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**A Blind Eye: The Consideration for Terrain and Environment
in Air Force Doctrine**

Reading and Research Paper

Lt. Judson Fancher

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Introduction

Broadly defined, doctrine is a body of principles taught or advocated that represents an official statement of policy. Specifically, the subject of doctrine describes accepted beliefs for the proper employment of military force. US Air Force doctrine has developed over the last three-quarters of a century as a result of existing military thought, the impact of technology, and experience. Doctrine is not a static code, but a constantly evolving process whereby air strategists reexamine these factors in consideration of national goals and restraints. The Air Force, like the Army and Navy, must compromise between finite resources (personnel, equipment and funding), and the requirements to maintain a flexible and formidable national defense. The political limitations on the form, function and control of military forces combine with military objectives to form a statement of current missions, and recommended guidelines for producing the most effective and prepared aerospace forces. Furthermore the most important aspect of these tenets is the guidance they provide for proper employment of military forces. This essay will explore the guidance that doctrine has provided towards the relationship between terrain and geography, and the effect it has on the employment of air power.

Doctrine is an important subject of concern for those interested in how a military service, in this case the US Air Force, has operated and evolved. The Air Force has used its basic doctrine to establish its fundamental reasons for existence, and the role that the service fills within the Department of Defense. Military professionals, especially commissioned and non-commissioned officers have been encouraged to read and understand their service's basic doctrine to gain an understanding of how their work relates to the achievement of overall

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goals. For the historian, it is important to perceive how the Air Force operates as an institution, and doctrine is one key to understanding the enduring personality of the Air Force within the national security arena.

Into this turbulent arena of competing issues and policies, the importance of a combat theater's geographic and environmental nature has not been given sufficient emphasis in current Air Force operational doctrine. To ground forces such as the Army and the Marine Corps, the geography and terrain upon which they fight are fundamental to the development of the proper strategy and tactics. Environmental factors often limit what ground forces can and cannot do. Terrain can facilitate or restrict mobility, dictating the types of forces, whether mechanized (with tanks and trucks) or light (only foot-soldiers), that the commander should employ to best achieve the specific objective. Yet Air Force doctrine has traditionally disregarded environmental concerns, specifically terrain and geography, and their effects on the employment of air power in support of national and military objectives. This paper will address the contention that past and current Air Force planning has overlooked the effects of environment and terrain on the capabilities and employment of air forces.

Historically, Air Force doctrine has been broadly based on military theory, such as those principles of war derived by Antoine Henri Jomini's exacting study of ground warfare in Napoleon's era. Yet, these ideas and concepts for war were developed before the advent of manned flight, and those ideas which described the influence that geography has had on a land campaign were ignored in the subsequent evolution of air power doctrine. Essentially it evolves from a belief that if a plane is able to fly above the terrain features, then its geography should not concern anyone. This apparently blind lack of regard stems from both the unwillingness to acknowledge air power's limitations, and the inability to draw lessons from the Air Force's past experiences.

Terrain, geographic and environmental factors, such as weather and vegetation are important for two broad reasons. The first and most important is the direct effect that the type of terrain, be it hilly or flat, jungle or desert, has on the aircraft's (and pilot's) ability to locate, identify, and engage the selected target. Accurately delivering ordnance on a target in a flat desert is much easier than in a hilly region blanketed with trees. The other, more currently recognized, influence of geography is the availability of appropriate airbases or the existence of suitable land on which to build a base. If the nearest airbase to an area of conflict is at such a distance that it forces the aircraft to operate at or beyond the limit of its fuel range, the resulting combat capability will be drastically reduced, or become prohibitively expensive to support.

* * *

In examining war, due to its difficulty and complexity, contemporary theorists have divided it into three broad levels, so that it can be clearly examined, studied and understood. These divisions break down a conflict into a progression of decreasing areas of responsibility. At the highest level is the *strategic* perspective, which addresses the overall conduct of the war, the approximate forces available, and the various weights of effort in each theater. In World War II, the decision to prioritize the European theater before the Pacific illustrates a strategic level perspective. In the middle of the spectrum is the *operational* level of war, which is primarily concerned with the achievement of strategic objectives with the forces allotted, and where plans are made for the actual employment of military forces in the campaign. Using WWII again as an illustration, the drive across northern France into Germany in 1944 and 1945 typifies the operational level of war. The *tactical* level represents the lowest level of conflict, where opposing forces meet, and objectives are relatively short ranged, and generally very clear. Guidance from higher authority here is usually

precise in terms of using the forces in a specified manner. Examples of this level are the most basic, such as ground forces advancing through a valley to capture and hold a vital bridge or crossroad.¹

Correspondingly, the Air Force divides doctrine into basic, operational, and tactical subjects; thereby separating the task of providing long-term guidance from the immediate role of providing solutions to battlefield problems. Basic, or strategic doctrine, represents the broadest and most encompassing ideas about air power and the use of military force. Basic doctrine manuals reflect the national military objectives of the United States, and set forth the general military theories and guidelines for the achievement of these goals with current capabilities. Below basic doctrine comes the operational level, where the emphasis is lower than the global level; its ideas and concepts address theaters of conflict, using maneuver and military force to achieve strategic and national objectives.

The current Air Force Manual 1-1 defines doctrine as, "What we hold true about aerospace power and the best way to do the job in the Air Force."² Doctrinal theorists must constantly compromise between giving general guidance and specific recommendations. The Air Force Chief of Staff, General Merrill McPeak, introduces the latest edition of AFM 1-1 by stating that doctrine represents the lessons of history. Specifically, he states that, "Doctrine is what history has taught us works in war, as well as what does not, and that doctrine provides a framework for understanding how to apply military power."³ This statement is not revolutionary; each of the nine previous editions of this manual

¹Col. John A. Warden III, The Air Campaign: Planning for Combat (Washington: National Defense University Press, 1988), pp. 3-6.

²Air Force Manual 1-1, Basic Aerospace Doctrine of the United States Air Force (Washington: Department of the Air Force, Vol. 1, March 1992) p. vii.

³AFM 1-1, p. v.

has stressed the importance of experience in the evolution of Air Force doctrine. Unfortunately, doctrine has not evolved due to the lessons of history, but reflects a continuing belief in the fact that strategic bombing represents the central role of the Air Force. Basic doctrine still echoes the concerns for air power autonomy prevalent before the end of World War II, by emphasizing the decisive impact of air power (independent strategic bombing) and the belief that the Air Force alone is best suited for guarding the nation and decisively winning our wars.

The lowest level of doctrine is tactical, and its guidance represents the most specific ideas concerning the best and most efficient methods for using weapons and personnel to achieve operational objectives. Where current doctrine proves weakest is its inability to provide comprehensive guidance to operational level planners, specifically the influences that geographic and environmental factors have on campaign planning. This middle level of doctrine is potentially the most important, since it attempts to provide the best guidance in theater level planning and conflict. The Persian Gulf war and the ongoing struggle among the former Yugoslavian republics represent recent examples of theater level military conflicts.

The basic level of doctrine presents a problem for the military professional and the Air Force. Basic doctrine generally should not provide specific planning guidance; instead it concerns broader topics such as national and service goals and objectives. Nevertheless, the latest AFM 1-1 digresses, in its third chapter that is ironically titled 'Employing Aerospace Forces,' by giving specific guidance that goes well beyond the basic level of doctrine. Arguably, earlier versions of this manual addressed themselves more toward national and executive level issues than the concerns of operational and theater commanders. Occasionally, as in the 1979 edition, this manual is ridiculed by the rank and file of the Air Force, its guidance providing little to foster an air of professionalism regarding

the way the service viewed doctrine.⁴ Great effort has been exerted in the most recent edition to correct this and present a manual which provides historically based guidance that is succinct and professional. Individuals within the military are encouraged to read the basic doctrine manual, but rather than providing general guidance, it serves only to preach the dogmatic ideas and goals that presently guide the Air Force. In contrast, tactical doctrine, as exemplified by Tactical Air Command Manual (TACM) 2-1, provides comprehensively specific guidance and solutions for battlefield and tactical problems that face unit commanders and air crews. This type of manual outlines the best methods and techniques for accomplishing combat tasks and missions. The gap between these two areas is where operational doctrine, in its current state, falls short.

The weakest areas of Air Force doctrine have been the operational level issues which address the effect of the theater's specific terrain, and historically certain difficulties can be traced to the lack of coherent ideas on how the shape of the terrain and environment, be it rugged or flat, have effected air operations in the theater of combat. Basic doctrine just touches on the subject of operational level conflict, and most of the other manuals, regardless of title, are actually tactically oriented. What the Air Force has lacked is a doctrine manual that directly addresses operational level air warfare.⁵ This paper will argue that this shortcoming arises out of a lack of critical historical analysis within air power doctrine and the Air Force community.

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⁴Lt. Andrew Dembosky, Meeting the Enduring Challenge: United States Air Force Basic Doctrine Through 1992, (Master's Thesis), (North Carolina State University, April 1993) p. 3.

⁵LtC. Price T. Bingham, Oral interview, and follow-up, (Maxwell Air Force Base, Alabama), 19 Jan, 1993.

From the earliest air power pioneers, flyers saw the ocean of air covering the planet as a unique medium, freeing aerial forces from their dependence on the earth and enabling them to rain destruction on the enemy's military and homeland with impunity. Recognized as one of the first theorists writing about the potential uses of aircraft in winning wars, Italian Air Marshal Giulio Douhet stated in 1921 that, "Nothing man can do on the surface of the earth can interfere with a plane in flight, moving freely in the third dimension."⁶ The most recent edition of Air Force Manual (AFM) 1-1, over seventy years later, echoes this continuing belief: "[Air] 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."⁷ Although tied to their supporting bases and airfields, aircraft consistently were seen as supremely flexible, able to apply military force and provide air support on or well behind the battlefield, as the situation dictated. Douhet saw this new dimension of freedom as a way to avoid the stalemated trench warfare that horrified military leaders and civilians alike in World War I.

During the interwar period, other air power prophets, notably Hugh Trenchard and William "Billy" Mitchell, argued that air power in the form of strategic bombing would become the decisive element in future warfare. This new weapon of air power could be aimed at both the enemy's capability to wage war, *and* the enemy population's will to fight. These men argued that although war would be waged on the cities of the enemy's homeland, the swift surrender which these tactics prophesied would ultimately justify the increased, indiscriminate violence. American strategic bombing proponents, gathered at the Air Corps Tactical School in Alabama in the 1930's, developed the concepts of

⁶Giulio Douhet, trans. by Dino Ferrari, The Command of the Air (Washington: Office of Air Force History, 1983) p. 9.

⁷AFM 1-1, Vol. 1, p. 5.

high-altitude, daylight precision bombing that were exercised later in World War II. This bombing doctrine, which stressed precision accuracy, became the core of ideas around which the fledgling Air Corps structured itself. These ideas were later formalized in AWPD-1; an air plan completed by the Air War Plans Division in August 1941, that guided the massed precision bombing raids over Germany.⁸

By the end of WWII, the merits of this bombing doctrine were firmly ingrained in the leaders of the Army Air Forces by the apparent lessons of their campaigns over Europe and Japan. The US Strategic Bombing Survey, the official postwar government assessment of air power's effectiveness, was cautiously optimistic regarding the bombing campaign's contribution to the war effort, yet the survey admitted that it was difficult to determine air power's specific contribution towards hastening the war's end. Indeed, independent bombing's contribution becomes more questionable, since 35 percent of total US war production went to her air forces.⁹ Furthermore, Army generals felt that tactical air power, with missions of close air support and battlefield interdiction, made more significant contributions to allied victory than the long range strategic attacks.¹⁰

Viewed as a whole, the new wartime role forged by the Air Forces' success stood as strong justification for establishment of an independent air force. These controversial issues relating to the primary mission of air power became embroiled in the politics of establishing an independent air force, with strategic bombing ultimately forming the strongest argument for Air Force autonomy.

⁸Robert Futrell, Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1984, Vol. 1 1907-1960 (Maxwell Air Force Base: Air University Press, 1989) pp. 108-13.

⁹Franklin D'Olier et al. The United States Strategic Bombing Survey (European War, Pacific War) (Maxwell Air Force Base, Alabama: Air University Press (Reprint), 1987) p. 5.

¹⁰Mark Clodfelter, The Limits of Air Power: The American Bombing of North Vietnam (New York: The Free Press, 1989), p. 11.

Following the war, strategic bombing formed the central core of the Air Force's future identity and doctrine. The air power lessons from WWII remain controversial, since historians cannot isolate the contribution that strategic bombing made towards winning the war. However, the subsequent development of Air Force doctrine has grown from the strong belief that air power was the decisive force bringing Allied victory, and that strategic bombing was (and is) *the* decisive use of air power.

* * *

Air Force basic doctrine evolved in several stages from its birth to the present day. Before 1947, the Army Air Forces fell under the jurisdiction of the U.S. Army, which in turn was controlled by the War Department. As a result, the air arm developed its own doctrine as a subset of official Army field doctrine. Their first comprehensive doctrinal manual was Field Manual 100-20, *Command and Employment of Air Power*, published in July 1943. Emphasizing centralized command, and flexibility, the manual established the co-equal status of land and air forces, and stressed that the gaining of air superiority should be a prerequisite for successful land operations.¹¹ FM 100-20 reflected some of the lessons learned from the air campaign in North Africa, where British and American forces established, through experience, the groundwork for what was called 'tactical' air theory and planning that applied until the end of the war. The manual centered less on the independent strategic operations, such as the Combined Bomber Offensive, instead concentrating on joint air-ground campaigns, like those that later advanced across northern France and into the German homeland, and across the islands in the southwest Pacific towards Japan.

¹¹Futrell, *Ideas* Vol. 1, pp. 137-138.

With the establishment of an independent Air Force by the 1947 National Security Act, the newly formed Operations Air Staff proceeded to create, "An Air Force publication of field manual scope, that will establish the doctrine and command of air power . . . and define our policies and strategies."¹² Although the Air Force formed this committee to rewrite FM 100-20, this manual's current ideas largely were ignored; new theories concerning the employment of atomic weapons argued that existing ideas were now obsolete. The deputy chief of air staff, as early as 1946, declared that although FM 100-20 had been a declaration of independence for the air force, its ideas were by then obsolete and entirely inadequate.¹³ The overwhelming popular sentiment among air power advocates following the war centered on the primary offensive and deterrent role of strategic bombardment, due to the developing Cold War standoff and Soviet threat. The Air Force, solely capable of delivering atomic weapons deep into the enemy heartland and forcing a rapid surrender, saw itself as the best protector for the United States, and turned its planning emphasis almost exclusively towards future atomic attacks.

The United States structured its post-war defense on atomic weapons and deterrence, for economic and military reasons. First of all, the Air Force believed that strategic bombing, including the atomic bomb, was one of the instrumental factors that helped defeat the Axis powers. By advocating atomic air power as the primary military force, the Air Force not only focused its effort on developing forces and weapons that had supposedly been instrumental in ending WWII, but ensured its position as the preeminent branch of the post-war military. The domestic political benefit to this defense posture lay in its economy; for although atomic weapons were expensive, they obviated the need

¹²Futrell, *Ideas* Vol. 1, p. 367.

¹³Futrell, *Ideas* Vol. 1, p. 366.

for a larger, and much more costly standing army, and replaced hundreds of squadrons of conventionally armed bombers with a smaller number armed with atomic weapons, capable of delivering a much greater destructive force. Since the US stood as the sole possessor of these new devices, this assured its foreplace in the international arena, and the Air Force was not displeased at its new role as the primary sword-wielder in the defense of democracy.

Due to this new focus in national defense, the ideas that went into the creation of the first Air Force basic doctrine manual concentrated on deterrence and national defense, and ignored the theater warfare lessons of WWII, embodied in FM 100-20. Finally published in 1953, the Air Force took six years to settle upon the final form and wording of its new manual, AFM 1-2, *United States Air Force Basic Doctrine*, and it emphasized the cold-war missions of deterrence, and repelling military aggression.¹⁴ The main thrust of the manual was that the nation could employ air power against the heartland of an industrial nation *or* in peripheral areas of conflict, that air superiority was desirable and sometimes essential, and that weapons of mass destruction should be used in heartland attacks, in case of a general war with the projected Soviet enemy.¹⁵ Unfortunately, this manual set a dogmatic trend that would stay in Air Force doctrine. AFM 1-2 ascribed to air power capabilities that had not yet been borne out by experience, much as the theorists at Air Corps Tactical School had done. 'Lessons' such as the ability of bombing to reduce the enemy's will to fight were not established. Furthermore, the manual ignored the entire Korean War, with its potential lessons, preferring to view the war as an aberration, with nothing to teach. Finally, the influence of the terrain and environment on air operations

¹⁴AFM 1-2 United States Air Force Basic Doctrine (Washington: Department of the Air Force, March 1953) p. 1.

¹⁵Futrell, Ideas Vol. II, p. 711.

was ignored. The manual excluded any discussion of these ideas, adopting a high-altitude bombing attitude, which embraced technology and atomic weapons as the keys to winning a future war.

In 1954 the Air Force revised AFM 1-2, but the new edition differed little from its predecessor, and it was not until the 1955 version that thinking derived from the lessons of Korea and the Cold War found its way into basic doctrine. New thinking discussed the appearance of peripheral conflicts and limited wars between the US and the Soviets, where the threat of atomic annihilation forced both countries to constrain the fighting by limiting the goals and weapons of the fighting. Even considering recent events, the latest basic doctrine viewed limited conflicts as aberrations, and air planners felt that addressing them should not be the focus of peace-time planning. Since the greatest threat was the Soviet Union, strategic planners argued that the Air Force should train to meet that threat, and this training would prepare it to conduct a lesser, peripheral struggle as well. Their argument implied that if the US's atomic forces were powerful enough to stop the Soviets, their deterrence value should certainly prevent the aggression of other, less powerful nations. This was unfortunate, for had the Air Force closely studied its recent experience in Korea, it would have found little to support its adherence to strategic bombing, and more to reinforce the idea that this action can have a negative effect, and strengthen enemy resolve. As a first test of deterrent strategy, President Harry Truman's desire to avoid escalation of the Korean War negated the deterrent effect of the Air Force's atomic striking power, thus making the Air Force's chief strategy relatively impotent.¹⁶

By the late 1950's, the strategic bombing strategies of Strategic Air Command (SAC), which was in charge of the bombers, dominated the Air Force.

¹⁶Futrell, Ideas Vol. I, p. 291-294.

By this time even Tactical Air Command (TAC), which was in charge of fighters and air combat, had become a miniature SAC, developing its own methods of nuclear delivery with fighter-bombers.¹⁷ In Air Force slang, the service had become 'SACumized.' Dr. Earl Tilford, former Air Force intelligence officer and author of the controversial Vietnam analysis titled, Setup: What the Air Force Did in Vietnam and Why, feels Air Force thinking in the 1950's and early 60's set the foundation for its debacle in Vietnam. He says that in that period, Air Force thinking and writing was increasingly insipid, and this led to adoption of inflexible and unsubstantiated dogma rather than carefully and critically considered doctrine.¹⁸

Due in part to the developing space-race in the late 1950's, the US and the Soviet Union actively pursued the development of Intercontinental Ballistic Missiles (ICBM's). The Air Force developed, and later deployed these new weapons as part of a balanced strategic force. The next version of AFM 1-2, issued in 1959, changed little from that of its predecessors. However, it introduced the idea that the employment of space weapons paralleled air weapons, and thus where the previous manuals mentioned the words 'air forces,' the new manual substituted the term 'aerospace forces' in its place. The 1959 version still embodied an adherence to the strategy of massive retaliation, focused around the use of manned bombers and ICBM's to deliver overwhelming destruction upon the enemy's population and industrial network.

Unfortunately, the 1959 edition continued to neglect a discussion of national policies, gave little guidance for the conduct of future operations. Planning for total war eclipsed issues such as air support and interdiction in

¹⁷Dr. Earl Tilford, Setup: What the Air Force did in Vietnam and Why (Maxwell Air Force Base: Air University Press, 1991) pp. 31-32, 47-49.

¹⁸Tilford, Setup. pp. 38-39.

limited war.¹⁹ The theories presented fifteen years previously, on the primacy of strategic bombing, and the role of post war bombing had now hardened into institutional belief. The Air Force of the late 1950's and early 60's concentrated almost exclusively on the delivery of nuclear weapons. The design of bombers and much smaller fighters concentrated on carrying these weapons, and consequently air crew training ignored virtually all tasks but those involved in waging nuclear warfare.²⁰

Because of this focus on the delivery of nuclear weapons, doctrine concerned itself less with the influences of geography on strategy and planning, and more on weapons effects and target selection. By its nature a nuclear warhead is an area weapon, and its requirement for accuracy is low. Although accuracy requirements changed in the 1970's with the desire to destroy 'hardened' targets, those reinforced against a nuclear explosion, by placing a warhead on top of it, the planners in the late 1950's were unconcerned with such accuracy, since large thermonuclear devices were capable of destroying 'soft' targets such as factories or urban areas from distances of several miles. Both tactical and strategic nuclear deliveries therefore put low demands on the pilots to consider terrain during bomb delivery. Tactical nuclear attacks typically used smaller fighter-bombers to drop a single warhead on a battlefield target, while strategic attacks were conducted by larger bombers attacking several targets designed to affect the enemy nation's ability to wage war. These attacking aircraft generally flew at high altitudes, and because of the abundance of destructive power and absence of interfering terrain, only light demands were placed on air crew navigation and bombing skills.

¹⁹LtC Donald Cromer, et al. A Critical Analysis of USAF Basic Doctrine (Unpublished Research paper, Air Command and Staff College, May 1973) Section II, Part A, p. 4.

²⁰Tilford, Setup pp. 30-34

Because of its eroding effectiveness, American military strategy followed the ideas of Gen. Maxwell Taylor, former U.S. Army Chief of Staff, and moved away from one of massive retaliation, to a new stance of flexible response. Taylor argued that the former American approach to warfare increased the possibility of conflict at the lower end of the spectrum, because the United States lacked a credible conventional capability. This deficiency would cause the US to act in an excessively cautious manner, desiring to avoid the risk of nuclear war, incapable of responding to threats at the lower end of the spectrum of conflict.²¹

Reflecting the Kennedy Administration's adoption of flexible response, the Air Force revised its doctrine, naming the new 1964 manual AFM 1-1, *United States Air Force Basic Doctrine*. The new 1-1 proved to be a significant departure from the previous versions, omitting a discussion of the principles of war, and according to historian Frank Futrell, it shifted away from the art and strategy of war, towards a more scientific, managerial viewpoint.²² It retained the earlier ideas concerning the flexibility and freedom of air forces, perpetuating the late 1940's departure from the lessons of joint warfare and WWII operational experience. Even though the new manual represented more than twenty years of thought, doctrine still insisted that the primary mission for air power was the long range, high-altitude delivery of nuclear ordnance. The effects of terrain and geography still received no attention, since the fundamental beliefs for ignoring them remained unchanged since 1945. As evidence that the Air Force retained its adherence to WWII bombing ideas, the Air Force Chief of Staff General Curtis LeMay, former Commander of Strategic Air Command for nine years, in 1964 described the B-70 bomber as a tri-sonic B-17, going over enemy lines and

²¹Tilford, *Setup* p. 28.

²²Futrell, *Ideas* Vol. II, p. 716.

dropping bombs just as he had dropped them on Germany and Japan in WWII.²³ Concentration on this mission caused the Air Force to enter both the Korean War and Vietnam poorly prepared for the different requirements of a limited conventional war. Official doctrine viewed these types of conflicts as aberrations, exceptional cases on the operating field of global cold war. It was not until after the difficult experience of Vietnam that the Air Force began to see a requirement for the reexamination of its doctrine and ideas.

Viewed twenty years after that war, the reasons for the American defeat in Vietnam might seem fairly clear, but such was not the case while the war transpired. Because of the war's political restrictions, unconventional nature, and domestic unpopularity, the Air Force experienced difficulty drawing the appropriate lessons regarding its doctrines' strengths and flaws from its experience. The 1970's and 80's saw the turbulent revision of doctrine in an attempt to incorporate new ideas from these lessons. The Air Force revised its basic doctrine manual in 1975, 1979, and 1984, each time attempting to balance the contradictions between fighting unrestricted nuclear campaigns against industrial enemies, and unconventional limited conflicts like Vietnam. Each version of AFM 1-1 reworded its ideas about air power and air support in land campaigns, but the basic premise of each document remained an adherence to the strategy of nuclear deterrence, and strategic bombing *remained* the essence of Air Force doctrine.²⁴ Each version paid more attention to the differences in the nature of a conflict and devoted more attention to support missions, such as airlift, in addition to combat missions. Yet in essence, basic doctrine had

²³Tilford. Setup p. 50.

²⁴Maj. Mark Clodfelter, Oral interview, and follow-up, (Maxwell Air Force Base, Alabama), 21 Jan, 1993.

remained fundamentally unchanged, it had grown only in the manner in which additional missions and capabilities were added to that of strategic bombing.

In examination of the development of doctrine from WWII through to the 1980's, it is accurate to summarize by saying the Air Force's experiences held value only if they confirmed dogma. There existed a propensity to dismiss history and open-minded analysis, and the reactionary papers and books of the 70's and 80's which addressed doctrine have seen this as Air Force doctrine's central shortcoming. These authors addressed the Air Force's narrow focus on the future of strategic bombing and bombers to the exclusion of tactical aviation, and the lessons of the past. Insecurity in the strength of Air Force independence, concern over budget appropriations, and the technological nature of air power have created and perpetuated an intellectual inertia that has proven difficult to change. Empirical evidence existed to refute certain doctrinal statements, but as Tilford has written, these theories of air power were grounded in prophecies that had no real basis in historical fact, therefore questioning the doctrine that was built upon these theories tended towards heresy.²⁵

With the latest revision of AFM 1-1 published in March 1992, written by the Air University's Airpower Research Institute, part of the Center for Airpower Doctrine, Research, and Education (CADRE), this document provided a new outlook on the Air Force and its doctrine. By using a two volume format, the authors have attempted to provide both a concise statement of strategy, and the background from which these ideas came. The first volume is a condensed statement of doctrine, much the same as past versions, but accompanied by a second volume, fifteen times longer than the first volume's twenty pages, which consists of detailed essays explaining and supporting the ideas and concepts

²⁵Tilford. Setup p. 38.

embodied in volume one. Although it represents a great leap forward in its breadth and depth of thinking, it still contains remnants of the bombardment ideas developed during the 1940's. This high altitude bombing campaign viewpoint has repeatedly resisted ideological change. A draft of the 1992 AFM 1-1 prepared by the Doctrine Office of the Air Staff in the Pentagon, which included a discussion of the importance of geography and climate, was overruled in favor of more traditional ideas.²⁶

Doctrine's continuing focus on the principles of strategic bombing inherently neglects consideration of terrain and geography. For instance, *The Bomber Roadmap* confirmed the unwritten strategic bombing-centered viewpoint of Air Force doctrine by stating that nuclear deterrence is still a central requirement and a key mission in national military strategy, and the international environment.²⁷ The Department of the Air Force released this document in June 1992, shortly after the publishing of the latest AFM 1-1; it outlined the Air Force's long term plans for strategic bombers, and how they still formed the primary arm of long-range power projection. The *Roadmap* contained ominous echoes of the ill-fated plans of 1942, where strategic planners insisted that long range bombers could penetrate enemy airspace in a self-supporting manner, surviving hostile opposition to deliver their bombs accurately. Many bomber crews lost their lives in the disastrous raids on the ball bearing plants of Schweinfurt and Regensburg in order to prove these ideas wrong.²⁸ The adherence to both air power and bombing's decisive impact is not limited to official doctrine, for numerous analyses of the Desert Storm campaign have

²⁶Col. Dave Tretler, *AFM 1-1 Air Force Basic Doctrine Employing Aerospace Power (Draft)*, (HQ USAF/XOXWD, May 1990) p. 33.

²⁷Col. Michael V. Hayden, *The Air Force Bomber Roadmap*, Air Force Memorandum (SAF/OSX: Department of the Air Force, June, 1992) p. 1.

²⁸Clodfelter, *Limits*, p. 5. and Futrell, *Ideas*, Vol 1. 157.

claimed that air power is now the decisive element in warfare, with modern fighter-bombers and stealth attack planes substituting for yesterday's B-17 or B-52 bombers.²⁹

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The evolution of Air Force doctrine has been intertwined with what RAND Corporation analyst Carl Builder has characterized as the evolution of institutional strategy and personality.³⁰ He argues that by looking at the Air Force's institutional history and behavior, one can better understand the roots of its military strategy, rather than the words with which they mask themselves. Builder is saying that the history of the Air Force explains the form of its written strategy and doctrine, rather than the service's own rationale for doctrine's evolution. Inherent in this analysis is the concern for institutional survival. The Air Force was emancipated only recently from its parent, the Army, and the arguments for service independence echo through even its present doctrine. Builder sees the Air Force as creating for itself a unique mission, one that only it can fulfill, that being the chief wielder of nuclear weapons, in the form of bombers and intercontinental missiles, which represent the nation's ultimate striking power, and deterrent force. By doing this, institutional survival is guaranteed, since the Air Force has positioned itself as the only service capable of fulfilling this national need. WWII strategic bombing, whereby the air forces attempted to independently defeat the enemy through bombing their civilian will and industry, naturally evolved into more modern nuclear strikes, yielding greater destruction with fewer and less costly forces.³¹

²⁹Terry L. New, "Air Power Indeed is Decisive Instrument of War," (*Air Force Times*, May 13, 1991) pp 23,61. and John D. Morrocco, "War will reshape Doctrine, but Lessons are Limited," *Aviation Week and Space Technology*, April 22, 1991. P. 42.

³⁰Carl H. Builder, *The Masks of War: American Military Styles in Strategy and Analysis*, (Baltimore: The Johns Hopkins University Press, 1989). pp. 3, 7-11.

³¹Builder, *Masks*, p. 28.

The second distinct characteristic of the Air Force is its wedded fascination with technology. Builder goes so far as to call technology the altar at which the Air Force worships, since technology was the instrument which gave the service its instrument for independence, the airplane. He also sees the pursuit of technology a self-fulfilling exercise, in which the fostering of technology leads to ever greater returns on its development, while strengthening the future need for an air force.³² Builder's ideas give motivation to the Air Force's reluctance to relinquish its present doctrine, and its use of technology to overcome operational problems. By questioning doctrine's tenets, one questions the writs upon which the institution has built and identified itself, as well as the means (technology) by which it develops its future.

The fundamental adherence to the primacy of strategic bombing *by its very nature* has led to the current disregard towards the influences of geographical and environmental factors on the potential effectiveness of air power in a conventional campaign. This attitude grows out of the relationship between the *area* nature of nuclear weapons effects and the traditional high altitude and standoff delivery methods. As discussed earlier, nuclear weapons do not require exceptional accuracy in their delivery and impact. Accuracy is measured using the term circular error probable (CEP), which describes the accuracy potential of a bomb or warhead as the radius of a circle within which half of the bombs dropped are expected to land. If a bomb has a CEP of 100 feet, there is a 50-50 chance that it will land within 100 feet of the target. The Air Force's relatively low concern for accuracy with nuclear weapons, compared to conventional munitions, is indicated by listing that the former's CEP in miles, while the latter is in feet. The aircraft that delivered a nuclear warhead of even moderate size

³²Builder, *Masks*, p. 19.

(100 kilotons) needs accuracy only within a few hundred feet, while destroying the same target with conventional bombs might require a direct hit. Since nuclear weapons do not require great accuracy, even blind radar bombing techniques, historically much less accurate than visual techniques, are sufficient to accomplish the mission.

Additionally, due to the powerful weapons effects that require the airplane to be several miles away at detonation, nuclear delivery is generally a medium to high altitude task. Even modern low altitude bombers designed to penetrate dense air defenses by hugging the terrain, spend only the brief portion of their mission where they penetrate enemy air defenses flying nap-of-the-earth, preferring to stay at higher altitudes to conserve fuel (a jet burns much less fuel in the cold, thin air at high altitudes) and avoid blast effects from the bombs dropped. The widespread use of powerful air defense radars rendered high altitude bombing untenable, because the bombers could be detected at great distances, giving the defenders ample time to have missiles and fighters waiting to shoot the bombers down. The Air Force's Strategic Air Command changed its tactics to avoid this vulnerability, thus their bombers would descend from their high cruising altitudes to fly at tree skimming altitudes when approaching and penetrating through the enemy's radar defenses. When the aircraft approached its target, the B-1's and B-52's used short range attack missiles (SRAMs) to maintain a safe distance from their targets. The targeting personnel were not concerned about the relative inaccuracy of these weapons when compared with modern cruise missiles and laser guided bombs, because a 200 kiloton warhead does not demand extreme precision. Since Air Force doctrine still considers strategic bombing to be a key mission, service attitudes frequently dismiss the

influence of environment and terrain.³³ The assumptions upon which this doctrine has operated were fundamentally the same as those formed thirty or forty years earlier from the "lessons" of WWII.

Although unrestricted nuclear warfare has been the most potentially severe military threat faced by the Air Force, it was not the only one that threatened, nor was it the most likely. The assumptions concerning strategic bombing's effectiveness are themselves unproven, especially in light of the mixed results obtained in WWII. In the fifty years since that war, no opportunity has arisen to exercise *that* same unique type of WWII aerial campaign, where long-range bombers used unrestricted bombing in pursuit of unconditional surrender. Yet the suppositions that guide present attitudes regarding the influence of terrain and environmental factors are derived from the high altitude bombing campaigns of that period, later translated into doctrine for nuclear warfare. The utility of conventional area bombing, due to technological changes ranging from ballistic missiles and nuclear weapons to defensive missile systems (and changes in the nature of war itself) was much lower in the 1960's and 70's, than in WWII. Arguably, unguided conventional bombing is used today in exceptional cases, while precision weapons are favored more, due to political concerns over the collateral damage caused by inaccurate bombing. Although the evolution of doctrine has appeared to be thoroughly up-to-date, its underlying assumptions and concepts remained questionable in the theaters of modern war.

* * *

The essential advantage inherent in applying force with air power is its ability to act directly upon the nation's leadership and industrial war fighting capability, rather than indirectly through attacking troops in the field. Col. John

³³Hayden, The Air Force Bomber Roadmap.

Warden, in his popular book *The Air Campaign: Planning for Combat*, argues that air forces are uniquely suited for applying mass against the enemy's center of gravity in this manner. Adopted from the ideas of Carl von Clausewitz, Warden describes center of gravity as the vulnerable point where an attack has the best chances of being decisive.³⁴ Warden argues that a nation's center of gravity consists of five concentric rings. At the center ring, most vulnerable, is the enemy leadership; in turn it is surrounded by key production facilities. The third ring is infrastructure, consisting of transportation and communication, followed by the fourth ring, which consists of the civilian populace. Finally, the nation's fielded military forces make up the fifth and last ring.

Essentially, the further inward towards the center ring one can apply military force, the more easily a commander can achieve victory and win a favorable peace; two contrasting examples of this idea of attacking centers of gravity are the Vietnam and Persian Gulf Wars. In Vietnam, the US aimed its effort primarily at the enemy's military forces in the field, and had little success in winning a negotiated peace. While in the Gulf campaign, Iraqi command structures were among the first targets, and primary effort did not shift to enemy ground troops until the end of the campaign.³⁵ It was not necessary to eliminate essential command and control in order to remove it from the conflict; if a commander isolated his enemy counterpart, by cutting communications with his forces, it delivered the same effect. Thus the air interdiction mission attempts to isolate both the troops from resupply, and prevent the enemy commander from maintaining effective control, a process congruent with Warden's concept of applying force in war.

³⁴Warden. p. 9, 53, 138.

³⁵Maj. Mark Clodfelter, "Of Demons, Storms, and Thunder: A Preliminary Look at Vietnam's Impact on the Persian Gulf Air Campaign", *Airpower Journal*, Vol. 5, No. 4, Winter 1991, pp. 23,27.

To understand the effects of terrain and geography on air interdiction, it is necessary to examine the interdiction mission, and how it changes with the varying nature of the conflict. Put simply, interdiction uses aircraft to reach behind the enemy's front line forces, destroying reserves and reinforcements, as well as such lucrative targets as command, control, communications and intelligence (C³I) structures, transportation, and fuel.³⁶ While most aspects of air power will be influenced by the geography of the theater in which they fight, even if only by the location and availability of suitable bases, historically the interdiction and close air support missions were impacted the most by terrain, geographic and environmental factors. Close air support means using aircraft to bomb enemy front-line positions, and directly support friendly ground forces. Air interdiction directs air attacks at enemy forces and reinforcements behind the front line, before they can be committed to battle. Due to the low-altitude nature of these attacks, terrain and the environment traditionally have had the greatest impact on these missions. LtC. Price T. Bingham, USAF (Ret.), former chief of the Current Doctrine Division at Airpower Research Institute notes that the poor weather during WWII over northern Europe, specifically from 1 September to 1 December 1944, had a huge impact on strategic bombing as well, restricting bombs crews from operating visually all but 24% of the time.³⁷ The weather forced the bombers to drop three out of four of their bomb loads blind, relying on inaccurate radio beam and radar navigation techniques.³⁸ The traditional interdiction fighter-bomber, which was much smaller than a bomber, had different strengths and weaknesses. Its main strength lay in its ability to bomb from lower altitudes, inherently increasing its accuracy; its weakness has

³⁶Joint Publication 1-02 Department of Defense Dictionary of Military and Associated Terms, December 1, 1989

³⁷Bingham, Oral interview, and follow-up, (Maxwell Air Force Base, Alabama), 19 Jan, 1993.

³⁸Bingham, Oral interview, and follow-up, (Maxwell Air Force Base, Alabama), 19 Jan, 1993.

traditionally been that until the 1980's, these aircraft lacked the bomber's sophisticated electronics, and therefore bombed almost exclusively by visual means. Due to their inherent flexibility, attack aircraft can support friendly ground troops, serving as a form of airborne artillery, or proceed behind the front line, attacking targets of value in the enemy rear. Before the development of aircraft, enemy ground troops were attacked by the indirect fire of artillery, but rear areas out of artillery range were relatively safe and secure from enemy observation and attack.

Because aircraft have the range to reach far beyond the immediate battlefield, they are suited ideally for interdicting rear area targets such as command and control facilities, lines of communication (such as bridges, tunnels and rail yards), logistics, and reinforcements. The first major American experience with coordinating air support and ground troops came from the WWII joint Anglo-American campaign in North Africa, duplicating many of the lessons learned earlier by the Luftwaffe in their blitzkrieg tactics. An integral part of the Allied experience was the ability to attack the enemy's vulnerable rear areas, jeopardizing supplies and logistics that were crucial in the desert environment. Subsequent air support experience, from the WWII strategy of FM 100-20, to the lessons learned in Southeast Asia and from observing the Arab-Israeli wars in the Middle East has led the Army to develop its present-day AirLand Battle doctrine, a detailed plan which uses air assets to support ground troops and interdict enemy forces well behind the front line. Capabilities have evolved to the point where aerospace forces can attack both front line enemy forces, as well as those several hours' or days' travel from the fighting, exploiting air power's key strength to apply force in a flexible manner. Once any opposing aircraft have been neutralized, and air superiority achieved, friendly air assets can attack tactical, operational or strategic level targets; thereby concentrating

mass and coordinated firepower against enemy forces and installations, and making the coordinated effort greater than the sum of its attacking parts. However, new concepts and tactics have not reduced the importance of accounting for the influence of environmental and terrain factors.

Air interdiction targets are usually either mobile or physically reinforced and protected from air attack. While fixed targets, because of their stationary nature, are easier for modern fighter and attack aircraft to find, mobile targets present other problems to both air planners and the air crews delivering the weapons. The difficulty is due to their mobile nature and small size, since intelligence data on their location, number, identity and local defenses is extremely difficult to gather, and this data is perishable. Put simply, it is a formidable task for reconnaissance and intelligence assets to gather information on the location and strength of enemy forces, and still analyze and distribute the data before the enemy forces move and render the gathered data useless. Once the targets disperse from their identified locations, effectively they are lost and difficult to reacquire. The primary tool for target acquisition by pilots is unaided eyesight, which limited capability and hazards such as glare, haze, and high speeds can effect.³⁹ Vehicles present difficult problems to aircrews which must identify the trucks, tanks, Armored Personnel Carriers (APCs), or other vehicles by eyesight, without complete information on their current location. In other words they are told, 'the targets were last seen here, go find and destroy them.' Modern technology has not eliminated this problem, for in the recent Desert Storm campaign, American A-10 attack jets shot up two trucks of British troops,

³⁹Bingham, Oral interview, and follow-up, (Maxwell Air Force Base, Alabama), 19 Jan, 1993.

exemplifying the difficulties of finding and identifying targets that still exist today.⁴⁰

Historically, the average attack jet navigated in a combat environment at speeds between 500 and 600 nautical miles per hour (knots), or between eight and ten miles per minute. This mission takes place at low altitude, typically below 500 feet, to avoid radar contact and hostile ground fire. Visibility limitations at that speed occur because objects that are relatively close, but located to the extreme left or right of the aircraft's flight path, are difficult to find. One can experience this phenomenon by driving sixty miles per hour on the highway and trying to focus on the surface texture of the pavement near the car. The road is simply going by too fast to see clearly. To compound this problem, a pilot can only spot a truck-sized target within a range of approximately two miles. At ten miles per minute, this gives the pilot a maximum of twelve seconds to spot and identify his target, if indeed it is located out in front of the aircraft, while he is busy flying the plane, configuring the weapons, and avoiding the enemy.⁴¹ In a recent discussion regarding the use of ground camouflage to deceive a pilot, Dr. William Marshak stated that this time period is realistically much shorter, ranging from only three to seven seconds.⁴²

LtC. Bingham, who has worked extensively with the US Air Force's Airpower Research Institute and Center for Aerospace Doctrine, Research and Education, in addition to serving three tours as a fighter pilot in Vietnam,⁴³ emphasizes that historically, air interdiction's toughest task was not hitting the

⁴⁰Richard Hallion, Storm Over Iraq: Air Power and the Gulf War (Washington: Smithsonian Institution Press, 1992) pp. 247.

⁴¹For a detailed description of tactical bombing, see Appendix A.

⁴²William Marshak, 'The Disguises of War' (Nova), 7 April, 1993.

⁴³Airpower Research Institute (ARI) is part of the Center for Aerospace Doctrine, Research, and Education (CADRE) at Air University (AU), Maxwell Air Force Base, Alabama. AU also contains the School for Advanced Airpower Studies (SAAS), Air Command and Staff College (ACSC), Air War College, and the Air Force Wargaming Center.

targets but locating them, a task which he characterized as extremely important, but made much more difficult by the interference of ground surface features on visual and sensor capability.

"Unlike a fluid medium, such as the ocean or atmosphere, the complexity of the ground's surface presents a far more difficult problem for aircrews trying to find enemy forces to attack. The major reason is that, until recently, aircrews had to depend on their unaided vision for finding mobile enemy ground forces."⁴⁴

Bingham continues by examining campaigns in both Korea and Vietnam to see the effect that concealing geography, vegetation, and camouflage had on frustrating the interdiction effort. Bingham insists that despite flying many interdiction sorties, US aircrews had trouble acquiring suitable targets and making attacks, due to the terrain and concealment, further compounded by the added difficulty of unfavorable weather.⁴⁵

Dr. Earl Tilford, a retired Major in the Air Force and a colleague of Bingham's from Air University, elaborated on this subject. Tilford saw repeated instances of the attempt to demonstrate that weapons and technology have advanced to the point where they allow air power to ignore environmental and geographic concerns, such as the harsh features of the karst geography in Vietnam. These rugged formations occur where the upper plateaus and mesa structures end abruptly in steep limestone cliffs which drop to the narrow valleys below, and the entire structure was overgrown with dense jungle. The

⁴⁴LtC. Price T. Bingham, "Air Interdiction and the Need for Doctrinal Change," Strategic Review, Fall 1992. P. 27.

LtC. Bingham goes on to say, "Due to ground clutter, technology in the form of radar was of limited utility for finding targets such as tanks. In contrast, even the primitive radar of World War II allowed aircrews to acquire enemy aircraft and ships at great distances, not only during daylight, but also in darkness and limited visibility. Radar allowed aircrews to perform effective attacks against aircraft and ships during these same conditions. This meant that with radar, air power was much more efficient in defeating an enemy air force or navy than it was in defeating an enemy army."

⁴⁵Bingham. P. 27.

jungle possessed a triple canopy, with three tiers of dense tree cover, at two-hundred, seventy-five, and twenty feet. This canopy did more than block visibility; it interfered with bomb fusing, causing the weapons to detonate ineffectively in the trees rather than penetrating through to the jungle floor. In an attempt to overcome the environment, aircraft attempted to strike in teams, where the first dropped napalm to burn the foliage so the next aircraft's bombs could penetrate to the surface.⁴⁶

The jungle offered weather hazards as well as foliage. The moisture evaporating in the morning created a strong haze, hiding ground features, effectively restricting bombing to between 8AM and 3PM. The difficulties posed by the geography and environment were the force behind operations 'Ranchhand' and 'Commando Hunt,' which were direct attacks on the vegetation and geographic features.⁴⁷ Ranchhand, running from 1962 through 1972, used chemical defoliants, notably Agent Orange, to reduce the jungle vegetation that caused visibility problems and hindered air attacks. Part of the 1968-1972 Operation Commando Hunt attacked geographic features, such as steep mountain passes along the Ho Chi Minh Trail from North to South Vietnam, in an effort to create enemy logistic delays. According to Tilford, the ultimate result of these attacks was to provide more gravel and rubble for labor gangs to use in rebuilding the trail, making these passes wider and *more* passable.⁴⁸

In an attempt to overcome obstacles to the effective employment of air power, the Air Force has traditionally turned to technology. Barry Watts remarks in his analysis of Air Force doctrine and the effect of 'friction', that Americans tend to see war as an engineering science, and that this attitude has

⁴⁶Earl Tilford, Oral Interview, 21 Jan. 1993.

⁴⁷Earl Tilford, Oral Interview, 21 Jan. 1993.

⁴⁸Earl Tilford, Oral Interview, 21 Jan. 1993.

remained strong for the four decades following WWII.⁴⁹ This mechanistic attitude has led to the desire to quantify allied and enemy weapons and capabilities, such that the required number of aircraft, sorties, bombs dropped, etc., becomes the simple answer to a mathematical equation. This belief has driven the shape of doctrine, and the course of weapons development. To provide solutions to problems of flying and navigating at night, finding and hitting targets under difficult conditions, and avoiding enemy detection, engineers have resorted to technology. While these steps are often beneficial, they have led to the belief that the best solution is the most advanced one, and that new inventions can overcome mistakes of past wars.

Desiring to provide sensors that had greater range and capability than the human eye, engineers in WWII developed radar. Radar is a method of detecting objects in the atmosphere and on the ground by analyzing high frequency radio waves reflected from their surface. Simple systems can provide range, speed, and heading information about an object, while state of the art designs in aircraft or satellites can map the ground in such detail that it resembles a photograph. Radar gives the capability to penetrate darkness and weather to provide an accurate picture, regardless of the actual visibility.

Present day airborne radar systems fall into two broad categories, those that spot other airborne objects, and those which spot objects on the ground. The former is a straight-forward task, because the only microwave reflections, or returns, will come from those radio waves that bounce off the airborne object. Since the rest of the signal is not reflected, any return an air-to-air radar receives is generated by another airborne object. The implications of this effect for air-to-ground radar are formidable. Most of the signal transmitted towards the ground

⁴⁹Barry D. Watts, The Foundations of US Air Doctrine: The Problem of Friction in War, (Maxwell Air Force Base: Air University Press, 1984) p. 47

returns, and it is a daunting task to filter meaningful information from ground clutter, which reflects enough of the radio waves to mask the desired echoes, unless powerful computers are used to filter out the unwanted signals. The net result for the air interdiction mission is that only in the last decade has the Air Force developed the technology to spot small vehicles on the ground with radar.

Infrared systems attempt to provide visual information, during nighttime or poor visibility, by imaging the heat (infrared) emissions of objects on the ground. The low-altitude navigation and targeting infrared for night (LANTIRN) system uses this capability to provide near daylight-quality images for aircrews at night, but it possesses weaknesses similar to radar. Both methods of augmenting visual target acquisition are limited to line-of-sight capability (which means they can't see behind hills or other objects), and these complex systems increase rather than reduce the pilot's workload. In combat, where the pilot desires the most to keep a vigilant watch outside the cockpit for ground and air threats, these complicated systems force him to devote more time inside the cockpit, increasing 'heads-down' time, and making the aircraft more vulnerable to attack. Furthermore, unlike the pilot's eyes, which he can focus in any direction, both radar and infrared systems are limited to a narrow field-of-view, normally in front of the aircraft, which makes it difficult for the pilot to spot targets well off his flight path.

The Air Force designed the joint surveillance and target attack radar system (JSTARS) specifically to overcome the problem of locating mobile ground targets and enhancing the interdiction mission. Consisting of a sophisticated airborne ground-mapping radar system, and a crew of radar and intercept control officers, the converted airliner serves as an airborne ground-traffic control system, allowing its crew to locate hundreds of targets as small as cars, and then vector aircraft to intercept them. Because the system processes the data

in real time, there is no delay between locating the enemy vehicles and vectoring their pursuit.

Until JSTARS, first used in Desert Storm, airborne and satellite reconnaissance gathered only photographic data, trained interpreters processed it in a remote location, and then forwarded the information to the local command structure, resulting in significant time between when the data was gathered (and accurate), and when it was received at the local level. This new system allows attack aircraft to remain in flight, waiting to be vectored immediately to a ground target when the system acquires it, as the fighter's sophisticated weaponry receives target data directly from JSTARS. The Achilles' heel of this advanced system is the radar, and by nature radar possesses its own inherent strengths and weaknesses.

John D. Morrocco, writing about the lessons from the Desert Storm campaign, cautioned about over-emphasizing the specific effectiveness of the JSTARS system, and air power in general. "The war was conducted over terrain which has historically favored air operations. Gen. John M. Loh, commander of the US Tactical Air Command, said it should not be overlooked that the flat, featureless terrain was ideally suited to air power. Unlike Vietnam, there were no triple-canopy jungles to conceal troop movements."⁵⁰

Radar's weakness lies in its restriction to line of sight operation. The microwaves cannot pass through or around solid objects, thus effectively hiding an object masked by hills or heavy vegetation from detection. As a result, air-to-ground search radars are very effective in maritime and desert operations, where there is little ground clutter to mask targets, but increasing the 'roughness' (hilly or mountainous nature) of geography proportionately shortens the radar's line of

⁵⁰John D. Morrocco, "War will reshape Doctrine, but Lessons are Limited," Aviation Week and Space Technology, April 22, 1991. P. 42.

sight range, and increases the concealing 'shadows.'⁵¹ Now, due to rough terrain, it may only be able to scan the surface within a twenty of thirty mile radius, where before, over open terrain, it was tenfold larger. Thus even though the Air Force can locate targets with unprecedented accuracy and capability, the features and geography of the terrain still constrain this system.

Each of these systems represents an attempt to provide a technological edge in modern combat. Yet none of them frees the pilot or the air planner from giving appropriate attention to the effects that terrain and environment will have on the mission and the campaign. Although the presence of jungle and rough terrain severely limited the ability for aircrews to deliver weapons during good weather and daytime in Vietnam, subsequent technology has not necessarily made this task easier. Since JSTARS and LANTIRN allow interdiction during low visibility (at night or during poor weather), but cannot make the terrain less rugged, the same task becomes *more* difficult at night or in the weather. When night interdiction is attempted using advanced sensors, the pilot must now perform a traditionally visual mission by relying only on the airplane's instruments.

Clearly, modern sensors and weapons have increased air power's flexibility, but have not eliminated some of its limitations. During the latter stages of the Vietnam War, laser guided bombs proved very effective when used against the naked bridges in North Vietnam, yet these same weapons were ill

⁵¹A detailed discussion of the roughness of terrain is included in Richard Simpkin, The Race to the Swift (London: Brassey's Defense Publishers, 1985) pp. 58-60. The author states that the relative roughness of the terrain is a combination of its irregularity, combined with the viewer's perspective. His analogy is that rough terrain for the small perspective, such as an ant, would be much smoother from a higher perspective, such as ours. The direct analogy for air power is that terrain that is rough from a fighter-bomber's perspective is smooth and unimportant *from a high altitude strategic bombing perspective*. [emphasis added]

suited for use against infiltration along the Ho Chi Minh, due to both their high cost and the inability to spot the targets in the rugged jungle terrain.⁵²

Historically darkness and concealing ground features have limited interdiction campaigns' ability to arrest enemy movement and resupply. In the Korean War, the Chinese Army managed to infiltrate 300,000 troops across the Yalu river, through the rugged terrain of the central mountains, and launch a surprise attack, *completely undetected*.⁵³ Even though UN forces possessed air superiority, and were actively conducting air interdiction, they could not fully stop the flow of enemy men and supplies.⁵⁴ The terrain and darkness allowed communist forces to maintain a reduced but steady flow of materiel to their forces, and to continue sustained combat operations.⁵⁵

In his paper titled 'Ground Maneuver and Air Interdiction in the Operational Art,' which discusses the sometimes accidental relationship between ground forces' maneuvers and the subsequent exposure of air interdiction targets, Colonel Bingham argues that the German army used the rugged terrain of the Italian peninsula during WWII to execute a fighting withdrawal, successfully trading time for space. Air power alone proved unable to cause the enemy forces' withdrawal, and only when allied ground forces maneuvered, thus forcing the Germans to expose their troops and increase their logistic requirements, did interdiction proved effective.⁵⁶ Bingham cites rugged terrain,

⁵²Tilford, Setup, p. 228.

⁵³Dennis M. Drew and Donald M. Snow, The Eagle's Talon's: The American Experience at War (Maxwell AFB: Air University Press, 1988), p. 253.

⁵⁴The shape of the terrain was only one of the factors that allowed the Chinese forces to move undetected, others included: a lack of night aerial reconnaissance capability, limited number of daytime reconnaissance assets, Army constraints on the use of visual reconnaissance aircraft, good camouflage discipline, and the relatively short distance from the Yalu River to the front lines. See Robert F. Futrell, History of the Korean War.

⁵⁵Drew and Snow, p. 247.

⁵⁶LtC. Price T. Bingham, Ground Maneuver and Air Interdiction in the Operational Art (CADRE Research Paper No. AU-ARI-CP-89-2, Maxwell AFB: Air University Press, 1987) p. 3.

ground cover and effective use of darkness as all posing hindrances to pilots visually searching the ground, and attempting to locate their targets. He further contends that even the availability of a JSTARS-type radar system would have been of limited utility in this situation, due to both the rough terrain and the requirement for visually locating the target before it was attacked. This limitation still exists with modern weapons, when there is a need to see the target with unaided vision before it can be bombed.

A similar situation occurred during Operation Rolling Thunder in Vietnam from 1965-1968, where the enemy's sporadic guerrilla warfare produced meager supply requirements. Major Mark Clodfelter, in his study of the air campaign over North Vietnam, remarks that, "Geography and weather provided additional limitations on Rolling Thunder. North Vietnam's lush terrain was ideal for camouflage, and the enemy frequently resorted to deception."⁵⁷ He goes on to examine the campaign, and shows that while bombing hindered the movement of supplies, it did not hinder infiltration or the North's war effort. Communist forces in all of South Vietnam needed only 34 tons of outside supplies per day to maintain the insurgency against the Saigon government -- and amount that could be carried in only seven 2 1/2 ton trucks.⁵⁸ Although the low total resulted from the enemy's infrequent combat, the terrain and environment of the Ho Chi Minh Trail made the Herculean task of effective air interdiction impossible.

Even in the modern battlefield environment, high technology weapons and sensors have weaknesses. During Desert Storm, weather problems, such as haze and sandstorms adversely effected air interdiction. The limited visibility

⁵⁷Mark Clodfelter, The Limits of Air Power: The American Bombing of North Vietnam (New York: The Free Press, 1989), p. 132.

⁵⁸Clodfelter, Limits, pp. 134-5.

caused by these environmental difficulties restricted the employment of laser-guided bombs and infrared-guided anti-tank missiles, in addition to causing maintenance problems due to the destructive abrasion of the sand. In the Persian Gulf war, coalition air forces expended great effort to locate and destroy the mobile Scud missile launchers. In spite of successes in other areas, air assets had only limited success neutralizing these politically valuable targets. The search became more difficult because the launch areas in northern and western Iraq were more rugged than the desert near Kuwait, inhibiting the airborne sensors used to locate and identify the launchers. It is ominous to note that the Scud was a first-generation ballistic missile, employing 1950's technology, yet both in the pre- and post-launch phases, coalition forces could not confront and fully eradicate this threat.⁵⁹ In the last decade, even with advanced systems and weapons, it is still extremely difficult for Air Force aircraft flying at low altitudes and high air-speeds to identify individual vehicles, let alone identify which ones are tanks. Added to this difficulty, precision guided air to ground missiles can be launched only one at a time, targeting only one vehicle.⁶⁰ While these restrictions may seem innocuous, repeatedly attacking an armored column protected by missiles, anti-aircraft guns and other aircraft is almost certain suicide for the pilot.

To compound these problems, the more valuable the interdiction target, the higher the probability that heavy air defenses will protect it. Ideally friendly forces would possess air superiority, where they control the skies, or air supremacy, where there is little or no enemy air activity at all. Without this

⁵⁹Richard Hallion, Storm Over Iraq: Air Power and the Gulf War (Washington: Smithsonian Institution Press, 1992) pp. 245-6.

⁶⁰LtC. Price T. Bingham, Air Power and the Close-in-Battle: The Need for Doctrinal Change (Unpublished Paper for the 1987 USAF Aerospace Power Symposium: Air University Library #3-9349-00431-5541, 8 May, 1987.) pp. 30-31.

dominant air control, enemy air defenses traditionally limit the time that an aircraft can spend locating and attacking a target, before the attacker loses the factor of surprise, and the enemy defenses coordinate their fire. These defenses have traditionally been either radar-guided surface to air missiles (SAMs), anti-aircraft artillery (AAA), or other aircraft. Such a valuable asset as a local command post is usually a hardened, camouflaged bunker, protected by SAMs and AAA. Attacks upon these types of targets must be quick and accurate; ideally, before the defenses can react, the attackers have already located it, destroyed it, and are exiting the area.

These target defenses can consist of a single AAA gun or progress to a system resembling a layered net, with SAMs and AAA mutually supporting each other in a redundant and camouflaged network. Pilots encountered these layered defenses in Vietnam, where Col. Jack Broughton, Deputy Commander of the 355th Tactical Fighter Wing, described the air defense in North Vietnam as being so tough that it was, "The center of hell with Hanoi as its hub."⁶¹ Broughton continues by remarking that geography there was a basic fact of life, with numerous steep nine-thousand foot peaks, cut like the teeth of a saw, rising abruptly from the plain that bordered the ocean.⁶² Since the US was unable, due to political limitations, to achieve air supremacy in Vietnam, the Soviet made surface-to-air missiles forced American pilots lower in altitude to combat this defensive threat. The SA-2 missile was most effective at medium and high altitudes, thus pilots remained within a few thousand feet above the terrain to avoid the missile threat. Unfortunately these low altitudes increased an aircraft's vulnerability to ground fire, and forced the pilots to negotiate the rugged terrain in an attempt to balance the threat of enemy fire with the danger of a crash.

⁶¹Col. Jack Broughton, Thud Ridge (New York: Bantam Books, 1969), p. 27.

⁶²Broughton, pp. 27-8.

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As Richard Hallion succinctly states, the Air Force is wedded to technology, and both doctrine and technology are closely related dynamic processes.⁶³ Because of their interdependence, when the development of doctrine lags advancing technology, it hinders both capability and new development. Current doctrine pays scant attention to the influence that the terrain and environment have on the proper employment of air power, particularly in the role of air interdiction. The lessons of past campaigns must be recalled and applied to newer air doctrine. Doctrinal evolution cannot be a simple additive process, since past lessons indirectly conflict with the ideas and purpose of present basic doctrine. Both Bingham and Warden call for the development of operational level doctrine, balancing both the art and science of war, producing a document useful both for its ideas and its campaign planning guidance.⁶⁴

Whereas basic and strategic level doctrine is too broad, and tactical is too detailed and specific, operational level doctrine encompasses the direction and development of tactical level events to achieve strategic level goals. At the operational level, concerns such as environment and terrain influence are of prime importance to the planner and commander. The key distinction between basic and operational level doctrine is that the former guides peacetime force structuring, procurement, and long range goals, while the latter serves as a direct guide for employing air power in combat. Operational level planning directs its effort towards the achievement of strategic level goals. But it accounts for the

⁶³Dr. Richard P. Hallion, "Doctrine, Technology and Warfare: A Late Twentieth-Century Perspective" Airpower Journal, Fall 1987, Vol. 1, No. 2. pp. 16-17.

⁶⁴LtC. Price T. Bingham, Operational Level Warfare and its Implications for the U.S. Armed Forces (Unpublished Paper: Air University Library #3-9349-00174-1848, MU 43796, 1987) and Warden, The Air Campaign. xxiii-8.

circumstances that make a conflict or campaign unique from other campaigns that would appear similar at the strategic level. Bingham argues that the concepts developed at the Air Corps Tactical School, which were later critically refined in FM 100-20, had this type of operational level orientation. Ironically, Soviet air doctrine concentrated on the operational level of warfare, and includes an examination on how the complexity of the land (shape of the terrain and geography) impact the effectiveness of air power.⁶⁵

Conclusion:

The absence of a US Air Force doctrinal emphasis on terrain and environment has been a product of the cold war emphasis on nuclear weapons and strategic bombing -- itself a legacy of WWII bombing experience -- and an institutional reliance on technology. The projected high altitude delivery of nuclear weapons allowed the planners to overlook geographic features, that will have little impact upon the weapons' effectiveness. When the emphasis shifts towards limited war fought with conventional weapons, which require more precise delivery, environmental concerns play larger roles. Commanders have not always fought in a featureless desert environment. Geography has dictated and restricted the types of ground forces and logistics capable of being employed in the past, air commanders have often been unaware of the effects upon interdiction. Since logistically, the desert is as inhospitable as the open ocean, enemy logistics and resupply have been much more vulnerable to interdicting air attacks in flat or open terrain than not. More rugged terrain poses its own challenges, by limiting the capability of armored and mechanized forces, and providing better conditions for camouflage and concealment. Yet this terrain can

⁶⁵Bingham, Operational Level Warfare, pp. 4, 10.

also benefit the friendly air commander, because it can constrain enemy cross-country movement, and steep terrain can limit what types of vehicles, heavy tanks for instance, can be used by the enemy. Since concealed infantry is much less exposed to aerial observation and attack in the hills or heavy vegetation, air attacks have proven to be less valuable, and air commanders have confronted the fact that air assets are traditionally less suited to supporting the ground campaign in rough terrain than would otherwise be possible.

US Air Force doctrine has developed over the last three-quarters of a century ostensibly out of its military experience in war and peacetime. This doctrine has been an evolving process compromising between finite resources and the requirements to maintain a flexible and formidable national defense. The ultimate result has been the development of an institutional mindset that says high technology can make terrain and the environment inconsequential. In exploring the guidance that doctrine has provided towards terrain and geography, past Air Force doctrine has lacked the ability to draw the important lessons from its experience, and remained attached to concepts which ignored terrain, due to an adherence to the bombing ideas developed and immortalized in WWII. Attempts to overcome the terrain, darkness, or the weather have met only limited success, usually with the result of making the pilot's task tougher rather than easier.

Environmental factors have formed part of the basis for limiting what air forces can and cannot do. Air Force doctrine has traditionally disregarded the importance of terrain and geography, and their effects on air power in support of national objectives, as well as the effects of environment and terrain on the capabilities and employment of air forces. Historically, Air Force doctrine has been based broadly on military theory, yet these concepts which described the influence that geography has on a land campaign were carefully ignored in the

evolution of air power doctrine. This apparently blind lack of regard stems from both the unwillingness to acknowledge air power's limitations, and the inability to draw lessons from the Air Force's past experiences.

To achieve success in employing air interdiction, air planners must fully consider the influence of terrain and geography. The task of initially locating targets is much easier in the flat environment of the ocean or desert, than it is in more mountainous or wooded terrain. Camouflage and rough terrain limits target acquisition by visual, infrared, and radar means. Varying terrain features possess their own inherent advantages and disadvantages to thwart attack. The fact remains that commanders and planners must take the variably influencing nature of terrain and geography on interdiction missions into account early in the campaign planning process, and determine the relative influence and importance of air interdiction on the campaign as a whole.

Appendix A

LtC. Bernard Appel gives a detailed description of the complexities involved in bombing from fighter aircraft in his article, "Bombing Accuracy in a Combat Environment." The reader must consider several facts while reading this article. The first is that LtC. Appel argues that current (he wrote it in 1975) bombing accuracy estimates and measurements were both outdated and unrealistic. Although he does not address terrain directly, his detailed description of aerial bombing is worthwhile on its own. The second factor is that the development of modern Continuously Computed Release Point (CCRP) and Continuously Computed Impact Point (CCIP) functions on today's fire control computers has served to increase bombing accuracy immensely. What these systems do not do is alleviate the difficult pilot workload during and after the bombing maneuver. Finally the reader must acknowledge that until the recent appearance of computerized bombing and Precision Guided Munitions (PGM's), known as 'smart bombs,' these unaided bombing techniques were *state of the art*. From WWII, through Korea and Vietnam, and for some aircraft still today (notably the A-10), this remained the best, most accurate, way for a pilot to bomb a target.

"Those who have not delivered weapons from an airplane have little or no conception of the problems involved or the requisite skills. There are so many variables in the accuracy equation and the chance for error is so great as to make one wonder how fighter pilots do as well as they do.

"Dive bombing, for example, must take into account the ballistics of the weapon, the dive angle, airspeed, altitude, aircraft attitude, g (gravity) conditions, symmetricalness [sic] of flight, and wind. Of these, the only constant is the weapon ballistics, but even this is subject to errors due to manufacturing

tolerances. Using tables, the pilot predetermines his release conditions--that is, airspeed, altitude, and dive angle--and computes a depression angle for his bombing sight. The reticle of the sight, if superimposed on the target when the pilot maneuvers the aircraft to his preplanned angle, airspeed, and altitude, should provide an accurate release point. The difficulty, though, is in simultaneously achieving these three main variables as the reticle crosses the target. That is where the skill of the pilot comes in. If the airspeed is too fast or too slow, the dive angle too steep or shallow, the altitude too high or too low, the bomb will be long or short. Similarly, release at a g force other than the cosine of the dive angle (.866 g at a 30-degree angle, for example) will affect the bomb trajectory. Inability to hold the wings level will throw the bomb left or right of the target. Lack of a coordinated flight condition will do likewise. Wind, too, is a strong factor, drifting the aircraft during the prerelease run-in and affecting the bomb in free fall after release. The problem of a pilot, then, is not the same as that of a rifleman. A pilot may have the target centered under the reticle and still encounter gross errors. The chances for these errors, then, even under the ideal conditions of a training range, are significant.

"Now take this same bombing problem of accuracy and place the pilot in a hostile situation where the chosen parameters are a much higher airspeed, [and] steeper angles . . .; force him to fly in a pod formation prior to bomb release; make it hard to find a target he has probably never seen before; make him keep one eye peeled for SAM's; fill the sky with antiaircraft fire; and you will have some appreciation of the difficulty, in a combat environment, of putting a weapon precisely on target."⁶⁶

⁶⁶LtC. Bernard Appel, "Bombing Accuracy in a Combat Environment" Air University Review, Vol. XXVI, No. 5, Jul-Aug 1975, pp. 40-41.

Into this difficult task for the pilot, one now adds the concerns of weather, terrain, and geography. The reader can now see that accomplishing the same mission in a desert or maritime environment becomes a great deal different than one in an environment possessing rugged features, heavy foliage, unfriendly weather, and poor visibility.

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