and mandated that Air Corps operation remain within 100 miles of the U.S. coast.<sup>57</sup> Craig further called for funding limits on any type of aircraft other than those suited for direct support of land forces. At the same time, the Army haggled with Boeing to lower the price of the few B-17s it had on contract in order to ensure adequate funding for its obligations.<sup>58</sup> Squabbles such as this served as a constant check against the Air Corps' ability to explore and expand its Battleplane capability. In 1938, the new Air Corps Chief, Major General Henry "Hap" Arnold made public his fears about the state of American airpower in saying, "Until quite recently, we have had marked superiority in airplanes, engines, and accessories. That superiority is now definitely challenged by recent developments abroad. This means that our experimental development programs must be speeded up."<sup>59</sup> A year later, the United States only produced three thousand aircraft. This number rocketed to one hundred thousand by 1944, but the stunting effects of resource limits on the B-17 and other technologies would hurt for most of WWII.<sup>60</sup>

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<sup>56</sup> John T. Correll, "Rendezvous with the *Rex*," *Air Force Magazine* December (2008), <http://www.airforce-magazine.com/MagazineArchive/Pages/2008/December%202008/1208rex.aspx> (accessed December 1, 2010).

<sup>57</sup> Philip S. Meilinger, *Airwar: Essays on its Theory and Practice*, Studies in Air Power (London: Frank Cass Publishers, 2003), 147.

<sup>58</sup> Bowman, 12.

<sup>59</sup> Dik A. Daso, *Architects of American Air Supremacy : Gen. Hap Arnold and Dr. Theodore von Kármán* (Maxwell AFB, AL: Air University Press, 1997), 58.

<sup>60</sup> Walter J. Boyne, *The Influence of Air Power Upon History* (Gretna, LA: Pelican, 2003), 151.

Resource limits proved to be a very regressive condition for the B-17. A marginally recovering economy naturally curtailed defense spending. The Army Air Corps had difficulty justifying the \$238,000 price tag for B-17s that clearly had capability beyond the doctrinal mission of coastal defense. Rivalry and acrimonious debate between the Army and Navy diluted funding further. Less money meant less research and development that could overcome technological hurdles as well as less training to develop tactics, doctrine, and strategy. Finally, the lack of national will to prepare for war meant that even the President could not remedy the resource vacuum for a Battleplane.<sup>61</sup> Resource constraints provided massive parasitic drag, but the enemy pulled at the B-17 too.

### Enemy Counter-tactics and Technology

Dismissal of a counter to airpower, specifically to strategic bombardment, from the ground or air is perhaps the most glaring flaw in early airpower theory. Mitchell argued that, “nothing can stop the attack of aircraft except other aircraft,”<sup>62</sup> while noting that, “The air is so vast and extends so far that the shooting of airplanes out of the sky, with cannon from the ground, it's almost impossible of achievement, especially when the planes are almost always protected by the clouds, by the glaring sun, or by darkness.”<sup>63</sup> Douhet similarly argued that incoming aircraft were undetectable prior to accomplishing their mission. Independent air forces should destroy enemy aircraft prior to takeoff. Antiaircraft artillery was even less useful to Douhet. Not only was it ineffective against aircraft, but it created a rain of shrapnel and ordnance back upon friendly troops and

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<sup>61</sup> Bowman, 14.

<sup>62</sup> Mitchell, 433.

<sup>63</sup> Ibid., 502.

civilians.<sup>64</sup> Unfortunately, the tendency to predict unrestricted growth of friendly technology and lethality while denying the same potential to enemies seems timeless.

The primacy of the “bomber will always get through” culture leading into WWII may have been a factor in the delayed development of long range escort fighters like the P-51 Mustang, but scarce funding and technology held such concepts back as well. In his reflection, Major General Haywood Hansell of Air War Plans Division/1 fame said, “The escort fighters, whose assistance had been predicted, were sorely needed. Penetration of German airspace had to be limited until long-range fighters could be provided. The solution came in the form of droppable auxiliary tanks. Why no one had thought of this earlier defies explanation.”<sup>65</sup> Hansell’s sentiment was common among the bomber school. General Lawrence Kuter, in discussing the lack of escort in a period where his unit lost twenty-five percent of its B-17s each month for three months said, “We just closed our minds to it; we couldn’t be stopped—the bomber was invincible.”<sup>66</sup> The Italian campaign in Ethiopia, the Spanish Civil War, the Battle of Britain, and in fact routine Air Corps training repeatedly proved the ability of pursuit aircraft to decimate bomber formations regardless of their organic weaponry.<sup>67</sup> The lack of escort was disastrous over Europe until the Allies achieved air superiority.

Over the course of the war in Europe, Germany developed a web of counter-tactics against the B-17 and other Allied planes. Antiaircraft artillery quickly matched the

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<sup>64</sup> Douhet, 17-18.

<sup>65</sup> Haywood S. Hansell, *The Strategic Air War Against Germany and Japan: A Memoir*, USAF Warrior Studies (Washington, DC: Office of Air Force History, 1986), 191.

<sup>66</sup> Severs, 8. General Lawrence S. Kuter, United States Air Force Oral History Interview, 1974, Air University (Maxwell AFB: Air Force Historical Research Agency), 112- 113.

<sup>67</sup> Lieutenant E. W. Kepner, Final Report (Pursuit Aviation), Joint Antiaircraft–Air Corps Exercises, Fort Bragg, 1938, (Maxwell AFB: Air Force Historical Research Agency), 2.

speeds and altitudes of Allied bombers despite earlier prognostications. German radar provided early warning, fighter intercepts, and artillery aiming.<sup>68</sup> The Germans spread industry, specifically aircraft and other component systems, not just throughout the country, but throughout conquered nations as well. Weather, while outside the control of either combatant, combined with smoke screens and other battlefield obscurations to drive down Allied bombing accuracy and contributed to the need to revisit targets frequently.<sup>69</sup> Germany used captured B-17s to infiltrate, confuse, and potentially attack Allied formations.<sup>70</sup> The Luftwaffe takes top honors among underestimated German defenses. Accounts vary, but B-17 losses in WWII, number as high as 4,750.<sup>71</sup> Attrition on sorties throughout 1943 averaged double digits with some missions losing over fifty percent. Antiaircraft artillery, or “flak,” made a deadly combination with the enemy fighters. In tactics that are still used today, the flak would either channel B-17s into envelopes favorable to the Luftwaffe or damage the bombers enough to create easy wounded prey for the fighters.

Many authoritative works on the subject agree that Allied attacks on German industry bled the Luftwaffe, but policy changes like General James Doolittle’s 1944 directive that, “The first duty of Eighth Air Force fighters is to destroy German fighters,” defeated the German Air Force.<sup>72</sup> When Allied tactics changed to allow escort fighters to seek and destroy the Luftwaffe both in the air and on the ground, the tide turned for good.

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<sup>68</sup> R. Cargill Hall, *Case Studies in Strategic Bombardment*, Air Force History and Museums Program (Washington, DC: Air Force History and Museums Program, 1998), 197.

<sup>69</sup> *The United States Strategic Bombing Surveys (European War) (Pacific War)*, 13.

<sup>70</sup> Roger Anthony Freeman, *B-17 Fortress at War* (London: Allan, 1977), 178-81.

<sup>71</sup> Martin Caidin, *Flying Forts* (New York: Meredith Press, 1968), 486.

<sup>72</sup> Hall, 212.

A thinking, interactive enemy provides an excellent analog to gravity. No matter what targets B-17s went after, German fighters, artillery, camouflage, and other counter-tactics pulled effectiveness down. Whereas the United States entered WWII with faith in the high altitude, precision, self-escorting Battleplane, it emerged realizing that strategic bombardment could not win wars without air superiority, which did not come from bombers alone.

## Summary

This case study does not intend to condemn the B-17, the Battleplane concept, or even strategic bombardment as products of uninformed conjecture. Quick, decisive war did not come from the B-17 or other early airpower ideas, but many other benefits did. At a macro level, the United States developed and maintained a large air force with a powerful deterrent element to it that has proved quite useful. Surely strategic bombardment is not the only reason, but total war has not engulfed the planet since WWII. Strategic bombardment in WWII demonstrated that complete sanctuary from enemy air forces may be impossible. Finally, the B-17 and other Allied bombers and pursuit aircraft explored and expanded the technologies that would shape future American wartime successes. Analysis vis-à-vis the Four Forces theory explains why ideal war could not come from the B-17 or other WWII aircraft despite the technology and doctrine available. It also establishes an important precedent: airpower advocacy, concepts, and theories might initially seem to lead to ideal war, but when they do not, they still make valuable contributions towards quicker, cleaner war.

## The Atomic Bomb

The free-fall nuclear bomb also failed to make future wars ideal. An attractive argument holds that since Japan surrendered after two atomic attacks, then technologically advanced strategic bombing can now deliver ideal wars. As this case study details and Figure 6 illustrates, the free-fall nuclear bomb, like the B-17 suffers from too much resource constraint drag and enemy technology and counter-tactics pull to enable ideal war. Douhet conducted optimistic informal weaponeering by assuming that technology could and would soon yield a “unit of bombardment.” This standard measure of destructive effects could destroy everything within five hundred meters of its impact.<sup>73</sup> Douhet did not specify that a single device should create this effect, but he did assume that it would contain explosive, incendiary, and poison and should come from the most efficient number of bombers possible. It is safe to assume that Douhet was unaware that scientists would leap over the five hundred meter radius with a single bomb twenty-four years later. Given his advocacy of poison bombs, Douhet would likely have endorsed nuclear bombs but his real influence on the development of nuclear weapons was perpetuation of the strategic bombardment tenet of airpower.

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<sup>73</sup> Douhet, 35-36.

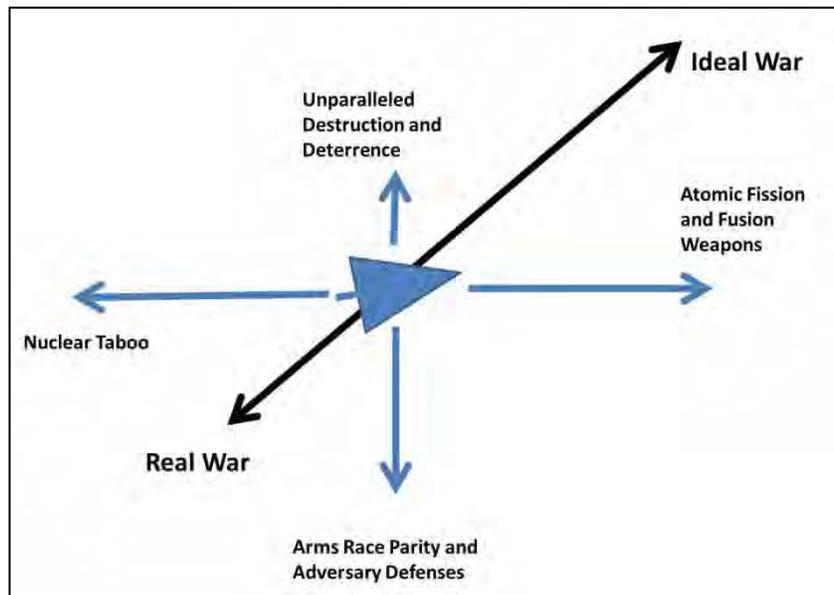


Figure 6. Four Forces Theory Applied to Free-fall Nuclear Bomb

President Roosevelt, both mortified at the continued savagery of the war and anxious to repay Japan for Pearl Harbor, continued to ratchet up pressure on the War Department for greater strategic bombing results in Japan.<sup>74</sup> Intelligence indicated that Japan had no intention of surrendering and Germany outpaced American atomic research.<sup>75</sup> The dominant narrative among Manhattan Project scientists, civilian, and military leaders was that an atomic bomb would be decisive and would save more lives than it would cost.<sup>76</sup> Douhet and Mitchell had passed, but Army Air Force Chief of Staff, General Henry “Hap” Arnold and the few other airmen who knew of the bomb prior to the Hiroshima attack could hardly wait for the first delivery. They were not alone. In

<sup>74</sup> Richard P. Hallion and Herman S. Wolk, "FDR and Truman: Continuity and Context in the A-Bomb Decision," *Air Power Journal* (Fall 1995): 3 [http://www.airpower.maxwell.af.mil/airchronicles/apj/apj95/fal95\\_files/wolk.pdf](http://www.airpower.maxwell.af.mil/airchronicles/apj/apj95/fal95_files/wolk.pdf) (accessed December 7, 2010).

<sup>75</sup> *Ibid.*, 4. Lt Col Tommy Dillard, "The Leadership Decision and Necessity to use Nuclear Weapons to End World War II" (Research Paper, Air War College, 1994), 14, <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA280658&Location=U2&doc=GetTRDoc.pdf> (accessed December 7, 2010).

<sup>76</sup> Marion D. Tunstall, "Legacies, Assumptions, and Decisions. The Path to Hiroshima" (Research Paper, National War College, 1997), 3, <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA442716&Location=U2&doc=GetTRDoc.pdf> (accessed December 7, 2010).

1945, the atomic bomb was a unique American crown jewel. The authors of the United States Strategic Bombing Survey noted that, “The capacity to destroy, given control of the air and an adequate supply of atomic bombs, is beyond question. Unless both of these conditions are met, however, any attempts to produce war-decisive results through atomic bombing may encounter problems similar to those encountered in conventional bombing.”<sup>77</sup> General Arnold stated that, “The influence of Atomic Energy on Airpower can be stated very simply. It has made airpower all important.”<sup>78</sup> War Secretary Henry Stimson articulated some of the competing sentiments about the bomb when he said, “It stopped the fire raids and the strangling blockade; it ended the ghastly specter of a clash of great land armies.”<sup>79</sup> The atomic bomb appeared to have delivered on the airpower promise. Perhaps future wars would be quick and decisive, because nuclear bombs would destroy vital military and industrial centers while driving civilian morale past its breaking point.

## Technology

The United States dropped fission bombs on Japan. They converted the mass of atoms into energy by splitting atoms apart. The Manhattan Project scientists also postulated a far more destructive capability in the fusion of atoms. In November 1952, the United States detonated the first fusion, or thermonuclear bomb, which yielded

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<sup>77</sup> *The United States Strategic Bombing Surveys (European War) (Pacific War)*, 113.

<sup>78</sup> Michael D. Gordin, *Five Days in August: How World War II Became a Nuclear War* (Princeton, NJ: Princeton University Press, 2007), 120.

<sup>79</sup> Henry L. Stimson, "The Decision to Use the Atomic Bomb," *Harper's* 1947 <https://www.asian-studies.org/EAA/StimsonHarpers.pdf> (accessed December 7, 2010).

approximately ten megatons.<sup>80</sup> Conventional bomb technology highlights the magnitude of this advance. The United States' primary heavy conventional bomb today is the two thousand pound class Mk-84. Approximately half of the mass is explosive material. The Hiroshima and Nagasaki fission bombs yielded the equivalent of twenty to forty thousand of today's Mk-84s. The first fusion bomb yielded as much as twenty million times the explosive effect of a Mk-84. For a similar leap in say, jet aircraft speed, which started out around five hundred miles per hour, scientists would have needed to produce an aircraft that could fly at least ten million miles per hour. The technological "thrust" of nuclear bombs when compared to the previous bomb technology is nothing short of stunning.

## Effects

Historians have documented the effects of the atomic bombings well. Over one hundred thousand people died immediately between Hiroshima and Nagasaki. Six square miles, nearly fifty percent of the cities ceased to exist.<sup>81</sup> Immediate injuries and radiation poisoning crippled or killed tens of thousands more people in the subsequent days, months, and years. President Truman clearly felt that the only way to avoid hundreds of thousands, if not millions of additional friendly and enemy casualties, was to employ nuclear bombs.<sup>82</sup> Japan surrendered almost immediately. If ideal war should be decisive, quick, and economical in lives and resources, then the atomic era portion of WWII seems to fit the bill. Unfortunately, history and the Four Forces theory suggest otherwise.

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<sup>80</sup> Christy Campbell, *Nuclear Facts A Guide to Nuclear Weapons Systems and Strategy* (London: Hamlyn, 1984), 37.

<sup>81</sup> *The United States Strategic Bombing Surveys (European War) (Pacific War)*, 96.

<sup>82</sup> Harry S. Truman, Letter to Richard B. Russell, August 9, 1945, [http://www.trumanlibrary.org/whistlestop/study\\_collections/bomb/large/documents/index.php?documentdate=1945-08-09&documentid=9&studycollectionid=abomb&pagenumber=1](http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/documents/index.php?documentdate=1945-08-09&documentid=9&studycollectionid=abomb&pagenumber=1) (accessed December 8, 2010).

## Resources

If the U.S. inventory of nuclear weapons, including missile versions, peaked around 1967 at thirty-two thousand individual devices, and between 1940 and 1996, the United States spent \$5.5 trillion on nuclear weapons programs, then monetary resources are not the principle resource constraint dragging nuclear bombs back from delivering ideal war.<sup>83</sup> A different type of resource constraint is however, the major source of drag on the effectiveness of nuclear bombs.

Despite forty-five years of the Cold War, a period that seemed to threaten global nuclear annihilation in a war between the United States and Soviet Union, no nuclear state has employed its weapons since 1945. Several arguments could tell the story. Nuclear deterrence comes from the idea, “the favorable results of a total war can never be sufficient to justify its cost.”<sup>84</sup> Barely a year after Japan’s surrender, Bernard Brodie very accurately predicted eight key aspects of the nuclear age while helping define American nuclear strategy. One of the most important, is that defense against nuclear weapons does not and cannot exist.<sup>85</sup> His other seven predictions lay the foundation for the concepts of retaliatory strikes and mutually assured destruction, which became key aspect of U.S. policy. Deterrence, born from fear of retaliation and assured destruction, is one of the most cited reasons why two nuclear powers have not fought each other with nuclear weapons. Deterrence does not answer sufficiently why nuclear states have not employed nuclear bombs against non-nuclear states.

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<sup>83</sup> Campbell, 26. Stephen I. Schwartz, "The Hidden Costs of our Nuclear Arsenal: Overview of Project and Findings," Brookings Institution, <http://www.brookings.edu/projects/archive/nucweapons/schwartz.aspx> (accessed December 14, 2010).

<sup>84</sup> Bernard Brodie, "The Anatomy of Deterrence" (Research Paper, Rand Corporation, 1958), 1.

<sup>85</sup> Bernard Brodie et al., *The Absolute Weapon* (New York: Harcourt, 1946), 28.

Stated U.S. nuclear policy has morphed over time, but actual policy outcomes have settled into what Nina Tannenwald calls the nuclear taboo. Tannenwald argues that this taboo is the resource drain on nuclear bombs and that it began almost immediately after the explosions at Hiroshima and Nagasaki. The nuclear taboo is the idea that because nuclear weapons are different from conventional bombs in both scale and effects, the international norm must be non-use. The massive explosive and incendiary power combines with radiological after-effects and rivals formally outlawed chemical and biological weapons. Tannenwald argues that revulsion and moral outrage at nuclear employment began even before the Soviets achieved the ability to visit nuclear destruction upon American soil.<sup>86</sup> President Truman captured the sentiment when he said, “I could not bring myself to order the slaughter of 25,000,000... I just could not make the order for a Third World War.”<sup>87</sup> Even though President Eisenhower and his Secretary of State John Dulles at one point sought to shift nuclear bombs back to the same stature as conventional weapons, the Korean War set the standard for non-use. Nuclear weapons were clearly not part of regular warfare in the nuclear age. While a stiff debate exists over the extent that public outcry against nuclear weapons affects national policy, the reality is that both an anti-war and anti-nuclear weapon narrative was a significant part of the American discourse in the Cold War.<sup>88</sup> The nuclear taboo developed not just from aversion to the specter of nuclear war, but a trend of national decisions. Tannenwald characterizes these national decisions such as non-use in all conflicts since 1945 and

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<sup>86</sup> Nina Tannenwald, *The Nuclear Taboo: The United States and the Non-Use of Nuclear Weapons Since 1945*, Cambridge Studies in International Relations (Cambridge: Cambridge University Press, 2007), 1.

<sup>87</sup> Harry S. Truman and Robert H. Ferrell, *Off the Record: The Private Papers of Harry S. Truman*, 1st ed. (New York: Harper & Row, 1980), 304.

<sup>88</sup> Tannenwald, 59.

entry into dozens of “freedom of action limiting” treaties and agreements as normative behavior.<sup>89</sup> Effectively, national will at both the public and policy-maker level, could not withstand the moral arguments against nuclear use nor the risk of annihilation that nuclear use virtually ensured. Overtime, inhibition against nuclear employment became self-reinforcing through precedent, mutual deterrence, and national will. The latter has become the ultimate friction against the nuclear bomb. It explains both why nuclear nations choose not to use nuclear weapons against each other and against non-nuclear states.

### Enemy Counter-tactics and Technology

A glance at any photo of Hiroshima or Nagasaki in August 1945 makes a cold argument against defense from nuclear weapons. The resource of national will is the greater force against the potential effectiveness of nuclear bombs, but enemy counter-tactics and technology provide heavy gravity too. The development of intercontinental ballistic missiles, target hardening, civil defense measures, and delivery system dispersal combined to help create an entangling arms race from which both Russia and United States are still trying to unwind. Throughout the Cold War arms race however, each side continued to prove to the other that no technology would result in decisive nuclear superiority.

The 1957 Soviet launch of the Sputnik satellite inaugurated the end of free-fall nuclear bomb supremacy. America realized, that however crude or inaccurate it might be, the rocket carrying Sputnik could also reach the continental United States with a nuclear

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<sup>89</sup> Nina Tannenwald, "The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use," *International Organization* 53, no. 3 (Summer 1999): 433, 36 <http://www.jstor.org/stable/2601286> (accessed Dec 14, 2010).

payload. Suddenly the American bomber fleet and nuclear bomb arsenal no longer guaranteed quick and devastating ideal war against the Soviets. Nuclear bombs no longer guaranteed victory or even security. Within five years, both the United States and Soviet Union had fielded sufficient missile forces to open the debate about counterforce strikes or targeting of enemy nuclear weapons.<sup>90</sup> The advent of the intercontinental ballistic missile spiraled into a tit-for-tat arms race. Submarine launched ballistic missiles could retain surprise and second-strike capability if newly fielded early warning systems detected intercontinental ballistic missile launches. The development of hardened missile silos drove the need for more accurate intercontinental and submarine launched ballistic missiles as well as increased warhead inventory. Anti-ballistic missile defense systems created the need for multiple independent reentry vehicle warheads that could frustrate anti-ballistic missile systems and conduct viable counterforce missions. Cold War missile proliferation would not taper off until the late 1980s.

Free-fall nuclear bombs did not vanish in the missile age. Intercontinental ballistic missiles and other missiles did not yet benefit from satellite precision guidance as they do today. To ensure sufficient accuracy for the most hardened targets, both sides developed a stream of bombers, supersonic bombers, and air-launched nuclear missiles that could attempt to penetrate or evade enemy radar. In order to prove that nuclear war would not actually annihilate the enemy state, both sides developed civil defense programs and shelters that could protect some of the population, at least during a strike. Finally, while submarines provided one form of hard-to-find weapons, the Soviets fielded, and the United States nearly fielded, mobile intercontinental ballistic missiles that could evade

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<sup>90</sup> Campbell, 44.

enemy intelligence in order to retain a credible second-strike capability.<sup>91</sup> While eventually negated by treaties, American and Soviet planners even sought to weaponize outer space and the ocean floors.<sup>92</sup>

No matter what each adversary developed, the other could match or defeat it within only a few years. The nuclear arms race that followed the first atomic bombs followed a similar pattern to the B-17. Air advocates continued the push for refined strategic bombardment technology only to find that the enemy voted to match, negate, or even defeat the new technology.

## Summary

For a short period after Hiroshima and Nagasaki, nuclear bombs seemed to hold the promise of ideal war that could at least save friendly lives if not those of the enemy. Some even argued that nuclear bombs could deter any future war since the chance of assured destruction could not justify the reward of aggression. National will, and eventually international will, to avoid employing the weapon created a nuclear taboo. That taboo now seems to provide nearly infinite drag on the use of any nuclear weapon by state actors. This taboo allows conventional wars, including those between nuclear powers such as Pakistan and India, but holds nuclear weapons as illegitimate tools of the state. Finally, enemy technology and counter-tactics rapidly negated the potentially decisive effects of nuclear bombs.

While, the Four Forces theory explains why the free-fall nuclear bomb failed to bring about either ideal war or deter war altogether, other benefits developed out of the

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<sup>91</sup> Ibid., 45.

<sup>92</sup> Ibid.

nuclear bomb. One argument is that deterrence against use of nuclear weapons by any rational state actor grows over time as non-use continues to be the norm. Another benefit is that if, at its extreme, ideal war is the absence of any war then a continuum of war leads to that extreme. If total world war among great power nation states (e.g. WWI and WWII) and limited war (Korea and Vietnam) both exist in that continuum, surely the lesser of and more desirable is limited war which, while not necessarily decisive or quick, is certainly less costly. Put another way, what would the world prefer: world wars that escalate to engulf entire nations or limited wars that, to avoid escalation to uncontrollable nuclear exchanges, drag on for years to indecisive conclusions? While not an appealing choice, the risk of annihilation in nuclear world war has made limited wars “best” available option. Finally, since nuclear have helped create such an aversion to destruction in war, nations such as the United States have developed more precise weapons (e.g. laser and satellite guided bombs) that achieve the desired destruction while minimizing collateral damage.

On the balance, the airpower advocacy that led toward the strategic bombardment extreme may have overshot the goal of bombing an enemy into a quick, clean submission. However, the character of war has drifted away from total war and no longer claims lives by the millions. The nuclear bomb did not create ideal war, but warfare has been less costly with its unappealing existence as a worst-case option.

### **The F-22A Raptor**

The F-22A Raptor is one of the most technologically advanced non-nuclear ideas grown from airpower advocacy. This case study demonstrates and Figure 7 illustrates,

that resource constraints, and to a lesser degree, enemy counter-tactics and technology prevent the F-22A from creating ideal war.

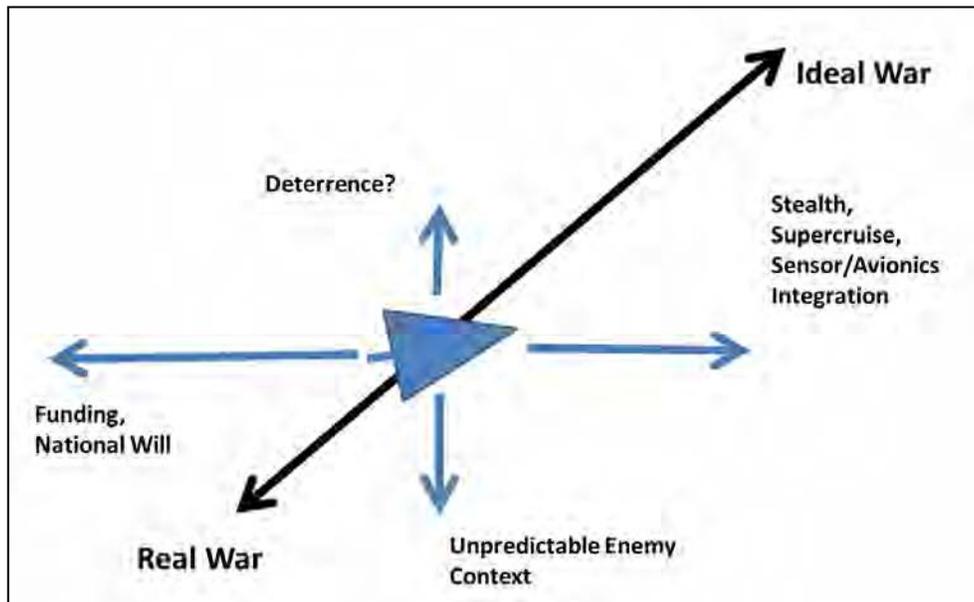


Figure 7. Four Forces Theory Applied to the F-22A

Much of the F-22A controversy that has played out in the media, congressional testimony and budgeting, and elsewhere stems from the cost of the system relative to the perceived need for its capabilities. This is where the story of airpower advocacy and the F-22A begins. The first significant congressional F-22A funding began in 1986 but the Air Force did not award a contract until 1991.<sup>93</sup> In actuality, the Advanced Tactical Fighter concept that led to the F-22A began in the 1970s while development the fourth generation F-15, F-18, and F-16 continued. Realization in 1978 that the Soviet Union

<sup>93</sup> Ronald O'Rourke, "Air Force F-22 Program: Background and Issues for Congress" (Research Paper, Congressional Research Service, 2009), 7, <http://www.fas.org/sgp/crs/weapons/RL31673.pdf> (accessed December 26, 2010).

would field the MiG-29 and Su-27 fighters early in the life of America's fourth generation fighters spawned the Advanced Tactical Fighter. Analysis of surface-to-air missile lethality in Vietnam contributed heavily as well. Air Force leadership felt that it needed enduring supersonic speeds and low observability, absent in emerging fighters, in order to defeat evolving Soviet air and surface threats.<sup>94</sup> This new requirement set the stage for a nearly three-decade struggle for the F-22A.

Throughout the 1990s to the final F-22A purchase decision, Air Force Chiefs of Staff served as the primary official advocates for the F-22A. Over nearly 20 years, their message stayed virtually the same. The F-22A would be primarily an air superiority fighter because without air superiority, joint forces could not perform any other missions. The F-22A would have a limited air-to-ground role, because it might be the only fighter able to penetrate advanced surface-to-air missile envelopes. During his tenure as Chief of Staff, Air Force General Merrill McPeak said that, "The F-22, I would anticipate, will sort out the air-to-air problem quickly, and then we would like to be able to do something else with it."<sup>95</sup> His successor, General Ronald Fogelman agreed, saying, "The combination of stealth, supercruise, and integrated avionics is a quantum jump. It will allow the United States to cease worrying about air superiority for the first 35 years of the next century."<sup>96</sup> Former Air Force Chief of Staff, General Michael Ryan testified to

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<sup>94</sup> David C. Aronstein, Michael J. Hirschberg, and Albert C. Piccirillo, *Advanced Tactical Fighter to F-22 Raptor: Origins of the 21st Century Air Dominance Fighter* (Reston, VA: American Institute of Aeronautics and Astronautics, 1998), 11.

<sup>95</sup> John Boatman, "The Jane's Interview," *Jane's Defence Weekly* 2, no. 12 (1993) [http://search.janes.com.lumen.cgsccarl.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw93/jdw00663.htm@current&pageSelected=allJanes&keyword=mcpeak&backPath=http://search.janes.com.lumen.cgsccarl.com/Search&Prod\\_Name=JDW&](http://search.janes.com.lumen.cgsccarl.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw93/jdw00663.htm@current&pageSelected=allJanes&keyword=mcpeak&backPath=http://search.janes.com.lumen.cgsccarl.com/Search&Prod_Name=JDW&) (accessed January 8, 2011).

<sup>96</sup> Richard H. Kohn, "The Early Retirement of Gen Ronald R. Fogelman, Chief of Staff, United States Air Force," *Aerospace Power Journal* Spring(2001): 14 <http://www.airpower.au.af.mil/airchronicles/apj/apj01/spr01/kohn.htm> (accessed January 8, 2011).

Congress that, “The F-22 will be able to penetrate these threats, neutralize them, and establish the CINCs’ (Commander in Chief) requirement for air dominance – so that other older aircraft that we can’t replace in the near future can fly their missions with acceptable risk levels for many years into the future.”<sup>97</sup> While serving as Chief of Staff, General John Jumper had the opportunity to qualify in the F-22A. He echoed his predecessors on the need for the F-22A citing that, “The Russians never got out of the fighter-building business. They are delivering aircraft to nations around the world that outperform anything else we have -- except the Raptor.”<sup>98</sup>

Because he presided in the time leading up to the final drawdown of the F-22A program, many associate former Air Force Chief of Staff General T. Michael Moseley as one of the stealth fighter’s greatest proponents. Moseley strongly supported the F-22A, but during his tenure from 2005 to 2008, other realities emerged. In 2006, over thirty years since the Advanced Tactical Fighter concept began and twenty years since its initial funding, General Moseley argued that despite its absence in the skies over Iraq and Afghanistan, the F-22A was critical because of the blossoming age of its predecessors. Noting that the current fighter force average age was almost 25 years, he complained that, “We’re going to reach a point where we could conceivably be forced to fly an 80-year-old airplane in combat, and to me that’s unconscionable.”<sup>99</sup> The age of the fleet was not the only problem. The F-22A reached initial operating capability in December 2005 with two

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<sup>97</sup> U.S. Senate, "Statement for General Michael E. Ryan, Chief of Staff, U.S. Air Force Before the Senate Armed Service Committee" General Michael E. Ryan, (Washington, DC:U.S. Senate, 1999) <http://armed-services.senate.gov/statemnt/1999/990105mr.pdf> (accessed January 1, 2011).

<sup>98</sup> William Powell, "General Jumper Qualifies in F/A-22 Raptor," <http://www.af.mil/news/story.asp?storyID=123009594> (accessed January 1, 2011).

<sup>99</sup> General T. Michael Moseley, "Flight Check," *Government Executive* 38, no. 15 (2006) <http://lumen.cgsccarl.com/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=mth&AN=22381519&site=ehost-live> (accessed December 19, 2010).

wars in progress. Unfortunately, the earth-bound and technologically inferior enemy that showed up to both fights left the F-22A looking like a solution without a problem.

## Technology

The F-22A is the Air Force's newest operational fighter aircraft. The Raptor's actual capabilities remain classified; however, its unclassified specifications suffice for the purposes of this study. The F-22A is nothing if not technologically advanced compared to any predecessor or competitor aircraft. The core technologies that make it unique are supercruise, stealth, and sensor and avionics integration.

Supercruise is the ability to maintain supersonic velocity without the exorbitant fuel consumption of engine afterburners. Analysis of both air-to-air and air-to-ground engagements during the Vietnam War indicated drastically improved survivability from sustained supersonic speeds.<sup>100</sup> Unlike its predecessor, the F-15C Eagle, the F-22A can maintain supersonic speeds without the use of afterburners.<sup>101</sup> This supercruise capability is not necessarily unique among the world's fighter aircraft and is a difficult attribute to quantify. Additionally, because the F-22A's actual performance is publicly unknown, speculation and deduction form the only basis for quantifying its performance. One measure of estimating supercruise potential is an aircraft's fuel fraction or the amount of its mass dedicated to holding fuel. The F-22A has an approximate fuel fraction of 28 percent.<sup>102</sup> While its combat configuration does not include external stores like most

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<sup>100</sup> Aronstein, Hirschberg, and Piccirillo, 11.

<sup>101</sup> O'Rourke. The Air Force originally planned to buy 750 F-22s allowing it to replace all F-15Cs. Program cuts have resulted in the need to keep some of the F-15C fleet to supplement the 187 F-22As.

<sup>102</sup> Bill Sweetman, "Fighting for Precedence," *Jane's International Defence Review*, <http://search.janes.com.lumen.cgsccarl.com/Search/documentView.do?docId=/content1/janesdata/mags/idr/history/idr2002/idr00435.htm@current&pageSelected=allJanes&keyword=fuel%20fraction%20F->

fighters, its fuel fraction does not imply the ability to supercruise for significant segments of a combat mission that might be necessary to evade deep and layered defenses.<sup>103</sup> The Air Force does not publish F-22A ranges other than non-combat ferry range with external tanks. As such, it is difficult to pronounce sentence on the F-22A's actual supercruise performance. The evidence casts doubt as whether the F-22A can supercruise significantly longer than other fighters.

The F-22A is a stealth platform owing to radar and infrared signature-negating shape and construction. Its actual stealth characteristics are just as shrouded as its supercruise performance; however, the Air Force widely touts its stealth advances. Since the first employment of stealth aircraft during Operation Just Cause in Panama, only two stealth aircraft (F-117A Nighthawk) have succumbed to enemy fire. The overall combat loss rate of Air Force aircraft from prior to 2003 was less than half a percent, so the loss rate of stealth aircraft is certainly small.<sup>104</sup> Stealth F-117A and B-2A Spirit bomber sorties accounted for approximately 1.7% of total allied sorties during Operation Allied Force.<sup>105</sup> With so few stealth aircraft-supported combat operations, it is too soon to assert the effects of stealth alone on survivability in light of evolving enemy counter-stealth

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22&backPath=http://search.janes.com.lumen.cgscarl.com/Search&Prod\_Name=IDR& (accessed January 8, 2011).

<sup>103</sup> Colonel (ret.) Everest E. Riccioni, "Description of Our Failing Defense Acquisition System as Exemplified by the History, Nature, and Analysis of the USAF F-22 Raptor Program. A National Tragedy-- Military and Economic " [http://www.mycity-military.com/Uploads/98029\\_58993541\\_f22.pdf](http://www.mycity-military.com/Uploads/98029_58993541_f22.pdf) (accessed January 9, 2011). Riccioni is a retired Air Force test pilot and part of the "fighter mafia" that helped bring about the F-16. He suggests that aircraft as old as the F-104 had as much supercruise range based on fuel factor and aerodynamics.

<sup>104</sup> Dr. Daniel L. Haulman, "USAF Manned Aircraft Combat Losses 1990-2002" (Research Paper, Air Force Historical Research Agency, 2002), 1 (accessed January 3, 2011).

<sup>105</sup> Lambeth, 61. Department of Defense, *Report to Congress: Kosovo/Operation Allied Force After-Action Report*, (Washington, DC: Department of Defense, 2000), 97, <http://www.defense.gov/pubs/kaar02072000.pdf> (accessed February 27, 2011). GlobalSecurity.org. "52nd Fighter Wing." <http://www.globalsecurity.org/military/agency/usaf/52fw.htm> (accessed February 25, 2011). The total number of Allied sorties was approximately 38,000. Stealth aircraft flew approximately 675 of these.

technology. Unlike the F-117A and B-2A bomber, the F-22A combines both radar absorbing and scattering technology with supersonic speed and extreme maneuverability. The F-22A is capable of the same nine “G” forces as other Air Force fighters enabling it to maneuver against incoming missiles and other aircraft.<sup>106</sup> Where stealth alone failed the F-117A, the F-22A will have additional maneuverability against agile threats. F-22A advocates typically refer to the Raptor as “nearly invisible” to enemy radar. Few would argue that the F-22A is a stealthy fighter, but it will have to endure combat to prove its true resistance to detection.

Advances in sensor and avionics technology also provide F-22A pilots with unparalleled situational awareness. The F-22A carries medium range radar missiles, short-range infrared missiles and two variants of precision free-fall bombs. The combination of these capabilities is supposed to allow the F-22A to penetrate any airspace, defended by any ground or air threat, at any time in order to achieve air superiority by destroying enemy aircraft and surface-to-air missiles with impunity.<sup>107</sup> The aircraft fuses off-board information about threats such as type, location, speed, and identity and with information from its own radar and passive sensors. The resulting display gives the pilot a single indication of his own aircraft’s lethality and potential vulnerability. Data link technology allows F-22As to share such information covertly

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<sup>106</sup> “G” force is aviation vernacular for the force or acceleration of gravity,  $9.8\text{m/s}^2$ . Aircraft have structural limits that can be expressed in multiples of the force of gravity. Humans can typically remain conscious under up to nine times the force of gravity, or 9G’s, which helps define the requirements for fighter aircraft design.

<sup>107</sup> Air superiority, according to Joint Doctrine is, “That degree of dominance in the air battle of one force over another that permits the conduct of operations by the former and its related land, maritime, and air forces at a given time and place without prohibitive interference by the opposing force.” See Joint Chiefs of Staff, *Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms*, (Washington, DC: Government Printing Office, 2010), 22.

with each other.<sup>108</sup> While much, if not all of this information is available in previous fighter aircraft, the pilot, not the aircraft computers, must analyze and synthesize data from independent radar, threat warning, identification, infrared, data link and myriad off board sources via voice communication. Under the dynamic conditions of enemy attack, supersonic speeds, or high “G” forces, the advantage of integrated avionics technology holds significant advantages.

After over twenty-five years of development, the F-22A is the most advanced fighter in the U.S. inventory, if not the world. While its actual supercruise capability might not live up to expectations, its lack of external stores in combat configuration implies advanced, efficient supersonic capability. In addition to being the newest generation of stealth technology, the F-22A maintains traditional fighter maneuverability and supersonic speed without sacrificing its radar signature. Finally, the integrated avionics suite reduces pilot workload while simultaneously providing a fused picture the air and ground situation. From a technology standpoint, the F-22A is an airpower advocate’s dream.

## Effects

Compared to the B-17 and free-fall nuclear bomb, the F-22A has had no tangible operational effects yet. The F-22A has flown homeland defense missions and deployed for strategic presence in the Pacific theater. Despite ongoing wars in Iraq and Afghanistan since its 2005 operational debut, the F-22A has not fought in either conflict. As such, no

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<sup>108</sup> GlobalSecurity.org. "F-22 Raptor Avionics." <http://www.globalsecurity.org/military/systems/aircraft/f-22-avionics.htm> (accessed January 9, 2011).

real evidence exists to describe how the F-22A has used technology to bring about ideal war. A discussion of less tangible considerations follows in the Summary section below.

## Resources

Much like the free-fall nuclear bomb, resource constraints pull strongly at the F-22A. The Air Force ended up with 25 percent of the fleet it wanted. Successive budget and defense requirement reviews slashed F-22A funding. Shrinking budgets and design difficulty reduced planned features. Competing defense priorities permanently stunted the program's growth. Resource dollars may end up being one of the greatest enemies the F-22A ever faces.

In 1986, when the Air Force originally contracted for Advanced Tactical Fighter candidates, it sought 750 copies. The production line is currently shutting down after only 187.<sup>109</sup> As the first prototypes flew in 1991, the Air Force reduced the number to 648. The end of the Cold War precipitated the Defense Department's Bottom-Up Review in 1993 and a cut to 438 copies. Four years later, the first Quadrennial Defense Review whittled the number down to 339 jets.

In 2002, as Congress considered further cuts, the Air Force briefly changed the aircraft's name from F-22 to F/A-22 for "fighter / attack." At a time when enemy fighter aircraft seemed reluctant to launch and provide a viable threat, the Air Force emphasized that the Raptor always had ground attack capability. Any public relations value from the name change seemed to dry up quickly as the Air Force changed the name again in 2005 to F-22A. General Moseley explained, "we're going to field an A model... ...we will not

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<sup>109</sup> O'Rourke, 6.

continue to add multiple millions of dollars' worth of duct-taped flashlights to it.”<sup>110</sup> This time the name change was a signal that the Air Force would accept the plane and capabilities it had in hand, rather than campaign for more spiral improvements. However, in December 2004, Program Budget Decision 753 cut the count down to 178 copies.<sup>111</sup> In 2009, Defense Secretary Robert Gates recommended that the F-22A assembly line begin to close permanently.<sup>112</sup>

The funding story follows a similar trajectory. The Government Accountability Office, the media, and Congressional detractors amplified and exploited F-22A program difficulties in order to build a case against further F-22A funding. The Government Accountability Office and others accused the Air Force of following a flawed “buy to budget” strategy that did not rely on requirements.<sup>113</sup> In 1994, the Government Accountability Office had already established a history of F-22 program scrutiny based on delays, budget over-runs, and contractor inability to solve technical dilemmas. Spurred by the Soviet collapse, the Government Accountability Office urged the Air Force to slow its development in order to mitigate risk, control costs, and reevaluate the possible

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<sup>110</sup> Moseley. The “A” designation indicates a finite set of capabilities in an aircraft. Major future upgrades such as structural or engine changes often constitute a “B” or “C” model, etc.

<sup>111</sup> Government Accountability Office, *Tactical Aircraft: Air Force Still Needs Business Case to Support F/A-22 Quantities and Increased Capabilities: Report to Congressional Committees*, (Washington, DC: Government Accountability Office, 2005), 5.

<sup>112</sup> O'Rourke, 22. The final number often quoted is 187. This includes planned combat-coded aircraft, production representative test vehicles and the four requested in the 2009 Defense supplemental bill. Lower numbers in the 130 aircraft range typically exclude those dedicated to test, pilot training, or the National Guard.

<sup>113</sup> United States Government Accountability Office and United States Congress House Committee on Government Reform, Subcommittee on National Security Veterans Affairs and International Relations, *Defense Acquisitions: Recent F-22 Production Cost Estimates Exceeded Congressional Limitation: Report to the Chairman, Subcommittee on National Security, Veterans Affairs, and International Relations, Committee on Government Reform, House of Representatives*, (Washington, DC: Government Accountability Office, 2000), 2.

threats.<sup>114</sup> In 1991, *The New York Times* challenged the Air Force to cancel the C-17A or B-2A rather than convert the post-Cold War “peace dividend” into a war dividend.<sup>115</sup> The *Times* editorial has echoed in the press for almost twenty years. Former Senator Dale Bumpers, a leading F-22A critic, frequently commented about the fighter to the effect, “I’m not arguing about what the capabilities are likely to be. I’m talking about the cost and what we get for it. The question is always, number one, how much is enough? In the United States, we spend twice as much on defense as the eight most likely enemies we’re ever likely to face. And that includes China and Russia, North Korea, Iraq, Iran, the rogue nations. We spend twice as much as all of them combined.”<sup>116</sup> Such arguments eventually eroded the F-22 budget. In 1991, the program included \$86.6 billion. Two years later, the Bottom-Up Review cut nearly \$15 billion. Public criticism led the Defense Department to create a Joint Estimate Team, which paved the way towards caps on the F-22A engineering, manufacture, and development phase as well as the production phase. By 2007, the program settled at \$64.5 billion.<sup>117</sup> Overall costs produced inflammatory criticism, but another figure tended to generate the most surprise.

While the program cost is appalling to some, the cost per aircraft stands out against historical norms. Prior to the 1991 contract award, the Advanced Tactical Fighter program’s “soft” goal was a fighter that met all performance requirements, weighed less

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<sup>114</sup> Government Accountability Office, *Tactical Aircraft: F-15 Replacement is Premature as Currently Planned*, (Washington, DC Government Accountability Office, 1994), 2.

<sup>115</sup> Editorial, “This Fighter Will Bust the Budget,” *New York Times*, April 29, 1991, <http://query.nytimes.com/gst/fullpage.html?res=9D0CE0DE143EF93AA15757C0A967958260&scp=20&sq=F-22%20fighter&st=cse> (accessed January 10, 2011).

<sup>116</sup> PBS.org, “Online NewsHour- The F-22 Debate Transcript.” [http://www.pbs.org/newshour/bb/military/jan-june97/f-22\\_4-4.html](http://www.pbs.org/newshour/bb/military/jan-june97/f-22_4-4.html) (accessed January 11, 2011).

<sup>117</sup> O’Rourke, 8.

than 50,000 pounds, and cost less than \$35 million per copy.<sup>118</sup> That number quickly faded and numbers closer to \$79 million became realistic.<sup>119</sup> As development difficulty, timeline growth, and budget reductions continually layered on costs, the per unit figure increased. In 1999, estimates had climbed to \$200 million per copy, but the aircraft had yet to enter full-scale production leaving serious questions as to its real costs.<sup>120</sup> Shortly before the first operational squadron stood up in 2005, the price per jet had topped \$330 million per aircraft.<sup>121</sup> While the Air Force advertises a cost of \$143 million per jet, this number represents the cost only of the procurement phase, not “sunk” costs such as the nearly \$40 billion engineering, manufacturing, and development phase. With these costs included, the cost per aircraft soars to over \$350 million.<sup>122</sup> The story of F-22A cost escalation played out in *The New York Times* alone at least seventy-nine times from 1991 to 2010 and helped to create a narrative of unconstrained defense spending on an unnecessary airplane.

Negative press coverage, Congressional pressure, and watchdog scrutiny certainly weighed heavily on the resources available to field the F-22A, but the national security context also drained support. Media coverage of the wars in Iraq and Afghanistan from 2004 through 2008 covered many topics that challenged justification for F-22A funding. Stories included soldiers buying their own body armor because of unit funding shortages,

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<sup>118</sup> Aronstein, Hirschberg, and Piccirillo, 108.

<sup>119</sup> "This Fighter Will Bust the Budget."

<sup>120</sup> Tim Weiner, "House is Prepared to Cut Off Funds for F-22 Fighters," *The New York Times*, <http://www.nytimes.com/1999/07/17/us/house-is-prepared-to-cut-off-funds-for-f-22-fighters.html?ref=f22airplane> (accessed January 13, 2011).

<sup>121</sup> Tim Weiner, "Arms Fiascoes Lead to Alarm Inside Pentagon," *The New York Times*, [http://www.nytimes.com/2005/06/08/business/08weapons.html?\\_r=1&ref=f22airplane&pagewanted=print](http://www.nytimes.com/2005/06/08/business/08weapons.html?_r=1&ref=f22airplane&pagewanted=print) (accessed January 13, 2011).

<sup>122</sup> U.S. Air Force. "F-22 Raptor Fact Sheet." <http://www.af.mil/information/factsheets/factsheet.asp?id=199> (accessed January 13, 2011). O'Rourke, 9.

welding scrap armor to Humvee's to protect against improvised explosive devices, and the 2004 cancellation of the Army's Comanche helicopter to recapitalize existing Army combat systems. Air Force leadership endured public admonishment that bolstered the perception that the Air Force would not shift its funding priorities. Secretary Gates has called F-22As "niche silver bullet solutions" when highlighting the ongoing need for more high-demand unmanned reconnaissance platforms such as the MQ-1 Predator and MQ-9 Reaper that underpin current operations.<sup>123</sup> Ultimately, as Secretary Gates explained his decision to seek no further funding for the F-22A despite Congressional pleas, he said, "The reality is we are fighting two wars, in Iraq and Afghanistan, and the F-22 has not performed a single mission in either theater."<sup>124</sup> Secretary Gates had the last words in the F-22 debate. He took the national F-22A criticism and scrutiny, weighed it against a strained wartime budget, and reprioritized resources away from further support for the program.

The drag of monetary resource constraints drastically shrunk the F-22A fleet. The cycle of "development and production problem invites scrutiny and criticism, which lowers budgets, which constrains development and production" became self-reinforcing. External conditions such as the lack of a suitable war and the presence of an unsuitable war for the F-22A only aggravated the sequence. The induced and parasitic resource drag has so far stalled the F-22A.

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<sup>123</sup> R. Jeffrey Smith, "Premier U.S. Fighter Jet has Major Shortcomings: F-22's Maintenance Demands Growing," *The Washington Post*, <http://www.washingtonpost.com/wp-dyn/content/article/2009/07/09/AR2009070903020.html> (accessed January 13, 2011). Robert M. Gates, "Secretary Gates Remarks at Maxwell-Gunter Air Force Base, Montgomery AL," <http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4214> (accessed January 13, 2011).

<sup>124</sup> "Hearing to Receive Testimony on the Defense Authorization Request for Fiscal Year 2009, the Future Years Defense Program, and the Fiscal Year 2009 Request for Operations in Iraq and Afghanistan", (Washington DC: 2008) <http://armed-services.senate.gov/statemnt/2008/February/Gates%2002-06-08.pdf> (accessed January 13, 2011).

## Enemy Counter-tactics and Technology

The proactive effects of a thinking and cunning enemy pulled at the B-17 and the free-fall nuclear bomb. The absence of an enemy weighs down the F-22A. The threats that Air Force planners thought the F-22A would face have failed to manifest in either sufficient time, numbers, or probability of engagement to make the plane urgently necessary.

The Advanced Tactical Fighter idea came about in order to fight the Soviet Union. Had the program proceeded according to the earliest plans, the F-22A would have been operational in 1991.<sup>125</sup> In this hypothetical scenario, only the last stages of the program would have been in the shadow of the 1991 Soviet Union dissolution. The Soviet Union's collapse culminated in December 1991 when the Air Force contract with F-22A lead contractor Lockheed Martin was seven months old. Critics questioned the continuing need for the F-22A while the Government Accountability Office and others called for program delays in order to determine future necessity while saving money.<sup>126</sup> By the time the F-22A achieved operational capability, not only did a Russian or other competitor aircraft fail to emerge, but F-15s, F-16s, and F-18s handled both air and ground threats in all conflicts.<sup>127</sup> The enemy fighter problem did not follow the same timeline as the F-22A solution.

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<sup>125</sup> Aronstein, Hirschberg, and Piccirillo, 158.

<sup>126</sup> "Tactical Aircraft: F-15 Replacement is Premature as Currently Planned," 2.

<sup>127</sup> Mark Crispin Miller, "Death of a Fighter Pilot," <http://query.nytimes.com/gst/fullpage.html?res=9E0CE7DB1031F936A2575AC0A964958260&&scp=1&sq=Speicher%20MiG-25&st=cse> (accessed January 13, 2011). During all three wars, there was only a single suspected loss to an enemy fighter, Navy Lt Cdr Michael Scott Speicher.

In 2001, Air Force Chief of Staff General John Jumper unveiled the Global Strike Task Force concept to warn of the growing threat that required the F-22A. Jumper wrote that the F-22A would be the “guarantor of air dominance for all friendly forces” when synergistically combined with the B-2A, electronic warfare, intelligence, surveillance, and reconnaissance platforms in the destruction of enemy targets defended with anti-access and area denial systems.<sup>128</sup> He described the Su-35 and Su-37 Flanker series of Russian fighters as well as SA-10 and SA-12 surface-to-air missiles that could shut the door to all technology other than an American Global Strike Task Force lead by the F-22A. General Jumper also warned that rampant proliferation of these systems was imminent to build the need for F-22As. The Straits of Taiwan are the typical example of such an anti-access and area denial scenario. China places overlapping SA-10 and SA-12 equivalents along with its advanced fighters in this area. Other than the Taiwan Straits however, the rampant proliferation of advanced anti-access and area denial technology is hard to find. The cost of a battery of Russian S-300 (SA-10 and SA-20 family) missiles and associated equipment is at least one billion dollars, putting them outside the budgetary reach of all but a few nations.<sup>129</sup> Even export versions of Russian Flankers exist only in ten other nations, most with less than two squadron’s worth of the

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<sup>128</sup> General John P. Jumper, "Global Strike Task Force: A Transforming Concept, Forged by Experience," *Aerospace Power Journal*, no. Spring (2001): 10 <http://www.airpower.au.af.mil/airchronicles/apj/apj01/spr01/jumper.htm> (accessed January 1, 2011).

<sup>129</sup> Jane's Defence Weekly. "Reflecting Change: 2007 Annual Defence Report." [http://search.janes.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw2007/jdw35118.htm@current&pageSelected=allJanes&keyword=SA-20%20costs&backPath=http://search.janes.com/Search&Prod\\_Name=JDW&](http://search.janes.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw2007/jdw35118.htm@current&pageSelected=allJanes&keyword=SA-20%20costs&backPath=http://search.janes.com/Search&Prod_Name=JDW&) (accessed January 13, 2011).

fighters.<sup>130</sup> Significant anti-access and area denial threat proliferation did not exist during F-22A development and production and has yet to emerge.

The final threat aspect that has not emerged to justify the F-22A is a likely conflict. While an undeniable air of imminent conflict, possible nuclear annihilation, and a spiraling arms race characterized the Cold War, the national security requirements have changed during the F-22A's history. This is not to suggest that anyone can predict the timing, participants, or other characteristics of the next war. However, the Cold War, which spawned the apparent need for the F-22A, was an ideological, political, and occasionally military-by-proxy war between two nations that could find little common ground for cooperation and mutual trust. China, which for the foreseeable future has the only real existing anti-access and area denial capability or defense budget to create additional such regions, is really the only nation against which the F-22A is the appropriate "silver bullet."<sup>131</sup> China and America have significant differences of opinion over issues such as the status of Taiwan, human rights, trade, and intellectual property rights. Future energy security seems like a far more likely topic that could require the United States to employ F-22A's in conflict with China. Thus, the relevance of the F-

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<sup>130</sup> Ibid. It is worth noting that in late 2010 and early 2011 respectively, both Russia and China flew the maiden voyages on prototype stealth fighters that would likely complicate the F-22A's missions. As with any new fighter aircraft, operational capability in significant numbers is likely to be five to ten years later at the earliest.

<sup>131</sup> Stockholm International Peace Research Institute. "Stockholm International Peace Research Institute Military Expenditures Database." <http://milexdata.sipri.org/files/?file=SIPRI+milex+data+1988-2009.xls> (accessed January 14, 2011). China's defense budget in 2009 was approximately \$100 billion. The U.S. maintains alliances, security agreements, or other cooperative military ties with all other nations that spend at least \$20 billion annually on defense except for Iran. In September 2010, Russia cancelled a sale of S-300 (SA-10 family) SAMs to Iran limiting, at least for a time, Iran's ability to create A2/AD regions. North Korea, has a much smaller Gross Domestic Product and corresponding defense budget. Jane's Defence Weekly reported that both Iran and North Korea may be acquiring S-300 or comparable technology from China. Sebastien Falletti, Duncan Lennox, and Ted Parsons, "Pyongyang Parades Missiles and Manpower Amid Signs of Succession," *Jane's Defense Weekly* (2010) [http://search.janes.com.lumen.cgsccarl.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw2010/jdw44358.htm@current&pageSelected=allJanes&keyword=North%20Korea%20S-300&backPath=http://search.janes.com.lumen.cgsccarl.com/Search&Prod\\_Name=JDW](http://search.janes.com.lumen.cgsccarl.com/Search/documentView.do?docId=/content1/janesdata/mags/jdw/history/jdw2010/jdw44358.htm@current&pageSelected=allJanes&keyword=North%20Korea%20S-300&backPath=http://search.janes.com.lumen.cgsccarl.com/Search&Prod_Name=JDW) (accessed January 14, 2011).

22A's unique ability to deal with anti-access and area denial regions seems to be a question of when vital U.S. national security interests might intersect with those of a nation capable of affording anti-access and area denial systems and whether or not this intersection occurs during the service life of the F-22A. It is impossible to predict the likelihood of conflict requiring the F-22A's attributes, but for the present, the airplane may to fulfill the role of expensive insurance policy rather than guarantor of ideal war.

## Summary

The Four Forces theory both suggests that economic and national will resources combine with an unpredicted enemy context to prevent the F-22A from delivering ideal war. Like the nuclear bomb, the F-22A's contributions to airpower and the character of war are not only in still in flux, but also potentially more subtle. One consideration is that by continuing to develop and field the F-22A when no competitor could match the effort, the United States added to its deterrent capability. This argument suggests that an adversary would need to carefully consider the task of outspending the United States on advanced technology. Other than homeland defense missions, the United States has not flown air superiority missions since the beginning of Operation Iraqi Freedom in 2003. This may contribute to the argument that potential enemies do not wish to risk a kinetic conflict with American technology. In essence, perhaps the F-22A contributes towards more ideal war by creating an effective deterrent. On the other side of this coin is the apparent trend towards asymmetric warfare by enemies that cannot field modern military forces. Again, this requires a judgment. Is a continued state of lower intensity conflict with insurgent and terrorist organizations better than major combat operations between

great power states? If so, then advanced airpower technology seems to achieve a more acceptable place on the continuum of war if not the ideal extreme.

## **Conclusions**

This paper set out to answer the question “Why does war fail to turn into the ideal war that airpower advocates envision?” The Four Forces theory provides a useful explanatory tool. Using the analogy of the four forces acting upon an airplane in flight, the Four Forces theory holds that airpower advocates seek technology as thrust and improved combat effects as lift but tend to downplay, underestimate, or rationalize the drag of resource constraints or gravity of enemy counter-tactics and technology. Powerful airpower ideas like strategic bombardment have driven airpower advocates from Giulio Douhet and Billy Mitchell to modern Air Force leaders to create technological manifestations that would fulfill the airpower promise of quick, clean, decisive war. Enemy counter-tactics and technology severely dampened the promise of the B-17, but the B-17 and other strategic bombers paved the way for lower casualties and limited wars in the future. National will limited the free-fall nuclear bomb, but its presence has contributed to limits on warfare and technology that reduces collateral damage. Funding and an unpredictable enemy context proved to be more drag than the F-22A could overcome, but the Raptor appears to pose a significant conventional deterrent capability. If the concept of ideal war is the dystopian state where war must exist, but the “best” version is brief, nearly bloodless, and decisive, then airpower technology is unlikely to bring it about. So, while the Four Forces theory cautions against searching for truly ideal war from airpower, it reveals other airpower contributions that have, on the balance, improved the character of war since airpower’s birth.

One of the central ideas of this monograph, that airpower inextricably intertwines with technology, is not new territory. Many airpower critics and supporters have suggested similar ideas. This monograph takes a different flight path by suggesting a novel theory to help explain why airpower does not deliver ideal war as advocates predict it should. Like any theory, its best use will be as a tool for viewing and explaining while making predictions about the future.

Another consideration of this theory is that it could be much broader. While it is outside of the author's expertise, it would not be surprising to find that the theory is applicable to land or sea power with little modification. Like other theories, ideas, and concepts, the Four Forces theory requires scrutiny and examination by concerned professionals in order to evaluate its utility and shortcomings.

This theory has two final purposes. The first relates to credibility. The Air Force struggled to become an independent military service. Technology certainly has fueled its successes. However, the almost blind pursuit of the most advanced technology has never brought about the promised version of war. Defense Secretary Gates' 2008 criticism of the Air Force's F-22A procurement in spite of the Combatant Commander's need for lower-technology unmanned platforms is striking evidence that airpower advocates put their credibility on the line when they seek the promise of technology when competing national security requirements go unfilled. The Four Forces theory cautions the airpower advocate. The theory demonstrates that, like the communist utopia, ideal war is not coming and therefore any promise to deliver it through technology is inherently false. Yet, from each of this monograph's case studies, other positive airpower technology consequences such as deterrence and casualty reductions come to light as well.

The second purpose of this theory is to aid understanding of the limitations of airpower in warfare. Examination of the airpower advocacy and theory, the pursuit of technology, and the less-than-ideal outcomes in this monograph demonstrates why a gap remains between airpower promises and ideal war. The layman can see that, from the Wright Brothers' first flight to the present day, airpower advocates have envisioned ways to mitigate the savagery of war. Ideally, ideas like strategic bombardment should, if perfected through technology, compel immediate enemy surrender while saving lives. It is a noble goal, but one that will likely remain just out of reach. The development of airpower ideas, concepts, theories, and pursuit of advanced technologies may not cause all future war to be quick, economical, or decisive. However, compared to the wars before airpower and the work of airpower advocates, the positive wartime and peacetime contributions of airpower advocates elevate war much closer to its ideal.

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