AU/ACSC/022/2001-04

AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

THE B-2A AND 500 POUND JDAM:

A NEW CONCEPT OF MASS

by

Steven L. Basham, Major, USAF

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Advisor: Lieutenant Colonel Jeffrey B. Hukill

Maxwell Air Force Base, Alabama

April 2001

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
01APR2001	N/A	-

Title and Subtitle The B-2A and 500 Pound JDAM: A New Concept of Mass	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Basham, Steven L.	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Air Command and Staff College Air University Maxwell AFB, AL	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es)	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 40	

Disclaimer

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government or the Department of Defense. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Contents

Page

Illustrations

Page

Preface

This research project provides an entering concept of operations for the employment of a 500-pound near-precision weapon, Joint Direct Attack Munition (JDAM), from the B-2A Bomber. A single B-2, carrying 80 JDAM 82, provides global, survivable, and all-weather near-precision strike capability across all levels of conflict in a variety of scenarios. This paper provides operational commanders and planners scenarios, as a starting point for using either single or multiple B-2s for striking a large number of targets on a single mission.

I want to thank all the individuals who provided their time and expertise toward the completion of this project. Particularly, Lieutenant Colonel Jeffrey Hukill, Air Command and Staff College Faculty, for his advice and guidance. In addition, a special thanks to Major Chad Stevenson, Whiteman Air Force Base, and Major Bob Colella, School of Advanced Airpower Studies, for their time, expertise, and warrior spirit.

Abstract

As a key tenant of Joint Vision 2020 and one of the core competencies of the United States Air Force, precision strike is a key component to fast and decisive victory in war and some operations other than war. Precision strike is now more than ever the norm for employment of military forces and especially the air arm. The capability of a single or multiple B-2s, carrying 80, 500-pound near-precision weapons each, to strike a large number of targets with precision, while evading enemy radar, minimizes the number of aircrews in danger and maximizes the effects across the strategic, operational, and tactical levels of the campaign. With limited assets, the United States military must maximize the effectiveness of each weapon system.

This paper gives a closer look into the concept of operations for employing the B-2 and JDAM 82. The B-2's long-range, stealth, and heavy-payload capabilities coupled with the JDAM 82's near-precision accuracy make an extremely viable weapon system across a range of operational scenarios. When considering the appropriate use of the B-2 carrying the JDAM 82, there are a number of influences that should be considered such as collateral damage, weather, enemy air defenses, intelligence, mission planning, and aircrew workload. Considering these influences provides the foundation for understanding how to employ the B-2 with the JDAM 82 to achieve a desired outcome in differing scenarios.

Chapter 1

Introduction

> *If our Armed Forces are to be faster, more lethal, and more precise in 2020 than they are today, we must continue to invest in and develop new military capabilities.*
>
> -- Joint Vision 2020

Precision strike is the capability to attack targets with the exactness and intensity required for achieving the desired military effect with minimum collateral damage and a relative economy of force.[1] Due to decreasing numbers of available assets, the military must achieve maximum desired effects from each weapon system to ensure efficiency and economy of force. By increasing the effects produced by each individual aircraft, the Air Force takes those limited assets and maximizes their combat capability.

A concept of operations for employing the B-2A Bomber carrying 80 near-precision 500-pound weapons, capable a striking 80 different aimpoints, provides the capability to increase the desired effects produced and maximize the capabilities of a powerful aircraft in limited supply. The B-2A Bomber provided a decisive all-weather, near-precision strike capability in 1999 during Operation ALLIED FORCE (OAF) with a relatively new weapon. The weapon is a global positioning system (GPS) guided 2000-pound MK84 bomb called Joint Direct Attack Munition or JDAM 84. The B-2A can carry 16 JDAM 84 and strike up to 16 individual targets. On the horizon is a 500-pound version of the JDAM, of which the B-2 will carry 80. The B-2A,

employing 80, 500-pound JDAMs (JDAM 82), provides commanders and planners flexibility, versatility, and increased capability to achieve desired effects from a single aircraft on a single mission.

At the operational level, the unique properties of global attack and precision strike allow U.S. air and space forces to shape the battlespace from a distance; to significantly influence the adversary's area of operation from outside his area and beyond his reach, thereby minimizing the placing of friendly forces in harm's way. Properly supported, precision strike provides massed effects without the need for massed forces. The capability for one aircraft to engage many targets on one sortie not only provides efficiency, but also frees other assets (platforms) to cover even more targets, thereby permitting breadth of coverage and intensity of firepower needed.[2] Only air and space forces have the range, speed, deployability, and flexibility to engage rapidly and accurately in any region. For example, when used in response to a cross-border invasion in a short-warning scenario, long-range air power equipped with large quantities of smart munitions has the ability to halt enemy movement before critical territory is lost.[3]

The true merit of precision strike is not just the increased efficiency in destroying targets; rather it is much more far-reaching. The benefits of fewer sorties and smaller munitions expenditures per target include reducing force package requirements, logistic needs, costs, forward basing, and war-fighters at risk. Alternatively, the benefits are still increased targets destroyed. More dramatically, the implication is the capacity to prosecute parallel attacks at the strategic, operational, and tactical levels simultaneously with long-range systems.[4] Former Air Force Chief of Staff, General Ronald Fogleman, put this in perspective:

> By comparison, during World War Two, the 8th Air Force attacked something like 50 target sets in all of 1943. During DESERT STORM, the coalition struck 150 individual targets in the first 24 hours. Not too far into the next century, we may be able to engage 1,500 targets within the first hour, if not the first minutes, of a

> conflict. Gone are the days of calculating aircraft-per-target kinds of ratios. Now we think in terms of targets-per-aircraft.[5]

Scope of Analysis

The primary focus of this research is to develop a concept of operations (CONOPS) for the B-2 employing the JDAM 82. The scope of this analysis starts with the capabilities of the B-2A and joint direct attack munition. The next section looks at influences affecting precision-strike capability and how the B-2 and JDAM 82 address these influences. Finally, different scenarios incorporate the B-2's capabilities with the influences on precision strike to provide entering arguments for a concept of operations when employing the JDAM 82. The analysis uses information from various sources including RAND Corporation, B-2 and JDAM contractors, B-2 aircrew, and research by noted historians.

Limitations of the Study

This study does not take into consideration the logistical side of the concept of operations for employing the JDAM 82 from the B-2. Quantities of available weapons and time required to load 80 weapons add to the planning considerations. Likewise, the reliability of release and the potential for hung weapons requires contingency planning for possible missed targets. The maintainability of the B-2 and its low-observable material are also considerations that add to the overall equation. However, the length requirement of this research does not provide the required amount of space to accurately address each of these areas.

One other limitation is the lack of historical data on one aircraft having such extreme capability. Never before has an aircraft had the capability to strike such a large number of targets on a single sortie with such precision. Therefore, the scenarios are a look into the future and are limited by the planner's ability to think on such a broad scope.

Notes

[1] Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997, 108.

[2] Gouré, Daniel, and Stephen A. Cambone. *Air and Space Power in the New Millennium.* Edited by Daniel Gouré and Christopher M. Szara.. Washington D.C.: The Center for Strategic and International Studies, 1997, 14.

[3] Jackson, Jeffrey A. *Air and Space Power in the New Millennium*. Edited by Gouré, Daniel, and Christopher M. Szara. Washington D.C.: The Center for Strategic and International Studies, 1997, 111.

[4] Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997, 108-112.

[5] Fogleman, Ronald R. "Getting the Air Force into the 21st Century (remarks delivered to the U.S. Air Force Association's Air Warfare Symposium, Orlando, Fla., February 24, 1995), n.p. On-line. Internet, 20 March 2001. Available from http://www.af.mil/news/speech/current/Getting_the_Air_Force_into_.html.

Chapter 2

Background

The guiding principle of bombing actions should be this: the objective must be destroyed completely in one attack, making further attack on the same target unnecessary.

— Guilio Douhet

The B-2 Bomber and the JDAM performed tremendously in the combat debut of each during Operation ALLIED FORCE (OAF). Aircrew from Whiteman Air Force Base, Missouri, flew the B-2 CONUS to CONUS on 49 sorties in support of OAF, striking targets in Serbia and then returning home nonstop. The B-2 contributed to less than one percent of the total sorties flown during OAF but struck eleven percent of the targets. The Aircrew delivered over 650 JDAM achieving a hit ratio of 84 percent. The limited sorties and numerous targets were a direct reflection of the enhanced capabilities of the B-2 and JDAM.[1]

JDAM Capabilities

The Joint Direct Attack Munition, produced by The Boeing Company, is a low cost guidance kit, which converts existing free-fall bombs into accurately guided "smart" weapons. The guidance kit consists of a 3-axis inertial navigation system (INS) tightly coupled with a global positioning system (GPS) receiver. Once released, the INS guides the bomb to its target via movable fins regardless of weather with position updates from the GPS receiver. The

guidance control unit (GCU) provides accurate guidance in both GPS-aided INS modes of operation and INS-only modes of operation. The GPS-aided INS mode provides a 13-meter Circular Error Probable (CEP) and the INS-only mode provides a 30-meter CEP or better, depending on weapon time of fall. The accuracy for GPS-aided INS mode was 10.3 meters during flight-testing, significantly better than the 13 meter requirement.[2] In the event the JDAM is unable to receive GPS signal after launch for any reason, jamming or otherwise, the INS will provide rate and acceleration measurements which the weapon software will develop into a navigation solution. The GCU provides accurate guidance in both GPS-aided INS modes of operation and INS-only modes.[3]

During Operation ALLIED FORCE, the B-2 employed the tail sections (guidance kits) added to existing inventories of MK-84 and BLU-109 2,000 pound bombs, providing a highly accurate weapon delivery in any "flyable" weather. The MK-84 is a general-purpose weapon while the BLU-109 is a penetrating weapon. The tail sections also fit the MK-83 and BLU-110 1,000 pound bombs. Growth of the JDAM family led to the development of a tail section for the MK-82 500-pound weapon. (Figure 1)

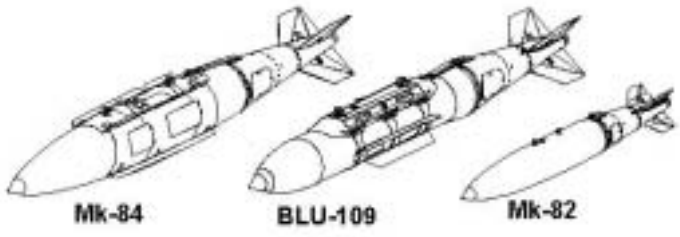

Figure 1 JDAM 84, JDAM 109, JDAM 82

The U.S. Air Force recently awarded $45 million to The Boeing Company for engineering, manufacturing and development of the JDAM 82. Boeing funded the initial development of the 500-pound JDAM using the same components found in the standard 2,000-pound JDAM

configurations. Boeing touts this smaller version of the JDAM as improving mission capability by allowing more JDAMs to be loaded on an aircraft while reducing collateral damage around the intended target due to the smaller warhead.[4] A variety of aircraft currently carry or will carry the 2,000-pound JDAM, including the B-2, B-52, B-1, F/A-18, AV-8B, F-22, F-117, F-16, F-15, and JSF.[5] However the release system for bombers to carry large numbers of 500-pound JDAM requires release racks fitted with a 1760 Mil-Standard wiring bus that will allow the aircraft computers to talk with each weapon. Currently, the B-2 is the only bomber funded to have all of its MK-82 compatible Bomb Release Assemblies (BRA) modified to carry the JDAM 82, thus creating a Smart BRA (SBRA). (Figure 2.)

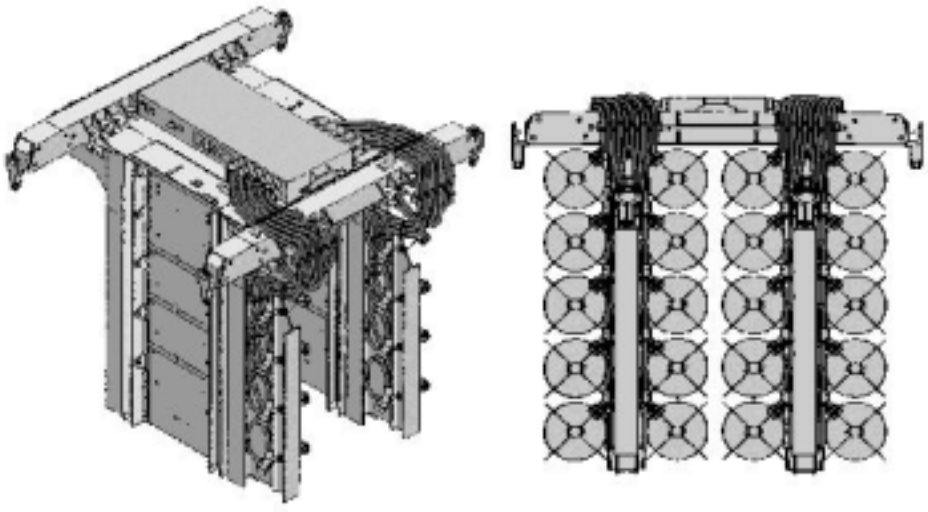

Figure 2 Smart Bomb Release Assembly for B-2 showing 1760 Wiring

B-2 Capabilities

The B-2 provides long range, large payload, low observabilty (stealth), and high precision. Long range (base-to-target distance covering several thousand miles) and large payload (bomb loads weighing tens of thousands of pounds) distinguishes heavy bombers, like the B-52, B-1, and B-2, from other strike aircraft. "Stealth" sets the B-2 apart from older heavy bombers, as

well as other aircraft, except the F-117A stealth fighter, which is a generation older in stealth technology. The B-2's low observabilty is a combination of reduced infrared, acoustic, electromagnetic, visual, and radar signatures. These signatures make it difficult for sophisticated defensive systems to detect, track, and engage the B-2. The ability of the B-2 to deliver highly accurate precision-guided munitions (PGMs) highlights the destructive potential of its large payload.

The large payload capability of the B-2 carrying the JDAM 84 is very similar to the B-1 and B-52 capability, however the JDAM 82 capability is currently unique to the B-2. The B-52 can deliver 12, 2,000-pound JDAM, 24 for the B-1 and 16 for the B-2. To put this in perspective, each of these aircraft are capable of attacking the number of targets equivalent to the number of weapons carried, one target, one weapon. This is very different from the days when large numbers of weapons were released to destroy just one target on a single sortie. However, of the three bombers, currently only the B-2 is programmed to carry the 500-pound JDAM. This increases the payload of the B-2 from 16 near-precision weapons to 80. This increase in total JDAMs carried is one enhanced capability of the B-2 over other aircraft, while its ability to refine target coordinates inflight is another.

Although the JDAM is a highly accurate weapon, there are still errors introduced into the targeting equation that cause the weapon to strike less than perfect. The circular error probable (CEP) of a weapon gives the radius from the target within which the probability of a weapon hitting within that radius is 50 percent.[6] Stated another way, 50 percent of all released weapons should fall within that radius while taking into account all weapon delivery errors. The cause for errors include target location error (TLE) and weapon error in the form of navigation, guidance, and mission computer software errors. TLE derives from the accuracy of target coordinates

estimation by intelligence sources as they mensurate the coordinates using a variety of methods or simply errors in plotting coordinates. Navigation error refers to the fluctuating accuracy of the GPS position provided by the satellites. Guidance and software errors are inherent in the weapon and accepted. However, the B-2 has the unique capability to refine the TLE and GPS navigation error by using its synthetic aperture radar (SAR) to correct any TLE and eliminate much of the GPS error, up to the resolution of the radar. By taking a radar map of the target area, the pilot can minimize the error between where the navigation system thinks the target is and the actual position. This capability is unique to the B-2 and referred to as GPS Aided Targeting™ (GAT). A JDAM release from a B-2 is either a GAT release or JDAM-only. JDAM-only is a weapon released without using the radar to refine the coordinates. By using the radar, the B-2 can reduce the JDAM CEP to 10 meters or less. This capability is relevant when discussing collateral damage, mission planning, and crew workload issues later in the paper.

Notes

[1] House of Representatives. Performance of the B-2 Bomber in the Kosovo Air Campaign: Hearing before the Military Procurement Subcommittee on the Committee on Armed Services. 106th Cong., 1st sess., 1999. 1-10.

[2] "JDAM Program Background." JDAM Program Office Website, On-line. Internet, 20 March 2001. Available from www.eglin.af.mil/jdam/jdam/info/info-main.html.

[3] Federation of American Scientist. "Military Analysis Network, Joint Direct Attack Munition (JDAM)," n.p. On-line. Internet, 20 March 2001. Available from www.fas.org/dod-101/sys/smart/jdam.htm.

[4] "Boeing Awarded $45 Million for 500-pound JDAM Development." Boeing Web Site, BOEING Company, Saint Louis, September 29, 2000, n.p. On-line. Internet, 20 March 2001. Available from www.boeing.com/news/releases/2000/news_release_000929n.htm.

[5] JDAM Program Office Website, On-line. Internet, 20 March 2001. Available from [5] "JDAM Program Background." JDAM Program Office Website, On-line. Internet, 20 March 2001. Available from www.eglin.af.mil/jdam/jdam/info/info-main.html.

[6] Circular Probable Error. Encyclopedia of Statistical Sciences. Vol. 1. A Wiley-Interscience Publication, John Wiley and Sons. 1982. 479.

Chapter 3

Influences to Employing the B-2A with JDAM 82

Many influences have lead to the pursuit of weapon systems that can overcome concerns with collateral damage, weather, air defenses, and mobile targets. The stealth technology of the B-2 and the near-precision accuracy of the JDAM 82 address many of these issues. RAND Corporation published a report in 1996, tasked by the Commission on Roles and Missions of the Armed Forces to evaluate deep attack and precision conventional strike (PCS), which offered a framework for development and acquisition of future precision weapons. Specifically the report identified influences affecting PCS weapons and offered direction for acquisition of weapons such as JDAM.

The RAND analysts concluded that existing weapons at the time provided fairly robust capabilities against soft and semihardened fixed structures, stationary mobile targets, and some targets moving with predictable speed. However, influences such as collateral damage constraints, weather, availability of target intelligence, and adequate mission planning limited the effectiveness of existing weapons. Furthermore, where terminal air defenses have not been suppressed and air superiority has not been established, existing weapons cannot be effectively delivered against heavily defended targets unless stealth aircraft are employed. As a result, PCS weapons of the day were considered unable to make major contributions to achieving campaign objectives as diverse as suppressing war-supporting infrastructure and halting invading armies.[1]

However, many capabilities today address the very issues of the research and provide the opportunity for precision strike with the B-2 employing the JDAM 82. Each of these influences affect a joint forces commander (JFC), joint force air component commander (JFACC), or subsequent targeting cells when determining the right weapon and weapon system for a particular target. This section discusses how the B-2 and JDAM 82 address each of these influences and builds a foundation of knowledge for the scenarios in the next section.

Collateral Damage

One of the greatest advantages of the precision weapon is the confidence of striking the intended target that it offers. A decision-maker prefers precision type weapons when confronted with having to contemplate using force in circumstances where so-called 'collateral damage' would be either unacceptable or call into question the viability of continued military action. Even in high tempo, high-level-of-violence conflicts, attitudes towards both 'enemy' and 'friendly' (or 'neutral') casualties have undergone a remarkable transformation since WW II when, for example, a single air raid could kill tens of thousands of individuals and not raise any significant moral outcry. Increasingly, conflict scenarios involve the use of force in dense, population-heavy environments, where the negative publicity of misplaced weaponry could have profound implications for public opinion and policy.[2]

In an effort to minimize damage to unintended targets, the choice of weapon systems may be restricted to the most accurate ones; those having a very low probability of impacting away from their aimpoint. Selected PCS systems might be limited to those with smaller warheads to limit the chance of blast and other effects damaging nearby facilities.[3] During OAF, the B-2 was assigned some targets in downtown Belgrade that required a surgical strike to keep collateral damage and civilian casualties to an acceptable level. Using a GAT maneuver, the crews

successfully accomplished these missions with JDAM 84s and precision accuracy, but the JDAM 82 might have been preferred had it been available due to its lower fragmentation pattern. If some of the aimpoints during a mission with Mk 82s require higher probability of damage than provided by a single 500-pound weapon, the B-2 can deliver up to ten weapons on the same DMPI. Although the fragmentation pattern of a 500-pound weapon may not be significantly less than that of a 2000-pound weapon, approximately one-third, it does provide some limited restraint upon undesired damage.[4]

It is also important to note that a JDAM is a launch and leave type weapon. Unlike a laser guided weapon that requires a laser to be maintained on the target at all times, the JDAM does not require the pilot to remain in the loop once the weapon leaves the aircraft. Therefore, the possibility of a weapon going astray and hitting an unintended target because of lost laser tracking, possibly due to aircraft threat reaction after the weapon release but before impact, is negated.

Weather

Weather can have a profound influence on the effectiveness of some PCS systems by degrading the ability of target-imaging sensors or platform-based sensors to see the target. Poor weather can render unusable some infrared-guided weapons and those relying on electro-opitical sensors, including LGBs.[5] Because of improvements in technology, not only can air and space forces perform their missions under ideal conditions; they can also increasingly operate in adverse circumstances. No longer does the nighttime provide a cover for adversary movement.[6]

However, the weather still poses a problem with striking targets. In Kosovo, Serbian military forces, well trained in concealment and deception used cloud cover to their advantage. The winter weather conditions over Kosovo led Admiral Ellis, the Joint Task Force (JTF)

commander, to comment that, "We may own the night, but the poor weather creates sanctuaries and operational lulls."[7] We have the capacity to control the air, and strike fixed targets with great precision. Our enemies will undoubtedly attempt to exploit any available sanctuaries from air attack.

The provision for global positioning system guidance for aircraft and munitions and the resolution of synthetic aperture radar reduces the problem historically posed by the weather to effective air strikes.[8] The B-2 with JDAM 82 offers a method to attack many point and small area targets rapidly, despite adverse weather conditions. If coordinates are available for the target, the B-2 can release a JDAM against that target with near-precision accuracy. In addition, the B-2 can identify, to some degree of accuracy, targets below weather using its synthetic aperture radar to refine or designate target coordinates. Such a capability holds enemy forces at risk whenever detected and identified in a fixed geographic position; i.e. whenever they stop moving. They would gain no respite from the covering clouds, just the worrying possibility that a GPS-guided weapon might be dropping towards them, at any moment.[9]

Enemy Air Defenses

Enemy air defenses can affect the utility of PCS systems by threatening the delivery platform, the weapon, or both. Defenses might be sufficiently heavy to rule out specific platform-munition combinations or require suppression ahead of time. Alternatively, they could influence the tactic necessary for safe delivery of the weapons, perhaps restricting approaches to less than optimal for weapon effectiveness.[10]

With the B-2's stealth capability, precision navigation, launch and leave weapons, such as the JDAM 82, electronic countermeasures, and automated mission planning to avoid known threats, the dilemma of balancing effectiveness with survivability has been minimized. This

qualitative new level of functionality allows air forces to achieve the effects of mass without the need to mass forces on the scale required for wars fought earlier in the century. Whereas in World War II it took 3,000 aircraft and 9,000 bombs to provide 90 percent assurance of destroying a target[11], it now takes as few as one aircraft and one bomb.

Intelligence

Limitations on the amount of targeting intelligence available may restrict or prohibit the practical employment of certain classes of PCS weapons in unplanned-for-scenarios. Poor intelligence could lead to striking the wrong target or sufficiently imprecise target coordinates, increasing the CEP and causing collateral damage.[12] The effective use of precision guided weapons requires various types of general information. High-resolution imagery of the target and precise coordinates help weapon planning, delivery, and assessment of collateral-damage potential to objects in the vicinity. Next, the determination of the appropriate weapon to use depends upon the desired effect versus the level of destruction. Finally, accurate multisource data determines damage, since functional kill can be difficult to assess using post-strike imagery alone.

Precision weapon employment requires intelligence of a sufficiently high order to determine a desired DMPI on an individual target. Some PCS weapons are very dependent on target imagery, such as systems using automatic target-recognition-algorithm for terminal seeker lock-on and certain man-in-the-loop systems that require imagery for final aimpoint guidance whiles others simply require coordinates of the target. Horizontal integration of present day intelligence sources such as JSTARS, Rivet Joint, satellites, U-2s, and numerous unmanned aerial vehicle (UAV) systems, including the RQ-1 Predator, provide the means for gathering imagery and coordinates. Target acquisition sensor assets available to air commanders during

AWOS were more varied and capable than what had been available during the Gulf War.[13] However, the enormous volume of information required as well as obtained can overwhelm the intelligence community and in turn, decrease the timeliness of intelligence information flow. Knowing the objective and prioritizing the ISR assets aids gathering the right target imagery and coordinates, decreasing the time from collection to strike. Once this information is gathered, targeting offers its particular challenges for appropriate use of precision weapons.

In the precision weapon era, there is far greater opportunity to target key nodes of a system for destruction, thus precluding a need for greater military effort and multiple strikes into high-risk areas. Obviously, to accomplish this requires, again, the closest possible connections between the targeting and intelligence communities. As Colonel Meilinger, former Commander of School of Advanced Airpower Studies, states: "Airpower is targeting, and targeting is intelligence." Targeting must examine the appropriateness of precision guided munition use against a particular target. Some targets may require precise weapon accuracy but not overwhelming destructive force. Destroying a target may require extra time and assets versus those required to just functionally disable a target. Intelligence must assess the desired outcomes of striking a target to ensure the effective utilization of limited assets. However, some targets, especially those covering large areas such as warehousing, truck parks, large industrial plants, and army formations in the open, where issues of collateral damage are not a concern, may well be more suitable for attacks by aircraft carrying large numbers of dumb bombs, area denial munitions, cluster munitions, fuel-air explosives, and the like. This is particularly true of troop formations, where the shock, noise, and dislocation of air attack has essentially a paralyzing and demoralizing effect upon troops all out of proportion, on occasion, to the actual physical destruction achieved. In the Gulf War, for example, the most feared attacker by Iraqi forces was

the B-52[14], a large capacity dumb-bomb-dropper capable of dispensing up to 33,750 pounds of ordnance, i.e. 45 M-117 general purpose bombs over a wide area.

No less significant is the importance of bomb damage assessment (BDA). BDA relates directly to campaign assessment and issues such as scheduling revisits to targets not considered sufficiently damaged. Intelligence personnel must conduct bomb damage assessment to determine if sufficient damage to the target occurred. Poor or no BDA can lead to unnecessary re-strikes against targets that have already sustained adequate damage. This was, together with intelligence collection and analysis, one of the most controversial aspects of the Gulf War. Failures in the intelligence and BDA process almost derailed the Gulf War air and land campaigns, and caused serious concerns in the minds of policy-makers as to whether their goals were being met.[15]

The intelligence requirement for establishing the number of DMPIs that one or more B-2s are capable of striking during a single mission can be extremely taxing on the intelligence process. With the B-2 carrying such a large number of weapons and having the ability to strike so many targets in one sortie, more rapid strike operations require greater intelligence information and coordination in a compressed amount of time. This may require a prioritization of ISR assets to collect the information, tasking already high demand assets. Although the JDAM 82 only requires coordinates to strike a target, the intelligence community still requires imagery to determine those coordinates. B-2 aircrew may also need the imagery if coordinates need increased accuracy via GAT, further tasking the intelligence community. The B-2 with JDAM 82 offers the intelligence community the versatility and flexibility to achieve various different effects due to its wide range of targeting capabilities and options. As for BDA, the JDAM does not provide any type of indication of success since it has no optical or infrared

terminal seeker. Other information gathering assets must help determine the damage of the target. Even then, the damage provided by photos may not be able to determine the extent of damage.

Mission Planning

Next to gathering intelligence to determine which targets to strike, mission planning may be the most perplexing and time consuming aspect of striking a large number of targets with a single aircraft. Mission planning a B-2 sortie with 80 different targets requires substantial modifications to the current mission planning process to keep the planning time at an acceptable level.

Before the B-2 specific mission planning begins, the air tasking cycle (ATO) must occur, providing the efficient and effective employment of air assets available. The Joint Air Operation Center (JAOC) identifies, prioritizes, and selects all potential targets that meet the JFC's objectives and guidance. The product of this process is the Joint Integrated Prioritized Target List (JIPTL), which provides the basis for weaponeering assessment activities. The final prioritized targets are then included in the Master Air Attack Plan (MAAP), which forms the foundation for the Joint ATO. This entire process takes 24 hours on a notional ATO cycle. Then, ATO development and dissemination occurs over the next 24 hours and is executed over the subsequent 24-hour period.

In order to plan for the large number of targets, the B-2 community must receive potential targets before the completion of the ATO to allow for required mission planning time and flight time to the AOR. During OAF, the time required to plan 16 targets per B-2 sortie required sending the targets to mission planners at Whiteman well before publication of the ATO. In addition, many times the B-2 launched, due to the range from the AOR, just hours before release

of the ATO. As the time to mission plan increases because of the increased targets per sortie, so does the amount of lead-time for getting targets to mission planners and before actual ATO release. This will leave little time for possible changes required prior to launch and may require the crew to make last minute changes when airborne to the targets.

Targeting and weaponeering includes choosing the desired mean point of impact (DMPI) for maximum effect with minimum collateral damage, choosing optimum impact angle and azimuth, and minimum number of weapons required. Targeting and weaponeering functions are normally provided by the Theater Battle Management Core System (TBMCS) and performed at the AOC. This is how it worked during OAF, with the exception of choosing impact and azimuth angle and number of weapons.[16] In the case of JDAM, the B-2 mission planner receives the target to strike and then chooses the weapon, generally the JDAM 84 or 109 during OAF and the weapon delivery options, which are then manually entered into the mission planning system.

Once B-2 mission planners receive target coordinates, minimizing the time required for inputting data into the Air Force Mission Support System (AFMSS) will largely depend on automation and the method for employing the JDAM 82. For example, the number of target complexes per mission, number of JDAMs released on each complex, number of area desired mean point of impacts, DMPIs spread evenly over an area (e.g., runway, large warehouse complex, etc.), versus single point DMPIs per complex all impact the time required to plan a mission. Enhancing the JDAM aircraft/weapons/electronics (A/W/E), or avionics software, to calculate DMPI locations for area targets based on a user-defined pattern and known mensurated location(s) will help the process. Truly distinct point targets will require mensurated locations for each DMPI.[17] A paper study shows the time to plan an 80 DMPI mission with three area targets with the current mission planning configuration is 2 hours and 42 minutes. With

automated target coordinates generation added to the process, the time can be cut to 55 minutes.[18]

There are numerous planning tools proposed to decrease the mission planning time but of course, the key is to acquire these tools. One target area-planning tool is a DMPI calculator for area targets that would either calculate a pattern (target size and DMPI spacing known), calculate target area size (pattern and DMPI spacing known), or calculate DMPI spacing (pattern and target size known). With location of target area center missing, another useful tool might calculate new latitude/longitude by applying a distance to a known latitude/longitude along a specified course. A scenario for this tool is striking a runway and evenly spacing weapons on both sides of the runway to effectively cut the runway and limit the enemy's use. This could also be used to determine impact points for a parallel runway and taxiway combination. In addition, probability of damage calculations such as Joint Munition Effects Manual (JMEM) type calculations could save time. Other time savers envisioned are JDAM A/W/E DMPI duplication capability, copying an existing DMPI as starting point for new DMPIs, interfacing with existing DMPI extraction systems (e.g., Raindrop), and further utilization of Precision Guided Munitions Target Database (PGMTDB).[19]

Aircrew Workload

The workload going from delivering 16 JDAM to 80 can be quite high. B-2 aircrews were close to maximum task-load during Kosovo operations when required to identify targets with radar and designate on each target. It was generally accepted that, under current pilot vehicle interface (PVI), eight DMPIs were about the maximum for a GAT maneuver. In addition, when B-2 aircrew were asked to flex, switch from primary to secondary popup targets, the workload increased due to the required procedures for creating the target in the aircraft's computers. Then

setting parameters for weapon release and strike increased the workload further. Studies are underway by contractors for hardware and software changes on the B-2 to enhance the PVI for weapon delivery. Information entry must be made easier to enter and more available to increase pilot situational awareness. These are not insurmountable tasks. Before now, the need for better interface was not envisioned to this extent. Coming from a cold-war environment where one weapon was released at a time, the need for multiple target identification in a short span of time was not required. Now the future requires the capability to deliver large quantities of weapons in a short period to avoid revisiting target complexes multiple times.

Cost

Perhaps more intriguing, precision weapons themselves become a justification and means to acquire more cost-effective precision-weapon platforms that can radically transform the capabilities of a nation to project power and influence, even when compared to other forms of precision attack. For example, a single sortie by a B-2A carrying 80, JDAM 82 can strike 80 targets at a pure weapon cost of $20,000 per weapon. A nonstealthy Boeing B-52H Stratofortress carrying 20 conventional air-launched cruise missiles (CALCM), 3,000-pound class weapons, is capable of striking only 20 different targets. The cost differential of the weapons alone is $1.6 million for the JDAM vs. $23.2 million for the CALCMs ($1.16 million per weapon), for fewer targets struck. Bring the number of targets for the B-2 with JDAM 82 down to 20 by releasing 4 JDAM 82 per target to increase the mass on each target and the cost differential is still 15 times more for the CALCMs assuming the target does not require a 3,000-pound warhead.[20] Such cost savings, whether accumulated by substituting precision weapons for other less cost-effective precision weapons that may demand larger infrastructure investment or sortie generation, or by substituting precision weapons for large numbers of dumb weapons

demanding even larger infrastructure, sortie, and even force-structure investment, can thus constitute a powerful and significant argument for development of sophisticated multi-mission attackers, particularly stealthy ones, such as the B-2.[21]

Each of these influences to operational employment of a weapon system, particularly the B-2 with JDAM 82, helps determine the best weapon system to use for a desired effect. The near-precision capability of the JDAM 82 employed from the B-2 minimizes collateral damage while maintaining all-weather capability. Stealth technology of the B-2, combined with standoff capability of the JDAM 82, avoids dense enemy air defense systems and allows deep strike within the adversary's territory. Intelligence resources provide the vital link between a complex and time consuming mission planning process, and putting weapons on precise coordinates. Finally, cost may be the determining factor when deciding to use the B-2 and JDAM 82. The next section provides scenarios for actual employment that incorporates aspects of each of the influences.

Notes

[1] Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold Was Military Strategy.* RAND Corporation. National Defense Research Institute. 1996. xiii-xiv.

[2] Hallion, Richard P. "Precision Guided Munitions and the New Era of Warfare." AIR POWER History 43, no. 3 (Fall 1996): 5-21.

[3] Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold War Military Strategy.* RAND Corporation. National Defense Research Institute. 1996. 12-13.

[4] Stevenson, Chad, Major. Wing Weapons Officer, 509th Bomb Wing, Whiteman AFB.

[5] Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold War Military Strategy.* RAND Corporation. National Defense Research Institute. 1996. 13.

[6] Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997, 9.

[7] Evan, Thomas C. "The Future of All-Weather, Rapid Reaction Precision Targeting." Research Report at Air Command and Staff College. Maxwell AFB, AL. April 2,000. 2.

[8] Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997, 9.

Notes

[9] Evan, Thomas C. "The Future of All-Weather, Rapid Reaction Precision Targeting." Research Report at Air Command and Staff College. Maxwell AFB, AL. April 2,000. 2.

[10] Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold War Military Strategy.* RAND Corporation. National Defense Research Institute. 1996. 13.

[11] Gouré, Daniel, and Stephen A. Cambone. *Air and Space Power in the New Millennium.* Edited by Daniel Gouré and Christopher M. Szara.. Washington D.C.: The Center for Strategic and International Studies, 1997, 16.

[12] Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold War Military Strategy.* RAND Corporation. National Defense Research Institute. 1996. 14.

[13] Evan, Thomas C. "The Future of All-Weather, Rapid Reaction Precision Targeting." Research Report at Air Command and Staff College. Maxwell AFB, AL. April 2,000. 9.

[14] Hallion, Richard P. "Precision Guided Munitions and the New Era of Warfare." AIR POWER History 43, no. 3 (Fall 1996): 5-21.

[15] ibid.

[16] Briefing. 509th Bomb Wing. Subject: JDAM MK-82 Mission Planning TIM. 14 December 2000.

[17] ibid.

[18] Briefing. 509th Bomb Wing. Subject: Targeting Flow Architectures for B-2/JDAM Mk 82. 14 December 2000.

[19] Briefing. 509th Bomb Wing. Subject: JDAM MK-82 Mission Planning TIM. 14 December 2000.

[20] Federation of American Scientist. "AGM 86C/D Conventional Air Launched Cruise Missile" and "B-52 Stratofortress" Cost assessment analyzed by information on the AGM-86C and B-52. The unit cost of the CALCM considers the original $1 million for the AGM-86B and $160,000 to convert to a Block IA AGM-86C. The estimated cost of the JDAM 82 is $20,000 per tail-kit. On-line. Internet, 20 March 2001. Available from http://www.fas.org/man/dod-101/sys/smart/agm-86c.htm and www.fas.org/nuke/guide/usa/bomber/b-52.htm.

[21] Hallion, Richard P. "Precision Guided Munitions and the New Era of Warfare." AIR POWER History 43, no. 3 (Fall 1996): 5-21.

Chapter 4

B-2A and JDAM 82 in Action

> *So, from the sky in the aerospace medium, we will be able to converge on a multitude of targets. We will be able to envelop our adversary with the simultaneous application of air and space forces. The impact will be the classic ways you win battles--with shock and surprise. Shock and surprise. Every major turn in the history of warfare has come from the introduction of shock and surprise. It won't just be at the tactical level, but at the operational and strategic level as well. (Air Force Association, Orlando, 24 Feb 95)*
>
> —General Ronald R. Fogleman, Retired

This section provides scenarios for employment of the JDAM 82 from one or more B-2s at different levels of targeting. The first two scenarios involve striking a large number of strategic and operational targets in much the same way bombers have always attacked targets with the exception of more targets per sortie now. The third scenario, flex-targeting, uses a dynamic targeting capability demonstrated during Operation ALLIED FORCE.

There are many options for dividing the number of JDAM 82s carried on a single sortie between either one target complex or between many. The air operations center staff must select appropriate complexes. One choice would be large target complexes with many individual aimpoints. Examples include airfields, factories, transportation nodal points, utilities, munitions storage areas, troop garrisons, logistics depots, troop concentrations. A typical airfield has a large number of potential aimpoints to be attacked including: runways, taxiways, aircraft parking areas, revetments/hardened aircraft storage, hangars, refueling pit/equipment, fuel storage, operations buildings, tower, C3 facilities, maintenance shops, AGE, munitions areas, instrument

landing aids, emergency equipment, etc. A second choice would be several medium size target complexes, each of which has 10-20 DMPIs. Another choice would be to use the B-2 in an airborne alert/loiter mode to respond to targets of opportunity with the right weapon. This could easily be tasked as an addition to a normal bombing mission because of the very large number of bombs carried on the SBRA.[1] However, if the B-2 loiters, then other assets may also have to loiter to ensure support.

CONOPS Assumptions

When discussing some of the concept of operations options for employment of the JDAM 82 from the B-2, certain assumptions are made. First, the limited number of B-2s and the demand for its capabilities make it similar to a low density/high demand asset, although not categorized that way. Second, it is important for the B-2 to operate both day and night, with or without jamming support, although support is preferred. Finally, the primary tasking of the B-2 will always be against high value, highly defended and normally deep targets. In addition, some assumptions are made about future upgrades for the B-2, which are on the way, such as an in-flight replanner, 10-inch display for added situational awareness, capability to change weapon fuse settings in-flight, planning and communication upgrades necessary for JFACC retasking, and C^4ISR systems continue to develop.

Employment Scenario 1 – First Night Shock Effect

Major Scott D. West, a graduate of the School of Advanced Airpower Studies, describes Colonel John Warden's theory on using parallel attack to reduce the enemy's capacity to attack. Parallel attack is the rapid, simultaneous attack of the enemy's centers of gravity. It "deprives [the enemy leadership] of the ability to respond effectively, and the greater the percentage of targets hit in a single blow, the more nearly impossible his response.[2] Via parallel attack, an

enemy with a small number of strategic targets and the inability to quickly repair or replace them can easily become incapacitated. The first employment scenario involves using the B-2 much the same way as with JDAM 84 except now the B-2 can target 80 DMPIs versus 16. Since the JDAM 82 can successfully attack about 80 percent of the target set that the JDAM 84, 2,000-pound bomb is targeted against, the potential exists to damage a great many times the number of enemy targets per B-2 sortie.[3] Depending on the overall size of the attacking force, the JFACC could design an extremely "intense" initial air campaign. Such a concentrated attack can serve to get the enemy's attention quickly, as well as to conserve friendly forces by placing fewer of our aircraft and crews at risk. A large number of targets assigned to a single aircraft will be very useful to the planners, who must apportion the friendly forces, especially during the buildup phase, when there are fewer assets to task in the ATO. Depending on the number of B-2s tasked, targets could range throughout the entire AOR including command and control, fielded forces, storage facilities, utilities, communication, etc. The key is to make the first strike an overwhelming blow to the enemy's will and/or capability to continue. The potential exists for the enemy to lose many more targets per B-2 sortie than before, which could convince the enemy to capitulate immediately and help to shorten the conflict and avoid casualties on both sides.

This scenario minimizes many of the problems associated with the influences to precision strike. Depending upon the preparation time for such a strike, intelligence sources can identify and ensure the accurate coordinates of fixed targets in order to minimize collateral damage. Since this may be the initial and only action in the AOR, all available intelligence assets can be focused on this operation. Weather has little impact on this operation with the exception of a thunderstorm enroute or over the AOR. In addition, using the element of surprise to deliver such a massive first blow reduces the likelihood that air defense assets will be alerted to the strike.

The minimum required number of personnel involved in such a strike also reduces the possibility for a breach of operational security. This mission can originate from the United States and return due to the B-2's long-range capability, again adding to surprise. Since an operation of this magnitude might be planned over several days or weeks, the time crunch of mission planning is not as compressed. As for crew workload, anytime a single B-2 attacks as many as 80 different targets, the workload will be high. Keeping the workload manageable depends on the accuracy of the coordinates, the number of target complexes, and the requirement for a GAT on some of the DMPIs.

Employment Scenario 2 - Strategic Campaign - Large Target Complex

Perhaps the most appealing option is to attack a large target complex with 80 weapons. Such an attack would severely degrade any of the large targets: airfields, ports, railyards, refineries, factories, etc. This is true even if some of the DMPIs required more than one weapon for desired damage level. With new software programs for the SBRA, up to ten weapons may be released on a single DMPI. The release will take approximately 13 seconds, allowing enough time to release all 80 weapons in a relatively confined area. An airfield provides a good example containing runways, taxiways, C^3, LOC, IADS, WMD, etc., all which could be destroyed in a single mission by multiple B-2s carrying a variety of weapons including JDAM 82. Likewise, rapid destruction of entire systems such as utilities, communications or transportation, becomes an option. An example is against above ground petroleum, oil, and lubricant (POL) tanks and offload points. The destruction of the above ground storage at airfields and offload points of a notional country such as Iran, would severely hamper the enemy's military operations.

There are some requirements associated with dropping such a large number of weapons in such a short period. The pilots who flew in Operation Allied Force found that their ability to

perform the GAT target refinement actions on a single pass was limited to about eight DMPI, even though the system allows GATing 16 DMPIs. Therefore, all target coordinates in such a complex must minimize TLE since a GAT maneuver would not be available for all DMPIs. This limitation is mitigated by the fact that most of the DMPIs in these type complexes suitable for a 500-pound weapon are "soft" targets, and the GPS/INS accuracy is sufficient for considerable damage. Of course, multiple B-2s can attack complexes with greater than 60-80 DMPIs to ensure visiting the complex only once.

Some of the major influences to consider in this scenario, besides aircrew workload, include intelligence and mission planning. Target lists for such large area targets are readily available and therefore may not over-task the intelligence resources unless no imagery is available for a particular complex. This also becomes a simple target for the AOC planner since they can task one or two B-2s against it and reduce deconfliction requirements with other assets in the AOR. However, mission planning still takes a moderate amount of time to input all the DMPIs and the data associated with each weapon, although the time required is less than if routing were required for multiple complexes on the same sortie. Collateral damage around such targets may be a lower concern since these large target complexes contain few non-military viable structures. However, air defense systems around such areas are usually more dense due to the enemy's desire to protect its military capability.

Employment Scenario 3 – Flex-Targeting

In the Air Command and Staff College research paper, *Dynamic Targeting Are We Ready*, Major Kevin Fox describes time-critical targeting, dynamic-targeting, or flex-targeting, as the unplanned prosecution of a target that is lucrative, fleeting or a high priority to friendly forces. Examples of dynamic targets include mobile rocket launchers (MRLs), weapons of mass

destruction (WMD), mobile high-threat surface-to-air missiles, and mobile command and control vehicles. These targets are not stationary in the area but dynamic, always moving about the area of operation.[4] Time-critical-targets are dynamic targets that the JFC upgrades the priority for striking and will require immediate attack to seize the tactical initiative. Strides in gaining capability to target these forces made great leaps during OAF. Present day intelligence sources such as JSTARS, Rivet Joint, satellites, and UAVs provide the means for gathering these coordinates. If the location of the enemy is known and precise coordinates determined, a bomb can be delivered through any weather at any time.[5]

The B-2 performed flex-targeting during OAF, demonstrating the ability to attack alternate targets while enroute to their primary targets. Given the range, loiter, and ordnance capability of the B-2, especially carrying 80 JDAM 82s, the AOC planners can consider the aircraft for a search and destroy mission. With the vast weapons load, each B-2 can perform this mission with little degradation to its preplanned mission. To have the most flexibility, the AOC personnel would want to be able to direct the B-2 to fly a revised routing either created in flight or passed to the aircraft from the ground. This capability is essential to operate in a mobile threat environment. The current modernization program for the B-2 envisions installing Link16, ten-inch display, and an in-flight re-planner.[6] These upgrades, combined with improved performance and readability of the defensive management system display, will allow the aircrew to prosecute short dwell targets that the intelligence preparation of the battlefield indicates will have a reasonable probability of being found, fixed and tracked by the ISR system while the B-2 is flying through the area deep in enemy territory. If they are not located, the B-2 will attack pre-planned targets.

In order for optimum employment of JDAM, the aircrew will need to either have mensurated coordinates or be able to identify the target image on radar. The former requires at least ten minutes today using RAINDROP, an imagery mensurating tool. However, the Air Force has funded the Enhanced Precise Positioning Integrated Capability (EPPIC) project, with the goal of reducing the mensuration process on the ground to two minutes, regardless of the ISR product used to identify the target.[7] The latter, using B-2 radar, requires an image to be transmitted to the crew, a process which has been demonstrated using Link 16, but is time consuming and uses a lot of bandwidth. However, in many cases, the required probability of damage may be possible by using multiple JDAM against an unmensurated DMPI, assuming collateral damage is not a factor. The B-2, carrying 80 JDAM 82, gives the AOC operators a wide range of flexible options.

This scenario requires the greatest effort across all of the influences in order to put a JDAM on a time-critical target. Mission planners must build extra DMPIs into the mission for possible flex-targets increasing the total time required to complete the mission. Aircrew must prepare to strike various targets increasing workload. The potential for collateral damage goes up due to the dynamic nature of identifying mobile targets in such a short period and possibly in confined areas. Air defense becomes a bigger issue since the B-2 might need to diverge from planned routing and possibly move closer to threats originally routed around. Finally, the greatest increase in effort comes from the intelligence gathering assets that must detect, identify, accurately fix the location, and then pass the coordinates to the B-2 for attack. Then the crew must go through the process of building the target, moving the aircraft within range while avoiding threats, and then releasing the weapon. All of this must occur in a short duration before the target moves again.

These scenarios provided only a glimpse of the many operational uses for the B-2 employing the JDAM 82 as well as potential impacts of the influences discussed. Although there are limitations in intelligence preparation, mission planning, and even the preciseness of the JDAM 82, the ability to make every weapon hit a desired target versus open dirt gives a single B-2 enormous destructive potential.

Notes

[1] Briefing. 509th Bomb Wing. Subject: Concept of Operations for JDAM 82 Employment on the B-2A. December 2000.

[2] West, Scott D. "Warden and the Air Corps Tactical School Déjà Vu?" School of Advanced Airpower Studies. Maxwell Air force Base, Alabama. October 1999. 13-14.

[3] Briefing. 509th Bomb Wing. Subject: Concept of Operations for JDAM 82 Employment on the B-2A. December 2000.

[4] Fox, Kevin L., Major. *Dynamic Targeting Are We Ready?* Air Command and Staff College, Maxwell AFB, Alabama. April 1999. 2-3.

[5] Evan, Thomas C. "The Future of All-Weather, Rapid Reaction Precision Targeting." Research Report at Air Command and Staff College. Maxwell AFB, AL. April 2,000. 9.

[6] Briefing. 509th Bomb Wing. Subject: Concept of Operations for JDAM 82 Employment on the B-2A. December 2000.

[7] Ibid.

Chapter 5

Summary

The ability to deploy one's own forces more effectively and across a wider target set creates the opportunity for precision strike campaigns. The breakthrough in precision targeting is less "one pass, one kill" than the potential to conduct many discrete passes with discrete kills simultaneously across the entire theater battlespace. Consequently, rather than having to concentrate forces against sets of high-priority target in series, United States air and space forces can use smaller numbers of systems to cover greater numbers of targets simultaneously. These factors, coupled with the inherent reach of modern air and space platforms, mean that air and space power, from the attacker's perspective, can be anywhere, and from the adversary's perspective, is everywhere.[1]

The B-2's long range, large payload, and stealth capabilities coupled with the JDAM 82's all-weather near-precision accuracy open many doors to conceptualize operations involving their use and address many influences to precision strike. The shear number of weapons available allows for varied delivery options from attacking many target sets to attacking a single complex with many individual targets. Likewise, as long as coordinates of a target can be accurately determined, the B-2 can flex to time-critical targets with minimum notice. The near-precision accuracy of the JDAM 82 and the reduced warhead help minimize the prospects of collateral damage. Weather no longer provides a safe haven for the adversary who conceals movement

below the clouds. In addition, stealth technology reduces the effectiveness of enemy air defenses and increases the vulnerability of the enemy.

However, there are tradeoffs to increasing the number of targets assigned to a single sortie. Intelligence requirements increase and time required to receive, interpret, and disseminate information is compressed. Likewise, the added number of targets increases the amount of lead-time required for mission planners to complete the mission before aircraft launch. Finally, depending on the accuracy of the target coordinates and the enroute changes to targets, the aircrew workload may increase.

Combining the B-2 with the JDAM 82 adds flexibility and versatility to the war planner's options for waging war from the air. Increase the number of targets that a single aircraft can attack on a single sortie with unquestionable success, and the principle of mass takes on an entirely new dimension.

Notes

[1] Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997, 16.

Glossary

A/W/E	Aircraft/Weapons/Electronics
AFMSS	Air Force Mission Support System
AOC	Air Operations Center
ATO	Air Tasking Order
AWOS	Air War Over Serbia
BDA	Bomb Damage Assessment
BRA	Bomb Release Assembly
CAOC	Combat Air Operations Center
CEP	Circular Error Probable
CONUS	Continental United States
DMPI	Desired Mean Point of Impact
GAT	GPS Aided Targeting
GPS	Global Positioning System
IADS	Integrated Air Defense System
INS	Inertial Navigation System
ISR	Intelligence, Surveillance, and Reconnaissance
JAOC	Joint Air Operations Center
JDAM 109	2,000-Pound Penetration Joint Direct Attack Munition
JDAM 82	500-Pound Joint Direct Attack Munition
JDAM 83	1,000-Pound Joint Direct Attack Munition
JDAM 84	2,000-Pound Joint Direct Attack Munition
JDAM	Joint Direct Attack Munition
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JPITL	Joint Prioritized Integrated Target List
JSTARS	Joint Surveillance Target Attack Radar System
JTF	Joint Task Force
LOC	Lines of Communication
OAF	Operation ALLIED FORCE
PCS	Precision Conventional Strike
PVI	Pilot Vehicle Interface
SAR	Synthetic Aperture Radar
TBMCS	Theater Battle Management Core System
TLE	Target Location Error
UAV	Unmanned Aerial Vehicle
WMD	Weapons of Mass Destruction

Bibliography

"Boeing Awarded $45 Million for 500-pound JDAM Development." Boeing Web Site, BOEING Company, Saint Louis, September 29, 2000, n.p. On-line. Internet, 20 March 2001. Available from www.boeing.com/news/releases/2000/news_release_000929n.htm.

"JDAM Program Background." JDAM Program Office Website, On-line. Internet, 20 March 2001. Available from www.eglin.af.mil/jdam/jdam/info/info-main.html.

Birkler, John, et al. *A Framework for Precision Conventional Strike in Post-Cold Was Military Strategy*. RAND Corporation. National Defense Research Institute. 1996

Briefing. 509th Bomb Wing. Subject: JDAM MK-82 Mission Planning TIM. 14 December 2000.

Briefing. 509th Bomb Wing. Subject: Targeting Flow Architectures for B-2/Jdam Mk 82. 14 December 2000.

Briefing. 509th Bomb Wing. Subject: Concept of Operations for JDAM 82 Employment on the B-2A. December 2000.

Circular Probable Error. Encyclopedia of Statistical Sciences. Vol. 1. A Wiley-Interscience Publication, John Wiley and Sons. 1982. 479.

Evan, Thomas C. "The Future of All-Weather, Rapid Reaction Precision Targeting." Research Report at Air Command and Staff College. Maxwell AFB, AL. April 2,000.

Federation of American Scientist. On-line. Internet, 20 March 2001.

Fogleman, Ronald R. "Getting the Air Force into the 21st Century (remarks delivered to the U.S. Air Force Association's Air Warfare Symposium, Orlando, Fla., February 24, 1995), n.p. On-line. Internet, 20 March 2001. Available from http://www.af.mil/news/speech/current/Getting_the_Air_Force_into_.html.

Fox, Kevin L., Major. *Dynamic Targeting Are We Ready?* Air Command and Staff College, Maxwell AFB, Alabama. April 1999. 2-3.

Gouré, Daniel, and Christopher M. Szara. *Air and Space Power in the New Millennium*. Washington D.C.: The Center for Strategic and International Studies, 1997.

Hallion, Richard P. "Precision Guided Munitions and the New Era of Warfare." AIR POWER History 43, no. 3 (Fall 1996): 5-21.

House of Representatives. Performance of the B-2 Bomber in the Kosovo Air Campaign: Hearing before the Military Procurement Subcommittee on the Committee on Armed Services. 106th Cong., 1st sess., 1999. 1-10.

Jackson, Jeffrey A. *Air and Space Power in the New Millennium*. Edited by Gouré, Daniel, and Christopher M. Szara. Washington D.C.: The Center for Strategic and International Studies, 1997, 111.

Stevenson, Chad, Major. Wing Weapons Officer, 509th Bomb Wing, Whiteman AFB.

West, Scott D. "Warden and the Air Corps Tactical School Déjà Vu?" School of Advanced Airpower Studies. Maxwell Air Force Base, Alabama. October 1999.