

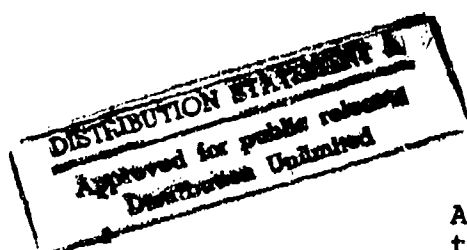
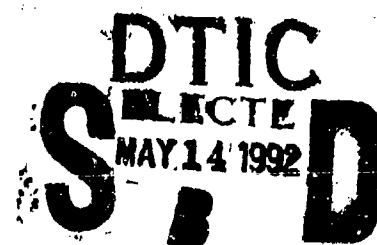
Naval War College
Newport, Rhode Island



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STEALTH, A REVOLUTIONARY CHANGE TO AIR WARFARE



A paper submitted to the Faculty of the Naval War College in partial satisfaction of the Department of Operations. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College, the Department of the Navy, or the United States Air Force.

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PREFACE

An in depth operational study of stealth does not require classified research in special access programs. Our prospective enemies do not have access to this information, yet they certainly draw conclusions about stealth capabilities. From an operations perspective, it doesn't matter what the radar cross section values are--it matters what the asset brings to the battlefield.

Allies and foes alike have seen the stealth controversies. Allies and foes alike have seen stealth perform in Desert Storm. Allies and foes alike can draw valid conclusions based on this open source information.

I have no experience in any stealth program. I undertook this project as an "unbeliever" from a B-52 background who wanted to know what made stealth technology so "revolutionary" that it could justify the number one priority in Air Force funding.

My research led me to quite a different end than I expected.



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ABSTRACT

"Stealth, A Revolutionary Change To Warfare" highlights the unique capabilities stealth weapons bring to the battlefield and asserts they offer new and valuable options to the commander. It suggests these capabilities must be fully understood to be fully effective. With a focus at the doctrinal level, the paper claims: stealth assets take away from the absolute primacy of aerospace control (air superiority) and in many cases, allows force application to become the primary task. It also asserts; stealth assets expand and enhance the potential opportunities for effective use of air power across the spectrum of warfare to include the force presence role. These and other changes will impact air warfare at all levels. Capitalizing on stealth requires: (1) a recognition of unique stealth attributes; (2) fully embracing these attributes through Air Force doctrinal changes; and (3) a fresh look for potential applications in all operational planning.



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INTRODUCTION

(In Desert Storm) "The F-117 ...carried a revolution in warfare on its wings."¹
President Bush (June 1991)

"The B-2 (is) ...a revolutionary blending of stealth technologies..."²
Secretary Rice (Summer 1990)

While many may argue over the revolutionary versus evolutionary attributes of stealth¹; the real issue is not an academic one for grammatical correctness but rather an operational one with far reaching implications. The discussion and focus of this paper are not an advocacy for stealth, or an academic argument for the correct modifier of stealth assets. From strictly an operational perspective, this paper specifically asserts stealth aircraft bring revolutionary capability to the battlefield and suggests the changes needed to maximize this contribution.

Parts I and II address the academic issue to develop a common base understanding of capabilities. Parts III and IV then shift the focus to identifying the unique and revolutionary attributes stealth aircraft demonstrated in Desert Storm and what these new qualities can do in the application of air power in "Future Storm."

¹ "Stealth," as a concept, is not new; but something which has been practiced for ages. "Stealth" as it is used in this paper references the relatively new technologies which make this concept a viable consideration on aircraft platforms. Stealthy aircraft or low observable (LO) platforms are only produced through an integrated effort to control all emissions. Reductions are not only made in radar cross section but also in visual signature, infrared signature, acoustic signature, and requirements for radio-frequency emissions.



Part V focuses on action needed to realize stealth assets full potential.

Stealth aircraft are revolutionary! Their capabilities are new, their potential great, their utilization only in infancy. Stealth has changed the nature of air warfare. We need to recognize it, capitalize on it and ensure we employ it to the utmost of its potential. Our air warfare doctrine can be the foundational cornerstone or the stumbling block to the fulfillment of these critical issues. This paper addresses why and what is needed to make it the former rather than the latter.



PART I: STEALTH IS REVOLUTIONARY

Revolutionary: A Dialectic Leap³

In Russian thinking both evolutionary and revolutionary changes are described in the dialectic process. In dialectic thinking an initial "thesis" describes a certain type of warfare, a starting point; such as the introduction of aircraft. This warfare is countered with an "antithesis," or a counter; such as pursuit aircraft or radar combined with defensive systems to locate and shoot down aircraft. The resulting interaction of the two produce a "synthesis." The synthesis becomes the new thesis and the process is repeated in a continual evolution of warfare.

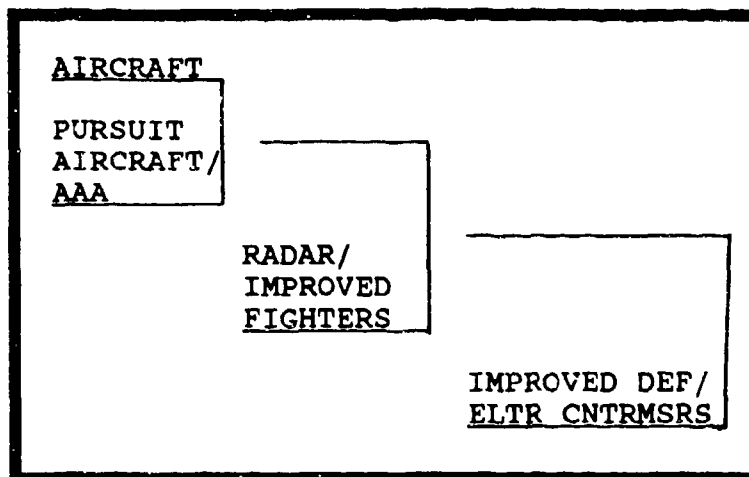
Occasionally an antithesis' interaction with its thesis produces a type of synthesis which represents a completely different nature of warfare; a revolutionary change called a dialectical leap. Such a leap is represented by new and unique capabilities which change the thesis/antithesis equation to such a degree that the evolutionary cycle is broken and a completely new cycle is begun.

Returning to our aircraft example, the antithesis to pursuit airplanes and radar, were radar workarounds and fighter escorts. New tactics, such as flying low level and dropping chaff, were used to hide from or blind radar. Fighter aircraft were developed with improved agility and firepower. As the evolution continued more sophisticated ground and air threats were invented to which more



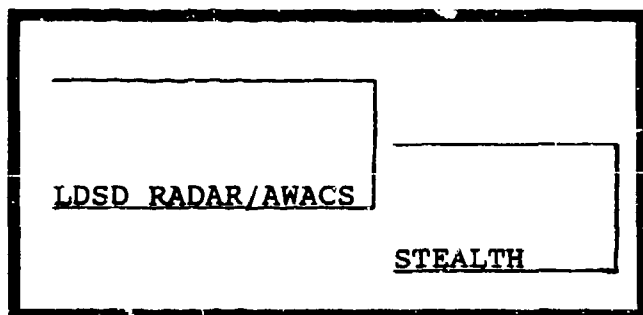
Table I
The Dialectic Process

advanced electronic
countermeasures
responded. Look
down/shoot down (LDSD)
radar and the Airborne
Warning and Control
System (AWACS) were
invented to control the
air battle.



This evolutionary process continued for seventy plus years until an antithesis of stealth was produced. Stealth's interaction with the thesis of today's sophisticated air defense networks has produced a dialectic leap, a revolutionary change to the nature of air warfare. This synthesis,

Table II
The Dialectic Process



between today's air defense systems and stealth, has produced a break in the dialectic continuum started with the invention of radar.

Stealth has broken the old continuum because it is the first antithesis which has not worked around radar but actually defeated it. On this new continuum, the entering thesis for force application aircraft will be stealth and the antithesis has yet to be invented.



Revolutionary, Even Without Hindsight

Hindsight provides tremendous clarity in determining the revolutionary impact of different weapon innovations, but most of the time our hindsight lacks depth perception. It is easy to accurately say gunpowder was a revolutionary development and yet have absolutely no appreciation for the period of time over which this "revolutionary" development matured or "evolved."

This 1200 AD revolutionary discovery made the battle ax, bow and arrow, sword, pike, scaling tower and battering ram obsolete.⁴ Yet 500 years after the discovery of black powder, Benjamin Franklin recommended bows and arrows over muskets. As the American colonists began their fighting with Britain in 1775 short supplies of black powder led some groups to support the switch.

"Franklin argued...that going back to the bow and arrow of medieval times was not as ridiculous as might first appear. A good bowman could aim as accurately as a man with a musket. Four arrows could be discharged in the time it took to load and fire a bullet, and no smoke obscured the bowman's view. A rain of arrows hurtling at an enemy had a terrifying effect. The most convincing argument of all was that bows and arrows could be supplied much faster than musket, ball, and powder."⁵

Benjamin Franklin's recommendation was obviously given under extremely extenuating circumstances; yet, note the apparent validity these arguments still carried over 500 years after black powder's discovery. By comparing it to the weapons of old the arguments failed to recognize the unique qualities black powder offered over former weapons.



Stealth assets, like black powder, are revolutionary because they have changed the nature of warfare. In the same way applications of black powder rendered all former methods of self-defense obsolete; so also applications of stealth aircraft have rendered obsolete all former methods of air defense. You don't need hindsight to see this is true, you need foresight.

There will always be a crowd to debate the issue. With few exceptions, new creative inventions which the inventor might claim as revolutionary will be met by an equally boisterous group of disclaimers. Only as time passes, after true capabilities are demonstrated and counter-capabilities are proven effective or ineffective is any consensus reached over the revolutionary changes of a particular system. Unfortunately, waiting for a revolutionary consensus could unnecessarily delay the proper application of stealth capabilities available today.

The example also highlights the importance of fresh thinking when considering the appropriateness of the title "revolutionary" for a new innovation. It was far easier, as the arguments were made, to compare black powder to the thing it is replacing and quantify its merits simply from that perspective. It was far more difficult to analyze whether a new system is in fact a form different than its predecessor with capabilities previously unseen. Stealth assets must be studied for their unique qualities rather than as an expensive replacement for B-52s, F-15s or F-16s. When enumerated,



these capabilities produce a vision as clear as 100 years of hindsight.

Revolutionary: Counter-Stealth Tests Prove It

"On the basis of the experience of the Air Force and other services with the revolutionary potential offered by stealth, the United States is investing heavily in stealth technologies for incorporation into almost all future military platforms."⁶

Donald Rice, Secretary of AF

Air defense networks protect airspace by detecting intruders (surveillance), tracking and targeting the aircraft (fire control) then fuzing a weapon in sufficient proximity to effectively destroy an aircraft (kill). All three efforts, or problems, use radar to derive their respective solution. Unique stealth characteristics seriously complicate all three problems.

Stealth technology has rendered radar systems ineffective by greatly reducing their detection ranges. Some low frequency ground based radars have limited capability to detect low observable (LO) platforms; but detection alone does not solve the defense problem.² These low frequency, large radars have weather related operational constraints and limited accuracies which make them unable to accurately track the target.⁷ Due to their size, low frequency radars cannot be taken airborne. Stealth technology essentially takes airborne detection, the greatest threat to penetrating aircraft, out of the picture.⁸

² Low frequency radars are discussed further in Part II.



The combined impact of smaller detection rings for all but low frequency ground based radars, and the elimination of the airborne targeting and tracking capability, has virtually nullified the threat of an air defense system to the penetrating stealth aircraft. The official Air Force position states: "stealth technology makes the B-2's probability of survival extremely high against the type of enemy defenses projected into the 21st century."⁹

The "Red Team" has been a critical part of the stealth development program. Formed in the late 1970s, this team of stealth technology experts were given the sole mission of finding the "Achilles' Heel" which would negate the apparent low observable platform advantage. Since its inception, the counter-stealth program has tested forty of the most promising techniques to defeat stealth and "none have proven viable challenges to stealth...the counter-stealth program is finding no effective, affordable method to defeat stealth."^{10 3}

³ Some of the concepts evaluated included: Acoustic Systems, Bi-Static Radar Systems, Infrared Detection Schemes, Corona Discharge Detection, Interaction with Cosmic Rays, Passive Coherent Detection Schemes, Radar Shadow Detection, Land Mines, Magnetic Disturbance Detection, Hybrid Bi-Static Space Radar, High Frequency Surface Wave Radar, Detection of Aircraft Emissions, Radiometric Detection, Air Vehicle Aerodynamic Wake Detection, and Ultra Wide Band (Impulse) Radar.



Revolutionary, A Dream Fulfilled

In his day Giulio Douhet was viewed as a fanatic who made ludicrous claims about the importance airpower would come to hold in warfare. Douhet was neither vindicated nor pardoned in World War II. Airpower's growth throughout the war never came to be all Douhet claimed it would be. The bombers that would always get through became the bombers whose success has been questioned by many and was a far cry from the invulnerable asset Douhet forecasted would bring the enemy to their knees so quickly.

For now, the Douhet 1920's vision for a revolution in air warfare has been realized in stealth platforms. Stealth survivability and flexibility on the battlefield are unmatched in the history of flight. When coupled with the effectiveness of precision guided munitions (PGMs), the Douhet vision is advanced beyond its own limits. We now have an operational asset that has the inherent qualities to get through defenses and, with unmatched accuracy, strike at vital centers of gravity as the political situation dictates; that is revolutionary!



PART II: THE EVOLUTIONARY ARGUMENT

"Every countermeasure produces a crop of counter countermeasures, and stealth is no exception..."¹¹

The "evolutionary" advocates basically consist of two groups; those who feel low observable technology has not proceeded to such a stage so as to achieve true "stealth," and those who feel low observable technology can be effectively countered. Both parties are saying the LO platforms of today are nothing more than another evolutionary progression in weaponry.

Evolutionary Party I

"Stealth is not a new idea; it is simply a new name for something that has been going on for eons."¹²

Radar Cross Section (RCS) is only one of the facets which must be managed to produce a low observable aircraft. RCS signatures vary depending on look angle so every aircraft has a multitude of different RCS values associated with its platform. RCS is tied to detection range, and even a minute incremental increase in RCS can drastically increase the effective detection range; there is virtually no tolerance for error in this area.

One unclassified effort to quantify this relationship was made in a January 1991 United States Naval Institute Proceedings article. The chart on the following page displays values extracted from the article's RCS/Radar range graph. Two caveats were offered along



with the graph: (1) The values were all taken from unclassified sources which "may not be accurate;" (2) Radar cross section varies greatly with aspect, radar frequency and other factors.¹³ Despite these potential errors, the graph illustrates the important lesson mentioned above. Note the relationship between RCS reduction and radar range relative value is far from proportional. It is only with ultra-fine tuning of RCS that significant reductions in detection range are made.

RADAR CROSS SECTION SENSITIVITY		
RADAR CROSS SECTION	OBJECT OF THIS RCS VALUE	RADAR RANGE RELATIVE UNITS
10	CONVENTIONAL JET FIGHTER	200
1	B-1B	170
0.1	CRUISE MISSILE	70
0.01	LARGE BIRD	40
0.001	INSECTS	12

Table III

Evolutionaries might point at B-2 RCS testing results and claim the technology for producing a truly LO platform is impossible or has yet to arrive. The Air Force did report the B-2 failed to meet a radar signature objective in a July 1991 testing. The exact RCS data is highly classified and the significance of the deviation can only be a speculation for the uninformed, but it doesn't take much to eliminate a great deal of any platforms LO characteristics.

Secretary Rice said he'd characterize the problem area "as a (grade



of) D. It is not a failure...(but) it has to be improved."¹⁴ This has led many to question the B-2's value. However, Secretary Rice also said, "In the domain where we are dissatisfied, the B-2 is already substantially better than the F-117."¹⁵ The logic then is, if we are happy with the performance of the F-117, and the B-2 is "substantially better" we shouldn't be concerned about the B-2's stealthiness.

Evolutionary Party II

"The key to successful detection and identification in the future is not going to depend on magic new sensors, according to several experts. It will come from the better utilization of the existing ones."¹⁶

The second party of "evolutionaries" consists of those who feel technology is readily available to counter "stealthy" aircraft. They claim the air defenses of today can be reinvigorated through the use of sophisticated computer processing capability and a different type of radar transmitter/receiver configuration.

LO platforms are designed to "absorb" and refract radar signals rather than reflect them. New radar technologies would use low frequency radar or Ultra Wide Band (UWB) radar to defeat the Radar Absorptive Material (RAM) coating on the LO platform. Multiple receivers would be located separately from the transmitters and tied together through sophisticated computers. The weak returns from a LO platform would reach several of the receivers and through the computer processing the individually weak returns could be



synergized to produce a viable aircraft track.

Overly sensitive radar receivers would naturally produce a lot of false targets, but the computer processing of several weak returns would be able to eliminate them. The critical link is the computer integration of the radar returns from multiple receivers. International Defense Review reported: "A large amount of computation is needed...and new types of computers providing massive amounts of parallel processing are likely to be needed."¹⁷

UWB advocates say such a system has potential for detecting stealth aircraft. Congress was so interested, that in 1989 it allocated \$25 million specifically for further UWB research.

Evolutionary Party II Silenced

"It is also true that significant research is necessary to bring this (UWB) potential to fruition."¹⁸

Capt J. Patton, a retired submariner who has written extensively on the commonalities of stealth between submarines and aircraft, suggests hindsight might be the best way to look at counter-stealth claims. He has said:

"Claims regarding the detection and vulnerability of low-observable aircraft...are reminiscent of similar reports issued since World War I postulating the demise of the submarine...An examination of anti-submarine warfare further suggests that those forecasting the demise of the stealthy aircraft may be falling into the same sort of traps as those who foretold the failure of the submarine."¹⁹

The Congressional appropriation of \$25 million dollars to further



research UWB technology whetted many an appetite for proponents of UWB efforts. In an effort to focus the investigations a special radar panel was created to identify the best avenues for further research. The panel met throughout 1990. The "well respected experts in the radar field" produced their final report which "appeared to go out of its way to discredit UWB proponents and their anti-stealth claims."²⁰ "Our panel of experts thought these claims had been exaggerated, and wanted to state that forcefully in the report."²¹ Perhaps Capt Patton's comments were true, at least for now.

The Defense Department contracted its own studies with Institute for Defense Analysis, Rand, and the Center for Naval Analysis in July 1991. These efforts had a somewhat different focus. "We think we know stealth works but this will help us quantify it. So the effort is to look at where stealth has taken us and what it is buying us..."²²

For those who are have yet to be convinced of the revolutionary qualification of today's LO platforms; perhaps the best perspective of its real beauty is not in the eye of the United States beholder but in that of the potential adversary.



PART III: THE ENEMY PERSPECTIVE

Lessons From Desert Storm

Scenes from Saddam Hussein's worst nightmare have to include downtown Baghdad on January 17, 1991. His most valued national assets were targeted and effectively destroyed in the opening hours of Desert Storm despite his investment in an Integrated Air Defense (IAD) network, including a sophisticated Air Force, to protect them. Any potential US adversary would certainly look to Desert Storm to assess their "enemy's" LO capabilities.

The power of the coalition air arm was immense, but it was the LO platforms which provided us with the ability to surgically strike in the opening minutes of the war. The air war which unfolded over the ensuing weeks had multiple objectives, our focus is on those the F-117 helped achieve.⁴

The F-117s with their 2,000 pound Precision Guided Munitions (PGMs) gave a new shape to the anticipated battle. They destroyed Nuclear, Biological, and Chemical (NBC) production and storage centers. They destroyed laboratory, research and production facilities, communication centers, air defense sites, hardened aircraft shelters, Iraqi Air Force Headquarters and telecommunications centers. Their LO capabilities proved effective

⁴ Non-stealthy cruise missiles are not the focus of this paper and therefore are not addressed. However, they do add flexibility in targeting, even in their non-stealthy form.



in allowing them to virtually strike at will. F-117s were not the single star of the Desert Storm Air Campaign but their unique accomplishments and demonstrated capability certainly adds significant unknowns to any adversary's defense equation.

The enemy might not know what the RCS of the F-117 is, but it apparently was invisible to the air defense system which was supposedly protecting Baghdad. The F-117 struck critical assets in Baghdad autonomously and before the air defense nets were destroyed.⁵ "Effectively compressing the detection range of radars, stealth fighters could trace their way through a layered, redundant air defense network the way a commuter might step around pools of water on the way to work."²³

Enemies might not know whether LO platforms are revolutionary or evolutionary but they certainly recognize the F-117 assets as the vehicles which combined penetration with precision and enabled the Coalition to strike with such surprise and concentration. "Though constituting less than two and one-half percent of all Allied fighter and attack aircraft in the Gulf, the F-117 attacked over 31% of strategic Iraqi targets struck on the first day of the war. Overall, during the entire Gulf air war, the stealth fighter flew only 2% of the combat sorties, but attacked 40% of the strategic

⁵ "Myth of the Lone Gunslinger," an article in the November 18, 1991 US News and World Report says; that although EF-111s did not actually accompany F-117s, they supported F-117 operations by diverting Iraqi attention from areas where stealth fighters were attacking.



targets."²⁴

Desert Storm demonstrated the enemy's potential courses of action were significantly impacted by airpower and especially stealth assets. He did "Delay" but suffered mightily for it. He couldn't "Reinforce" because his lines of communication were cut. His ability to "Attack" was severely reduced because of the damage done. Even when he attempted to "Withdraw" his forces were held at risk. He planned to "Defend" but his Maginot lines were circumvented and destroyed. If he wanted to "Escalate"⁶ he found his stocks of nuclear, chemical and biological weaponry severely curtailed (this is a significant capability in itself and is discussed further later in the paper).

General Horner listed five agenda items in the Air Campaign. They were: (1) Isolate and incapacitate Hussein regime (leadership and C3 target sets); (2) Gain/maintain Air Supremacy to permit unhindered air operations (Air defense and Airfield target sets); (3) Destroy Iraqi Nuclear, biological, and Chemical (NBC) warfare capability; (4) Eliminate Iraq's offensive military capability (Key military production, infrastructure, and power projection target sets); (5) Render Iraqi army in Kuwait ineffective, causing their collapse (Bridge destruction, direct destruction of armor,

⁶ Lt Col Bill Spain (USMC), an Operations Department instructor at the Naval War College, recommends the addition of this additional Enemy Course of Action to the original DRAW-D list.



artillery, and personnel).²⁵ Most potential enemies would recognize LO platforms as only a part of a total Air package, but they were the part whose unique capabilities allowed it to strike at targets across four of these five objectives. Never before have such strategic targets been attacked in the opening minutes of an air war. Independent of the academic discussion of appropriate stealth modifiers, the LO platforms added a significant "wrinkle" to the enemy's plan of war.

Lessons learned from Desert Storm will impact future enemies political, economic, as well as military strategies. Separating out the lessons specifically taught by LO assets would be moving onto "very thin ice." Still, the apparent vulnerability of critical resources specifically put at risk by LO assets is a new lesson learned by our prospective challengers.

How revolutionary would we consider LO technology if the Soviet Union was alive and well today with LO fighters assigned to forward bases in Eastern Europe? How would NATO defend against fighters who could launch an attack like something out of a Tom Clancy novel? How would the US do battle when its AWACS and JSTARS eyes are poked out by stealth fighters they never saw coming? How would we have defended air bases in the Gulf desert against stealthy assets?

Some fail to see the revolutionary capabilities because they lack



hindsight; some because of the classifications which have precluded the majority of military and civilian alike to know the "real" data; but most all of the evolutionary bunch never see the revolutionary capability because they've failed to get in the other guy's shoes. It only takes a few hours in those shoes, combined with a recognition of the significant cost of any potential counter (especially in tougher economic times) and many would begin to see the revolutionary capabilities of LO technologies.



PART IV: OPERATIONAL STEALTH ASSETS, WHAT'S NEW?

Stealth has brought a multitude of changes to the battlefield touching all levels from tactical to doctrinal. The three primary changes are discussed below.⁷

What's New? The Proximity of Absolute to Reality

In the same way Clausewitz begins his discussion of war with a description of its absolute form, Air Force Manual 1-1 lays out the absolute attributes of Aerospace Power. The description includes:

"Aerospace provides access to all of the earth's surface... Aerospace power can quickly concentrate on or above any point on the earth's surface... Aerospace power can apply force against any facet of enemy power."²⁶

These points clearly communicate the absolute conditions of airpower but not day to day reality.

Clausewitz follows his absolute description of war with the factors which take war away from its absolute form; the Air Force doctrinal manual fails to do this. The fact is that there is not free access to all points over the earth's surface; F-111s added 13 hours to their El Dorado Canyon strike missions because of overflight right squabbles. Aerospace forces can not be quickly gathered over any point on the earth's surface; B-52s survival rate in the threat

⁷ Discussion of peripheral changes would detract from the primary focus of the paper. These issues are discussed briefly in Appendix II.



envelope of an SA-10 are not good (at least not for the B-52 crews). Aerospace power can not apply force against any facet of enemy power; deeply buried or hardened shelters with air defenses are too hard of a target for most all Air Force or Navy assets.

If you recognize the vast difference of reality from the absolute, you begin to see the significance of the unique capabilities brought to the operational commander with the arrival of stealth assets. The reality has never been closer to the absolute than it is today with these revolutionary aircraft.

Lieutenant General Boyd, Air University Commander, says LO technology has produced:

"The capability to put any feature of the enemy at risk--which includes the ability to threaten every asset an enemy possesses with unprecedented probability of target engagement and low risk of interference, loss, or capture..."²⁷

What's new with the arrival of stealth aircraft, especially with precision guided munitions (PGMs), is the change in proximity between absolute and reality. The things Douhet was called a fanatic for in the 1920s have become a virtual reality in the 1990s.



**What's New? The Effectiveness
And Breadth of Potential Use**

El Dorado Canyon and Desert Storm portray a vast difference in political objectives and the forces needed to fulfill the objectives. The use of military force is always an instrument of policy; so the variance in the breadth of policy is a critical factor in determining the forces needed. Aerospace power can be used separately or as a component part of a larger military force. When the

political objective is very broad, several military components may be needed; but when the objective is extremely limited only the specific type of military force best suited for the limited goal will be the force of choice in fulfilling it. With stealth, both the breadth and effectiveness of air assets has been expanded.

Stealth has produced a new and unique instrument for fulfilling national policy objectives. In an article about stealth aircraft, Lieutenant General Boyd commented on their capabilities when married to a Precision Guided Munitions (PGMs):

**Table IV
What's New?**

WHAT'S NEW?

What changes have been brought to the operational arena with the arrival of stealth assets?

1. Decreased proximity between absolute and actual aerospace power; realized by degrading air defense systems.
2. Greater effectiveness across a broader portion of the spectrum of warfare.
3. Aerospace control primacy no longer absolute.

Peripheral Issues
Discussed in Appendix II



"Above all, PGMs connect political objectives to military execution with much greater reliability than ever before. The political leader can have far greater confidence that discrete objectives can be met and can thus gain broader latitude in formulating the overall objective. This is not just a change in air power or even in military power; it is a fundamental change in warfare."²⁸

If you need the accuracy of a PGM, more often than not you will need the stealth aircraft to deliver it. What's new with stealth technology is the increased effectiveness it can have across a broader portion of the war fighting spectrum. Increased effectiveness across a broader spectrum; that is operational capability.

Stealth aircraft, with secure basing access, could even make a very effective "presence" statement. Much like a CVBG with non-stealthy aircraft is considered force projection; presence would certainly be communicated with a deployed squadron of F-117s and a few tanker assets. Stealth survivability, precision, and demonstrated ability to penetrate air defenses would make a forceful impression in the mind of the enemy. With basing available, this would prove a potent deterrent.



What's New? Aerospace Control Primacy, No Longer Absolute.

"Air superiority is a necessity. Since...1939, no country has won a war in the face of enemy air superiority, no major offensive has succeeded against an opponent who controlled the air, and no defense has sustained itself against an enemy who had air superiority. Conversely, no state has lost a war while it maintained air superiority, and attainment of air superiority has consistently been a prelude to military victory."²⁹

Air superiority, now called aerospace control in Air Force doctrine, has been the top priority of air power since the 1942 reorganization of air assets in the African theater. As the quote above summarizes, this has been the primary goal in the employment of air power. With stealth aircraft its primacy is no longer absolute.

Air Force doctrine says "Aerospace control assures the friendly use of the environment while denying its use to an enemy."³⁰ Broken down into two components this says first, our aircraft will be able to use the environment as they desire. This means the enemy is not able to stop us from using it as we desire. The second component of aerospace control is denying this free use to the enemy. This means we have the ability to physically hinder his air operations. With stealth aircraft we have free use of the environment; the first half of the aerospace control equation.

These two components are extensively discussed by John Warden in The Air Campaign. Table V is taken from his discussion of Air Superiority.



Colonel Warden describes Case II as "the commander's dream" because "his bases are nearly immune from enemy attack, but he can attack all parts of his enemy's structure."³¹ This describes the situation for the US with operational home based B-2s or F-117s/F-22s deployed in the theater of conflict. Stealth asset capabilities provide the flexibility to proceed directly to the force application roll whenever it is desired.

AIR SUPERIORITY CASES			
Blue Air Fields		Red Air Fields	
<u>CASE</u>	<u>and Rear Areas*</u>	<u>Battle Lines**</u>	<u>and Rear Areas</u>
I	Vulnerable	Reachable	Vulnerable
II	Safe***	Reachable****	Vulnerable
III	Vulnerable	Reachable	Safe
IV	Safe	Reachable	Safe
V	Safe	Unreachable	Safe

* Blue and Red fields encompass supporting infrastructure such as power, fuel, and command and control facilities.

**Normally the ground front, but could be a border.

***Safe means that fields are not likely to be hit either because the enemy is unable to hit them, or chooses not to do so, or they are protected by political constraints.

****When Case II progresses to its logical conclusion, Red will probably be unable to reach even the battle lines.

TABLE V

Force application "brings aerospace power to bear directly against surface targets."³² In the past, a premature shift to this stage could inflict significant penalties. In World War II the force



application (strategic bombing) was conducted without aerospace control and the penalties were incurred. Aerospace control enhances every friendly mission accomplished beneath its protective wings and is obviously a desirable objective in some cases. However, stealth assets provide their own protective wings.

From an enemy's perspective this is much more than just an ability to rearrange top priorities. We are getting inside of his decision loop and driving his choices by limiting or eliminating his potential courses of action.

Stealth assets have the ability to strike directly at the potentially most dangerous enemy course of action, escalation. As discussed earlier, the F-117 was used specifically to limit the viability of this option to Saddam Hussein; and in so doing removed a significant risk to the forces and coalition in Desert Storm.

Beyond just the limitation of escalation options, stealth can help shape the battlefield. Stealth assets used in the force application role can curb virtually all of the potential enemy courses of action. If direct force application is insufficient to meet political goals, we can conduct efforts to obtain aerospace control simultaneously. Aerospace Control will enhance the mission capabilities of all assets operating beneath it, so its priority is high; but because of unique stealth capabilities force application can be, and will be when the situation allows, an even higher



priority yet.¹

The new National Military Strategy seems to recognize this new ability. In the midst of its discussions of the four major military force packages, it hints at a new priority for air assets:

"At times of crisis, we must have the capability to reinforce our forward presence forces while still maintaining our commitments in other regions. These requirements underscore the need to preserve...air forces that can strike an enemy's vital centers of gravity, achieve air superiority and conduct other missions to achieve theater commander objectives."³³ (Emphasis mine.)

Note the sequence of the stated priorities.

Desert Storm demonstrated exactly this capability. The "vital centers of gravity" were hit in the opening minutes. What's new about stealth forces is their ability to place the force application role ahead of the aerospace control role without suffering the consequences in survivability.

¹ The caveat is added because if we, like the Israeli's in 1973, are caught off guard we may not be able to set the pace or priority of our air battle initially.



PART V: NOBODY ASKED ME, BUT...

We Need To Change Doctrine

If the F-117 was the Nautilus of airborne stealth warfare and the B-2 the George Washington (the strategic nuclear counterpart), then the ATF is the Scorpion. While all but the brightest saw Nautilus as a "better" SS--more easily accomplishing the same missions--all but the dullest saw the Scorpions and the Polaris submarines as revolutionary developments--new types of platforms which gave birth to entirely new employments and missions.³⁴

If you want people to recognize and apply revolutionary new capabilities you must get them to change their thinking. Doctrine has an impact on logic of thinking--logic of thinking has a direct impact on modes of application. Put into the operational world; the staff putting together the operational plan will apply their logic of thinking in determining how to apply weapon systems available. If you want operational plans to reflect new capabilities to their utmost potential you need to change the old molds of thinking and replace them with new capabilities and new objectives.

We Need To Get The Word Out

"It is not entirely apparent that those warriors who stand most to benefit from these latest products of high tech understand fully the great tactical and operational changes that are required if their potential is to be realized."³⁵

James Patton, Capt, USN (Ret)

The biggest hindrance to employing revolutionary technology is divorcing it conceptually from past applications of its most recent predecessors. This is not to say that all lessons learned to this



point need to be dismissed--but it does mean they need to be reevaluated in view of the new development. This is a thought recognized over time; consider this rather lengthy quote from Mahan:

"The seaman will observe...changes of tactics have not only taken place after changes in weapons, which necessarily is the case, but that the interval between such changes has been unduly long. This doubtless arises from the fact that an improvement of weapons is due to the energy of one or two men, while changes in tactics have to overcome the inertia of a conservative class; but it is a great evil. It can be remedied only by a candid recognition of each change, by careful study of the powers and limitations of the new ship or weapon, and by a consequent adaptation of the method of using it to the qualities it possesses which will constitute its tactics."³⁶

Mahan logically makes the point that change is slow in coming because the few have to overcome the "inertia of the conservative class." He ties together not only the information dissemination but also the "candid recognition" of the new capabilities as the limiting factors for proper employment.

Those who are best informed about the current weapon systems are the very ones who are best qualified to recognize how to implement the revolutionary innovations; but they are also the ones who will have the most difficult time seeing these innovations as something more than a mere replacement to its predecessor. Capt James Patton's quote above summarizes just this point.

Changes required for revolutionary capability stretch all the way from the tactical to the doctrinal level. The rapidity with which these changes will be implemented is impacted by many things; LO



procurement, adversary development of LO technology, or the level of world tension. The most essential factor to realizing this revolutionary potential lies in recognizing and embracing the new capabilities fully in Air Force doctrine.

Doctrine Gets The Word Out

New capabilities include the potential to utilize stealth aircraft in a wider portion of the conflict spectrum, to include force presence/deterrent role. New capabilities include the ability to limit one of the potentially most dangerous of enemy options--escalation. New capabilities are available allowing force application to be the number one priority; to include B-52 conventional cruise missiles, Tomahawks launched from ships and submarines, and F-117s applying PGM weapons (not to mention B-2s and F-22s). All this could be done with force application versus air superiority as the number one priority. New capabilities include the opportunity to shape the battlefield like never before; to drive the enemy's decisions by reducing or eliminating his potential courses of action.

These kind of new capabilities should be reflected in doctrinal changes. The Air Force doctrinal description of Aerospace Power in the absolute needs to be compared to the picture of a real theater of warfare; a new section or chapter in the doctrine that describes the hindrances, the problems, the conflicts that take away from the



absolute. It needs to discuss the variation in breadth of a policy which will directly impact the form and content of your force package, the missions it must fulfill, and the priority in which they must be fulfilled.⁹

Then, with both pictures clearly painted, the discussion of forces can focus on how best to utilize stealth and non-stealth assets. Then, with both perspectives in mind, we will begin to see how aerospace power is applied to mold the warfare reality into the degree of absolute we want our forces fighting in. Then we will begin to see the real capabilities and limitations of our non-stealth force; and we will obtain a new and fresh appreciation for the unique contributions fielded with our stealth aircraft and weapons.

The time has never been better for a fresh look. As the Joint Strategic Capabilities Plan is rebuilt to demand a more expanded list of inputs from our theater CINCs, we need to capitalize on the opportunity and ensure all our operational warriors have the same fresh perspective of the new capabilities proven in Desert Storm.

General Boyd cautions, "We certainly need to guard against creating a popular expectation that air power has attained some form of mechanistic perfection."³⁷ Certainly this caution needs to be

⁹ These concepts could logically be expanded on in AF Manual 1-1, Volume II. My proposals are discussed further in Appendix I.



heeded, but just as certainly the viable options made attainable with stealth assets needs to be applied in the revolutionary way that equals their full potential.



APPENDIX I: MY PERSPECTIVE ON AFM 1-1 CHANGES

There are a multitude of experts working on AFM 1-1. I do not claim to have a unique and accurate perspective on how the manual ought to be written. I simply offer how I perceive, conceptually, changes ought to be made.

Chapter two addresses Aerospace Power in the absolute and should be titled as such. There should be no doubt to the reader that we perceive an absolute and we recognize that we don't live with the absolute from day to day. It also then flows naturally into a discussion of those things which take away from the absolute. These include political objectives which are limited in nature, defenses on the ground, airborne defenses, natural limitations like environmental conditions, geographic airfield locations, and range limitations of aircraft. Volume II could provide a tremendous expansion on these concepts by discussing the political limitations which frustrated airpower in Vietnam, the problems encountered with basing and logistical support. There are a lot of limitations which keep us from putting air assets where we want them and these are critical to our thinking when we want to utilize these assets.

I believe the Volume I discussion should also include an appreciation of the different political objectives and how theater force structures vary based on these objectives. Volume II could



expand with a compare and contrast between Desert Storm and El Dorado Canyon; between B-52s sitting alert and President Carter's use of unarmed F-15s in Saudi Arabia. Differing objectives can demand completely different force structures and attack plans--a seemingly obvious, but doctrinally basic thought.

After drawing both the absolute and the real world pictures of Aerospace Power then introduce how policy, absolute, reality and force structure come together. Chapter two would introduce this subject. Chapter three could provide greater detail. I envision the chapter two introduction to look something like this.

The Critical Blend

An Air Commander's responsibility is to utilize the forces available in the most effective manner to achieve the military goals. It's important to recognize, that every air campaign, or every air phase of a larger campaign; is ultimately designed to fulfill or contribute towards the achievement of the overriding political goal.¹⁰

The political goals will drive the extent to which the air campaign must control aerospace. If the political goals are very limited,

¹⁰ Airpower may be used alone in a very limited objective mission, or may be part of a larger multi-faceted campaign. The words "phase" and "campaign" are not interchangeable but for simplicity purposes I use "campaign" with the intent of meaning one or the other, as would be appropriate.



the air campaign will have to be assembled with the most precise tools available. Due to the limited scope of the objectives; total aerospace control may not be required but rather the air campaign would be specifically focused on force application against a specific set of assets. The air commander would use his precise tools to perform a military mission designed to meet the limited objective.

Broader political objectives will translate into broader military goals, demanding a greater degree of aerospace control. In this case the efforts in force application would combine with efforts to obtain aerospace control and achieve the degree of air superiority required to support the friendly forces deployed in the theater of conflict. (The priority of one mission over the other would be driven by a number of factors).

The air commander must recognize the breadth of the political objectives, hence the breadth of the military goals; and appropriately tailor the air campaign (or phase of a campaign) to fulfill those mission objectives. This is when it is absolutely critical to have a clear understanding of the unique capabilities stealth and non-stealth assets can bring to the battlefield. For it is in blending stealth and non-stealth, precision and less precise weapons; it is in knowing capabilities and limitations of each weapon system that the best of air commanders can design an air campaign that is well tailored to, as precisely as possible,



make the military force meet the political objective he has been
tasked to fulfill.



APPENDIX II: WHAT ELSE IS NEW?

The number of changes brought about by revolutionary stealth capabilities are too significant to list here. Even the issues addressed here are only discussed on a surface level. They are important, but were considered peripheral to the main focus of the paper. For this reason, they were moved to this appendix.

What Else is New? Enhanced Ability in the Principles of War.

Unique stealth qualities put a fresh look on the principles of war and the methods which air assets can be utilized within them.

OBJECTIVE - Can be even more finely tuned than ever before.
Closer military/political match feasible.

OFFENSIVE - Enhanced capability to do this quickly and across a wider portion of the spectrum of conflict.
Ever more critical to use this as adversaries gain stealth capabilities.

MASS - Allows mass to be concentrated directly against enemy operational centers of gravity in opening minutes of conflict (as seen in Desert Storm). Unique stealth qualities allow this to be more of a reality than ever before because of their impact on air defense capability.

ECONOMY OF FORCE - Force reductions due to downsizing and fewer assets due to the costs associated with stealth procurement reduces overall denominator. Application of this principle becomes more critical than ever; as does the issue of balancing procurement of costly stealth assets with less costly non-stealth assets.

MANEUVER - Flexibility multiplied immensely by virtual removal of air warfare obstacles (air defense systems).

UNITY OF COMMAND - No change conceptually. JFACC needs to ensure the stealth/non-stealth mixing is thought



through. Stealth representatives critical on staff.

SECURITY - Multiplies the value of our assets. Increases the enemy's incentive to strike them first (as only mode of defense). Politically sensitive issue (losing very expensive stealth aircraft) increases the need for maximum security efforts.

SURPRISE - Better able than ever to achieve this with every mission due to the narrowing of the proximity between absolute and actual aerospace power.

SIMPLICITY - A smaller, more potent strike package may simplify a strike effort.

What Else is New? Stealth/Non-Stealth Mix.

The mixture of stealth/non-stealth force package will be critical from force procurement through mission execution. The stealth assets bring unique capabilities to the battlefield but limited resources can only be spread so thin before losing mission effectiveness due to insufficient forces. Limited defense dollars will demand a balance of stealth aircraft with the overall quantity of aircraft needed to fulfill requirements.

Operationally, prioritizing most critical requirements will blend with economy of force issues and drive commanders to use non-stealth assets due to higher priority stealth asset commitments. Planners must ensure mission plans with stealth/non-stealth mixing do not detract from the stealth asset's effort to remain hidden. Command and control procedures, air refueling tracks and especially procedures to eliminate blue on blue engagements must all be coordinated in such a way so as to minimize the necessity for



airborne communication. The mix of aircraft make this a more complex problem than it is today.

What Else is New? Additional Changes

The enemy will quickly determine the best way to defeat a stealth asset is while it is on the ground. Deployed stealth assets will become a prime target for terrorist and preemptive attacks. The impact of destroying an F-117, F-22, or a B-2 will carry a significantly different message than the destruction of a F-15 or B-52. As the stealth assets decrease the enemy's potential courses of action they place him in a box with one of his few options being an initiative seizing attack against the very assets holding him at risk. Air Force leaders seemed to be well aware of this when they chose the basing locations for the F-117 in Desert Storm.

Table VI
What Else Is Now?

1. New capabilities in applying the Principles of War.
2. Criticality of considering stealth/non-stealth force mix in all realms of planning.
3. Value of stealth aircraft will make it the focus of enemy attack.
4. Accelerates the demand for PGM mission and the curtailment of "dumb" bomb mission.
5. The criticality of stealth in future aerospace control, force application, and perhaps force enhancement aircraft.
6. The need to scrub tactics for disconnects with stealth interfaces.
7. Promises even bigger challenges when adversaries develop stealth capability.



The precision targeting seen in Desert Storm will continue to accelerate the demand for more PGM missions and curtail the demand for conventional "dumb" bomb missions. The hand/glove matching of political goal to military action will continue to be the more frequently chosen mission for force application assets.

The criticality of stealth in future aerospace control and force application aircraft is only going to heighten as other countries develop similar capabilities. The Red Baron studies of air combat in Southeast Asia showed that 82 percent of the air-to-air victories during the Vietnam war were attributable to the victim's being able to attack prior to his opponents awareness of his presence.³⁸ Stealthiness will ensure our aerospace control assets get the first-look, first-shot capability.

The more stealth assets we bring into the force structure the more we will need to ensure our tactics fit the employment principles stealth demands. This means tactics need a thorough scrubbing to ensure there are no disconnects with stealth interfaces. The stealth advantage in war fighting is uniquely ours today but it will not be so in the future. The challenges of properly employing stealth will only grow larger as adversaries develop the capability as well.



NOTES

1. President George Bush, Reaching Globally, Reaching Powerfully: The United States Air Force In The Gulf War, USAF Report, September 1991, p 56.
2. Donald Rice, "The Manned Bomber and Strategic Deterrence," International Security, Summer 1990, p 104.
3. This section draws heavily from: Christopher Donnelly, The Red Banner (Alexandria, Virginia: Janes Publishing Inc, 1988), pp. 59-60.
4. Norman B. Wilkinson, Explosives In History (Chicago: Rand McNally and Company, 1966), p. 8.
5. Norman B. Wilkinson, Explosives In History (Chicago: Rand McNally and Company, 1966), p. 14.
6. Donald Rice, "The Manned Bomber and Strategic Deterrence," International Security, Summer 1990, p 105.
7. The Case For The B-2, An Air Force Perspective, Department of the Air Force, June 1990, p. 12.
8. The Case For The B-2, An Air Force Perspective, Department of the Air Force, June 1990, p. 13.
9. David F. Bond, "USAF Study Asserts That Soviet Defenses Would Be Ineffective Against B-2 Bomber," Aviation Week and Space Technology, October 30, 1989, p. 29.
10. The Case For The B-2, An Air Force Perspective, Department of the Air Force, June 1990, p. 13.
11. Dan Boyle, "Fusing the Data In the Search for Identity," International Defense Review, August 1989, p. 1101.
12. J. Jones, Stealth Technology The Art of Black Magic, ed. by Matt Thurber (Blue Ridge Summit, Pennsylvania: Tab Books, 1989), p. 1.
13. William D. O'Neil, "Don't Give Up On the Ship," United States Naval Institute Proceedings, January 1991, p. 48.
14. Donald B. Rice, "The B-2 Stealth Question," Aviation Week and Space Technology, September 23, 1991, p. 7.
15. Donald B. Rice, "The B-2 Stealth Question," Aviation Week and Space Technology, September 23, 1991, p. 7.



16. Dan Boyle, Fusing The Data In The Search For Identity," International Defense Review, August 1989, p. 1102.
17. Dan Boyle, "Fusing the Data In The Search For Identity," International Defense Board, August 1989, p. 1103.
18. William B. Scott, "UWB Radar Has Potential To Detect Stealth Aircraft," Aviation Week and Space Technology, December 4, 1989, p. 41.
19. James H. Patton, Jr. and Robert P. Haffa, Jr., "Analogues of Stealth: Submarines and Aircraft," (Unpublished work obtained from Mr. Haffa) p. 1.
20. William B. Scott, "Report Critical of Impulse Radar Triggers Controversy," Aviation Week and Space Technology, November 19, 1990, p. 19.
21. William B. Scott, "Report Critical of Impulse Radar Triggers Controversy," Aviation Week and Space Technology, November 19, 1990, p. 20.
22. John D. Morrocco, "Pentagon Launches Independent Review of Tactical Stealth, Counterstealth," Aviation Week and Space Technology, July 1, 1991, p. 66.
23. Reaching Globally, Reaching Powerfully: The United States Air Force In The Gulf War, USAF Report, September 1991, p. 19.
24. Reaching Globally, Reaching Powerfully: The United States Air Force In The Gulf War, USAF Report, September 1991, p. 21.
25. Charles A. Horner, "Reflections On Desert Storm," briefing slides obtained from HQ USAF.
26. "Basic Aerospace Doctrine of the United States Air Force," Air Force Manual 1-1, Volume 1, September 1991, pp. 5-6.
27. Charles G. Boyd; Charles M. Westenhoff, "Request Unrestricted Climb," Airpower Journal, Fall 1991, p. 12.
28. Charles G. Boyd; Charles M. Westenhoff, "Request Unrestricted Climb," Airpower Journal, Fall 1991, p. 12.
29. John Warden, The Air Campaign (Washington: Pergamon-Brassey's International Defense Publishers, 1989), p. 10.
30. "Basic Aerospace Doctrine of the United States Air Force," Air Force Manual 1-1, Volume I, September 1991, p. 6.
31. John Warden, The Air Campaign, (Washington: Pergamon-Brassey's International Defense Publishers, 1989), p. 33.



32. "Basic Aerospace Doctrine of the United States Air Force," Air Force Manual 1-1, Volume I, September 1991, p. 6.
33. 1992 National Military Strategy, pp. 21, 22.
34. James H. Patton Jr., "Stealth Is A Zero-Sum Game: A Submariner's View Of The Advanced Tactical Fighter," Airpower Journal, Spring 1991, p. 17.
35. James Patton, "Some Operational Implications of Stealth Warfare," Naval War College Review, Winter 1990, p. 67.
36. Alfred T. Mahan, The Influence of Sea Power Upon History 1660-1783, (New York: Dover Publications, 1987), pp. 9-10.
37. Charles G. Boyd; Charles M. Westenhoff, "Request Unrestricted Climb," Airpower Journal, Fall 1991, p. 13.
38. James H. Patton, "Stealth Is A Zero-Sum Game: A Submariner's View of the Advanced Tactical Fighter," Airpower Journal, Spring 1991, p. 6.



BIBLIOGRAPHY

- Air Force Performance In Desert Storm. Department of the Air Force, April 1991.
- Aspin, Les. "The B-2 Should Be Halted." Aviation Week and Space Technology, September 17, 1990, p. 15.
- Auster, Bruce B. "The Myth Of The Lone Gunslinger." US News and World Report, November 18, 1991, p. 52.
- B-2 Conventional Capabilities. Briefing slides obtained from HQ USAF.
- "B-2 Redesign Option." Air Force Magazine, January 1992, p. 18.
- B-2 Survivability Against Air Defense Systems. Department of the Air Force: March 1990.
- "Basic Aerospace Doctrine of the United States Air Force." Air Force Manual 1-1, Volume I (September 1991 Draft).
- "Basic Aerospace Doctrine of the United States Air Force." Air Force Manual 1-1, Volume II (August 1990 Draft).
- "Black Secrets." Jane's Defence Weekly, September 14, 1991, p. 481.
- Bomber Modernization: Deterrence At The Crossroads. Department of The Air Force briefing, May 1990.
- Bond, David F. "USAF Study Asserts That Soviet Defenses Would Be Ineffective Against B-2 Bomber." Aviation Week and Space Technology, October 30, 1989, pp. 29-30.
- Bond, David F. "Radar Networks, Computing Advances Seen As Keys to Counter Stealth Technologies." Aviation Week and Space Technology, December 4, 1989, p. 41.
- Bond, David F. "USAF Believes Impulse Radar Not Feasible for Detecting B-2." Aviation Week and Space Technology, February 26, 1990, p. 53.
- Bond, David F. "USAF Resists Change In B-2 Configuration." Aviation Week and Space Technology, November 4, 1991, pp. 69-70.
- Boyd, Charles G.; Westenhoff, Charles M. "Request Unrestricted Climb." Airpower Journal, Fall 1991, pp. 4-15.



- Boyle, Dan. "Fusing The Data In The Search For Identity." International Defense Review, August 1989, pp. 1101-1103.
- Brinkley, Randolph H. "Future US Fighters Are At A Cost/Technology Crossroad." Armed Forces Journal International, January 1991, pp. 49-50.
- Canan, James W. "Lesson Number One." Air Force Magazine, October 1991, pp. 26-31.
- Chain, John T. "A Warrior's Perspective on the B-2." Armed Forces Journal International, September 1990, pp. 78-80.
- Clausewitz, Carl Von. On War. Edited and translated by M. Howard and P. Paret. Princeton: Princeton University Press, 1984.
- Clodfelter, Mark. The Limits Of Air Power. New York: The Free Press, 1989.
- "Command And Employment Of Air Power." War Department Field Manual FM 100-20. Washington: United States Government Printing Office, July 21, 1943.
- Cunningham, Jim. "Cracks In The Black Dike Secrecy, The Media, and the F-117A." Airpower Journal, Fall 1991, pp. 16-34.
- Donnelly, Christopher. The Red Banner. Alexandria: Janes Publishing, 1988.
- Douhet, Giulio. The Command Of The Air. Translated by D. Ferrari. Washington: Office of Air Force History, 1983.
- "F-117A Reportedly Tracked By Saudi SAM Battery, But Another Radar Unable To Establish Fix." Aviation Week and Space Technology, October 1, 1990, p. 24.
- "Fired Boeing Employee's Suit Raises Questions About Attempts to Squelch UWB Research." Aviation Week and Space Technology, October 21, 1991, p. 22.
- Friedman, Norman. Desert Victory The War For Kuwait. Annapolis: Naval Institute Press, 1991.
- Gilmartin, Patricia A. "Senate Tightens B-2 Restrictions In Wake Of Stealth Testing Dispute." Aviation Week and Space Technology, September 23, 1991, p. 25.
- Green, Brian. "Proving Ground." Air Force Magazine, April 1991, p. 13.



Horner, Charles A. Reflections On Desert Storm The Air Campaign. Briefing slides.

Jones, J. Stealth Technology The Art Of Black Magic. Edited by M. Thurber. Blue Ridge Summit: Tab Books, 1989.

Lenorovitz, Jeffrey M. "F-117s Drop Laser-Guided Bombs In Destroying Most Baghdad Targets." Aviation Week and Space Technology, February 4, 1991, p. 30.

Mahan, A. T. The Influence Of Sea Power Upon History 1660-1783. New York: Dover Publications, 1987.

Michel, Marshall, "Up And Yonder--The Future Combat Aircraft." NATO's Sixteen Nations, July/August 1991, pp. 33-38.

Morrocco, John D. "Pentagon Launches Independent Review Of Tactical Stealth, Counterstealth." Aviation Week and Space Technology, July 1, 1991, pp. 66-67.

National Military Strategy. Joint Chiefs Of Staff: 1992.

National Security Strategy Of The United States. Washington: U.S. Government Printing Office, August 1991.

Nevin, David. Architects Of Air Power. Alexandria: Time-Life Books, 1981.

North, David M. "Carrier-Based U.S. Aircraft Flying Third of Desert Storm Sorties." Aviation Week and Space Technology, February 4, 1991, p. 27.

O'Neil, William D. "Don't Give Up On The Ship." United States Naval Institute Proceedings, January 1991, pp. 46-51.

Patton, James H. "Command and Control of Stealth Warfare Platforms." Defense Science, March 1990, pp. 26-31.

Patton, James H.; Haffa, Robert P. "Analogues Of Stealth: Submarines and Aircraft." An unpublished article, October 1990, obtained from Mr Haffa.

Patton, James H. "Some Operational Implications of Stealth Warfare." Naval War College Review, Winter 1990, pp. 67-72.

Patton, James H. "Stealth Is A Zero-Sum Game: A Submariner's View Of The Advanced Tactical Fighter." Airpower Journal, Spring 1991, pp. 4-17.

Reaching Globally, Reaching Powerfully: The United States Air Force In The Gulf War. US Air Force Report, September 1991.



- Rhodes, Phil. "Stealth What Is It Really?" Airman, September 1991, pp.22-24.
- Rhodes, Phil. "Giving Us The Edge." Airman, September 1991, pp. 25-27.
- Rhodes, Phil. "Stealth On Display Getting The Low-Down On Low Observables." Airman, September 1991, pp. 28-29.
- Rice, Donald. "The Manned Bomber and Strategic Deterrence." International Security, Summer 1990, pp. 100-128.
- Rice, Donald. "The B-2 Stealth Question." Aviation Week and Space Technology, September 23, 1991, p. 7.
- Scott, William B. "UWB Radar Has Potential To Detect Stealth Aircraft." Aviation Week and Space Technology, December 4, 1989, pp. 38-41.
- Scott, William B. "Report Critical of Impulse Radar Triggers Controversy." Aviation Week and Space Technology, November 19, 1990, pp. 18-20.
- Sokol, A. E. "Sea Power In The Next War." United States Naval Institute Proceedings, May 1952, pp. 519-531.
- Sweetman, Bill. "Stealth Technology Put To The Test." Interavia Aerospace Review, August 1990, p. 648.
- The Air Force And U.S. National Security: Global Reach--Global Power. Department of the Air Force, June 1990.
- The B-2 And US Security: Global Reach--Global Power. Department of the Air Force, August 1990.
- The Case For The B-2, An Air Force Perspective. Department of the Air Force, June 1990.
- "The Case For The B-2 Bomber A Rand White Paper." RAND Research Review, Fall 1991, pp. 3-5.
- The United States Strategic Bombing Surveys. Maxwell Air Force Base: Air University Press, 1987.
- "Wanted: The B-2 Facts." Aviation Week and Space Technology, September 30, 1991, p. 9.
- Warden, John A. The Air Campaign. Washington: Pergamon-Brassey's, 1989.
- Whitestone, Nicholas. The Submarine, The Ultimate Weapon. London: Davis-Poynter, 1973.



Wilkinson, Norman B. Explosives In History. Chicago: Rand McNally and Company, 1966.

Yates, Ronald W. "Advance By Stealth The Future Combat Aircraft." NATO's Sixteen Nations, Feb 1991, pp.79-82.