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IMPROVING NATO's INTEROPERABILITY

THROUGH U.S. PRECISION WEAPONS

BY

MAJOR TODD C. WESTHAUSER

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Preface

Major Todd C. Westhauser (BS, USAF Academy; MAS, Embry-Riddle Aeronautical University) is an Air Force senior pilot with 2,700 hours of experience in the B-52H and B-1B. A recent graduate of the School of Advanced Airpower Studies, he is assigned to the Air Staff, Checkmate Division, the Pentagon. As a graduate of USAF Weapons School and Air Command and Staff College, his previous assignments include B-1B Chief of Weapons and Tactics at Ellsworth AFB, South Dakota and B-52H Standardization and Evaluation pilot at Carswell AFB, Texas.

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I thank Dr. David Mets and Dr. Harold Winton for their excellent guidance and support in helping me create this thesis. I also thank Major Jay Kreighbaum for all the information he provided concerning the Joint Direct Attack Munition (JDAM). Finally, I thank Major Tim Lindemann who acted as a sounding board for many of my thoughts about air strategy.

Abstract

The U.S. has combined advances in stealth, information integration, and precision-guided munitions (PGMs) to produce significant lethality in its air forces. These advanced weapon systems are contributing to a widening technology gap between the United States and its allies. This widening gap has raised concern in NATO as it considers expanding its membership. After making some reasonable assumptions on what NATO countries are capable of affording and procuring, it appears that NATO can most readily increase its precision weapons capability to narrow the technology gap. This paper compares and contrasts two U.S. advanced precision weapons capabilities, the Paveway LGBs using "buddy-lasing" tactics and the JDAM, against the criteria of training, cost, interoperability, and force multiplication. With the present NATO force structure, it appears that in the short-term the Paveway LGB "buddy-lasing" tactic offers the best solution; the JDAM is a better investment in the long-term. By procuring these options, America's allies should be able to play a larger role in NATO operations.

Chapter 1

NATO's Widening Technology Gap

> *The most important thing is to have a flexible approach…The truth is no one will know what air fighting will be like in the future. We can't say anything will stay as it is, but we also can't be sure the future will conform to particular theories, which so often, between the wars, have proved wrong.*
>
> —Robin Olds

When examining the capabilities required for success at the high-end of conventional conflict, one finds the United States as the world leader. The U.S. has combined advances in stealth, information integration, and precision-guided munitions (PGMs) to produce significant lethality in its air forces. Both Operations Desert Storm and Deliberate Force demonstrated the effectiveness of these integrated capabilities. Today, the U.S. is designing these technologies into its newest aircraft such as the F-22 and the Joint Strike Fighter (JSF). These and other advanced weapon systems are contributing to the widening technology gap developing between the United States and its allies. This widening gap has raised concern in NATO as it considers expanding its membership.

The NATO leadership is concerned about the effectiveness of its alliance as significantly disparate capabilities develop among its members. The present U.S. Ambassador to NATO, Robert Hunter, recently highlighted this concern during a speech given in Washington, D.C. where he noted that NATO is moving toward a three-tiered membership. He stated that the United States would reside on the top tier having the capability to perform all military missions. The second tier would consist of the close European allies capable of performing only some of the required missions. Finally, the bottom tier would contain the new NATO members who are not trained or equipped to execute western style warfare.[1] A three-tiered NATO could create tension among the member states with the risk that some states would not share the defense burden during a conflict.

The end of the Cold War has exacerbated this widening technology gap. During the Cold War, NATO forged a strong alliance against the Warsaw Pact. NATO's goal was “to preserve the status quo along the Elbe River [through] deterrence rather than compellence--having military power [but] not using it.”[2] The NATO countries and their differing capabilities united together creating an effective defense against the Soviet Union. Tension over the differing capabilities was not as apparent as it now is because NATO defended its own territory and enjoyed the advantage of interior lines of communication. With the demise of the Soviet Union and the Warsaw Pact, NATO has had to grapple with unprecedented challenges and previously unanticipated military operations. The concept of “out-of-area” operations and expeditionary forces evolved as NATO members participated in Operation Desert Storm and the alliance conducted Operation Deliberate Force. What NATO has witnessed, however, has been the dominance of military action by the U.S. with the relegation of many European members to peripheral roles.

NATO countries also witnessed the strength of U.S. airpower during the Gulf War. Only five of the sixteen member nations sent combat air forces to the region, which included the United States, the United Kingdom, France, Canada, and Italy. Of the total combat sorties[3] flown during the war, the U.S. flew 85-percent, the British 4.2-percent, the French 1.6-percent, the Canadians 1.3-percent, and the Italians 0.2-percent. A more interesting fact from a technological viewpoint was that only the United States, the United Kingdom, and France had the capability to employ precision-guided munitions.[4] The size and the technological capability of the United States dwarfed that of the other coalition members. Only Britain and France had anything resembling an expeditionary or "out-of-area" capability.

Likewise, European NATO countries realized they were not equipped to conduct a precision air campaign without the United States' leadership during the Bosnian conflict. During Operation Deliberate Force, eight NATO countries sent combat airpower to the theater. These included the United States, the United Kingdom, France, Germany, Italy, Netherlands, Spain, and Turkey. Only the United States, the United Kingdom, France, and Spain employed precision weapons. Of the 708 precision munitions employed, the U.S. dropped 88-percent, the U.K. dropped 6.7-percent, Spain dropped 3.3-percent, and France dropped 2.0-percent. The remaining countries either did not have the capability to use precision weapons or were politically restrained by their respective governments from participating in offensive bombing operations.[5]

The statistics from Desert Storm and Deliberate Force do not tell the entire story. The reason the U.S. flew the most sorties during the conflicts relates to it having the majority of the air assets in theater. In addition, it provided almost all the airlift, tanker, and electronic warfare support. Likewise, it operated almost all the strategic reconnaissance and surveillance assets. Some of the NATO countries such as Britain and France are technologically comparable with the U.S., but they do not have the economic base to support a significantly larger role. Therefore, depending on the conflict, the relegation of some countries to peripheral roles could be due to their own politics, the size of their military forces, or technological constraints. This study will focus on the technological limitations of the European NATO members' air forces.

The trends from Desert Storm and Deliberate Force coupled with the United States' continued improvements in advanced technologies have made some of the NATO allies ill-equipped to participate in the next conflict. This problem was brought to the attention of the U.S. Air Force's Air Combat Command (ACC) Commander, General Richard E. Hawley. He subsequently challenged the Air Force to address this problem and desired some innovative thinking on how best to use advanced weapon systems in coalition training exercises and operations to reduce this concern.[6] General Hawley was most interested with addressing the following systems: stealth aircraft such as the B-2, F-22, and JSF; information technologies provided by unmanned aerial vehicles (UAVs), Joint Surveillance Target Attack Radar System (JSTARS), and satellites; and advanced weapons to include Global Positioning System (GPS)-aided munitions, small precision weapons, and non-lethal munitions.[7]

In order to narrow the scope of General Hawley's request, it is important to understand how his systems of interest relate to considerations within the NATO alliance. Several ingredients are necessary for successful allied operations. First, the alliance requires a unified purpose or common political objectives. Second, the leadership needs the appropriate means to command and control the forces. Third, the allies require interoperable equipment to ease the logistical burden and increase fighting efficiency. Finally, the alliance should have common doctrine, tactics, and plans that focus training to create fighting capability.[8] General Hawley's systems of interest relate directly to equipment interoperability, command and control, and training. Ideally, the NATO alliance would best be served if all the members could procure interoperable weapon systems and command and control equipment. If this is not feasible, innovative procedures using existing capabilities must be developed to produce comparable results. Such solutions, however, require excessive training and coordination. Additionally, these makeshift solutions do nothing to narrow the widening technology gap.

Affordable interoperable equipment therefore offers the most realistic solution to address NATO's problem. Affordability is important to many of the smaller NATO countries. In terms of pure capital, the European NATO members' combined defense budget is only two-thirds that of the United States'.[9] Developing and maintaining formidable air forces is equipment intensive and expensive. Attempts by other countries to match current U.S. airpower capabilities would require investments made possible only through a strong economy and considerable wealth.[10] Even in a climate where the U.S. government is willing to sell advanced technological equipment to sustain its alliances and preserve its defense industrial base, allies will find that capabilities such as stealth and advanced information integration are unavailable and not affordable.[11]

Based on these facts, it is necessary to make some reasonable assumptions about the affordability and likelihood of NATO countries procuring advanced technologies. A reasonable assumption is that the allies will not fund and develop comparable stealth technology as employed by the U.S. Additionally, it is reasonable to assume that the allies will not fund all the components to produce information integration such as surveillance, reconnaissance, communications satellites, UAVs, and JSTARS. One can assume, however, that the U.S. will allow the allies access to integrated information and protection offered by its stealth assets. Essentially, the allies can afford to procure precision guided munitions. This seems the most reasonable way for the allies to bring a robust capability to an air campaign without depleting their respective defense budgets.

Because precision guided munitions appear to be the most reasonable technology for the allies to explore, it is prudent to identify affordable and versatile options. Precision weapons employ different guidance mechanisms to achieve the desired accuracy. These guidance mechanisms include laser, Electro-optical (EO), infrared (IR), and GPS-aided/inertial navigation system (INS). The least expensive and most used precision weapon in both Desert Storm and Deliberate Force was the laser-guided bomb.[12] EO and IR weapons were much more expensive and tended to serve unique targeting requirements. GPS-aided munitions offer the latest technology in precision weapons. These munitions are even more affordable than laser-guided bombs with improved versatility. Based on these considerations, the most promising precision weapons options for the NATO alliance appear to be the laser-guided bomb and the new GPS-aided munitions.

The purpose of this paper is to examine the best way for the NATO allies to use precision weapons in order to enhance their interoperability and contributions to future air campaigns. This paper compares and contrasts two U.S. advanced precision weapons to determine whether one, both, or neither of the options addresses General Hawley's concern.

The first option entails the use of laser-guided bombs (LGBs). Most NATO countries possess older generation western aircraft and some LGB capability. Some countries do not possess the autonomous laser-designating equipment needed to employ LGBs. These countries also have limited defense budgets, making the purchase of expensive upgrades unlikely. However, one possibility is to sell these countries additional LGBs and develop training programs in which they can work with allied countries that do have autonomous laser-designating equipment. The training programs can teach the tactic of "buddy-lasing." This tactic uses one aircraft to designate the target while another aircraft drops the weapon. "Buddy-lasing" has been practiced since Vietnam and offers a possible solution that can increase each country's offensive bombing capability.

The second option entails using GPS-aided munitions. The U.S. could sell its NATO allies the latest weapon using this technology called the Joint Direct Attack Munition (JDAM). The JDAM may provide the allies with a relatively autonomous near-precision weapon capability. Through minor coordination with the United States' advanced information technologies, the allies could bring a substantial offensive near-precision weapon capability to the next conflict.

These two options will be judged against four criteria: training, cost, interoperability, and force-multiplication. First, the analysis assesses the extent of training required for each option. Second, it compares the associated costs. Third, it determines the degree that each option increases or decreases the interoperability among the allies. Finally, it examines the extent to which each can enhance an air component commander's offensive bombing capabilities. Answers to these questions will lay the groundwork for a recommendation concerning each option's overall value.

This paper is organized as follows. Chapter Two addresses the current United States' policies toward alliances and precision weapons engagement. This includes the vision from the President's *National Security Strategy* down through the Air Force's Basic Doctrine. Chapters Three and Four address the capabilities and limitations of each option: the LGB "buddy-lasing" tactic and the GPS-aided JDAM, respectively. Chapter Five compares and contrasts the two options against the four criteria--training, cost, interoperability, and force-multiplication--and offers an overall assessment. The final chapter addresses implications of precision weapons on future U.S. strategy, the possibility of international defense collaboration on producing future precision weapons, and ideas about how the NATO allies could increase their role in the defense of Europe and Southwest Asia.

This paper should be of interest to airmen because it examines the enduring topics of technology and alliances in warfare. Airmen have always had a fascination with technology. Similarly, Americans have seldom fought a conflict without an allied or coalition partner. This paper will highlight how America's advanced technological capabilities can be used as a force-multiplier to enhance cooperation and the effectiveness of allied warfare. This paper is unique in that it ties tactical concepts of advanced weaponry to strategic concerns of building proper alliances to achieve overall political objectives.

Notes

[1] Barbara Starr, "USA Warns of Three-tier NATO Technology Rift," *Jane's Defense Weekly* 28, no. 13 (1 October 1997): 4.

[2] Josef Joffe, "Is There Life After Victory? What NATO Can and Cannot Do," *The National Interest*, Fall 1995, 21.

Notes

[3] The author defines combat sorties as interdiction, close air support, combat air patrol, and offensive counter air when using the comparative percentages between NATO countries during Desert Storm.

[4] Major Lewis D. Hill et al., *Gulf War Air Power Survey,* vol. v, *Statistical Compendium and Chronology,* (Washington, D.C.: Department of the Air Force, 1993), 42-45, 232-233. Statistics were extrapolated from text and tables found on these pages.

[5] Lt Col Rick Sargent, "Weapons and Tactics," in *Balkans Air Campaign Study* (Forthcoming), ed. Col Robert C. Owen (Maxwell AFB, AL: School of Advanced Airpower Studies, 1997), Ch. 9. Percentages calculated from numerical data presented within chapter.

[6]Letter from Lt Gen Brett M. Dula, Vice Commander of ACC, to commander, Air University, subject: Interoperability with Allied Forces (Attachment 2), 2 Oct 1997.

[7] Ibid.

[8] Commander Juan Carlos Neves, "Interoperability in Multinational Coalitions: Lessons from the Persian Gulf War," *Naval War College Review* 48, no. 1 (Winter 1995): 50-61.

[9] David C. Gompert and Richard L. Kugler, "Rebuilding the Team: How to Get Allies to Do More in Defense of Common Interests," RAND Issue Paper (Santa Monica, CA: RAND, September 1996), 2.

[10] Christopher J. Bowie, et al., *Trends in the Global Balance of Power* (Santa Monica, CA: RAND, 1994), xiii-xvi. The study analyzed airpower from the perspective of fixed-wing aircraft, helicopter, surface-to-air missiles, cruise missiles, and ballistic missiles. The study realized this was not a perfect metric due to effective airpower also relies on other elements such as command, control, and surveillance capabilities in addition to highly trained personnel. While other countries presently do not have the wealth to match the U.S. symmetrically, potential adversaries are looking to exploit asymmetric avenues.

[11] Lt Col Michael N. Beard, "United States Foreign Military Sales Strategy: Coalition Building or Protecting the Defense Industrial Base," (Research Report, Air War College, March 1995), 27.

[12] Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis MD: Naval Institute Press, 1995), 280-281. During Desert Storm, the U.S. dropped a total of 9,342 laser-guided bombs (LGB) and 5,448 EO/IR missiles (and some bombs). The unit cost for a basic LGB ranges from $9,000 to $22,000. Some special LGBs designed for particular targets cost as much as $150,000. The unit cost of basic EO/IR weapons ranges from $64,000 to $110,000 with some specially designed versions costing as much as $270,000. Also, Sargent, *Balkans Air Campaign Study*-(Forthcoming). Of the total of 708 precision weapons employed during Deliberate Force, 653 were LGBs while only 42 were EO/IR weapons.

Chapter 2

U.S. Strategy, Vision, and Doctrine

> *Understanding requires theory, theory requires abstraction; and abstraction requires the simplification and ordering of reality…. Obviously, the real world is one of blends, irrationalities, and incongruities; actual personalities, institutions, and beliefs do not fit into neat logical categories. Yet neat logical categories are necessary if man is to think profitably about the real world in which he lives and to derive from its lessons for broader application and use.*
>
> —Samuel P. Huntington

This chapter analyzes the importance of alliances and technology to the U.S. national security. In particular, it focuses on the NATO alliance and the advanced technology of precision weapons. By using the "strategy-to-task"[1] methodology, this chapter highlights what the *National Security Strategy*, the *National Military Strategy*, *Joint Vision 2010*, *Global Engagement*, and *Air Force Basic Doctrine* envision as the roles of alliances and precision engagement for America's security.

National Security Strategy

The strategy for America's national security is built upon three core objectives. The first is enhancing security through effective diplomacy and military forces that are ready to fight and win. The second is bolstering economic prosperity; and the third is promoting democracy abroad.[2] To achieve these objectives, the strategy anticipates that America may act unilaterally, especially if vital interests are at stake. The strategy also accepts the reality that America may not be able to achieve these objectives alone. Effective, mutual relationships with allies and other friendly nations are central to our security. "Accordingly, a central thrust of our strategy is to strengthen and adapt the security relationships we have with key nations around the world and create new structures when necessary."[3] The President understands that achieving our national objectives requires strong relationships with other countries that share our goals of peace and prosperity.

The *National Security Strategy* provides guidance to the armed forces concerning what types of capabilities to maintain. The strategy states that "our military forces will have the ability to respond to challenges short of war, and in concert with regional friends and allies, to win two overlapping major theater wars."[4] To accomplish these tasks, the armed forces must be able to transition from current small-scale deployments, such as those in Bosnia and Macedonia, to fighting a major theater war. Withdrawing from these lesser operations could, nevertheless, create significant political and operational challenges."[5] Therefore, the necessity to win two overlapping major theater wars will require allied support, either by filling the vacuum for a small-scale deployment from which the U.S. must withdraw, or by stabilizing a region as U.S. forces transition to the new theater of operations.

Finally, it is important to understand what the *National Security Strategy* says about our relationship with NATO. The U.S. objective is to "complete the construction of a truly integrated, democratic and secure Europe, with a democratic Russia as a full participant…. NATO remains the anchor of American engagement in Europe and the linchpin of transatlantic security."[6] In order to preserve a vibrant and effective NATO, the United States and other senior NATO partners must formulate what NATO's new purpose will become. That is why NATO is devoting much effort to formalizing “out-of-area” operations. The U.S. ultimately desires a strong NATO to deal with minor crises that occur on the European continent.

National Military Strategy

The *National Military Strategy* continues where the *National Security Strategy* leaves off concerning the importance of operating in concert with our allies. It states that the most effective means to nurture and expand our capability with allies is through exercises. Exercises show allies and adversaries alike American resolve and commitment to a region. They also provide the conditions to test the technologies, systems, and procedures that must operate correctly in times of crisis. Finally, exercises encourage the allies to share the burden of regional defense allowing for better integration of forces.[7] Exercises are essential bridges between the different levels of technology and capability that exists within alliances, especially within NATO.

The U.S. recognizes that effective combined forces are required to advance and protect its interests. According to the *National Military Strategy*:

> Although we must retain the capability to act unilaterally, we prefer to act in concert with our friends and allies. Laying a solid foundation for interoperability with our alliance and potential coalition partners is fundamental to effective combined operations. We remain committed to doctrinal and technological development with our key allies and to combined training events and exercises that contribute to interoperability.[8]

The U.S. forces are dedicated to foster an environment that shares technology with their allies and trains with them to create an effective combined force.

Joint Vision 2010

To meet the objectives of the U.S. military strategy, *Joint Vision 2010* lays the conceptual framework to focus organizations and technological innovations toward effective warfighting capabilities. Although the U.S. armed forces will maintain sufficient strength to act unilaterally where necessary, *Joint Vision 2010* also highlights the importance of creating interoperability among our allies. It states that the U.S. expects “to work in concert with allied and coalition forces in nearly all of our future operations, and increasingly, our procedures, programs, and planning must recognize this reality.”[9] Implied in this statement is that the U.S. still does not totally integrate its allies into its planning, programs, and operations. Part of the hesitancy comes from its strength to act unilaterally and the reluctance to share its most capable technology with other countries. Nevertheless, if the *National Security Strategy* still holds to fighting and winning two major theater wars, reliance on allies with interoperable technology will enhance the U.S.' capability for success.

Joint Vision 2010 also examines the importance of precision technology on the modern battlefield. The Chairman of the Joint Chiefs of Staff identified long-range precision capability, combined with a wide range of delivery systems, as an emerging key factor in future warfare.[10] Precision engagement will rely on a “system-of-systems” that should allow forces to locate, identify, track, target, assess effects, and reengage if necessary.[11] Airpower provides one of the most versatile and effective means to deliver precision weapons, especially at the high-end of the spectrum of conflict.

Global Engagement

Global Engagement, the Air Force's vision to provide air and space capabilities to protect the United States' security, is grounded in the concepts from *Joint Vision 2010*. It anticipates how advanced technology and the changing threat will cause a restructuring of the U.S. Air Force. In the past, the Air Force has relied on forces that were permanently based overseas to carry out its commitments. Presently, the Air Force is adopting an expeditionary force structure to maintain its global engagement capability. In the future, CONUS-based forces will probably become the primary means for projecting power to a crisis.[12] If this trend continues, the U.S. must place more emphasis on allied airpower to assist in crisis response. Such emphasis seems to require integrated planning, procedures, equipment, and operations among the U.S. Air Force and the air forces of its future partners.

Global Engagement further explains what precision engagement means to the Air Force. The Air Force identifies precision engagement as one of its six core competencies. A "core competency provides a bridge between doctrine and the acquisition and programming process."[13] This bridge ensures that new weapon systems are designed and procured to increase the precision capability of the warfighter. Furthermore, the Air Force defines precision engagement as "the ability to apply selective force against specific targets and achieve discrete and discriminate effects…with minimum risk and collateral damage."[14] Advances in technology have created pinpoint accuracy for modern strike platforms. During World War II, thousands of bombers were employed in hopes of destroying a critical target. Today, it is possible for one bomber to destroy multiple targets with minimum collateral damage. This capability allows planners to focus on the desired effects created by targeting versus considering what forces are required to strike and re-strike a target.

Air Force Basic Doctrine (AFBD)

Finally, *Air Force Basic Doctrine* takes the vision from *Global Engagement* and "establishes general doctrinal guidance for the application of air and space forces…across the full range of military operations…."[15] It reiterates the idea that precision engagement is changing the way the Air Force will conduct future operations. It maintains that air and space forces will provide:

> The "scalpel" of joint service operations--the ability to forgo the brute force-on-force tactics of the previous wars and apply discriminate force precisely where required…. The Air Force is clearly not the only Service capable of precise employment of its forces, but it is the Service with the greatest capacity to apply the technology and techniques of precision engagement anywhere on the face of the earth in a matter of hours or minutes.[16]

The basic doctrine emphasizes that precision capability, when added to air platforms, creates a force multiplier. With a relatively few number of airpower assets, the Air Force can rapidly create a significant effect upon an enemy.

Reliable precision weapons, combined with modern information systems, have re-defined the meaning of mass. Fewer forces may achieve desired effects through pinpoint accurate weapons and advanced information systems. "Mass no longer means many hundreds of aircraft attacking a single target…. It is the effect, rather than forces applied, that is the defining factor."[17] The Air Force is discovering that it can apply this capability asymmetrically[18] against an enemy by simultaneously attacking tactical, operational, or strategic targets from the onset of hostilities.

A unique aspect of the advanced technological equipment required to the employ airpower asymmetrically is that the capability resides solely within the United States armed forces. Other countries and allies may have PGM capability and some information systems; however, no one except the United States has the capital and the resources to combine all the diverse technological capabilities into an operational "system-of-systems." This could mean that parallel attack and destruction of fielded forces from the air could become an option only available to the U.S. and those allied members who possess similar, if not identical, capabilities. This fact has many NATO allies concerned because they may be relegated to peripheral roles during the next conflict.

This chapter has demonstrated that allied and coalition warfare is central to American security strategy. It has also demonstrated that several future American warfare concepts are heavily dependent on advanced technology, especially precision engagement. Given the growing technical disparity between the United States and the majority of the NATO allies, something must be done to address the problem of a significant lack of equipment interoperability. The next two chapters will describe two potential ways to solve this very significant problem.

Notes

[1] Glenn Kent and William E. Simons, "Objective-Based Planning," in *New Challenges for Defense Planning: Rethinking How Much is Enough*, ed. Paul K. Davis (Santa Monica, CA: RAND, 1994), 278. "The concept centers on a subordination of objectives whereby outlining a plan for attaining stated goals at one level of organization defines objectives to be achieved at subordinate levels of implementation. It describes a process by which one may proceed coherently from stated national security objectives, to national military objectives, to regional campaign objectives, to operational objectives, and finally to military tasks."

[2] The White House, *A National Security Strategy for a New Century*, May 1997, i.

[3] Ibid., 2.

[4] Ibid., 5.

[5] Ibid., 12.

Notes

[6] Ibid., 21.

[7]Chairman of the Joint Chiefs of Staff, *National Military Strategy: Shape, Respond, Prepare Now -- A Military Strategy for a New Era*, May 1997, n.p.; on-line, Internet, 28 March 1998, available from http://www.dtic.mil/jcs/nms.

[8] Ibid.

[9] Chairman of the Joint Chiefs of Staff, *Joint Vision 2010*, (Washington, D.C.: Pentagon), 9.

[10] Ibid., 11.

[11] Ibid., 21.

[12] Secretary of the Air Force, *Global Engagement: A Vision for the 21st Century Air Force* (Washington, D.C.: Department of the Air Force), 11.

[13] Ibid., 9.

[14] Ibid., 13.

[15] Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*, 1997, v.

[16] Ibid., 30.

[17] Ibid.

[18] Marine Corps Doctrinal Publication (MCDP) 1-1, *Strategy*, 1997, 66. Asymmetric capabilities connote the application of one category of means against another to which the enemy cannot effectively respond.

Chapter 3

LGBs and "Buddy-Lasing"

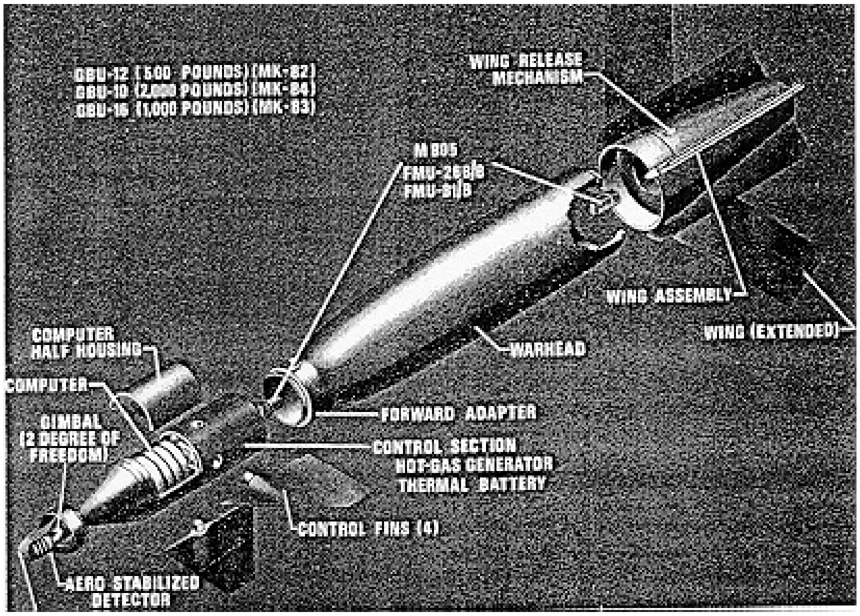
We have never been likely to get into trouble by having an extra thousand or two of up-to-date airplanes at our disposal. As the man whose mother-in-law had died in Brazil replied, when asked how the remains should be disposed of, "Embalm, cremate, and bury, Take no risks."

—Winston Churchill

This chapter describes the United States' laser guided bomb (LGB) systems. It explains the "buddy-lasing" concept and its history since Vietnam. The chapter concludes with a discussion of the U.S. Air Force National Guard's "buddy-lasing" tactics that could serve as a model for the NATO allies who do not possess autonomous laser-designation capability.

The U.S. employs the Paveway family of LGBs. These weapons were designed to mate bolt-on precision guidance technology to standard iron bomb warheads. Each weapon consists of three major components: the forward section that holds the laser seeker, guidance control unit, and four moveable canards; the main body that contains a Mk-80 series (unguided bomb) warhead; and the large stabilizing tail assembly that consists of four deployable fins (Reference Figure 1).[1] The deployable fin assembly allows enhanced weapon-to-aircraft compatibility, which increases the number of weapons carried per bomb rack and simplifies the loading procedure.[2] Because the

Paveway system uses the standard “dumb” bomb warhead, nearly all western-style aircraft can employ them.



Source: Duncan Lennox and Arthur Rees, ed., *Jane's Air Launched Weapons*, Issue 20 (Alexandria, VA: Jane's Information Group, March 1995): n.p.)

Figure 1. Paveway Laser Guided Bomb Systems

There are two versions of the Paveway weapons system--Paveway 2 and Paveway 3. The Paveway 2 is employed from medium altitudes due to limitations in its seeker and guidance control system. The medium altitude release requirement, however, can cause degraded target acquisition and weapon accuracy. Additionally, low clouds and smoke have often restricted its use. These limitations drove several improvements into the Paveway 3 system. The Paveway 3 added a low-level, high-speed release capability to the Paveway 2 design by incorporating an autopilot, a new laser seeker, and a new guidance control system. These features allowed delivery of the weapon at low altitude, below a cloud deck, outside the cone of reflected laser light. Following weapons release, the Paveway 3 maintains level flight while autonomously searching for the laser spot. A limitation of the Paveway 2 was that weapons release had to occur within the “cone” of laser light or the weapon went unguided. The new features of Paveway 3 allow crews to maneuver away from the target after weapons release to avoid surface-to-air threats. Both versions of the Paveway LGB performed successfully during Desert Storm and Deliberate Force.[3]

The aircrews must be highly trained to employ the Paveway LGBs effectively. Prior to weapons release, the crew must slue the infrared sensor and the laser designator to the desired target area. They must identify the target and manually fine-tune the laser designator onto the desired impact point. The challenge is keeping the laser designator aimed at the appropriate impact point, especially while maneuvering the aircraft to avoid threats. Once the LGB is released, the laser seeker captures the reflected laser light and sends guidance control signals to the weapon's forward canards steering the weapon to impact.

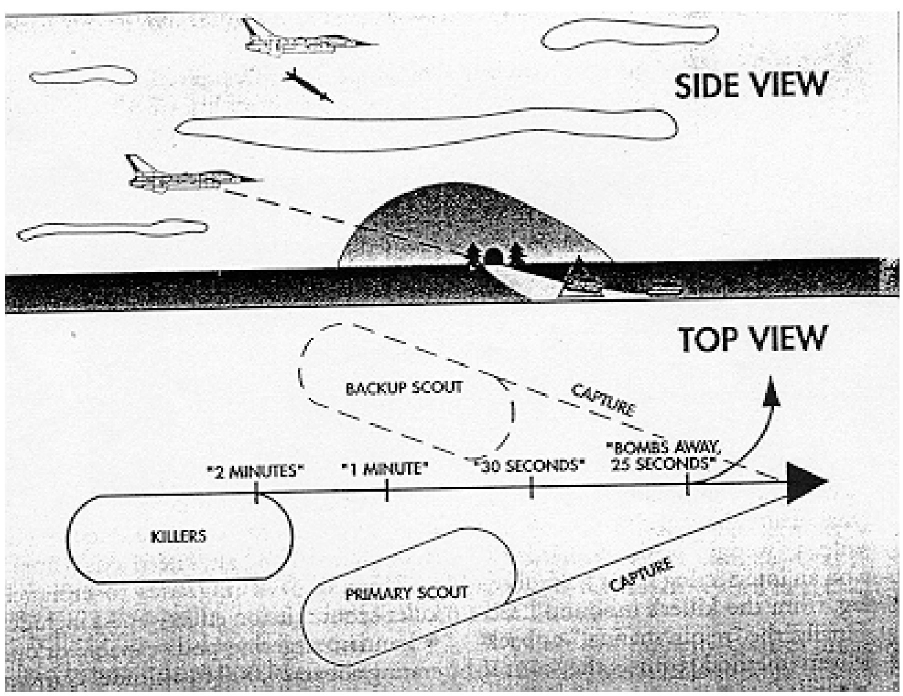
With an appreciation of LGB operations, one may better understand the coordination required when performing the “buddy-lasing” tactic. During Vietnam, the tactic initially involved a two-ship formation of F-4 aircraft. The designator F-4 was equipped with a laser “gun” mounted in the rear cockpit facing to the left. To employ the system, the pilot had to fly the aircraft in a left-hand orbit over the target while the weapons system officer (WSO) aimed the laser. The other F-4 carrying the LGB would fly ahead and above the designator aircraft. At the appropriate time, the LGB aircraft would dive and release the weapon so its seeker would fall within the “cone” of reflected laser light.[4] Later during the war, a night LGB capability was developed by placing a laser designator on an AC-130 Gunship. By boresighting the laser-designator to the AC-130's low light TV or infrared sensor, the crews could designate targets at night for orbiting F-4s.[5]

Similar to American tactics in Vietnam, many countries participating in Desert Storm employed the "buddy-lasing" concept. When the coalition air forces transitioned to medium altitude due to the Iraqi low-level threat, the United Kingdom deployed twelve of their Buccaneer aircraft with the day-only Pave Spike laser system to the theater. These aircraft laser-designated for Tornado aircraft that were originally configured for low altitude operations. Later in the war, the Tornado aircraft were re-equipped with their Thermal Imaging and Laser-Designating (TIALD) pods and designated their own weapons, as well as LGBs employed by Saudi F-5's.[6] Additionally, U.S. Marine and Navy aircraft employed precision missiles that were laser-designated by ground forces.[7] In other situations, a single F-15E aircraft would designate for his wingmen due to insufficient numbers of laser-designating pods being available in theater.[8]

Because of differing levels of capability within the U.S. Air Force, the concept of "buddy-lasing" lives on. Many Air Force active duty units fly with Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN) pods that provide aircrews autonomous laser designating capability. Many Air National Guard and Reserve units, however, fly F-16s or other modern aircraft without this capability. In order for Air National Guard units to employ LGBs, they have revived the old "killer-scout" tactics using fast-forward air control (FAC) techniques. In Vietnam, fast-FACs flew high-speed fighters and marked targets with white phosphorous smoke rockets. They then had orbiting aircraft deliver ordnance at or near the smoke. Today, active-duty, LANTIRN-equipped, "scout" F-16s are mated to Air Guard, non-LANTIRN, "killer" F-16s carrying

LGBs. Instead of white phosphorous smoke rockets, the killer aircraft mark the target with a laser spot. The "buddy-lasing" concept provides the Air Guard the ability to employ precision weapons during an air campaign.[9]

The coordination required for a scout aircraft to "buddy-lase" for a killer aircraft is very involved (Reference Figure 2). Usually, the killer aircraft orbits at an assigned control point while the scout aircraft patrols a designated "box" in order to identify and obtain geographic coordinates of desired targets. The scout must then pass the coordinates to the killer aircraft through radio transmission or data-link (This process is simplified if the killer-scout team pre-plans an attack on a fixed target). The killers then fly to the target making position calls so the scout can properly position the aircraft for designation. Several practice runs are required to become proficient at such a tactic.[10]



Source: William B. Scott, "Flight Underscores Demands of Killer-Scout Mission," *Aviation Week & Space Technology* 145, no. 17 (21 October 1996): 52.

Figure 2. "Killer Scout" Tactics

One consideration when using the "buddy-lasing" technique is the threat environment. The Air National Guard aircrews are careful to mention that these tactics are most applicable in low-threat environments. They cannot orbit over or near a target that is well defended. Most scouts can handle shoulder-fired SAMs and small arms fire; however, anything larger than that will seriously degrade their capability. Additionally, the scout mission requires considerable coordination on the radio that may not be feasible in a high threat environment. The ability to transmit the required release information by data-links greatly aids operations in such an environment.[11]

Overall, the "buddy-lasing" system can add capability to an air component commander's campaign plan. It offers the advantage of attacking many more targets with precision weapons in a single strike when compared with using self-designating aircraft only. The drawbacks for such capability include the amount of coordination and training required becoming proficient at successful employment and the fact that "buddy-lasing" is most feasible in a low threat environment.

Notes

[1] Duncan Lennox and Arthur Rees, ed., "Paveway Laser Guided Bomb Systems," *Jane's Air Launched Weapons*, Issue 20 (Alexandria, VA: Jane's Information Group,1995): n.p.

[2] David R. Mets, *The Quest for a Surgical Strike: The Air Force and Laser Guided Bombs* (Eglin AFB, FL.: Air Force Systems Command, October 1987), 99.

[3] Ibid., 108-116.

[4] Ibid., 65-67.

[5] Ibid., 74.

[6] Barry D Watts et al.,*Gulf War Air Power Survey,* vol. iv, *Weapons, Tactics, and Training,* (Washington, D.C.: Department of the Air Force, 1993), 65.

[7] Ibid., 137.

[8] Major Jay Kreighbaum, F-15E Weapons Officer and Gulf War veteran, 336th Fighter Squadron, interviewed by author, 15 January 1998.

Notes

[9] William B. Scott, "Revived Killer-Scout Tactics Leverage PGMs," *Aviation Week & Space Technology* 145, no. 17 (21 October 1996): 48.

[10] Ibid., 50-51. Scout aircrews practice three different tactics to "buddy-lase" LGBs. The first method is called the "restricted axis" tactic where the scout positions himself above a non-threatening target and guides the killer LGB until impact. The second method is called the "flexible axis" tactic. In this method the scout positions himself at a safe distance from a target and coordinates with the killer aircraft to fly 30-degree offset course that will intersect with the killer's inbound heading as he nears the target. This tactic is desired if threats are suspected in the target area. Finally, the scout can use the "rejoin manual" tactic or back-up method. This method requires the scout to fly on the killer's wing and direct the release of the killer's weapon prior to lasing. This method is used when the killer aircraft's navigational computers cannot determine position or weapon delivery information.

[11] Ibid., 49.

Chapter 4

GPS and the JDAM

We should base our security upon military formations, which make maximum use of science and technology in order to minimize the numbers of men.

—Dwight D. Eisenhower

When offensive weapons make a sudden advance in efficiency, the reaction of the side, which has none, is to disperse, to thin out, to fall back on medieval guerilla tactics which would appear childish if they did not rapidly prove to have excellent results.

—Gen G. J. M. Chassin

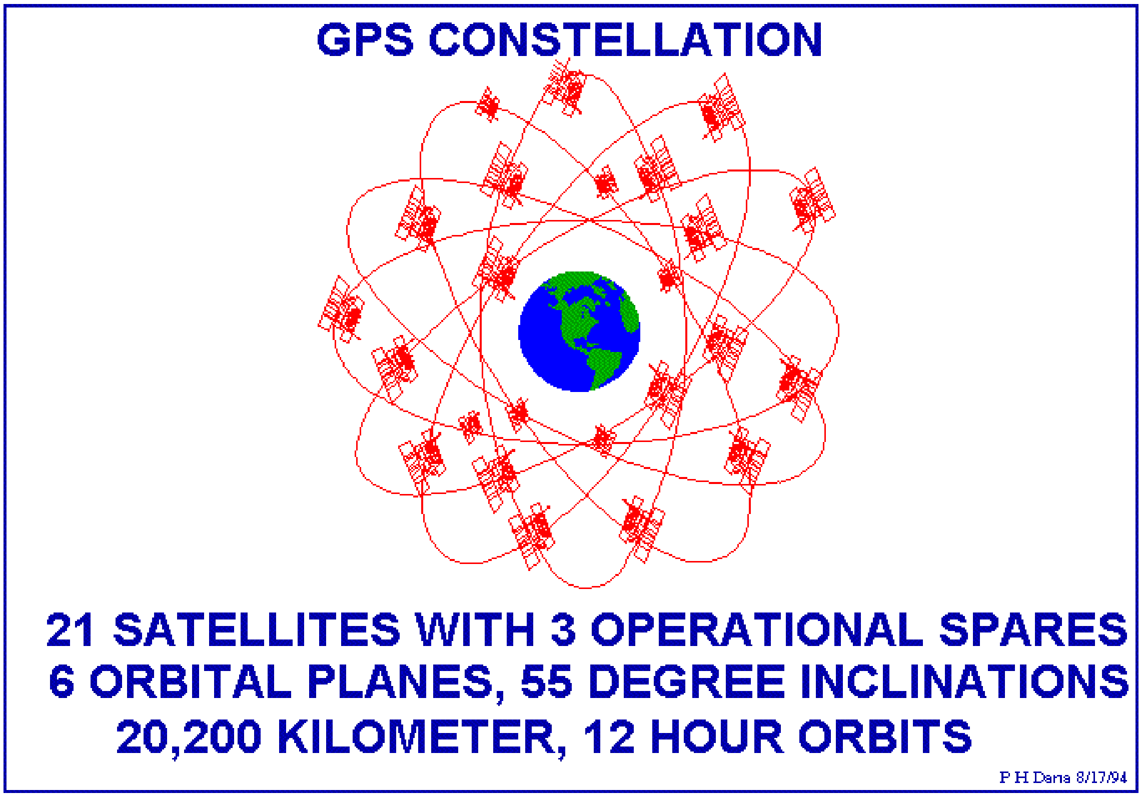
This chapter traces the evolution of the JDAM and examines possible employment options for its future use. Additionally, it addresses the GPS satellite constellation and its effect on the capabilities and limitations of the JDAM weapon. Finally, the chapter explores the "relative targeting" tactic that may become useful to NATO allies employing the JDAM.

Although laser-guided bombs proved invaluable during the Desert Storm and Deliberate Force, they did have limitations. "Laser designation was not possible through overcast skies, fog, or smoke. The designating aircraft also had to remain in the target area and within line of sight of the target until bomb detonation."[1] This meant that crews had longer exposure to possible threats. Additionally, LGB accuracy suffered from medium and high altitude due to laser spot scattering and inefficiencies in the Paveway

2's guidance system. Moreover, aircraft with internal weapons bays, such as the B-1, B-2, and the future F-22, would have limited ability to carry many LGBs due to size incompatibility. Also, stealth aircraft would increase their radar cross section (RCS) if an external targeting pod were mounted to them.[2] These limitations were serious enough for the Air Force Chief of Staff to direct the design of an inexpensive, all-weather precision weapon with launch-and-leave capability. Hence, the birth of the family of GPS-aided munitions, and particular to this paper, the Joint Direct Attack Munition (JDAM).

To comprehend how the JDAM functions, it is important to understand the GPS satellite network (Reference Figure 3). The GPS constellation contains 24 satellites (21 vehicles with three active spares) orbiting in six orbital planes each inclined 55-degrees with respect to the equatorial plane. The satellites are positioned at approximately 20,200 km from earth and make a full orbit every 12 hours. The orbit altitude is such that the satellites repeat the same ground track and configuration over any point on earth approximately every 24 hours. This GPS constellation provides the user with between five and eight satellites overhead for any point on the earth. This is important because it takes at least four satellites located above the horizon to make a position update. Using the signals from the four satellites, intelligent GPS receivers instantly solve four equations to determine latitude, longitude, height, and time.[3]

Because of the military's concern for signal security, GPS satellite signal structure is complex. The satellites transmit on two frequencies that carry the precision P-code. This code is designed for “authorized” military users only and provides Precise Positioning Service (PPS). The P-codes are encrypted because an “authorized” user can determine their position within five meters using a single hand-held receiver. One of the frequencies also carries a coarse acquisition C/A-code. This code is designed for non-military users and provides Standard Positioning Service (SPS).

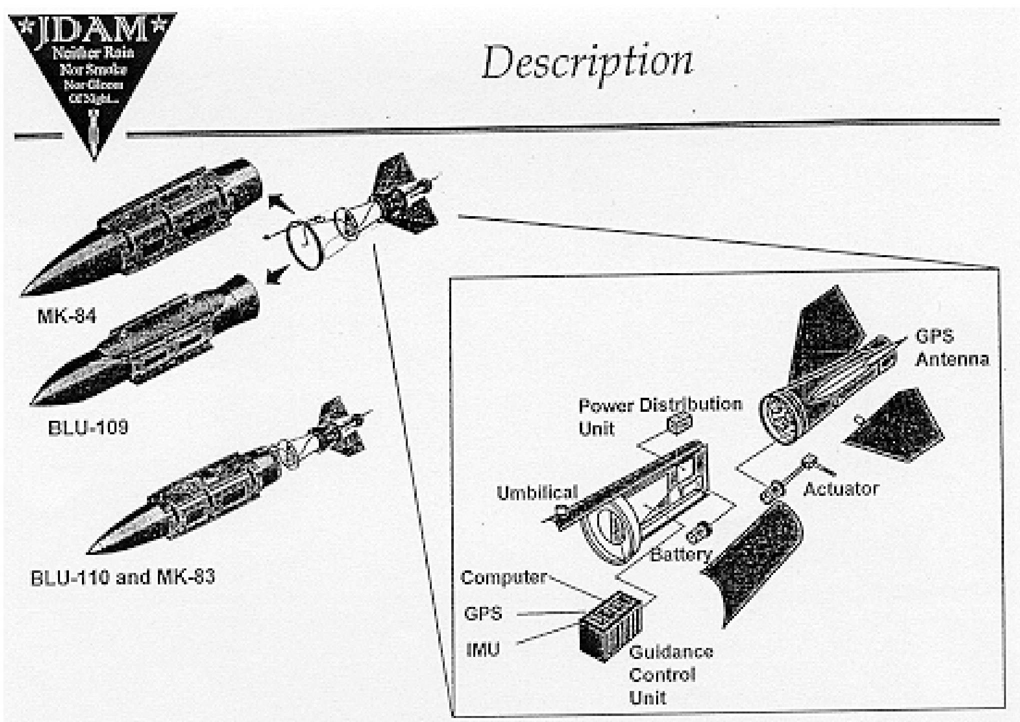


Source: Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Texas at Austin, 1998; on-line, Internet, 2 April 1998, available from http://wwwhost.cc.utexas.edu/ftp/pub/grg/gcraft/notes/gps/gps.html.

Figure 3. GPS Constellation

This code is less accurate, easier to jam, and easier to acquire. Because it is easier to acquire, the military receivers first track the C/A-code and then transfer to the P-code. The C/A-codes provide an accurate measurement around 20 to 30 meters. This accuracy is still very good and therefore is safeguarded with a function called selective availability. In selective availability, the military slightly falsifies the satellite's atomic clock signal and the navigational message. The combined effects of selective availability can degrade single-receiver users to about 150 meters.[4] This information will be important when limitations of GPS-aided munitions are discussed later.

The JDAM is a simple weapon using advanced navigation technologies. The weapon uses a tightly coupled INS/GPS[5] guidance system that relies on accurate target coordinates to ensure the weapon's accuracy.[6] This guidance system is contained in a tailkit that has retractable and moveable fins. The tailkit attaches to a standard Mk-80 series 1000-lb. or 2000-lb. warhead (Reference Figure 4).[7] Unlike the Paveway LGB system, the JDAM does not have forward canards. Because the aft fins steer the weapon, strakes were added to the bomb body to produce additional lift during flight.

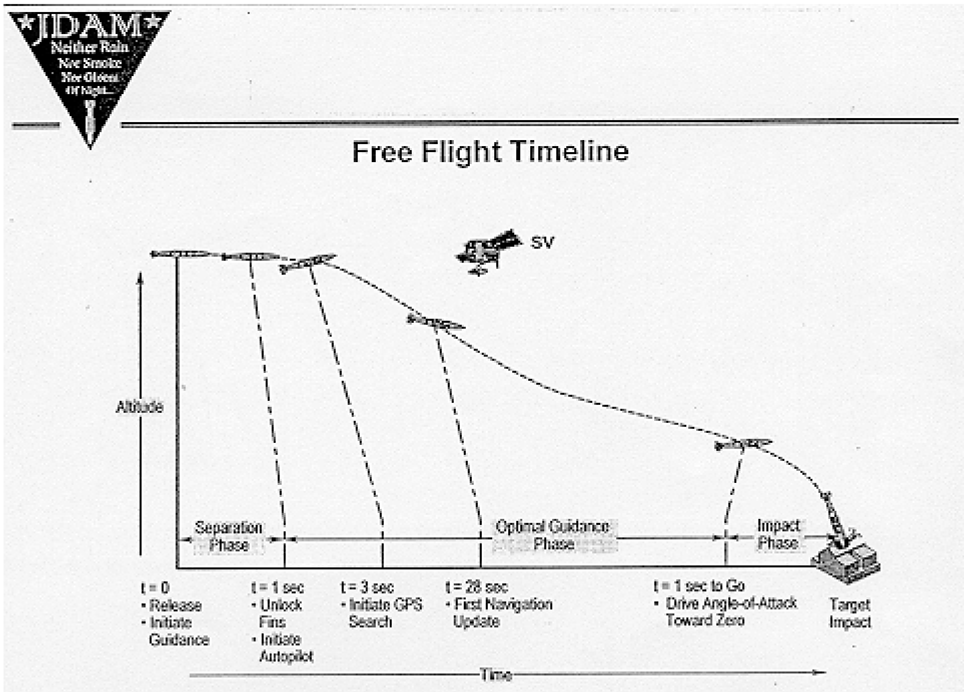


Source: Major Jay Kreighbaum, JDAM Operation Concept Brief, Air Combat Command/DRPW, June 1996.

Figure 4. JDAM system

The JDAM is an easy weapon to employ. During preflight, the weapons are loaded with target coordinates, target elevation, and the GPS crypto-key information. After takeoff, the JDAM's INS is transfer aligned to the aircraft's more accurate navigational system. In addition, the aircraft transfers GPS time and navigational data that allows the JDAM to lock-on to the GPS satellites following release. Once released, the INS provides sole guidance to the weapon for the first twenty-eight seconds while the GPS receiver performs its search. After twenty-eight seconds time-of-flight, the JDAM's GPS provides the first navigational update to improve INS's accuracy (Reference Figure 5). Following the first update, the INS continuously receives GPS inputs until weapon impact.[8]

Even with a tightly coupled INS/GPS, the JDAM is not as accurate as a LGB. A standard JDAM, with highly accurate coordinates, has an accuracy of approximately 40 feet, compared to the 10-foot accuracy of a LGB.[9] A technique being examined to rectify this problem is called wide-area differential GPS. This technique uses a reference GPS ground station located near the target area. Due to its accurately known position, this station can then transmit bias errors to the weapon.[10] With the bias correction added, Eglin's Air Force Development Test Center has found it can reduce aiming errors by 15 feet, to produce a 25-foot accuracy for the JDAM. These results were realized with GPS ground stations placed as much as 1,000-2,000 miles from the target.[11]

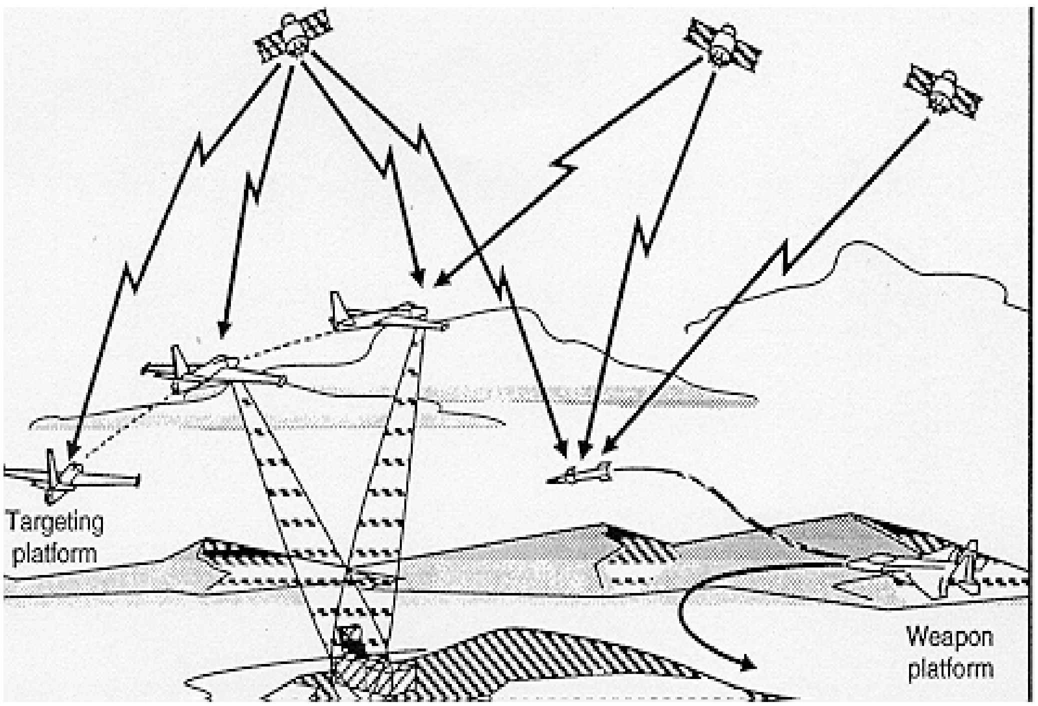


Source: Major Jay Kreighbaum, JDAM Operation Concept Brief, Air Combat Command/DRPW, June 1996.

Figure 5. JDAM Free Flight Timeline

In some conflict scenarios, it may not be possible to locate a wide-area differential GPS ground station near the target area. In that case, a relative targeting concept may be required (Reference Figure 6). The relative targeting concept involves a targeting platform and a weapons platform. Typically, the targeting platform is a reconnaissance aircraft capable of standing-off 100 to 200 km from the target area. The targeting aircraft would make two to three onboard SAR images of the target from different positions to produce the most accurate GPS coordinates. Preferably through data-link, these coordinates are transmitted to the JDAM carrying aircraft. The JDAM's accuracy depends on the SAR resolution and target designating capabilities of the targeting platform. GPS errors should be minimized due the fact that the targeting platform, the weapons platform, and the weapon all use the same set of GPS satellites.[12]

This relative targeting method has several advantages. The biggest advantage is that the weapon platforms can ingress to the target area in a different direction than the targeting platform. By using an unpredictable flight path, the attacking aircraft has a better chance of deceiving the enemy. Additionally, the targeting platform has the capability to task several weapons platforms in a large target area.



Source: Gerald Frost, *Operational Issues: For GPS-aided Precision Guided Weapons*, Project Air Force (Santa Monica, CA: RAND, 1994), 6.

Figure 6. Relative Guidance Targeting And Attack Concept

Several attack aircraft could enter the target area without emitting radar energy achieving surprise and mass while delivering their JDAMs. This GPS-based targeting system offers an excellent alternative to weapons that employ terminal imaging sensors.[13]

The JDAM was developed to bridge the gap created by the limitations inherent in Paveway LGBs. By using the GPS receiver coupled to a back up INS, the JDAM can provide most aircraft with all-weather, near-precision weapons capability. The relative targeting concept provides promise as a tactic to increase the effectiveness of precision weapons carrying platforms in future air campaigns.

Notes

[1] Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis, MD: Naval Institute Press, 1995), 193.

[2] Major Jay Kreighbaum, JDAM Operation Concept Brief, Air Combat Command/DRPW, June 1996.

[3] Alfred Leick, "GPS-A National Asset and Treasure," Department of Spatial Information, University of Maine, 1997, n.p.; on-line, Internet, 15 January 1998, available from http:\\www.spatial.maine.edu/leick.html.

[4] Ibid.

[5] Gerald Frost, *Operational Issues: For GPS-aided Precision Guided Weapons*, Project Air Force (Santa Monica, CA: RAND, 1994), 14-15. The reason why the JDAM uses both INS and GPS as onboard navigation systems is to take advantage of the strengths of each system. The INS accurately measures aircraft accelerations in a highly maneuverable environment while being immune to jamming. The disadvantage of the INS, however, is that through certain modeling errors, position and velocity accuracy are degraded over time. In contrast, GPS receivers can maintain position and velocity accuracy but cannot follow aggressive aircraft maneuvering. The GPS signal is also susceptible to electronic jamming. Therefore, an integrated INS/GPS can maintain accurate position, velocity, and attitude in a jamming or degraded GPS environment.

[6] Ibid., 3-5. The accuracy of the JDAM is highly dependent on the accuracy of the target coordinates, which is achieved by absolute or relative target designation methods. Absolute targeting methods use coordinates developed by the Defense Mapping Agency (DMA). Conversely, the relative targeting method uses the actual weapon system to determine the target coordinates. For example, a platform that has a synthetic aperture radar (SAR) can map a target and have the navigational computer, tied to the onboard GPS receiver, produce the target coordinates.

[7] Duncan Lennox and Arthur Rees, ed., "GBU-29/30 JDAM," *Jane's Air Launched Weapons*--Issue 20 (Alexandria, VA: Jane's Information Group,1995), n.p.

[8] Kreighbaum, JDAM Operation Concept Brief. The JDAM offers two desired guidance capabilities: a programmable weapon impact angle for creating certain effects and off-axis launch. Off-axis launch means that once the weapon is released, it can maneuver laterally from the flight path striking targets approximately three-to-nine miles from centerline. This is beneficial because it can minimize the crew's exposure to surface-to-air threats

[9] David A. Fulghum, "JDAM Errors to be Slashed," *Aviation Week & Space Technology* 142, no. 9 (27 February 1995): 46-47.

[10] Leick, "GPS-A National Asset and Treasure." The biases are created from satellite orbital position errors, receiver and satellite clock errors, and atmospheric effects on signal propagation

Notes

[11] Fulghum, 46-47.
[12] Frost, 6-7.
[13] Ibid.

Chapter 5

The Precision Weapon Solution

The military student does not seek to learn from history the minutiae of method and technique. In every age these are influenced by the characteristics of weapons currently available and the means at hand for maneuvering, supplying, and controlling combat forces. But research does bring to light those fundamental principles, and their combinations and applications, which, in the past, have produced success.

—General Douglas MacArthur

This chapter examines the options of using the Paveway LGB "buddy-lasing" tactic or the GPS-aided JDAM to produce more lethal and interoperable NATO air forces. The analysis begins with a discussion of lessons learned by NATO form Desert Storm regarding precision munition capability. Then it addresses NATO's involvement in Operation Deliberate Force. It also examines NATO's present precision weapons capability and the scheduled modernization programs that each country plans to follow. Finally, it examines both options against four criteria: the amount of training and coordination required to employ the option, the cost to procure the option, the degree to which the air forces will become more interoperable, and the extent to which each option becomes a force-multiplier for an air campaign. With the results of the analysis, this paper concludes with the best option to address NATO's concerns about the alliance's technology gaps.

Operation Desert Storm was an awakening for many of the NATO air forces. It highlighted numerous capabilities necessary for future "out-of-area" operations. This list included precision guided munitions (PGMs), Suppression of Enemy Air Defenses (SEAD), airlift, mobility, stealth, and theater command, control, communications, and intelligence (C3I).[1] Of these capabilities, the one that NATO could adopt most quickly and inexpensively is the PGM. According to a RAND study on NATO's future tactical air forces:

> Although the great utility of PGMs has long been accepted, their cumulative effect, especially compared to conventional dumb munitions, and the relatively low cost of the operations during Desert Storm, surprised many observers. Furthermore, the basic PGM--a dumb bomb with a strap-on laser kit--is relatively cheap and well within the means of most air forces…. [LGBs] may permit the European air forces to maintain significant attack capabilities without developing the more expensive munitions.[2]

Typical of most air forces following the Cold War, the European air forces may downsize 40-percent when compared with their 1990 end strength. Nevertheless, if the forces are equipped with the appropriate precision munitions and support assets, they could be much more capable than they were in 1990.[3]

Four years after Desert Storm, several NATO air forces participated in the Balkans air campaign during Operation Deliberate Force. As mentioned earlier, only four of the eight participating countries employed laser-guided bombs. The governments of Germany and Turkey politically restrained their air forces from participating in offensive air strikes. The Germans were allowed only to fly reconnaissance and SEAD sorties, while the Turks were directed to fly Combat Air Patrol (CAP) missions. The Dutch and the Italians did not participate in offensive air strikes, but were permitted to engage in close air support operations in support of the NATO Rapid Reaction Force

(RRF).[4] Overall, the European countries had sufficient precision air strike capability to prosecute the air campaign, but became hampered with political restrictions and proficiency issues when attempting to employ precision weapons.

Presently, NATO's air force capabilities vary drastically by country (Refer to Table 1). Some countries, such as the United Kingdom and France, have capabilities approaching those of the United States, while others such as Iceland and Luxembourg, do not even have air forces. Although there are different levels of ability, most countries fly very comparable third generation fighters--the F-16, F-18, or Tornado. Similarly, all the countries that have air forces, except Belgium and Portugal, maintain Paveway LGBs. Additionally, only Belgium, Denmark, the Netherlands, Norway, and Portugal cannot self-designate when employing LGBs. On whole, NATO has a good offensive attack capability, but there exists an obvious "tiered" structure of ability depending on the size and economic strength of each country.[5]

Norway provides an example of a smaller NATO air force currently enhancing its precision strike capability. *Jane's Defense Weekly* reported that the Royal Norwegian Air Force employed its Paveway 2 LGBs for the first time in September 1997. During an exercise, it attacked targets laser-designated by an army forward-air-control team that was part of NATO's Immediate Reaction Forces (IRF). The Norwegians are adding capabilities to their fighter aircraft that once were focused toward the air defense role during the Cold War. Today, their air force is capable of performing reconnaissance and air-to-ground missions as well. Ultimately, the Norwegians want to deploy their squadrons with a complete support package for "out-of-area" operations, similar to those performed by the IRF. Step-by-step, NATO air forces are posturing for precision capability and a larger role in offensive operations.[6]

Table 1. NATO Air Forces Laser-guided Bomb Capability (Excluding the United States)

Country	**Attack Aircraft**[7]	**Paveway Capability**[8]	**Aircraft SELF-LD**[9]	**Future Upgrades**[10]
Belgium	F-16A	-----		F-16 MLU
Canada	CF-18	2/3	X	JSF?
Denmark	F-16A/B	2/3		F-16 MLU JSF?
France	Mirage 2000 Mirage F-1 Jaguar	2	X	Rafale Mirage 2000+
Germany	Tornado F-4	3	X	EF2000
Greece	F-16C/D	2	X	F-16C/D+
Iceland	----	----		----
Italy	Tornado	2	X	EF2000
Luxembourg	----	----		----
Netherlands	F-16A/B	2		F-16 MLU JSF?
Norway	F-16A/B	2		F-16MLU JSF?
Portugal	F-16A	----		F-16A+
Spain	EF-18A	2	X	EF2000
Turkey	F-16C/D F-4	2	X	F-16C/D+
United Kingdom	Tornado Jaguar Harrier	2/3	X	EF2000 JSF?

LD - Laser-designation
MLU - Mid-life Upgrade
EF2000 - Eurofighter 2000
JSF - Joint Strike Fighter

Because Operation Desert Storm and Deliberate Force reinforced the importance of precision weapons, most NATO countries are striving to upgrade and modernize their current capabilities. Referring to Table 1, one can generalize four modernization trends. The first trend is the F-16 Mid-life Upgrade (MLU). This upgrade consists of a radar upgrade for beyond-visual-range (BVR) capability, a digital terrain following system, GPS equipment, cockpit enhancements, integrated data modem, Advanced Identification Friend-or-Foe (AIFF), and advanced night capabilities allowing all-weather precision attack.[11] The second trend is the Eurofighter 2000. This is a multinational program designed for the United Kingdom, Germany, Italy, and Spain to replace their aging aircraft with the latest in multi-role fighter capability. The Eurofighter 2000 will be capable of employing BVR missiles and precision attack weaponry.[12] The third trend shows several countries' interest in the development of the United States' Joint Strike Fighter (JSF) as a replacement for their aging F-16, F-18, and Tornado aircraft around 2008.[13] The last trend is for countries either to buy more of their latest generation aircraft or invest in minor updates. All four trends aim to add multi-role air defense capability with all-weather precision attack systems. As usual, budgetary restrictions may delay these forecasted modernization programs.

With the NATO air forces currently pursuing modernization programs to adapt precision weapons capability, the question becomes whether the Paveway LGB "buddy-lasing" option or the JDAM option may best suit their plans. The following sections analyze the advantages and disadvantages of each option.

Training

"Buddy-lasing." The "buddy-lasing" option definitely requires extra coordination and training. As mentioned in Chapter Three, whether a unit pre-plans an attack or creates a plan while airborne, the aircraft need to share information. The different units must coordinate items such as the target coordinates, altitude, airspeed, attack axis, rendezvous point, and egress maneuver. Ideally, this information would be data-linked

between aircraft, but typically is passed by radio communications. In a high threat environment against an enemy who can jam communication frequencies, “buddy-lasing” coordination becomes very difficult. Ultimately, “buddy-lasing” works best with units that can train together regularly.

NATO has developed several exercises allowing its fighter units the opportunity to train together. These exercises are called composite air operations (COMAO). NATO realized that conducting multi-national operations requires a level of coordination that could best be achieved through COMAO exercises. A typical COMAO scenario may materialize as follows: enroute tanker support is provided by the United Kingdom or the U.S.; stand-off jamming by the U.S.; SEAD by Germany or the United Kingdom; fighter sweep and escort by the Norwegians or Spanish; and the strikers provided by a combination of Dutch, Belgian, Italian, French, and U.S. forces employing precision weapons.[14] COMAO may be the tool that allows NATO units to develop the high level of proficiency required for successful “buddy-lasing”.

Composite air operations were conceived from the Allied Air Forces Central Europe (AIRCENT) Tactical Leadership Program (TLP). During the Cold War, the Central Region air forces desired a way to improve and develop tactics, techniques, and procedures. The TLP evolved to meet this requirement. Presently, its membership consists of Belgium, Denmark, Germany, Italy, the Netherlands, the United Kingdom, and the United States; Canada, France, and Spain only maintain liaison officers on the TLP staff.[15] TLP is best described as a cross between the U.S. Air Force's “Red Flag” training exercises and its Weapons School Instructor Course. TLP offers an ideal forum for NATO countries to develop “buddy-lasing” techniques.

JDAM. In contrast, the JDAM was designed for a minimum amount of coordination and training. The weapon was engineered as an all-weather, launch-and-leave system. The crew either loaded the target coordinates during pre-flight or obtained them in-flight prior to weapons delivery. There exists, however, an additional employment consideration for an allied NATO air force to employ the weapon.

JDAM employment requires information that only the U.S. can presently provide its allies. First, the allies must obtain access to the crypto-key P-codes for the highly accurate GPS navigational information. Second, the allies also require the very accurate target coordinates generated by the Defense Mapping Agency, which are produced from U.S. overhead sensors. Without this information, JDAM would not meet its stated 40-foot accuracy. As mentioned in Chapter Four, the JDAM can be employed without the P-code or accurate coordinates, but this seriously degrades its performance envelope and accuracy. Three inputs contribute to JDAM accuracy: target location, GPS navigation, and weapon guidance and control.[16] Because the U.S. builds the weapon, maintains the security of the GPS constellation, and employs the most accurate overhead sensors, it controls the accuracy of the weapon. Therefore, the NATO allies must rely on the United States' information systems to employ the JDAM most accurately.

One aspect of JDAM employment that requires training and coordination is the relative targeting method. As discussed in Chapter Four, this method requires a standoff reconnaissance platform to map the target and relay the coordinates to a JDAM-carrying aircraft. This allows real-time targeting combined with discrete attack axes. This tactic may require the same amount of coordination necessary to employ the “buddy-lasing” tactic. If true, NATO's TLP and COMAO offer the best venues to practice such maneuvers.

Cost

Paveway 2/3. The cost of the Paveway LGB kits is relatively inexpensive when compared to other precision missile systems available today. Raytheon Texas Instruments (TI) Systems, who builds and sells the Paveway system, quotes the cost of a Paveway 2 weapons kit between $30,000 - $35,000 in 1998 dollars. The more advanced Paveway 3 kit costs between $65,000 - $70,000 per weapon.[17] Because almost all the NATO countries own the Paveway series weapons, “buddy-lasing” is a relatively inexpensive option. For a modest price, some of the lower “tier” countries could create a formidable strike capability by building a robust Paveway weapon stockpile and training with laser-designating capable countries.

JDAM. The cost of the JDAM kit is also inexpensive when compared to other advanced weapons, but there is a catch. The JDAM kit costs between $14,000 - $18,000 in 1996/1998 dollars.[18] The catch is that the aircraft must undergo some avionics modifications. For example, the aircraft must be outfitted with a GPS receiver that is integrated into the navigation avionics system. In addition, the aircraft requires a new weapons interface unit called the Mil-Std-1760 data bus. This allows the weapon to communicate with the aircraft's navigation and weapons computers, especially to receive GPS updated information.[19] In essence, the JDAM kit is less expensive than a Paveway kit; however, it does require two avionics upgrades to the aircraft.[20] Most NATO aircraft will eventually receive with GPS navigation upgrades. Nevertheless, there is still a question whether all the countries will upgrade to the Mil-Std-1760 data bus or wait on possible "work-arounds" to their present systems.

Interoperability

NATO's past difficulties with ensuring standardized and interoperable equipment may ease as the new century approaches.[21] In the past NATO had too many different aircraft in its inventory to create an interoperable force structure. According to a RAND study, "no less than 16 different types of aircraft were present in 1970; by the 1990s, 12 different types of aircraft [formed] the backbone of European allied airpower in the Central region."[22] As the turn of the century approaches, the study estimates that 75-percent of the air forces will consist of F-16, Tornado, Mirage 2000, and the Eurofighter 2000 aircraft (This correlates to the data listed in Table 1).[23] As the number of types of systems decreases, the ability to make the force structure interoperable increases. This relationship also correlates favorably with the Paveway 2/3 or JDAM options. If a majority of the countries rely on either option or both as their primary precision weapons capability, standardization and interoperability will increase dramatically.

The efficiency created for an air component commander whose force is interoperable makes logistics and maintenance functions much easier and the force more lethal. For example, a future NATO force flying roughly four different aircraft all capable of delivering either Paveway LGBs or JDAM drastically reduces the stress on the support infrastructure. Similar aircraft can be based together and use the same petroleum, oil, and lubricants (POL), spare parts, and weapons. This creates economies of scale for logistics requirements and maintenance workloads. A combat force that is well equipped and highly reliable provides more sorties to the air component commander to prosecute the air campaign. Therefore, by adopting one or both options, NATO increases its precision weapons interoperability.

Force-Multiplication

By examining the lessons learned from the Deliberate Force air campaign, one may better understand how either "buddy-lasing" tactic or the JDAM can become force-multipliers. According to the *Balkan Air Campaign Study*, precision capable aircraft and weapons still had the numerous problems. First, most aircraft could deliver all the munitions, but only certain aircraft could provide terminal guidance (i.e. laser-designation). Second, some advanced PGMs were designed for certain aircraft, thereby limiting the utility of their use. Third, some advanced PGMs were retrofitted to existing aircraft, which caused anomalies in weapon delivery software and overall airframe interoperability. Finally, several of the advanced technology PGMs were available only in limited quantities due to their high cost. The study concluded that these four constraints tied certain aircraft to specific weapons, thus limiting them to specific roles. This created difficulty in generating a 24-hour tasking cycle as well as complicating tactical considerations for employment.[24] From these critiques of the air campaign, one could conclude that an inexpensive and robust PGM capable of employment by any NATO attack aircraft provides a desirable capability to the air component commander. The Paveway LGB "buddy-lasing" tactic or the JDAM option could be the weapon that produces this desired force-multiplication. These options provide inexpensive and interoperable systems that all NATO air forces could deploy. Such capability would give the air component commander many more aircraft and weapons to meet the air campaign's targeting needs. These options become force-multipliers--tools to expand the lethality of the combat aircraft.

Recommendation

Paveway "buddy-lasing." This option provides the user with an extremely accurate weapon for a relatively inexpensive price tag. Almost all the NATO countries either own one or both versions of the weapon, which creates an environment for interoperability between air forces. The drawbacks are that the weapon does not have an all-weather, launch-and-leave capability[25] and that it requires extensive training and coordination with laser-designating units to be successfully employed. Logically, the respective air forces could overcome the extra training requirements by purchasing their own laser targeting equipment; however, budgets are tight and countries desire to strike a balance between precision attack and air defense upgrades as they modernize their forces.

JDAM. This option also provides the user with an inexpensive precision weapon capability. The system provides an all-weather, launch-and leave capability and is simple to employ. Presently, the major drawbacks are its <u>near</u> precision accuracy and the extra modifications required updating NATO's current aircraft. As noted earlier, some of the aircraft will need GPS receivers and the Mil-Std-1760 data bus to allow the aircraft to transmit GPS information to the weapon. This modification could be an expensive proposition for some of the smaller air forces, similar to purchasing laser-targeting equipment. Another concern for the European allies is the requirement to obtain the GPS P-code and highly accurate target coordinates from U.S. intelligence sources.[26]

Based on the above advantages and disadvantages. NATO will probably find that the best decision is to invest in both options. In the short-to-mid-term because most

NATO countries have the Paveway weapons, all that is required is an aggressive training program such as a TLP to make each country a force multiplier for an air component commander. Although the coordination may be difficult, it provides a positive benefit in creating standardization and interoperability among the air forces. In the mid-to-long-term, the JDAM will be the best option to pursue. Although it requires more capital and aircraft modifications to employ, it provides NATO with a more robust precision weapon force, and ideally, more capability (force multiplication) to support the air component commander.

Notes

[1] Mark A. Lorell, *The Future of Allied Tactical Fighter Forces in NATO's Central Region*, RAND Report R-4144-AF (Santa Monica, CA: RAND, 1992), 42.

[2] Ibid.

[3] Ibid.

[4] Lt Col Rick Sargent, "Weapons and Tactics," in *Balkans Air Campaign Study* (Forthcoming), ed. Col Robert C. Owen (Maxwell AFB, AL: School of Advanced Airpower Studies, 1997), Ch. 9.

[5] The author's comparison of NATO countries only includes the current 16 member states. As NATO expands to include Poland, Hungary, and the Czech Republic (not to mention other Eastern Bloc nations), there exists the possibility of increased "tiering" of capability within the alliance.

[6] "Norway: Air Force Raises Fighters to a Multi-role League," *Jane's Defense Weekly* 29, no. 4 (28 January 1998): 27.

[7] Duncan Lennox and Arthur Dees, ed., "Worldwide In-Service Combat Aircraft: Analysis," *Jane's Air Launched Weapons*, Issue 26 (Alexandria, VA: Jane's Information Group, March 1997), n.p.

[8] Jimmy Smith, Raytheon TI Systems, Paveway Missile Systems, interview by author, 2 March 1998.

[9] Ibid.

[10] *Foreign Military Markets: NATO and Europe* (Newton, CN: Forecast International, June 1997), n.p.

[11] "F-16's Mid-life Update Enters Decisive Phase," *Jane's Defense Weekly*, 8 October 1997, 49.

[12] Robert Ropelewski, "Friends, Allies, Competitors: European NATO Prepares New Generation of Fighters," *Sea Power*, March 1995, 22-24.

[13] *Foreign Military Markets: NATO and Europe* (Newton, CN: Forecast International, June 1997), n.p.

[14] Squadron Leader J. H. Deane, RAF, "Why TAM? Why COMAO?" *NATO's Sixteen Nations*, no. 2 (1995): 19.

[15] "Tactical Leadership Program History and Mission," United States Air Forces Europe Homepage, n.p.; on-line, Internet, 1 April 1998, available from http://www.usafe.af.mil/direct/foas/aog/tlp-hist.html.

Notes

[16] Major Jay Kreighbaum, JDAM Operation Concept Brief, Air Combat Command/DRPW, June 1996.

[17] Jimmy Smith, Raytheon TI Systems, Paveway Missile Systems, interview by author, 2 March 1998.

[18] Major Jay Kreighbaum, JDAM Operation Concept Brief, Air Combat Command/DRPW, June 1996.

[19] Ibid.

[20] It is important to note that if a country wanted self laser-designation capability, it would also require additional modifications to the aircraft for a targeting and designation pod.

[21] As stated in a previous note, the author makes the statement based on the current 16 member NATO. If NATO absorbs many of the former Warsaw Pact countries, then interoperability problems may increase once again.

[22] Christopher J. Bowie, Mark A. Lorell, John R. Lund, *Trends in NATO Central Region Tactical Fighter Inventories: 1950-2005*, RAND, N-3053-AF (Santa Monica, CA: RAND, May 1990), 8.

[23] Ibid., 21.

[24] Sargent, Ch. 9.

[25] Jimmy Smith, Raytheon TI Systems, Paveway Missile Systems, interview by author, 2 March 1998. Raytheon TI Systems has developed a weapon called the Enhanced Paveway 3 to rectify this limitation. This weapon, besides being a LGB, also contains a back up INS/GPS providing it an all-weather capability. Additionally, the weapon does not require a Mil-Std-1760 data bus interface. During pre-flight, target coordinates are loaded into the weapon. The weapon receives GPS information autonomously in-flight while on the wing of the aircraft. This method increases the time for the weapon to acquire the GPS signal. The primary option will be to use the weapon as a LGB. If weather or smoke obscures the target, the crew can release the weapon using the INS/GPS back up system. The main limitations of the Enhanced Paveway 3 are the lack of real-time targeting in the INS/GPS mode (because the aircraft cannot exchange target information with the weapon) and its increased cost.

[26] David A. Fulghum, "JDAM Errors to be Slashed," *Aviation Week & Space Technology* 142, no. 9 (27 February 1995): 47. Also in David R. Mets, "Air Armament Technology for the Deep Attack: Did it Work? What if it Works Next Time?" *Military Review* (Forthcoming), 19 Aug 1997. There exists a possibility that a terminal seeker may be attached to a small percentage of JDAM weapons. Normally, if the weapon can arrive within twelve meters of the target, the terminal seeker does not need a large scan volume and can be built rather inexpensively. The terminal seeker could consist of SAR, millimeter-wave radar, or a terrain matching system similar to the Tomahawk. This capability would not only improve the accuracy of the weapon, but it would also reduce the intelligence requirements. Intelligence requirements would be minimal because one would not have to ascertain the exact coordinates of a target to launch a JDAM. Additionally, in Gerald Frost, *Operational Issues: For GPS-aided Precision Guided Weapons*, Project Air Force (Santa Monica, CA: RAND, 1994), 22-24. The McDonnell Douglas contractors are looking at the possibility of a Mil-Std-1760 work around.

Notes

Similarly to Raytheon TI Systems, the possibility exists to place the burden on the weapon's GPS receiver in acquiring the needed information prior to launch. This does increases the acquisition time of the GPS signal and thus can reduce the weapon's performance envelope.

Chapter 6

Implications

> *You will usually find that the enemy has three courses open to him, and of these he will adopt the fourth.*
>
> —Moltke, The Elder

Given the recommendation for NATO countries to adopt the "buddy-lasing" option in the short-term and the JDAM option in the long-term, this chapter examines possible implications of these courses of action. In particular, it determines how these options could change the U.S. strategy to employ and procure precision weapons. Additionally, it addresses expanding Europe's burden sharing role if the European NATO members procure a robust precision weapon capability.

Strategy of Attrition by Air

After Vietnam, one of the debates in the Air Force was whether quality or quantity of equipment was more important for a fixed budget environment. The Air Force questioned whether it should buy a smaller number of more capable weapons systems like the F-15, or a larger quantity of less technologically capable systems like the F-5. As history has shown, the Air Force opted to buy the higher quality system, which has proven successful to date. A similar debate has occurred over purchasing precision weapons. As a 1996 RAND study observed:

> Resource constraints have often led the United States to pair smart platforms with dumb bombs, or smart weapons with dumb submunitions--or to expect a few smart systems to facilitate the use of more-numerous, less expensive assets. This approach has been necessitated, in part because the technology necessary for [precision] systems has been relatively expensive, and the demands put upon them, high. However, recent technological changes have included the advent of very powerful, low-cost microprocessors and lower-cost sensor systems. It has thus become possible to contemplate highly proliferated [precision weapons] that will be able to achieve a large fraction of the capability of more-expensive systems at a lower cost.[1]

This implies that the U.S. has the opportunity to purchase both quality and quantity in advanced weapons systems. This trend can be observed in its present procurement of the JDAM.[2] Additionally, this condition of numerous highly accurate weapons could lead to a change in American defense strategy.

This change in capability could lead the U.S. Air Force toward a subset strategy of annihilation--the strategy of attrition for high-end conflict.[3] Airpower has the capability to destroy effectively individual pieces of ground equipment. The idea of "tank plinking" is attractive because precision weapons are relatively inexpensive. This capability could allow a small air force to attrite a large enemy ground formation. Due to advances in command and control and information integration, numerous aircraft can attack enemy centers of gravity simultaneously, or if the situation dictated, mass at critical targets of opportunity. As the U.S. moves toward an air strategy of attrition, it would be beneficial if the NATO air forces would do the same. NATO could provide additional precision weapon capable aircraft to such an air campaign while not feeling relegated to peripheral roles.

Defense Industrial Bases

An issue that needs to be briefly addressed concerns international weapons collaboration. This concern developed from the fact that American defense contractors build both precision weapons options presented in this paper. It is also apparent that American defense companies build a large percentage of aircraft flown by the NATO alliance. These trends bring forth the concerns over economic matters within the alliance and the issue of interoperability.

European countries are as concerned about the survival of their defense industrial base as is the United States. Two prominent methods of cooperation may become more prevalent to ensure the prosperity of both--co-production and co-development. Co-production authorizes participating nations to produce portions of a product without allowing some nations access to critical manufacturing processes or technologies. A good example of this was the U.S.' F-16 program co-produced with Belgium, Denmark, the Netherlands, and Norway. Conversely, co-development involves countries working together from the development stage to manufacturing the product. This method is usually less preferred because it involves increased time and compromise. A good example of co-development is the Tornado aircraft developed by the British, Italians, and Germans. In producing this aircraft, it took twice as long and three times as much as the F-16 program. Whether Europe and the U.S. choose to co-produce or co-develop the next weapon system, these methods offer a way to preserve both defense industrial bases while increasing interoperability.[4]

If European NATO desires a larger role in combined operations with the U.S., it has two options to consider. First, it can continue buying into American technology, such as the Paveway or JDAM weapons systems, taking advantage of the United States' "system-of-systems" infrastructure. This would increase interoperability and force multiplication within the alliance but may degrade the European defense industrial base. The second option, to preserve Europe's industrial base, is exploiting cooperative designs that either co-produce or co-develop weapons systems that could take advantage of the United States' intelligence infrastructure. While economically beneficial to both, this option would require political tenacity to ensure the programs stayed on track. Either way, these are options worth contemplating if Europe wishes a larger role in combined operations.

Burden Sharing

The final concern is how to get the European NATO allies more involved in the defense of common interests. Ideally, Europe should take responsibility for its regional stability, "with an engaged, collaborative United States in a close supporting role."[5] Even if Europe acquired the United States' peacekeeping role in the region, then the U.S. could spend more resources modernizing its high-end military capabilities. This would benefit the U.S. as it develops its *Joint Vision 2010* concepts of a smaller, more lethal force that must project power from the CONUS. In addition, Europe and NATO would benefit because the U.S. would bring improved capabilities to global crisis situations.[6] "Until Europe can acquire capabilities in such areas as intelligence, information warfare, and strategic lift, its military reactions will be largely tethered to U.S. commitment and support in these functions."[7] Nevertheless, if Europe would bring a respectable precision weapon capability to a crisis, this would at least relieve the burden of the U.S. deploying a majority of its strike platforms into a region.

Furthermore, the European NATO allies need to assist the U.S. in implementing its nearly two-major theater war strategy. As Chapter Two indicated, the *National Security Strategy* and the *National Military Strategy* both highlight the importance of allies to America's security. Presently, the U.S. forces stationed in Europe for the defense of NATO are also tasked to reinforce the Persian Gulf region. This means if a crisis developed in Southwest Asia and then one developed on NATO's eastern border, the U.S. would not have the forces available to respond promptly enough to reinforce NATO. A proposed solution is a more equitable split in the defense of Europe and the Persian Gulf. The solution suggests a two-thirds American and one-third European force structure in the Persian Gulf with the ratio reversed for the defense of Europe. This solution would entail keeping American forces permanently stationed in Europe to meet all treaty obligations for the defense of NATO. If a second conflict would occur near simultaneously in the Persian Gulf, then European NATO forces would have to deploy reinforcing the U.S. forces positioned in the region.[8] In essence, the U.S. needs to develop its allies' capabilities to create confidence in them to share more equitably in the defense burden.

This paper has shown how the U.S. can move toward meeting some of these conditions by adopting the precision-guided munition recommendations with the NATO alliance. Developing combined training programs and interoperability measures to ensure the allies can use the Paveway and JDAM weapons systems effectively is just one small step in the right direction toward enhanced security arrangements for the U.S. It is also a positive step to ease the allies concern of not being relegated to peripheral roles during the next conflict.

Notes

[1] John Birkler etal., *A Framework for Precision Conventional Strike in Post-Cold War Military Strategy*, RAND Report (Santa Monica, CA: RAND, 1996), 35.

[2] David A. Fulghum, "JDAM Errors to be Slashed," *Aviation Week & Space Technology*, 27 February 1995, 46. The Air Force plans to buy 62,000 kits and the Navy plans to buy 12,000 kits.

[3] Harold R. Winton, "Delbruck and Jomini," lecture, School of Advanced Airpower Studies, Maxwell AFB, AL, 25 August 1997. An attrition strategy is where a strong force wears down an equal or weaker force--it also could be referred to a slow annihilation because it has a positive aim. This should not be confused with an exhaustion strategy where a weaker force must decide between maneuver and battle. It has to decide when to be daring and when to use economy of force. This produces a negative aim--hold what one has and inflict pain on the enemy in hopes that he retreats.

[4] Lt Col Michael N. Beard, "United States Foreign Military Sales Strategy: Coalition Building or Protecting the Defense Industrial Base," Research Report (Maxwell AFB, AL: Air War College, March 1995), 25-26. See also Mark Lorell and Julia Lowell, *Pros and Cons of International Weapons Collaboration*, RAND Study (Santa Monica, CA: RAND, 1995), ix-x.

[5] Lt Col Charles L. Barry, "Creating a European Security and Defense Identity," *JFQ*, no. 15 (Spring 1997): 68.

[6] Marten van Heuven and Gregory F. Treverton, *Europe and America: How Will the United States Adjust to the New Partnership?*, RAND Issue Paper (Santa Monica, CA: RAND, 1998), n.p.

[7] Barry, 68.

[8] David C. Gompert and Richard L. Kugler, *Rebuilding the Team: How to Get Allies to Do More in Defense of Common Interests*, RAND Issue Paper (Santa Monica, CA: RAND, September 1996), n.p.

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