Naval War College Review

Volume 46
Number 2 *Spring*

Article 9

1993

Stealth: A Revolutionary Change in Air Warfare

Kevin J. Kennedy
U.S. Air Force

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A Revolutionary Change in Air Warfare

Major Kevin J. Kennedy, U.S. Air Force

WHILE MANY MAY ARGUE over whether stealth is revolutionary or evolutionary in its attributes, the real issue is not an academic one of semantic correctness but rather an operational one with far-reaching implications.[1] The intent of this article is not to advocate stealth or to present an academic argument for the correct relevant adjective (though that matter will be addressed). Rather, its purposes are to assert, from a strictly operational perspective, that stealth aircraft bring revolutionary capability to the battlefield and to suggest some changes needed to help maximize the contribution of stealth.

The first two sections develop a common understanding of basic capabilities. The next two shift the focus to identifying the unique and revolutionary attributes stealth aircraft demonstrated in Desert Storm and what these new qualities offer in the application of air power in the future. The final discussion focuses on action needed to realize the full potential of stealth assets.

Revolutionary:
The Appropriate Adjective for Stealth

If stealth aircraft are truly revolutionary, then by definition the capabilities they alone offer should be able to alter air warfare drastically and extensively. If the capabilities they provide are less than this, the more appropriate adjective would be "evolutionary," because they represent a gradual change or progression in warfare.

Evolutionary changes in warfare are much more prominent in history than revolutionary ones. They represent faster, more capable derivatives of their

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Major Kennedy is a B-52 instructor pilot assigned to the training wing at Castle Air Force Base in California. He is a 1978 graduate of the United States Air Force Academy and has served at Headquarters Strategic Air Command and on the Joint Strategic Target Planning Staff. He graduated in 1992 from the Naval War College, in the College of Naval Command and Staff.

The author greatly appreciates the support and assistance of Colonel Rocky Roland, USAF, Colonel Bill Spain, USMC, and Professor Jon Breemer, and also wishes to thank Lieutenant Colonel Rick Pruaut for his assistance in gathering documentation.

predecessors, while revolutionary assets bring entirely new options that were simply not possible before. To describe stealth aircraft as revolutionary is to say that we now have *operational* assets that have the inherent qualities needed to get through defenses as did none of their predecessors, and that strike with unmatched accuracy at strategic, operational, or tactical centers of gravity, as the political or military situation dictates. To call stealth aircraft revolutionary is to say they provide drastically new possibilities in air warfare.

. . . ***Even Without Hindsight.*** Hindsight provides tremendous clarity in determining the revolutionary nature of different weapon innovations, but usually our hindsight lacks depth perception. We may accurately say that gunpowder was a revolutionary development and yet have absolutely no appreciation for the period of time over which this "revolutionary" development matured or "evolved."

A revolutionary discovery of 1200 A.D. made the battle ax, bow and arrow, sword, pike, scaling tower, and battering ram obsolete.[2] Yet five hundred years after the discovery of black powder, Benjamin Franklin was recommending 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 proposal. 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."[3]

Franklin's recommendation was obviously given under extremely stressful circumstances; yet he marshaled arguments that still had at least superficial validity centuries after black powder's discovery. However, that he compared gunpowder directly to bows and arrows was to fail to recognize the unique qualities powder offered over its predecessors.

Stealth, like black powder, is revolutionary because it has changed the nature of warfare. Eventually, applications of black powder made all former methods of self-defense obsolete. In the same way, today's operational stealth aircraft have rendered obsolete all former means of air defense. To see that this is true, we need not hindsight but foresight.

There will always be those who will debate the issue. With few exceptions, creative inventions that an inventor might claim as revolutionary will be met by equally vociferous groups of disbelievers. Further confusion is added when wrong conclusions are drawn about new capabilities because of a failure to integrate a system doctrinally (e.g., the initial efforts with the tank in World War I). Only as time passes, after doctrine catches up with potential, are true

capabilities demonstrated, counter-capabilities proven effective or ineffective, and consensus reached about the revolutionary nature of a particular innovation. Unfortunately, waiting now for a consensus that stealth is indeed revolutionary could unnecessarily delay the proper application of its capabilities already available.

The gunpowder example also highlights the importance of fresh thinking when considering the appropriateness of the title "revolutionary" for an innovation. Benjamin Franklin found it easier, as he made his argument, to compare black powder to the thing it had replaced and measure its merits from that simple perspective. It is far more difficult to perceive whether a new system is in fact something essentially different from its predecessor, having capabilities previously unseen. Stealth aircraft must be studied for their unique qualities rather than as simply expensive replacements for B-52s, F-15s or F-16s. When enumerated, these capabilities produce a vision as clear as a hundred years of hindsight can offer.

Counter-Stealth Tests Prove It. Air defense networks protect airspace by detecting intruders (surveillance), tracking and targeting them (fire control), then fuzing weapons to detonate sufficiently close to destroy (kill) them. Today, all three efforts, or problems, use radar to derive their respective solutions; unique stealth characteristics seriously complicate them. Stealth technology has rendered radar systems ineffective by greatly reducing their detection ranges. Some low-frequency ground-based radars have a limited capability to detect low-observable (LO) platforms; detection alone, however, does not solve the defense problem. These large, low-frequency radars have weather-related operational constraints and also limited accuracies which make them unable to track targets accurately.[4] Due to their size, low-frequency radars cannot be airborne. Stealth technology essentially takes airborne detection, the greatest threat to penetrating aircraft, out of the picture.[5]

The combined impact of smaller detection radiuses for all but low-frequency, ground-based radars, and the elimination of airborne targeting and tracking, has virtually nullified the threat an air defense system can pose to 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."[6]

A critical part of the stealth development program has been the "Red Team." Formed in the late 1970s, this group of stealth technology experts was given the sole mission of finding the "Achilles' heel" that would negate the apparent advantage of a low-observable platform. Since its inception, the counter-stealth program has tested forty of the most promising techniques for defeating stealth and "none have proven viable challenges to stealth. . . .The counter-stealth program is finding no effective, affordable method to defeat stealth."[7]

A Dream Fulfilled. In his day, Giulio Douhet was viewed as a fanatic who made ludicrous claims about the importance air power would come to hold in warfare. He prophesied many things which to a great extent never have been and never will be true. However, at a time (the 1920s) when aircraft were nothing more than support assets, he wrote of the critical need to achieve command of the air. He rightfully pointed out the inability of the strongest army or navy to hinder air power from spreading terror and wreaking havoc. World War II separated Douhet's wheat from his chaff. The bombers that Douhet thought would always get through became bombers whose success has been questioned by many; they were a far cry from the invulnerable asset that Douhet forecasted would bring the enemy to their knees so quickly.

Morality and budget constraints kept many of Douhet's theories from penetrating U.S. air power planning. Rather than striking directly at populations with gas and incendiary weapons, the U.S. Air Corps of the 1930s proposed targeting vital centers of industrial infrastructure; these represented the choke points in an opponent's industry, the destruction of which would bring industry to a halt and thus cripple his entire war-making capability. When the United States and Britain formulated their combined bomber offensive at Casablanca in 1943, they followed these concepts. The plan still relied on a bomber that could reliably get through enemy defenses.

Stealth platforms are the technological realization of the aircraft the allies sought in 1943. Stealth is not the "cheap fix" which obviates the need for all other forces; but it does bring unprecedented efficiency, effectiveness, survivability, and flexibility to aerial warfare. When coupled with the effectiveness of precision-guided munitions, stealth advances the vision of strategic bombing effectiveness far beyond its World War II framework.

The "Evolutionary" Argument

The "evolutionary" advocates basically form two groups: those who feel low-observable technology has not proceeded to such a stage as to achieve true "stealth," and those who feel it can be effectively countered. Both parties are saying that LO platforms of today are nothing more than another evolutionary progression in weaponry—that is, that "every countermeasure produces a crop of counter-countermeasures, and stealth is no exception."[8]

Evolutionary Party I. Radar Cross Section (RCS) is only one of the factors that must be managed to produce a low-observable aircraft. RCS signatures vary depending on "look angle"; accordingly, every aircraft has a multitude of different RCS values. RCS is tied to detection range, and even a minute increase can drastically increase effective detection range; there is virtually no tolerance for error in this area.

Table 1 is an unclassified effort to quantify this relationship. Two caveats are that the values were all taken from unclassified sources of uncertain accuracy, and that radar cross section varies greatly, as noted, with aspect, radar frequency, and other factors. Despite these potential errors, the graph illustrates the important lesson that the relationship between RCS reduction and radar-range relative value is far from proportional or linear. It is only by extremely fine adjustments of RCS that significant reductions in detection range are made.

Table 1

Radar Cross Section Sensitivity

Radar Cross Section (Square meters)	Objects of This RCS Value	Radar Range (Relative units)
10	Conventional Jet Fighter	220
1	B-1B	170
0.1	Cruise Missile	70
0.01	Large Bird	40
0.001	Insects	12

Source: William O'Neil, "Don't Give Up on the Ship," United States Naval Institute *Proceedings*, January 1991, p. 48.

"Evolutionaries" might point to B-2 RCS testing results to claim that technology for a true LO platform is impossible, or has yet to arrive. The Air Force did report that the B-2 failed to meet *a* radar signature objective in a July 1991 test. The exact RCS data is highly classified, and in its absence the significance of the deviation can only be speculative, but it does not take much to eliminate a great deal of any platform's low-observability characteristics.

Secretary of the Air Force Donald Rice said he would characterize the problem area "as a [grade of] D. It is not a failure . . . [but] it has to be improved."[9] This situation has led many to question the B-2's value. However, Secretary Rice also said that "in the domain where we are dissatisfied, the B-2 is already substantially better than the F-117."[10] The logic then is: if we are happy with the performance of the F-117, and the B-2 is "substantially better," we should not be concerned about the B-2's stealthiness.

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

LO platforms are designed to "absorb" and refract radar signals rather than reflect them. New radar technologies would use low-frequency or ultra-wide-band (UWB) emissions to defeat the radar absorptive material (known as RAM) coating on LO platforms. Also, multiple receivers would be located separately

from the transmitters and tied together through sophisticated computers. The weak reflections returned by an LO platform would reach several of the receivers; through computer processing, the individually weak signals could be "synergized" to produce a usable aircraft track.

Highly sensitive radar receivers would naturally produce many false alarms, but the comparative processing of several returns would allow the system to eliminate the false targets and identify real ones. The critical link is the computer integration of the radar returns from multiple receivers. As *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."[11]

Advocates say that a system combining a number of such approaches has potential for detecting stealth aircraft. Congress was so interested that in 1989 it allocated $25 million specifically for such technologies as UWB.

Captain James H. Patton, USN, 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 such counter-stealth assertions. "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."[12]

The congressional appropriation of $25 million dollars for further research in counter-stealth technology, including UWB, whetted the appetite of its proponents. In an effort to focus the investigations, a special radar panel was created to identify the best avenues for further research, and met throughout 1990. The "well respected experts in the radar field" produced a final report that "appeared to go out of its way to discredit UWB proponents and their anti-stealth claims. . . . Our panel of experts thought these claims had been exaggerated, and wanted to state that forcefully in the report."[13] Perhaps Captain Patton's comments were true, at least for the time being.

In July 1991 the defense department contracted for its own studies with the Institute for Defense Analysis, Rand, and the Center for Naval Analyses. 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."[14]

For those who have yet to be convinced of the revolutionary qualification of today's LO platforms, perhaps the best perspective on its real beauty is not our own but that of the potential adversary.

The Enemy Perspective: Lessons from Desert Storm

Saddam Hussein's worst nightmare surely includes scenes of downtown Baghdad on 17 January 1991. National assets among his most valued were destroyed in the opening hours of Desert Storm despite his investment in an integrated air defense network, supported by a sophisticated air force, to protect them. Any potential U.S. adversary would certainly look to Desert Storm to assess their prospective enemy's LO capabilities.

The power of the coalition air arm was immense, but it was the LO platforms that provided the ability to strike surgically in the opening minutes of the war. The air war that unfolded over the ensuing weeks had many objectives; our focus here is on those that the F-117 helped achieve.[15]

The F-117s, with their two thousand-pound precision guided munitions, gave a new shape to the anticipated battle. They destroyed nuclear, biological, and chemical production and storage centers, as well as 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, allowing them to virtually strike at will. Whatever the RCS of the F-117 really is, the aircraft was apparently invisible to the air defense system supposedly protecting Baghdad. The fighter struck critical assets in Baghdad with impunity, and this before the air defense nets were destroyed.[16] "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."[17] F-117s were *not* the only star of the Desert Storm air campaign, but their unique accomplishments and demonstrated capability certainly added significant unknowns to that adversary's defense equation.

Enemies might not know whether LO platforms are revolutionary or evolutionary, but they certainly recognize that the F-117 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 targets."[18]

Desert Storm demonstrated that an enemy's potential courses of action are significantly affected by air power and especially by stealth assets. Of the courses of action one might consider available to an enemy, Saddam did impose delay, but suffered mightily for it; he could not reinforce, because his lines of communication were cut; his ability to attack was severely reduced by the damage done to him; he planned to defend, but his Maginot-like lines were

circumvented and destroyed; even when he attempted to withdraw, his forces were held at risk; finally, if he wanted to "escalate," he found his stocks of nuclear and biological weaponry severely curtailed. (This latter accomplishment is a significant capability in itself and is further discussed later in the article.)

General Charles Horner, USAF, the Central Command air component commander, listed five objectives for the air campaign: isolate and incapacitate the Hussein regime (leadership and command-and-control targets); gain and maintain air supremacy to permit unhindered air operations (air defense and airfield targets); destroy Iraqi nuclear, biological, and chemical warfare capabilities; eliminate Iraq's offensive military capability (key military production, infrastructure, and power-projection targets); and render the Iraqi army in Kuwait ineffective, causing its collapse (bridges, armor, artillery, and personnel).[19] Most potential enemies would recognize LO platforms as only a part of a total air threat, but in Desert Storm it was LO whose unique capabilities allowed it to strike at targets related to four of these five objectives; the LO platforms added a significant "wrinkle" to the enemy's plan of war.

Lessons learned from Desert Storm will influence the political, economic, as well as military strategies of future enemies. To separate out the lessons specifically taught by low-observable aviation would be to move 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 stealth technology to be if the Soviet Union were alive and well today, with stealth fighters of its own assigned to forward bases in Eastern Europe? In such a world, at what level of tensions would one launch a preemptive strike or evacuate forces to protect them from an enemy strike? How would Nato defend against fighters that could launch an attack like something out of a Tom Clancy novel? How would the United States do battle with its airborne "eyes" poked out by stealth fighters no one ever saw coming? How would we have defended air bases in the Gulf desert against stealthy assets? How would we establish aerospace control with enemy stealth fighters still operational? How successful would our non-stealth assets be with stealth fighters flying against them? The stealth-versus-stealth environment verifies the criticality of recognizing the revolutionary attributes this new asset brings to the air war.

Some fail to see these revolutionary capabilities because they lack hindsight, some because of security classification that has prevented the majority of military people and civilians alike from knowing the real data. Most people on the "evolutionary" side, though, never see them because they have failed to "get in the other guy's shoes." It takes only a little while in those shoes, and a recognition of the significant cost of even a potential counter (especially in tough economic times), to begin to perceive the revolutionary nature of LO technologies.

Operational Stealth Assets: What's New?

Stealth has brought a multitude of changes to the battlefield, touching all levels from tactics to doctrine to procurement. The three primary changes are discussed below.

The Proximity of Absolute to Reality. In the same way that Clausewitz began his discussion of war with a description of its *absolute* form, Air Force Manual 1-1 lays out the absolute, or ideal, attributes of aerospace power: "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."[20] These points clearly communicate the absolute conditions of air power, but *not* its day-to-day reality.

Clausewitz followed 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 thirteen hours to their El Dorado Canyon strike missions (against Libya in 1986) because of overflight-rights squabbles. Aerospace forces can *not* be quickly gathered over any point on the earth's surface that they choose; the assessed B-52 survival rate in the threat envelope of a (formerly Soviet) SA-10 surface-to-air missile is not good (at least not for the B-52 crews). Aerospace power can *not* apply force against any facet of enemy power it wishes; deeply buried or hardened shelters with air defenses are targets too hard for most air force or navy assets.

Once the vast difference between reality and absolute is recognized, the significance of the unique stealth capability becomes more readily apparent to the operational commander. The reality has never been brought closer to the absolute than it has been today by these revolutionary aircraft.

Lieutenant General Charles G. 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."[21] Stealth offers not just bombers "that can always get through" but aircraft that narrow as never before the separation between the ideal and the practical.

The Primacy of Aerospace Control Is No Longer Absolute. Air superiority, now called "aerospace control" in air force doctrine, has been the top priority of air power since the reorganization of air assets. Doctrinal reasoning for this priority

is well founded in the concepts of offensive action, economy of force, and attrition.

What Is Aerospace Control? Why Is It Important? Much as for sea control, the choices for protecting forces on the ground from air attacks fall between a defensive strategy—requiring ample forces sufficiently strong at all places at all times—and an offense that seeks to protect by eliminating the enemy threat. The more cost-effective and inherently stronger method is to seize the initiative, establish an offensive, and destroy the enemy's capability before he brings injury to us. Failure to do this results in attrition of friendly forces and inability to exercise our own strategy because of the continual need to react to enemy initiatives. Thus, aerospace control is a term used to describe both the defensive and offensive actions that produce a degree of safety and freedom of action for all the forces operating under its umbrella.

Aerospace control is a "zero-sum" proposition: air force doctrine says it "assures the friendly use of the environment while denying its use to an enemy."[22] This idea can be broken down into two components. First, friendly aircraft will be able to use the environment as they desire; that is, the enemy will not be able to stop us from doing so. The second component of aerospace control is to deny such free use to the enemy, by virtue of our having the ability to hinder physically his air operations. It is important to recognize the two-sided nature of the problem: not only obtaining what we want but also frustrating the enemy's wish to do the same.

This detailed review of a seemingly simple term should serve to emphasize the criticality of establishing aerospace control and that such control is seldom an end in itself but rather a means to an end. Given a specified political goal, aerospace control alone will seldom fulfill that goal but will, rather, enhance the ability of land, naval, and other air forces to fulfill it. It is *through* aerospace control that other efforts are better able to achieve the military ends for which they are executed and, thereby, the larger political ends for which the military action was designed (Figure 1).

Aerospace control was maintained over the assembling forces during Desert Shield and was quickly achieved over the entire theater upon the initiation of Desert Storm. Although this was a primary goal, it was not the desired end but rather a contribution to it. With the establishment and maintenance of aerospace control, force application—that is, the application of combat power—became the primary mission.

Stealth and the Need for Aerospace Control. The special feature of the Desert Storm example, and the primary focus of this entire question, is the extent to which stealth assets have changed the rules. Much as a submarine does not need effective sea control to be able to attack, neither does a stealth air asset require aerospace control to execute its mission.[23]

U.S. naval doctrine since Mahan has preached the vital importance of sea control—our free use of the seas while denying the similar use to the enemy. In World Wars I and II, U-boats wreaked tremendous havoc although the Germans did not have sea control. Submarines could use their stealthiness, only a fraction then of what it is today, to operate independently of surface forces. The degree of independence of submarines from the surface fleet has been a continual point of discussion within the U.S. Navy; nevertheless, it is a recognized fact that the submarines operate with a different operational and tactical doctrine than does the surface fleet.

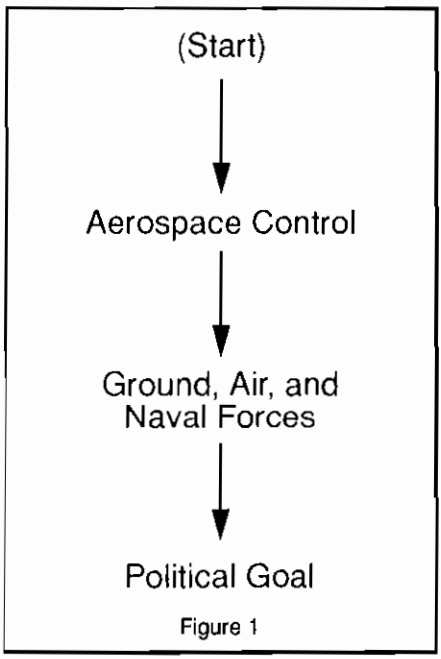

Figure 1

The parallels between stealthy submarines and stealthy aircraft are strong. Like a submarine, stealth aircraft can be employed in the strike mode from the initiation of hostilities. Stealth aircraft do not have to establish free use of the environment—they already have it! Unlike non-stealthy assets, they need no air superiority (beyond the defense of home base) to enable their mission to succeed (See Figure 2).

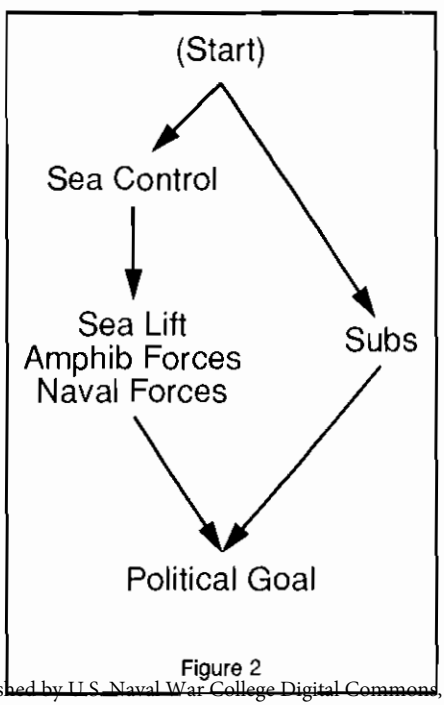

Figure 2

History has shown that one should apply offensive force only after the aerospace-control problem is well in hand, or suffer the consequences. In World War II, force was applied initially (in the form of strategic bombing) without aerospace control; significant attrition resulted. With stealth, force application can become a primary focus, or at least one that can be pursued concurrently with efforts to gain aerospace control. Stealth enables us to take a shorter route to the desired political ends, by moving directly to the main mission (Figure 3).

The ability to strike within hours of the outbreak of conflict, with stealthy B-2s, F-117s, and future stealth assets we might procure, offers potential for seizing the initiative as never before. The capabilities offered by stealth assets go far beyond the new meaning they bring to "surgical strike" missions. Stealth can be used in the opening salvos of a conventional battle to strike directly at vital centers of gravity, thereby moving immediately to the force-application role. Stealth and other technological innovations have given us a phenomenal opportunity to initiate an immediate offensive, with F-117s carrying precision-guided weapons, B-52s launching cruise missiles, and Tomahawks launched from surface ships and submarines (not to mention B-2s and F-22s).

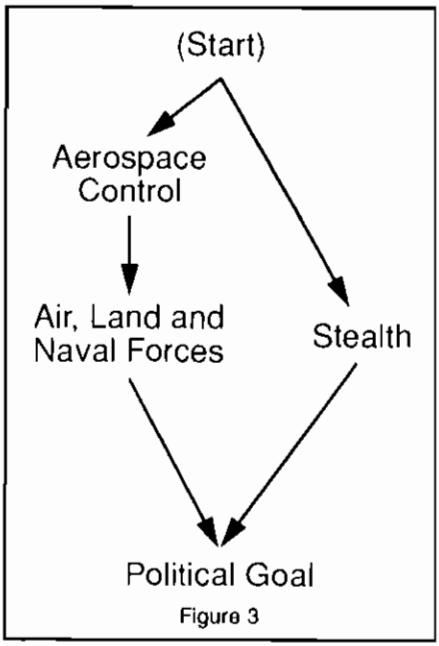

Figure 3

From an enemy's perspective, this is much more than just a rearrangement of our top priorities; it is rather the prospect that we will get "inside his decision loop" (i.e., drive the pace beyond his ability to react), maintain the initiative, and force his choices by limiting or eliminating his potential courses of action. Stealth assets have the ability to strike directly at his combat capabilities, thus decreasing the scope of surprises he can wield against us. The F-117 was used specifically to limit Saddam Hussein's escalation options and in so doing lower the risk to the coalition and its forces. Not all of Iraq's nuclear weapon construction plants were hit in Desert Storm, but not because they could not have been; with stealth, intelligence data rather then aircraft capability becomes the limiting factor.

The new National Military Strategy seems to recognize this new ability. In its discussion 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."[24] Note the sequence of the stated priorities.

The Effectiveness and Breadth of Potential Use. El Dorado Canyon and Desert Storm represent a vast difference in political objectives and the forces needed to fulfill them. The scope of a given policy is a critical factor in determining the

forces needed. Aerospace power can be used separately or as a component of a larger military force. When the political objective is very broad, several military components may be needed; but when it is extremely limited, the single type of force best suited for it will be the weapon of choice. With stealth, both the breadth of applicability and effectiveness of air assets have 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 precision guided munitions (PGMs): "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."[25] Stealth aircraft armed with PGMs offer increased effectiveness across a broader spectrum of conflict—that, truly, is operational capability.

For comparison, the naval presence mission involves showing the flag, political or diplomatic "signaling," or even preparation for a contingency response. Typically, a carrier battle group with non-stealthy aircraft has fulfilled this presence role; in scenarios of limited size, however, presence could be communicated by a deployed squadron of F-117s and a few tanker assets. As noted, F-117s in Desert Storm showed the potency of a small stealthy force package. Stealth would make a forceful impression in the mind of the enemy—consider, in fact, how stealthy carrier aircraft would enhance naval aviation in its presence mission.

The expense of an F-117 deployment, with its supporting logistical baggage, may be too great for a no-notice diplomatic effort. However, supplementing international exercises with this aircraft would contribute here. In the "signaling" realm, an F-117 deployment is itself a very strong signal—so strong that in times of international tension many countries might not want it sent. A host nation allowing an F-117 deployment on its territory would be making a definite statement and taking a risk of being embroiled; watching a carrier battle group sail by in international waters would be a much lower risk.

The F-117 has capability beyond the obvious "pro-active" or reactive strike options. It is important to recognize that after its desert performance, its reputation has given it an ability to play at least some part in the presence mission. It is equally important, however, to recognize the constraints which accompany that capability; a deployment of F-117s does not provide the flexibility that a carrier battle group can offer in the presence mission. Even in its limited role, however, it represents new ground, new potential.

Stealth has given aerospace assets the cutting edge of a surgeon's knife. Against the backdrop of political statements of intent, they now offer deterrent credibility and significant potential for influence in some force-projection roles.

What Needs To Be Done

In a world where flexibility will be at an all-time premium, stealth looms with proven performance and promise of further potential yet unrealized. In the new world, stealth aircraft, even in small numbers, become all the more valuable. Stealth provides unmatched capabilities to support our National Security Strategy and National Military Strategy.

Are stealth assets too expensive? Only if one does not consider the associated costs of *not* having them when needed, only if one does not recognize all the capability this revolutionary asset adds to our force structure. It is in the nation's best interest, in the military's best interest, to recognize, pursue, and procure stealth technology. This is not a nice-to-have "extra"—it is a degree of flexibility perfectly suited for the world we live in today. The true value of stealth assets is not only in what they can do but also in what they can prevent.

Significant budgetary constraints have caused stealth to represent an ever larger percentage of service budgets. In this light, stealth appears to some as a luxury that we can no longer afford rather than a revolutionary technology with potential to solve a multitude of emerging problems.

It Starts with Perceptions. Many have advanced stealth as a revolutionary asset, but revolutionary developments bring significant changes. To think about a revolutionary change in warfare is to think about something with a significant impact on methods and equipment of warfare, and employment of forces: that is, doctrine.

According to General Curtis LeMay, doctrine reflects perceptions. "It represents the central beliefs for waging war in order to achieve victory. Doctrine is of the mind, a network of faith and knowledge reinforced by experience which lays the pattern for the utilization of men, equipment, and tactics. It is the building material for strategy. It is fundamental to sound judgement."[26]

In March 1992 the U.S. Air Force released a new fighting doctrine. Despite all the talk about revolutionary B-2 capabilities and the stellar performance of the F-117 in Desert Storm, despite the offensive striking power available today in F-117s, B-52s, and land-attack cruise missiles, stealth and all its attributes were not even mentioned, and force application remained secondary after aerospace control. There was no significant doctrinal change to capitalize upon the new and revolutionary capabilities available with stealth. Therefore, either stealth is not actually revolutionary, or it *is* revolutionary but not truly perceived as such by a "critical mass" within the Air Force.

The first step in doctrinal change has been described as the "perception of a need for change."[27] It seems clear that stealth technology in the U.S. Air Force has not arrived at this critical first step.

A Plan for Changing Perceptions. If we want people to recognize and apply revolutionary new capabilities, we must get them to change their thinking. Doctrine that is studied, disseminated, and improved upon influences modes of thought, which in turn affect methods of application. In operational terms, a staff putting together an operational plan will apply its accustomed logic in determining how to apply weapon systems available to it. If operational plans are to reflect new capabilities to the utmost, old molds of thinking must be broken and replaced with new capabilities and new objectives. This will not be done if doctrine does not change, nor can it be done if doctrine is *all* that changes.

The biggest obstacle, as we have seen, to employing a revolutionary technology is the difficulty of divorcing it conceptually from familiar applications of its most recent predecessors. This is not to say that all lessons learned up to this point need to be dismissed, but it does mean they need to be reevaluated. This is a thought long recognized, not least by Alfred Thayer Mahan: "The seaman will observe . . . [that] 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."[28]

The answer, then, does not lie in either changing doctrine or in changing perceptions; stealth potential can be realized only by changing *both*. A comprehensive plan of attack to enable the few to overcome the inertia of the many is required. Table 2 (wherein the "process" steps are drawn from an analysis of German World War I experience) provides an outline of such a broad effort for change.

Recognition. In the Air Force, as noted, the signals are definitely "mixed" concerning this simple first step. While procurement efforts seem to suggest that recognition has been achieved, the March 1992 doctrine is a clear indication that it has not been. If senior leaders are not convinced of a need for change, it will be difficult to get a plan for change off "square one"! However, once there is a perception of a need for change, the plan can quickly move into the second phase.

Education. Education means dissemination and discussion of new concepts in doctrine, in our service schools, and in our professional magazines. It also means encouraging our career professionals to deepen and broaden their professional knowledge through private reading so that new concepts can reach beyond the schoolhouse.

Table 2
A Plan for Change

Process	Phase
• Perception of a need for change	• Recognition: Revolutionary stealth technology demands changes in air warfare
• Solicitation of ideas, especially from battlefield units • Definition of the change • Dissemination of the change	• Education: Doctrine evaluated, changed, disseminated Service school focus Professional articles Professional reading program emphasis
• Enforcement throughout the service • Modification of organization and equipment to accommodate the change • Thorough training • Evaluation of effectiveness • Subsequent refinement	• Exercise/Refinement: Incorporation into training Incorporation into tactics Adjustments/enhancements through practice

Source (left column only): Timothy T. Lupfer, *The Dynamics of Doctrine: The Changes in German Tactical Doctrine During the First World War*, Leavenworth Papers no. 4, p. viii.

Once the perception of a need for change gains momentum, the few can indeed overcome the inertia of the many; where change is clearly needed, educated and thinking minds will begin to create it. Education will stimulate thought that will spread the perception of a need for change. Then will come the understanding that the role current doctrine intends to allot to stealth is nothing more than a peripheral one, when it should be up-front and center-stage.

Exercise and Refinements. Once minds perceive the potential, they will find the best ways to use it; training and tactics will then be adjusted so as to best employ it. Once the fire is lit, the refinement process will work: better and better ways will be discovered to exercise every bit of the new stealth advantage. This will be the easiest yet the most critical of the three phases.

In actual conflict it matters not what doctrine says—it matters how effectively we fight. However, we have always aspired to train as we will fight, and so methods of training return to doctrine and to tactics developed in light of doctrinal guidance. The new perceptions of stealth must start from the top and work their way down through doctrinal changes and emphasis in education. Then, just as critically, ideas will spring up from the ground levels as the operational crews apply and refine these conceptual principles.

A Plan for Procurement. Procurement policies will depend directly upon, after the doctrinal change and education process described above, a proper calculation of the opportunity costs involved in whittling force levels down to that which can be procured and maintained within the budget limitations imposed.

The obvious question is how many of these revolutionary assets are needed; the answer is that we will not know until we consider doctrinally how we will use them to fight. Doctrinal changes which reflect the revolutionary stealth capability now available would highlight the specific advantages stealth possesses and how these unique attributes can be maximized in air warfare in conjunction with other forces. Such changes will affect perceptions throughout the Air Force, leading to a recognition of stealth as having proven wartime capability rather than being a concept still in the research and development stages.

This recognition could awaken Air Force, and also naval, decision makers to the fact that they are at a crossroads with regard to stealth technology. Unlike the early 1980s, stealth technology does not represent a new place to put ample funds. Rather, it can be funded only by incurring opportunity costs, giving up other things. The services will not be able to justify higher budgets to purchase the stealth assets they may desire, but will be forced to make difficult choices between investment interests. It would be extremely difficult to give up program after program to acquire a handful of merely evolutionary assets; however, it would be equally difficult to fail to capitalize on an acknowledged revolution in capability, even if it required losing some desired depth in other areas.

A mission-area analysis based upon a new fighting doctrine would reveal the synergistic effects of incorporating stealth in new roles. The end product of these efforts would describe the general force mix by which to plan acquisitions—an accurate balance of stealth and non-stealth assets to provide the capabilities needed to conduct an air campaign.

Another factor other than cost also argues against stealth assets: attrition, or more specifically, timidity. The fleet of twenty B-2s can have unique and revolutionary potential, but can only realize it if used. Martin Van Creveld provides insight into this seemingly obvious point in his book *Technology and War*: "The battleship . . . represented a tremendous investment in money, science, industrial capacity, personnel, and sheer skill. . . . The loss of one came to be thought of as a minor national disaster. The growing power of individual ships was matched by a steady decline in their commanders' willingness to put them at risk. . . . To be of use in war, however, a weapon must be expendable."[29] No doubt the B-2 is a very costly asset to throw into a high-risk zone. However, the argument comes back again to education. Is the risk taken by a B-2 in an environment where it is virtually invisible any greater than that which the carrier HMS *Hermes* took by sailing into the Falkland War zone before Argentina's submarines were positively located? Would the B-2 be in a riskier environment than carriers in the Suez canal?

What about F-22s? Again, there is the matter of perception: that procurement costs require timidity in employment. The argument goes that the F-22 will cost three times what an F-15 was produced for; but then, the F-15 cost over three times the airplane it replaced, the F-4. No doubt the additional value of each

asset may result in an extra inspection or two, but when the nation expects to use the assets it has paid for, they are to be used.

A Final Word

Stealth is a revolutionary capability; yet despite the proof, this is not a common perception. Unparalleled budget cuts have forced and will continue to compel some extremely difficult procurement decisions. These critical force-planning tradeoffs are based on opportunity costs closely tied to perceptions of capabilities. A failure to recognize and correct inaccurate perceptions of stealth will at best result in an incomplete fulfillment of its potential—or, in the worst case, in wrongfully turning away from its capabilities altogether.

Notes

1. "Stealth" as a concept is not new but something that has been practiced for ages. "Stealth" as it is used in this article refers to the relatively new technologies that make this concept viable for aircraft platforms. Stealth aircraft, in the purest sense, are virtually invisible, while low-observable aircraft represent similar qualities but not to the same degree. From an operational perspective, the distinction is not critical. Therefore "stealth" and "low-observable" are used interchangeably throughout the paper and represent platforms on which comprehensive efforts have been made to control all emissions. Reductions are made not only in radar cross section through design and incorporation of radar-absorptive materials, but also in visual, infrared, and acoustic signatures. Systems upon these platforms must also be designed so as to minimize requirements for radio-frequency emissions.

2. Norman B. Wilkinson, *Explosives in History* (Chicago: Rand McNally, 1966), p. 8.

3. *Ibid.*, p. 14.

4. Department of the Air Force, *The Case for the B-2: An Air Force Perspective* (Washington: June 1990), p. 12.

5. *Ibid.*, p. 13.

6. David F. Bond, "USAF Study Asserts That Soviet Defenses Would Be Ineffective Against B-2 Bomber," *Aviation Week and Space Technology*, 30 October 1989, p. 29.

7. *The Case for the B-2*, p. 13. Some of the concepts evaluated included: acoustic systems, bistatic radar, infrared detection, corona discharge detection, interaction with cosmic rays, passive coherent detection, radar shadow detection, land mines, magnetic disturbance detection, hybrid bistatic space radar, high frequency surface wave radar, detection of aircraft emissions, radiometric detection, air vehicle aerodynamic wake detection, and ultra-wide-band (impulse) radar.

8. Dan Boyle, "Fusing the Data in the Search for Identity," *International Defense Review*, August 1989, p. 1101.

9. Donald B. Rice, "The B-2 Stealth Question," *Aviation Week and Space Technology*, 23 September 1991, p. 7.

10. *Ibid.*

11. Boyle, p. 1103.

12. James H. Patton, Jr., and Robert P. Haffa, Jr., "Analogues of Stealth: Submarines and Aircraft," unpublished work obtained from Mr. Haffa, p. 1.

13. William B. Scott, "Report Critical of Impulse Radar Triggers Controversy," *Aviation Week and Space Technology*, 29 November 1990, pp. 19-20.

14. John D. Morrocco, "Pentagon Launches Independent Review of Tactical Stealth, Counterstealth," *Aviation Week and Space Technology*, 1 July 1991, p. 66.

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

16. "Myth of the Lone Gunslinger," an article in the 18 November 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.

17. *Reaching Globally, Reaching Powerfully: The United States Air Force in the Gulf War*, USAF Report (Washington: September 1991), p. 19.

18. *Ibid.*, p. 21.

19. Charles A. Horner, "Reflections On Desert Storm," briefing slides obtained from Headquarters U.S. Air Force.

20. *Basic Aerospace Doctrine of the United States Air Force*, Air Force Manual 1-1 (Washington: U.S. Govt. Print. Off., March 1992), v. 1, p. 5.

21. Charles G. Boyd and Charles M. Westenhoff, "Request Unrestricted Climb," *Airpower Journal*, Fall 1991, p. 12.

22. *Basic Aerospace Doctrine*, p. 6.

23. It is true that the aircraft is much more dependent than the submarine upon its home base and that this home field must remain defended if the aircraft is to operate successfully.

24. Joint Chiefs of Staff, *1992 National Military Strategy* (Washington: U.S. Govt. Print. Off., January 1992), pp. 21, 22. (Emphasis added.)

25. Boyd and Westenhoff, p. 12.

26. *Basic Aerospace Doctrine*, p. i.

27. Timothy T. Lupfer, *The Dynamics of Doctrine: The Changes in German Tactical Doctrine During the First World War*, Leavenworth Papers no. 4 (Fort Leavenworth, Kan.: Combat Studies Institute, 1981), p. viii.

28. Alfred T. Mahan, *The Influence of Sea Power upon History 1660-1783* (New York: Dover Publications, 1987), pp. 9-10.

29. Martin Van Creveld, *Technology and War* (New York: The Free Press, 1989), p. 207.

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