# THE EFFECTIVENESS OF THE A-10 ON THE BATTLEFIELD OF 2010

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

# ABSTRACT


THE EFFECTIVENESS OF THE A-10 ON THE BATTLEFIELD OF 2010 by Major Ralph S. Hansen, 99 pages.

This study examines the ability of the upgraded A-10 to effectively support the Army's interim force in the year 2010.

The A-10A Thunderbolt II is the first and only USAF aircraft specifically designed to provide close air support to friendly ground forces. Designed in the 1960s to provide inexpensive close air support during the Cold War, the A-10 is now programmed to remain in service until 2028. To counter inevitable obsolescence, the PE modification will add data link, targeting pod, and smart weapon capabilities to the A-10 beginning in 2005.

The U.S. Army is transitioning to a lighter, more strategically agile force to respond more quickly to global challenges. The vanguard of this transformation is the Interim Brigade Combat Team, a highly mobile, technologically advanced maneuver force. Without many of the traditional fire support assets of heavier forces, these new units will depend heavily on joint fires while responding to the full spectrum of military operations.

With the proposed modifications, the A-10 will possess the capabilities required to successfully integrate into the future battle space and support advanced ground forces, while still retaining its original visual and close-in support capabilities.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ABCCC | Airborne Battlefield Command and Control Center |
| ACC | Air Combat Command |
| AFATDS | Advanced Field Artillery Tactical Data System |
| ALO | Air Liaison Officer |
| ASOC | Air Support Operations Center |
| AWACS | Airborne Warning and Control System |
| C2 | Command and Control |
| CAS | Close Air Support |
| CBU | Cluster Bomb Unit |
| CSAR | Combat Search and Rescue |
| DSMS | Digital Stores Management System |
| EPLRS | Enhanced Position Location Reporting System |
| FAC | Forward Air Controller |
| FAC(A) | Forward Air Controller (Airborne) |
| FBCB2 | Force XXI Battle Command Brigade and Below |
| FLIR | Forward Looking Infrared |
| GPS | Global Positioning System |
| HOTAS | Hands On Throttle And Stick |
| HUD | Heads-Up Display |
| IAM | Inertially Aided Munitions |
| IBCT | Interim Brigade Combat Team |

| | |
|---|---|
| IR | Infrared |
| JSTARS | Joint Surveillance Target Attack Radar System |
| JDAM | Joint Direct Attack Munition |
| JP | Joint Publication |
| LANTIRN | Low-Altitude Navigation and Targeting Infrared for Night |
| LGB | Laser Guided Bomb |
| NVG | Night Vision Goggles |
| PE | Precision Engagement |
| RSTA | Reconnaissance, Surveillance, and Targeting Acquisition |
| SADL | Situational Awareness Data Link |
| SINCGARS | Single Channel Ground and Air Radio System |
| SPI | Sensor Point of Interest |
| TACP | Tactical Air Control Party |
| TAD | Tactical Awareness Display |
| TGP | Targeting Pod |
| TTP | Tactics, Techniques, and Procedures |
| UAV | Unmanned Aerial Vehicle |
| USAF | United States Air Force |
| WCMD | Wind Corrected Munitions Dispenser |

# CHAPTER 1

## INTRODUCTION

The A-10A Thunderbolt II is the first and only United States Air Force (USAF) aircraft designed specifically to perform close air support (CAS) for land forces. Designed in the late 1960s from lessons learned in Vietnam, it became operational in 1978 with one purpose in mind: to provide a large number of inexpensive, easy to maintain, lethal aircraft to support the U.S. Army during a Warsaw Pact assault. As the U.S. military moves into the twenty-first century, the threat of world war on the plains of Germany has faded, and even major theater of war conflicts (such as Desert Storm) appear less likely. The United States and its allies now face transregional and nontraditional threats, nonlinear battlefields, military operation on urban terrain, and asymmetric threats of terrorism, weapons of mass destruction, and information attack. In response to these new threats and challenges, both the Army and the Air Force are currently in transition, seeking to transform themselves to meet the threats and missions of an uncertain future. These changes in the security environment have occurred so rapidly that the United States now finds itself with military forces filled with technologies and weapon systems procured in a different era for very different missions than the ones they currently face.

The A-10, which currently makes up 34 percent of the USAF fighter force structure, is a prime example of a legacy system that is in danger of being left behind in a new world order of unconventional battlefields and operations other than war. Live news reports bring the horrors of war and conflict into the living rooms of an information-savvy, casualty-averse world in real time. American civilian and military leadership are increasingly aware of friendly casualties and collateral damage, and high technology precision-guided weapons, which came of age during Desert Storm, now dominate military operations.

## Problem Statement

The old-fashioned A-10, designed specifically to provide low altitude CAS for friendly ground troops, suddenly seemed out of place at high altitude over the modern battlefield. The A-10 is at risk of being left behind in future conflicts if it is not updated to meet the needs of these new operations. This problem will only become worse as the slow and technologically challenged "Warthog" is slated to remain in service until at least the year 2028. The prohibitive cost of aircraft procurement and the low operational cost of the A-10 have driven this unforeseen longevity, effectively doubling the A-10's original programmed service life. This confluence of circumstances has forced the Air Force to determine whether an attack aircraft can remain tactically relevant for a fifty-year period. To address these concerns, the A-10 will soon undergo its most extensive upgrade ever. This modification, dubbed Precision Engagement (PE), brings twenty-first century technology to a twentieth century aircraft. The question remains: Will this modification be enough to keep the A-10 viable in the future, or will it be too little, too late?

## Research Questions

The Primary research question of this thesis is: Can the PE-modified A-10 operate effectively on the battlefield of 2010? This research question is broken into three subordinate research questions that will help in answering the primary question:

1. Can the A-10 integrate into the airspace above the battlefield of 2010?

2. Can the A-10 integrate with other fires and effectively support the U.S. Army's interim force on the digital battlefield of 2010?

3. Do current joint doctrine and tactics, techniques, and procedures (TTP) effectively address CAS fires on a digital battlefield, or are changes required to make digital CAS possible and effective?

## Background

In order to determine the effectiveness of the support an aircraft not yet flying can provide in a battle space not yet in existence requires a clear understanding of each combat element in the equation: the A-10, the U.S. Army forces now under transformation, the airspace of the future, and the procedures used to support ground forces through airpower. To further complicate the issue, each of these elements is currently undergoing dramatic change in a time of unparalleled technological advance. Operations in tomorrow's battle space will be very different than today, both from the air and from the ground perspective. How these forces will integrate with each other in the future is a question that is now only beginning to be asked. This question must be answered or U.S. military forces risk becoming overcome by technology.

### The Aircraft

The A-10A is a single-seat, two-engine CAS aircraft manufactured by the Fairchild Republic Corporation. The aircraft is specifically designed to be simple, survivable, and lethal. Precision and unguided bombs, rockets, and missiles are carried on eleven weapons pylons, in addition to an internally mounted thirty-millimeter Gatling gun. The A-10 has a worldwide commitment to perform day and night CAS, forward air control (FAC), air interdiction (AI), and combat search and rescue (CSAR) missions.

First fielded in 1975, the A-10 became operational 1978. A total of 713 aircraft were built, and 366 remain in active service.

Following the end of the Cold War, the Air Force became convinced that the multi-role F-16 could perform the CAS role instead of the A-10. Plans to retire the A-10 by 1993 were interrupted by Iraq's invasion of Kuwait in 1990. The ungainly Warthog became a media favorite during Desert Storm, flying over one-third of the total sorties and destroying over 5,000 tanks, vehicles, and artillery pieces. Following its Gulf War success, talk of retiring the aircraft ceased, and attempts to upgrade the aircraft began (Smallwood 1993, 17).

The A-10 received its first significant technological improvement in 1991 with the addition of a weapons delivery computer, and in 1999, a global positioning system (GPS) was added. During the 1990s, the A-10 flew in combat over Northern and Southern Iraq, Bosnia, and Kosovo. Civilian and military leadership became increasingly casualty conscious throughout these "low risk" conflicts, and during the Kosovo air campaign of 1999, collateral damage estimates were a key consideration for every possible target. Because the A-10 is not considered to be capable of employing precision munitions or to have the required systems necessary to minimize collateral damage, it was not initially used over Kosovo, and risks being marginalized in future conflicts. This problem will only intensify in the future, with the threat of obsolescence growing each year.

During the military drawdown of the 1990s, fighter modernization budgets were slashed, and several A-10 programs went unfunded. Then in 1999, several previously proposed improvements were combined into a single upgrade, and the PE program was born. This program includes: (1) situational awareness data link (SADL), the means to automatically communicate position and additional information with other aircraft and friendly ground forces; (2) the hardware and software necessary to carry the next generation of GPS and inertially guided "smart" weapons; (3) a digital stores management system (DSMS), allowing automatic control and inventory of all loaded weapons; (4) software integration for employment of a laser-equipped targeting pod (TGP); and (5) an upgraded power system to run the new equipment. This program has received overwhelming support from Air Force leadership, and is well on its way to being fielded from 2005 to 2007. A separate service-life extension program will double the longevity of the airframe itself, assuring the aircraft can indeed fly for many more years (Feldhausen 2000).

## Army transformation

The A-10 is not the only system that has undergone a dramatic change in the last decade. The U.S. Army is in the process of a sweeping organizational change. Following the end of the Cold War, the Army finds itself ill suited for many of the challenges of the new world security environment. The Army's light forces (infantry, airborne, and air assault) are rapidly deployable but lack the firepower, mobility, and sustainability to meet many of the world's challenges. On the other hand, the heavy forces (armor and mechanized infantry) have unmatched firepower, mobility, and sustainability, but take a very long time to deploy in theater. The goal of transformation is to produce an Army that is more strategically responsive and deployable than current heavy forces while at the same time being more lethal, survivable, and sustainable than current light forces--combat units that can quickly respond to any task throughout the spectrum of military operations. This comprehensive transformation will affect organization, equipment, leadership, acquisition, strategic planning, training, doctrine, and tactics, as well as integration with joint and combined forces at every level (Shinseki 1999).

The first product of Army transformation is the interim brigade combat team (IBCT), designed to be deployable within ninety-six hours of the first airlift takeoff. The IBCT is based around the future combat system, a wheeled armored vehicle light enough to be airlifted by a C-130, but as lethal and survivable as the larger and heavier M-1 Abrams tank and M2 Bradley fighting vehicle it replaces. A lighter fighting vehicle is only one advanced technology envisioned by Army transformation. The IBCT will expand on the digital battlefield concept the Army has been developing for many years. In the very near future, ground and air vehicles will be linked electronically via data link, giving both soldier and airman unprecedented and dominant situational awareness. Command posts, command and control systems, individual vehicles will be linked together in a web-centric network, with the goal that the IBCT will see first, act first, and finish decisively (Department of the Army 2001b, 7). Leveraging off the shelf technologies, six active and one reserve IBCT are being formed, the first reaching initial operating capability in 2004. The first two brigades at Fort Lewis, Washington have already been created, and are now developing TTP that will carry the Army through the early years of transformation.

## Tomorrow's Airspace

As the Air Force faces escalating global commitments, new technologies are being leveraged to provide real time targeting, even more precise weaponry, and common digital data link to electronically connect the battlefield. These advances are dramatically changing the way air forces will be employed in the future. The ultimate goal is to have a common operating picture, available to every weapons system and command and control element, which includes accurate information on all air and ground assets and threats. These systems will provide a quantum leap in situational awareness for all players, allowing them to employ more safely and effectively. The digitization of airspace and the integration of data link technology are dramatically changing the war in the air. Targets will be found, fixed, tracked, targeted, and engaged in a decision cycle measured in minutes instead of days.

As the USAF continues its transition to an Expeditionary Air Force, it is looking for new and different ways to combat the challenges of the new world environment. One such innovation is the Global Strike Task Force, the brainchild of General John Jumper, Air Force Chief of Staff. This concept--which includes the elements of decisive maneuver by air power, time critical targeting, information attack, and effects-based targeting, all without the benefit of immediately available forward operating bases--will significantly alter the way U.S. air forces operate in the future (Jumper 2001, 30).

## Close Air Support

America’s joint forces will operate on this new information battlefield using CAS doctrine that has remained essentially unchanged since the late 1940s. Nonlinear battlefields, digital data links, beyond visual range and GPS-guided weapons, and nontraditional air support aircraft have all changed the CAS paradigm. Challenges and questions facing the CAS mission today did not exist even fifteen years ago.

Although CAS may doctrinally be considered the least efficient use of application of airpower, "at times it may be the most critical in ensuring success or survival of ground forces" (Keithly 2000, 14) and will continue to be necessary and relevant on the future battlefield. The lighter and more agile Army will deploy with far less organic firepower than before. The IBCT will have mobile artillery and mortars, but these lighter units have necessitated a reduction in the both the number and caliber of fire support assets. This reduction in internal fires capability will force the lighter brigades to rely more on joint firepower on the battlefield of the future, such as fixed-wing CAS and naval gunfire, much as the U.S. Marine Corps does today (Baumgardner 1999, 1). In future IBCT operations, CAS must be integrated into the maneuver concept, and CAS fires will be depended on for fire support (Rodriguez 1999, 1).

## Assumptions

In order to control the scope of the research, the following assumptions are made for the purposes of this thesis:

1. The Army's IBCT and the A-10 PE program will continue to maintain their current level of funding and will be fielded as scheduled.

2. The surface-to-air threat environment will not make the A-10 obsolete. The aircraft's active and passive self-protection measures will continue to be updated and improved to counter increasingly sophisticated threats. Such improvements will likely include a missile warning system, active metal decoy infrared (IR) countermeasures, and enhancements to the current electronic countermeasures pod and radar warning detection system.

3. U.S. air forces will gain and maintain air superiority over the future battlefield.

Delimitations

Due to the breadth of the overall topic, the research will only focus on the following key areas:

1. This study will only address Air Force and Army programs and battlefield conditions. It is beyond the scope of this study to consider any further joint or combined operations.

2. Consideration will only be give to the interaction between the A-10 and the IBCT. While some attention will be given to the upgraded A-10's support of the legacy forces--especially digital ground components--the main effort of the research is the interim force, represented by the Army's IBCT.

3. The discussion on CAS in the future will be limited to support of the IBCT by advanced weapons and systems. The current debate over CAS doctrinal limitations, challenges to CAS employment, and interservice misunderstandings--while important--is beyond the scope of this thesis.

4. The research will not attempt to look beyond the 2010 time frame. Projections beyond this date would unnecessarily complicate the research and be purely speculative in nature at this time. The year 2010 was chosen as the baseline for this research because both the A-10's PE modification and the Army transformation's IBCT will have been in place long enough to be considered mature programs. The Army's follow-on objective force will not be in place before 2030, a time at which the A-10's future is very much in doubt.

## Significance of the Study

The answers to these research questions are critical to the future of the Air Force, the Army, and the combat capability of this nation. The A-10 System Program Office has already asked these specific questions, to insure that an upgraded Warthog will remain relevant in the future. On the eve of the most significant upgrade in the history of the aircraft, there is a concern that the A-10 will not be able to support its customers or remain a viable part of the Air Force's vision of the future. This study also evaluates current joint CAS doctrine for applicability and effectiveness in employing airpower on tomorrow's digital battlefield.

## Summary

The United States no longer has the luxury of making defense decisions based on specific nation-state threats and predeveloped war plans. Transforming equipment and methods to address these uncertain times is a difficult task. The A-10 is a good example of a weapons system caught between the Cold War of the twentieth century and the security environment of the twenty-first century. Before determining whether the A-10 can make such a transition, it is important to understand where it has been, where it is going, and what forces it is likely to support in the future.

# CHAPTER 2

# LITERATURE REVIEW

## Introduction

There is much written material available on the A-10, on the A-10 performing CAS, on the Army's transformation, and on the new IBCT. Very little has been written on the PE program, and nothing has yet been published on the future employment of the new and improved A-10 or on how it will integrate with the IBCT. The IBCT was organized very quickly and is relative immature, and very little exists in the literature on its tactics, employment, or integration. While both the PE A-10 and the IBCT are still in development, they are mature enough at this time to provide ample research material and a reasonable understanding of both programs. In the midst of the introduction of these two new systems, the CAS controversy continues, with authors from all services advocating widely varying views. While there is no consensus on the future of CAS, much research is available that gives some indication of what ground support will look like in the twenty-first century.

Since this study deals with the interaction of forces that are not yet fielded, gaining a clear understanding of the employment and interaction of these future systems is difficult. There is no official written policy or doctrine on the Army or Air Force's future--a future made even more uncertain as the nation struggles to respond to the threats of a new security environment--and previous research can be quickly overcome by events or technology.

The available literature will be organized into categories by subject: (1) the A-10, to include its historical context, its current status, and its future following the PE upgrade;

(2) the Army's interim force, emphasizing Army transformation and the IBCT; (3) the battle space of the future, to include tomorrow's airspace, Air Force transformation, the digital battlefield, and the impact of technology; and (4) CAS, to include its historical context, current status, doctrinal limitations, and air support of the future. The research will be limited to sources less than five years' old. While some articles written before that time deal with the issues in question, most authors did not foresee the rate of change in the post-Desert Storm era.

## The A-10

### History

Douglas Campbell's doctorate dissertation, "Plane in the Middle: A History of the U.S. Air Force's Dedicated Close Air Support Plane" (1999), provides an excellent and in-depth history on the A-10. This historical context is important for an understanding of how a simple aircraft from yesterday can play such an important part in the force structure today. The A-10 originated from the "A-X" (attack-experimental) program, designed to build the Air Force's only dedicated CAS aircraft. The original requirements directive stated that the A-X should be:

> Simple, lightweight, reliable, highly survivable and capable of operating from medium-length semi-prepared airstrips with a high utilization rate. It must be able to carry a large payload of mixed ordnance and deliver it accurately. It must have sufficient low-altitude range and loiter capability, airspeed range, and aerial agility to perform the entire spectrum of close air support missions. (Campbell 1999, 57)

The A-10 was also the first Air Force aircraft procured with a predetermined fixed price. These strict fiscal constraints, compounded by shrinking post-Vietnam War defense budgets, made for a very cost-conscious development program. The Deputy

Secretary of Defense at the time remarked, "I expect the Air Force to thoroughly review the design and eliminate any features not absolutely necessary for the accomplishment of the close air support mission" (Campbell 1999, 42). Many available technologies (such as an inertial navigation system, an advanced heads-up display (HUD), a chaff and flare countermeasures system, and an instrument landing system) were cut from the program to meet cost goals and insure procurement, and then added later during full-scale production. Even with these improvements, the A-10 still provided a low-cost, low-technology answer to the CAS needs of a large-scale European ground war. Sixteen years after its introduction, with no major modification, the A-10 flew over 8,100 sorties during Desert Storm.

## Current A-10 Status

Secretary of Defense Donald Rumsfeld stated in the 2001 *Quadrennial Defense Review Report* that current transformation includes "adapting existing military capabilities to new circumstances," and "selectively recapitalizing legacy forces to meet near-term challenges and to provide near-term readiness" (Department of Defense 2001, iv, 40). Efforts are underway to recapitalize legacy platforms, such as the A-10. The newest Air Force aircraft, the F-35 Joint Strike Fighter, scheduled to begin production in 2008, will gradually replace the A-10 by the year 2028. The Warthog has long been a workhorse of the combat air forces due to its low operating cost and high sortie rates, and the Air Force eventually realized that it must keep the A-10 in the force structure for as long as possible for economic reasons (Isby 2001, 1).

This unexpected longevity has resulted in unexpected challenges. The A-10 has been fiscally neglected throughout its history, according to the Air Combat Command

(ACC) Requirements office.  The congressionally mandated addition of a GPS receiver and an improved computer interface is the only significant capability upgrade in the eleven years since Desert Storm (Feldhausen 2000).  The GPS laid the foundation for all future modifications.  For the first time, the pilots can now accurately find targets based solely on geographic coordinates and can communicate accurate target locations to others using the same coordinate system.

## The A-10 of the Future

Several additional modernization programs introduced in the late 1990s fell prey to shrinking defense budgets.  When the reality of the A-10's extended service life became apparent, the Pentagon realized that a significant amount of money would have to be spent to upgrade the A-10 to extend its life and to prevent it from becoming operationally and technologically obsolete.  Three modifications were subsequently funded:  a data link capability, an upgraded munitions controller, and wiring to employ the next generation of "smart" weapons.  These programs were important, but did not give the A-10 all the capabilities required to make it viable in the twenty-first century (Feldhausen, 2000).

Noticing these critical shortfalls, the ACC Requirements office packaged these three separate but previously funded modifications into single one-time upgrade, producing tremendous savings in engineering, development, integration, and labor costs. These savings permitted the inclusion of three additional, previously unfunded modifications into the program:  IAM integration, a TGP interface, and an upgraded electrical system.  The combination of these six components into a single upgrade saved over $150 million from the price of the original three modifications, while at the same time greatly increasing the A-10's combat capability. The blending of greater capability and reduced cost caused support for the PE program to be overwhelming, with the plan to accomplish the upgrade from 2005 to 2007 (Feldhausen, 2001). An understanding of this $226 million program, the largest single upgrade ever for the aircraft, is necessary to appreciate what kind of Warthog will be flying over tomorrow's battlefield.

Information about the PE program comes from the only two primary sources available. The first is Major Tom Feldhausen's briefing to the ACC commander (2000), which outlines the proposal for the overall program. The second source is the PE design description document, a detailed description of the operation and capability of each element of the upgrade. When the Air Force leadership accepted the PE concept, ACC requirements requested that the author conduct a study on the pilot-to-vehicle interface for the new program to determine how the pilot could best control and employ the new hardware and software. After extensive research, the author produced the baseline interface that described exactly what functions and capabilities the new hardware would possess, and how the pilot would control them. This baseline study was subsequently delivered to the A-10 prime contractor for implementation (Hansen 2000). In conjunction with software and integration engineers, a team of experienced A-10 pilots extensively evaluated and discussed this baseline study to refine the interface and define the desired capabilities. The A/OA-10 Prime Team codified this final determination into a design description document (2002). These two sources contain most of the available information on the five combat enhancing elements of the PE program, explained in detail below.

Situational Awareness Data Link

The first and potentially most important part of the upgrade is the SADL system, which will provide A-10 pilots with unprecedented battlefield situational awareness. An enhanced position location reporting system (EPLRS) radio, the same unit used by the Army and Marines, is installed on board the aircraft, allowing the aircraft to be linked into the ground tactical internet. The SADL system was first tested on the A-10 in 1995, and is now fielded on Air National Guard F-16 aircraft that are tasked with the CAS mission (Situational Awareness Data Link 2000, 1). SADL provides three important new capabilities.

First, it provides precise location and combat identification of all friendly vehicles in the network, one of the most challenging aspects of CAS. Friendly positions are graphically depicted on the tactical awareness display (TAD), presented on either of two color monitors in the cockpit (see figure 1). Any symbol displayed on the TAD may be "tagged" by a cursor to obtain bearing, range, and precise location information. An "X" symbol overlays all friendly positions that lie within the HUD field of view to differentiate them from targets or other information to assist in fratricide prevention.

Second, SADL allows the electronic transmission of information between assets. A ground or air FAC equipped with SADL can transmit CAS briefings or other information directly to the cockpit of the fighters, where it is available for viewing in the standard nine-line format on the cockpit displays. Target coordinates passed from the FAC may be automatically entered into the aircraft's computer and displayed on the TAD and in the HUD. Information on aircraft position, weapons status, and time remaining on station may be obtained directly from the aircraft at any time without any action on the part of the pilot.

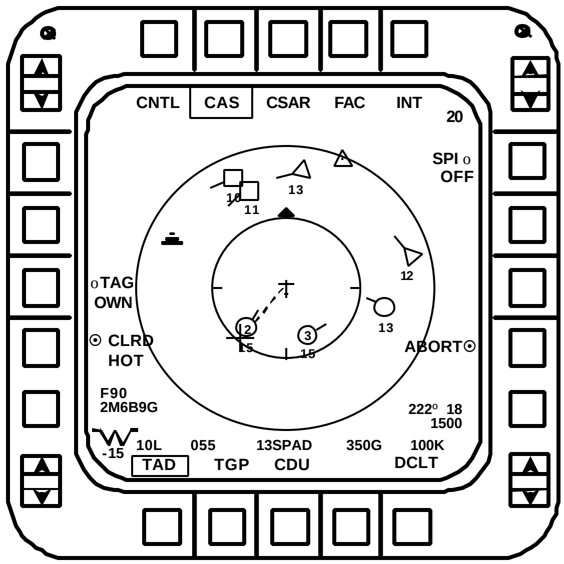


Figure 1. SADL Tactical Awareness Display (TAD)

Third, it provides a fighter-to-fighter network independent of the ground network. The position of each aircraft on the same net (up to four flights of four aircraft) is displayed on the TAD, including information on each aircraft's altitude, speed, direction, fuel remaining, and weapons status.

SADL is not directly compatible with Link 16, the primary USAF air-to-air data link. A gateway to allow two-way communication and interoperability between the systems has been developed and tested successfully. Recent exercises at the Army's National Training Center involving SADL-equipped F-16s and A-10s providing FAC and CAS support to the 4th Infantry "digital" Division were a resounding success (Gourley 2001, 2).

Targeting Pod

PE will provide the A-10 the software, wiring, and integration necessary to carry and employ current and future TGPs on the aircraft. Integration will be available for the Litening II, basic and enhanced versions of the low altitude and navigation and targeting infrared for night (or LANTIRN), and Sniper advanced TGP. The TGP itself is funded under a separate budget. The TGP brings completely new capabilities to the A-10 while enhancing current capabilities. The current USAF A-10 operational requirements document defines the capabilities the TGP must possess: (1) a targeting sensor to provide target acquisition, identification, designation, and precise coordinate generation to allow employment of the gun, air-to-ground missiles, laser guided bombs (LGBs) and intertially aided munitions (IAMs) out to maximum weapons range, in both the IR and visible spectrums; (2) a laser designator to provide ranging and designation from thirty thousand feet out to fifteen nautical miles; (3) a laser spot tracker to detect on board and off board laser designations; and (4) a marking laser visible to night vision goggles (NVGs) (Air Combat Command, 1999). The TGP is integrated with all other sensors on board the aircraft, allowing targets to be "handed off" from one sensor to another.

Inertially Aided Munitions

PE brings the A-10 a new 1760-series electrical bus, associated wiring, and software integration for employment of two types of IAMs: the joint direct attack munition (JDAM) and the wind corrected munitions dispenser (WCMD). Both weapons use an add-on kit that includes an inertial navigation system and movable fins. Target coordinates are transferred from the cockpit to the weapon via the 1760 bus, and the fins "fly" the bomb to the designated target. The GBU-31 JDAM is a 2000-pound general purpose bomb that adds a GPS receiver to update the navigation system and is accurate to less than thirteen meters.  The WCMD kit is added to existing cluster bombs (combined effects munition, gator mine, or sensor fuzed weapon) to increase the accuracy of these highly wind-sensitive munitions to thirty meters.  IAMs remove aiming, ballistic, and wind errors from weapons delivery and allow precision weapons effects from much higher altitudes and greater standoff ranges.  Both of these weapons were used with great success in Kosovo and Afghanistan, representing the new standard for precision.  These types of weapons will continue to dominate the Air Force inventory for many years.

<u>Digital Stores Management System</u>

The DSMS is a less-obvious upgrade, but is integral to the success of the program.  An additional computer and a new digital interface replace the unreliable analog armament control system and controls the employment of all loaded munitions. The DSMS allows the A-10 to drop IAMs and other smart weapons, provides preprogrammed weapons profiles to simplify weapons employment, real-time inventory and status of all munitions, extensive error checking, and additional employment options.

<u>Other Hardware Changes</u>

In addition to these enhancements, several new hardware additions are required to simplify and enhance the interface between pilot and aircraft.  These additional upgrades are:  (1) a new stick and throttles with additional switches and capabilites to facilitate hands-on-throttle and stick (HOTAS) control of all major employment functions; (2) an up front controller to provide heads-up data entry and system control; (3) two five-by-five-inch multifunction color displays to present all available information.  The new cockpit is depicted in figure 2.


Figure 2. Precision Engagement Cockpit

These changes and enhancements make the aircraft a very different platform, with many new and exciting capabilities. These improvements are necessary to support a more sophisticated and capable force that the U.S. Army will bring to the fight in the future.

## The Army’s Interim Force

### Army transformation

On 12 October 1999, Army Chief of Staff General Eric K. Shinseki and Secretary of the Army Louis Caldera unveiled a vision for a more strategically responsive Army for the twenty-first century. They envisioned an Army that would be more responsive, deployable, agile, versatile, lethal, survivable, sustainable, and dominant across the whole spectrum of military operations (Shinseki 1999). This transformation is the U.S. Army’s highest priority, affecting both current and future plans and operations at every level, as it seeks to create a force more suited to perform the kinds of operations demanded by this new global security environment. The primary source of information on Army transformation is still General Shinseki's original presentation. Most of what has been said since that time is merely a repeat of that historic briefing. During the transformation period, the Army will consist of three distinct forces. The first is the "Legacy Force," those heavy elements of the current force structure that must be sustained in order to maintain a credible fighting force during the transformation, and which supports the lighter forces that will follow. Legacy units will eventually transform into the second element, the "Objective Force." Objective units will take full advantage of emerging technologies--a futuristic Army utilizing equipment barely dreamed of today. While this transformation is taking place the third portion of the triad, the "Interim Force," will stand up as soon as possible to meet today's needs for a more agile and responsive force. This three-pronged approach to the future is graphically depicted in figure 3 (Shinseki, 1999).

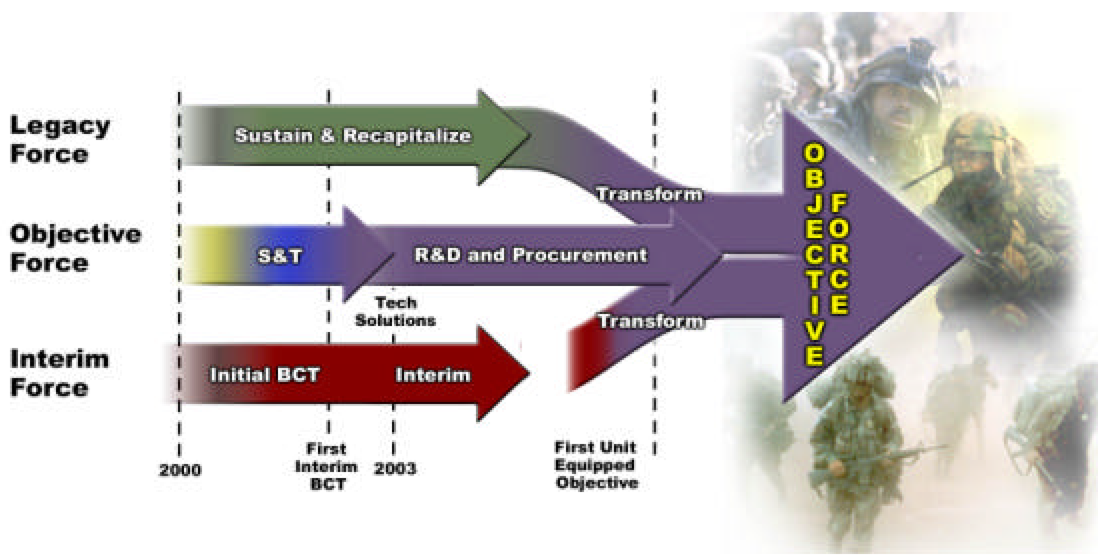


Figure 3. Army transformation

The need for such an Army revolution is readily apparent. An excellent review of Army transformation is found in a Government Accounting Office report (2001). While this report to Congress deals primarily with the acquisition challenges of transformation, it also provides an in-depth examination of the history and future of Army forces, including the IBCT. Since the end of the Cold War, and especially since Desert Storm, the U.S. Army's emphasis has shifted from infrequent large ground maneuver to frequent small scale contingencies. From 1950 to 1990, the Army participated in fifty-five operational deployments, including Korea and Vietnam. Since 1989, the Army has had fifty-three operational deployments (U.S. General Accounting Office 2001, 3). The Army's heavy force is able to dominate any ground force in the world with unmatched combat power. However, this force is difficult to move, and deploying even a single armored division into theater requires a great deal of lift assets and time. This weakness was never more evident than during deployment of Task Force Hawk in support of Operation Allied Force. The U.S. military can never again plan on the luxury of five months of preparation time enjoyed during Desert Shield in 1990-91--future adversaries will not repeat this mistake. For this reason, the first goal of Army transformation is to create units that are much more strategically agile than in the past.

Many articles have been written on transformation, but most only try to define the process without analyzing how the IBCT will be used. Articles in professional journals appear on the opposite end of the spectrum--narrowly focused on how the IBCT will affect a particular system or organization of interest. The most useful writings to this research come from the Army's field artillery branch, which have led the way in the digitization of the battlefield and in electronically integrating fire support. However, fire support from artillery and fire support from fixed-wing CAS remain separate topics, rarely brought together in the same article.

The terrorist attacks in America on 11 September 2001 have only accelerated the need for change. In a speech given three months later, President George W. Bush stated that the first priority in the new war against terror is “to speed the transformation of our military.” He referred to the unprecedented “combination [of] real time intelligence, local allied forces, special, forces, and precision air power” as the key to success in Afghanistan (Bush 2001).

## Interim Brigade Combat Team

The IBCT is a radical departure from the heavy force mindset of the U.S. Army of the past. Designed to be light, maneuverable, and smart, supporting the IBCT will present a new set of challenges for fixed-wing airpower. Colonel Michael Mehaffey, director of the Battle Lab Integration and Technology Directorate, provides a very detailed overview of the IBCT in his *Military Review* article, “Vanguard of the Objective Force” (2000). The IBCT is designed as a “full-spectrum, early-entry combat force,” capable in any theater but optimized for small-scale contingencies. As a lighter, first-entry force, it will be deployable within ninety-six hours of first airlift takeoff. Instead of moving to contact and then developing the situation as is now done by maneuver forces, the IBCT will often be able to develop the situation outside of contact, then maneuver rapidly to initiate contact in a position of advantage of the commander’s choosing. This new way of doing business is summarized in Table 1.

Table 1.

IBCT Conceptual Shifts

| Old Concept | New Concept |
|---|---|
| Make contact; develop situation; maneuver | Understand situation; maneuver; make contact |
| Deploy with all anticipated supplies/equipment | Take essentials--remainder on demand |
| Planning centric--sequential, hierarchical | Execution centric--parallel and collaborative |
| Relative knowns (environment, enemy, doctrine) | Relative unknowns (variety, conditions, "enemy") |
| Enemy as armed force combatants | Plus organizations, agencies, persons as obstacles |
| Forward deployed, prepositioned equipment | Rapid deployment with integral equipment |
| Mature theater, developed infrastructure | Immature theater, underdeveloped infrastructure |
| Combined arms at battalion level | Combined arms at company level |

*Source*: Smith 2000, 34

The principal fighting components of the IBCT are three infantry battalions, organized to conduct a variety of missions either autonomously or as part of any brigade team. The new reconnaissance, surveillance, and target acquisition (RSTA) squadron is tasked to develop situational awareness of the area of operations for the IBCT. Synthesizing information from a variety of sources, including national assets, organic overhead sensors, and human intelligence, the RSTA squadron provides the commander with a "neighborhood level" understanding of the battlefield situation. Support units include headquarters, intelligence, and signal companies; antitank and engineer companies; artillery battery; and support battalion. The IBCT will be augmented with armor, aviation, artillery, and other units as required (Department of the Army, 2000). This organization is depicted in figure 4.

Of significance to this thesis, the fire support system is completely reorganized in the IBCT. The brigade fire support element is replaced by a new fires and effects coordination cell designed to plan, coordinate, direct, synchronize, and manage all lethal and nonlethal fires in support of IBCT operations (Larsen and Walsh 2001, 7)

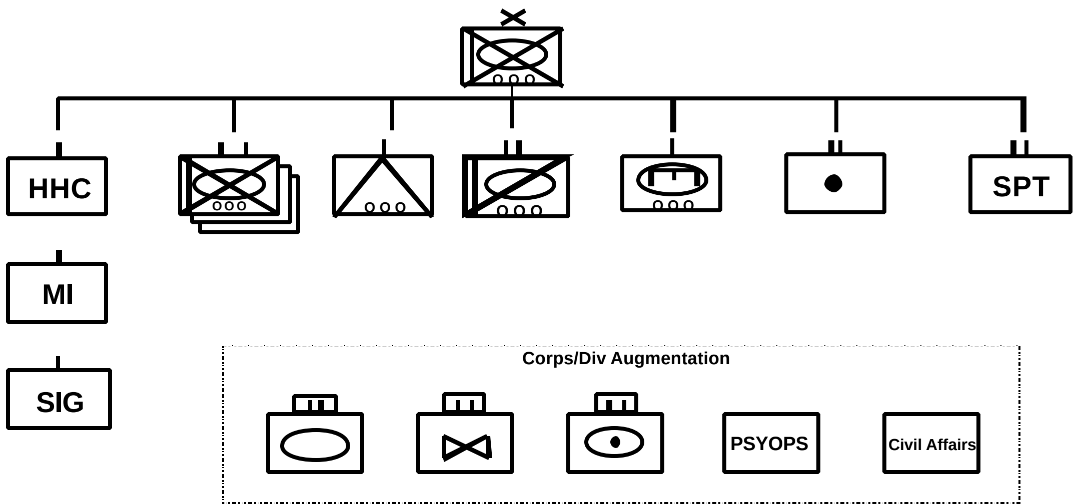


Figure 4. IBCT Organization

The IBCT will also significantly affect the USAF tactical air control party (TACP), the ground liaison units assigned to these units. The TACP consists of one or two Air Force aircrew assigned as air liaison officers (ALOs), and several enlisted terminal air controllers or terminal air command and control specialists assigned to each brigade. Each battalion TACP consists of a temporarily assigned pilot acting as battalion ALO or a permanently assigned enlisted ALO and several other enlisted specialists. Providing the appropriate air support to these new units is new challenge for the USAF, according to the commander of the 1st Air Support Operations Group, which is aligned with the first two IBCTs at Fort Lewis, Washington, who believes that "TACPs are the most significant fire support combat multiplier for an IBCT" (Walsh 2002a). The IBCT is designed to operate independently on a more fluid, nonlinear battlefield, with a much larger area of operations, and often without traditional fire support assets. The first line of defense for small units spread out over such a large area may be airpower. The IBCT will require air liaison down to a much lower level requiring greater TACP manpower. The Army expects the RSTA squadron, operating fifty to sixty kilometers forward of the main body on a 360-degree front, to be primarily supported by air. This unit will also require an additional battalion-sized TACP to support its unique mission. Unfortunately, the Air Force is currently not inclined to change TACP manning to support the IBCTs different mode of operations (Walsh 2002a).

Both the A-10 and the IBCT will operate in an environment unlike anything experienced before. This future environment will force great changes in operations for both air and ground forces.

## Future Battle Space

Tomorrow's operations are far more likely to be small-scale contingencies than major theaters of war. These limited operations are likely to follow the pattern of the recent past, with "restrictive rules of engagement, high-level political involvement in the targeting process, and public demand for low collateral damage" (Jumper 2001, 28). Enemies will seek to protect military assets by inviting collateral damage and then attempt to create an international outcry when it occurs, while at the same time attacking U.S. interests in new and asymmetrical ways. The battle space of the future will demand precision weaponry, seamless joint operations, and a high degree of situational awareness developed through superior informational sources.

### Tomorrow's Airspace

The airspace above the future battlefield will be much more crowded and more complicated, with manned and unmanned aircraft, artillery shells, rockets, and missiles from many different services and nations sharing the skies. Many changes will be made to facilitate control, integrate forces, and reduce fratricide.  The primary change in the future will be the addition of data links between most airborne assets to augment traditional radar capability now used for control.  With the additional information available through the data link, fewer command and control assets will be required to direct a larger number of aircraft with greater safety, and aircrews will not be as dependent upon off board systems for situational awareness (Putney 2001, 8).

### Air Force transformation

In his article *Air Force transformation:  Past, Present, and Future* (2001), Major General David Deptula, a key air planner during Desert Storm and head of the Air Force Quadrennial Defense Review, provides an overview of the future of his organization.  He describes the transformational changes that are occurring in three areas that are directly related to the future of the A-10:  (1) advanced technologies, including next-generation precision weapons that are smaller and have autonomous target recognition capability; (2) new concepts of operations, including targeting for effect rather than simply for attrition; and (3) organizational change, based on having ten equally-capable air expeditionary forces available.  He also lists fourteen critical future capabilities for the USAF.  Those that are applicable to this thesis are:  (1) continue to innovate on the integration of new concepts and technologies; (2) rapidly and persistently target and retarget mobile targets; and (3) provide real-time targeting information within minutes after tasking.

General John Jumper, USAF Chief of Staff, is moving the service towards a new concept of operations he calls the “Global Strike Task Force.” This idea seeks to project the nation’s military power anywhere in the world on short notice, even when forces do not have access to land-based airfields near the disputed region. According to Jumper, once thorough intelligence gathering has taken place, B-2 and F-22 aircraft, using stealth and precision weapons, can "kick down the door" by attacking key command and control and air defense nodes, "rolling back" the threats and allowing the bulk of the force to enter the theater. Those follow on forces must be able to integrate with collection platforms on the machine level, receive targeting information in real time, and quickly delivery precise weapons effects (Jumper 2001).

## The Digital Battlefield

Modern digital tools have the potential to enhance the military's ability to apply skills and abilities to conduct decisive operations. The most significant change from today's operations is intra-unit and inter-unit connectivity. The IBCT will be the first unit designed to be digitally linked from its inception. Using new and existing systems in the Army battle command system, the IBCT can automatically share information between and within echelons in near real time to reduce the fog and uncertainty of war and answer the to three questions that have plagued military forces from the beginning of time: "Where am I?" " Where are my forces?" "Where is the enemy?" The implications for such a unit when supported by SADL-equipped fighters are many, as both ground and air forces will have unprecedented awareness of each other's activities.

Units will be connected through a real-time tactical internet using current and future tactical radios: EPLRS, single channel ground and air radio system (or SINCGARS), and near-term digital radios (Boller 2000, 33). General James Dubik, deputy commander for transformation, believes that a force connected in such a manner will allow "more combat power at the point of battle." This interconnectivity will be a combat multiplier, allowing forces to integrate and synchronize combat power much more effectively--a battlefield revolution comparable to the introduction of the radio prior to World War II (Dubrik 2000). Using the system, units will have the ability to share information and work from a common battlefield picture to facilitate coordination and integration (Putney 2001, 8). Each unit and organization uses the same, or common, data according to their needs and objectives, choosing which information to display at what time (Boller 2000, 30). This common operating picture has been described as the "full situational awareness of all information sources integrated into one complete picture of the battlefield" (Perkins 2001, 19).

Many digital tools play an integral part in this battle space network. The future battle command brigade and below (FBCB2) system provides near real-time information and command and control through a common tactical picture of the battle space. Similar to the SADL TAD, FBCB2 graphically depicts friendly positions (automatically placed and updated through the tactical internet), enemy locations (as reported by observers, sensors, or through analysis), map data, and operational and tactical graphics. FBCB2 can automatically send position or other reports based on predetermined triggers or events. The advanced field artillery tactical data system (AFATDS) integrates, automates, and facilitates fire support operations and planning. The system handles all fire support functions for the maneuver units, including CAS and is fielded from echelons above corps down to the individual firing platoons (Boller 2000, 34). Army fire support assets now have visibility of the air tasking order, airspace control order, AI missions, AI requests, preplanned CAS missions, immediate CAS requests, and mission reports. Higher echelon units can sort requests to deconflict targets and airspace, delete duplicate requests, and check for violations of airspace and fire support control and coordinating measures (Williams 2001, 20). This increased connectivity allows management of control measures in real time and improves communication between ground and air forces. FBCB2 will also provide unprecedented battlefield situational awareness to the USAF TACP assigned to the IBCT (Putney 2001, 8). The Air Force is struggling to keep its TACP modernization program aligned with the Army's transformation, to insure that compatible and supportive digital tools are available to air liaisons (Walsh 2002b).

## Impact of Technology

Technology brings its own dangers to the military art. Technology is a tool, not a solution, and both designer and user must determine how best to integrate new and old systems. Technology can provide additional information to make tasks easier, but operators can easily be overcome by a flood of data. "Data cannot be dumped on warriors; it must be converted to information" (Unterreiner, et. al. 1996, 39).

The importance of information display and filtering has become more important than ever. The challenge for system designers is to insure that the reduction of fog and friction is greater than the additional resistance inevitably created by that technology. While technology will never be equally effective for all tasks, it must be applicable across all mission types (Kipp and Grau 2001, 97).

The new hardware, organizations, and battle space of the future will change the way air and ground forces integrate with each other. This thesis focuses primarily on fixed-wing air support of Army ground forces, and the integration of fire support on tomorrow's battlefield.

## Close Air Support of the Future

### Historical Context

The limitations of current CAS doctrine have been the topic of debate among the services for many years. In spite of repeated discussions and numerous articles written on the subject, progress in updating doctrine and procedures to fit new technological advances and operations on nontraditional battlefields have been slow in coming. Communications, equipment, and training have not kept up with new precision weaponry and tactics. CAS is by its very nature a joint problem, and changes and improvements in joint doctrine and TTP must be agreed upon by all services, which lengthens and complicates the process (Wood 2001, 16).

Some Air Force leaders have even gone on record as saying that modern airpower could make CAS obsolete on the future battlefield. General Mike Loh, former ACC commander, said that the Air Force's technological superiority could "relieve to a great extent the army's direct contact," making CAS unnecessary (Boatman 1992, 18). Another commander related that not only was CAS obsolete, but if it became necessary, any advanced fighter could easily perform the mission (Hall 1998, 94). Some air forces have shied away from the mission entirely. A recent commander of the Israeli Defense Forces believes CAS is now less relevant--teaching pilots to identify friendly forces is too difficult, since the mission is to identify and strike the enemy (Warden 2000, 86).

From the U.S. Army's perspective, CAS is still a critical mission. Field Manual 3-0, *Operations,* states:

> Air Force air platform support is invaluable in creating the conditions for success before and during land operations. Support of the land force commander's concept for ground operations is an essential and integral part of each phase of the

> operation. . . .Land force commanders understand that defeating enemy air and space capabilities is necessary to ensure freedom of action on the ground. (2001, 2-7)

Joint operations are becoming more and more common, even as ground forces become increasingly lighter. In the future CAS will be used more frequently to offset possible enemy armor and artillery shortfalls (Hoppe 2001, 20).

## Current Status

Recognizing the limitations of current CAS doctrine and procedures, the Office of the Secretary of Defense commissioned a joint close air support (JCAS) joint test and evaluation (JT&E) in 1998. The test was chartered to "investigate, evaluate, and improve the operational effectiveness of joint CAS," and to "identify changes to TTP, equipment, and training to increase effectiveness" (Brown 2001, 9). The test team initially observed twenty-two battles at the Army's National Training Center to evaluate current CAS effectiveness. Following additional testing, the JT&E will test various enhancements and use the results to make recommendations for improvement to CAS operations. The interim report from this test is a fascinating look at the current limitations in CAS doctrine, TTP, training, and equipment (Office of the Secretary of Defense 2000).

## Doctrinal Limitations

A great deal has been written recently on doctrinal disconnects, battlefield sanctuaries created by doctrine, and limitation of current procedures. Major Todd Serres's recent thesis, "New CAS Doctrine: Getting Control of Emerging Technology and Advanced Concepts" (2002), presents an excellent review of current CAS doctrine and provides recommendations for revisions to current TTP. This thesis will only address those procedures that apply to digital CAS and those that must be changed in order to fully exploit these technologies.

The "how to" of CAS is found in Joint Publication (JP) 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS)*, which lays out classic procedures as they have been taught and employed for years. "Unfortunately, its guidance is based on lessons learned from CAS employment in previous conflicts without the technological capabilities that are available today. U.S. forces currently do not have the equipment, TTP, or training necessary to employ CAS to the full extent of current force capabilities and requirements" (Brown 2002, 20).

CAS is defined doctrinally in JP 3-09.3 as "air action by fixed- and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces" to "accomplish military objectives assigned to tactical units" (1995, I-1). Questions arise in the CAS community as to how close "close proximity" is, and how detailed must "detailed integration" be? Air Force Doctrine Document (AFDD) 2-1.3, *Counterland*, defines close proximity as "the distance within which some form of terminal attack control is required for targeting direction and fratricide prevention," and detailed integration as "the level of coordination required to achieve the desired effects without overly restricting CAS attacks, surface firepower, or the ground scheme of maneuver" (1999, 4). It also reveals that:

> The two key factors when employing CAS have always been the need to provide flexible, real-time targeting guidance to CAS aircraft and the need to avoid hitting friendly ground forces in close proximity to the target. These have shaped the tactics and command and control (C2) methods currently employed for CAS operations. The fluidity of the ground situation that exists within this close

> proximity distance usually requires real-time direction from the terminal controller to ensure that targets of highest priority to the ground commander are struck. The need to react to a rapidly changing ground battle has led to the CAS C2 system in place today. (1999, 4)

Unfortunately, procedures have not yet been developed for air support of digitally connected forces that would provide the "flexible, real-time targeting guidance" desired.

In order to "avoid hitting friendly ground forces," JP 3-09.3 establishes very strict methods of terminal control. The preferred method to "be used whenever possible" is positive direct control. This method requires the terminal controller: (1) be in position to see the desired target; (2) be in position to see the attacking aircraft; (3) receive verbal confirmation that the attacking pilot has the target in sight; (4) determine that the aircraft is attacking the correct target; and (5) transmit "cleared hot" to the attacking aircraft prior to weapons release (1995, V-9). Accomplishing these five tasks is difficult under ideal conditions, and impossible for a ground controller directing a high-speed aircraft employing standoff munitions from high altitude in a battlefield environment. A 1999 JCAS JT&E mini-test revealed the difficulty of this problem. Experienced ground controllers in near optimum conditions (controlling large and slow A-10 fighters from medium altitude in a day, clear weather, desert environment) could make a correct visual determination of both the aircraft's attack axis and the target being attacked in only 38 percent of 666 observations. (Office of the Secretary of Defense 1999, viii).

Lieutenant Colonel Glenn Hoppe discussed the difficulty in current procedures in his Naval War College thesis, "Current Close Air Support Doctrine: Out of the Step with New Technology and Urban Requirements." Although specifically talking about urban operations, Hoppe believes that "a terminal controller may elect to sacrifice target acquisition for direct line of sight communication and still not not be able to visually acquire the delivering aircraft" (2001, 10). He also contends that "the requirement for the terminal controller to visually acquire both target and CAS aircraft" is "antiquated" and "impractical" for today's battlefield, and that "some modernization of positive control is warranted," suggesting that some type "virtual control" procedures be adopted (2001,20).

JP 3-09.3 does allow a terminal controller who cannot see the attacking aircraft to use "other means to confirm that the aircraft is attacking the correct target and has friendly positions in sight" (1995, V-9). A verbal description is the example of "other means" used in the TTP, and using data link to track the aircraft and confirm the target being attacked is not explicitly allowed under current guidance. However, the intent of the TTP is that the attacking aircrew visually acquire the target and the friendly forces. Accomplishing a long-range standoff attack using data link to digitally acquire both target and ground forces is clearly not allowed in doctrine. AFDD 2-1.3 refers to CAS conducted beyond visual range of terminal controllers, and acknowledges that a "doctrinal gap" exists for this situation. This Air Force doctrine states that a "method currently being employed" is to allow the aircrew to act as the observer and use indirect positive control procedures (1999, 57). This wording attempts to get around limitations in joint TTP and justify what is already being done, but is not clearly allowed by joint doctrine.

Fortunately, the latest draft of JP 3-09.3 (2001) makes the attempt to update of some these age-old procedures and tries to make sense of air support on the modern battlefield. However, this new publication only attempts to codify what is already accepted procedure and is not designed to predict future operational procedures. This proposed TTP replaces the current methods of direct control and reasonable assurance with three types of control. These methods of control are summarized in table 2.

Table 2.

Proposed JP 3-09.3 Terminal Attack Control (TAC) Procedures

| Type 1 Control | Type 2 Control | Type 3 Control |
|---|---|---|
| - Most restrictive control<br>- TAC visual with target and attacking aircraft<br><br>Considerations for use<br>- Language barriers exist between coalition forces<br>- Lack of confidence in a particular platform<br>- Lack of confidence in aircrew capability<br>- Troops in Contact situations | - TAC unable to see aircraft<br>- Aircraft unable to see mark<br>- TAC, observer, or other asset "sees" the target<br><br>Considerations for use:<br>- Timeliness and accuracy of targeting data<br>- Weapon time of flight<br>- Detailed planning and preparation for standoff weapons flight profile and aircraft/weapon/ terrain deconfliction<br>- Digital or data link providing situational awareness to TAC and aircrew | - TAC not visual with target<br>- Aircraft or observer acquires target<br>- Low risk of fratricide<br><br>Considerations for use:<br>- Specific parameters/restrictions issued to aircraft along with "blanket" clearance to engage TAC- coordinated/controlled targets<br>- Aircraft initiate attacks within parameters imposed by the TAC<br>- Observer may deliver CAS briefing/terminal guidance to aircraft<br>- TAC monitors transmissions to maintain control of attack |
| TAC will:<br>- Visually acquire target<br>- Deliver CAS brief to aircraft (verbally or digitally)<br>- Mark/designate target<br>- Visually acquire aircraft (verbally or digitally)<br>- Ensures friendlies safety by visual analysis of attack geometry/nose position (verbally or digitally)<br>- Provide "cleared hot" or "abort" based on compliance with above procedures (verbally or digitally)<br><br>Attack Aircraft will:<br>- Provide "In" call (verbally or digitally) | TAC will:<br>- Deliver CAS Brief to aircraft (verbally or digitally)<br>- Provide "cleared hot" or "abort" based on compliance with above procedures (verbally or digitally)<br><br>Attack Aircraft will:<br>- Confirm target elevation and location (verbally or digitally)<br>- Verify target location correlate w/expected target area (verbally or digitally)<br>- Provide "In" call (verbally or digitally) | - TAC will:<br>- Deliver CAS Brief to attack aircraft (verbally or digitally) to include area for attacks, restrictions/limitations, attack time window<br>- Provides "cleared to engage" to attack aircraft (verbally or digitally)<br>- Monitor engagement<br><br>Attack Aircraft will:<br>- Provide "attack complete" to TAC (verbally or digitally) |

*Source*: Serres 2002, 35.

The most noteworthy change in these procedures is the allowance made for both the aircraft and the TAC to not only exchange information digitally, but also to gain situational awareness of the attack through digital means.  AFDD 2-1.3 also warns that: "As with all new systems, however, reliability and compatibility must be proven before new sensors or weapons are employed, especially in the CAS environment" (1999, 58).

The JCAS JT&E initially found that not only is current doctrine and TTP lacking, it is not followed in the majority of cases due to lack of familiarity and training.  In 307 CAS weapons passes during the test, 50 percent used positive direct control, the preferred method.  The remaining passes used some other, nondoctrinal method of control or no control at all (Office of the Secretary of Defense 2000).

Literature is now becoming available that discusses how best to exploit available and future technologies to provide better air support.  While many of the sources listed here are applicable to this thesis, no references exist that adequately address the research questions.  This review of the literature has revealed that this research is vital to the future of joint fire support.

## Air Support of the Future

The lighter, more mobile IBCT will rely heavily on airpower for fire support.  To support the fast moving and fluid battlefield of the future, it is crucial that CAS capabilities are updated to meet these new challenges.  Existing TTP does not sufficiently address technologically advanced aircraft employing this potentially life-saving asset.  Aircrew can work around outdated TTP to accomplish the mission, but this is not the best way to sufficiently employ limited air assets (Brown 2002, 20-21).

SADL was used in a normal operational environment for the first time at the Army's National Training Center in late 2001. The TACP used SADL ground equipment to communicate with SADL-equipped F-16s with TGPs. The Brigade ALO reported the following observations:

1. SADL enhances friendly ground and air safety, improves deconfliction, and reduces fratricide.

2. SADL provided the TACP and brigade staff with faster and better battle tracking.

3. SADL was indispensable for airspace monitoring and situational awareness, from aircraft takeoff through actual attacks, especially at night, in bad weather, and beyond visual range.

4. SADL greatly enhanced command and control through digital transfer of CAS briefings and use of the digitally transmitted targets.

5. Targets found by the TACP or aircraft were quickly displayed on the SADL laptop computer, screened by the ALO, approved by the commander, and destroyed by CAS aircraft.

6. SADL gave the ground commander a high degree of situational awareness and confidence in the employment and affect of fixed-wind air support.

This TACP was very enthusiastic about SADL, and recommended that the ground portion of the system be procured and integrated down to battalion level to enhance TACP and aircrew safety, survivability, and effectiveness (Steele 2001, 1).

Major Kenneth Stefanek's thesis, "The Utilization of Inertially Guided Weapons in Performing Close Air Support" provides a succinct discussion of the realities of the modern battlefield. Visually delivering a more accurate weapon using conventional tactics can only increase CAS weapons effectiveness. However, the increased standoff range of IAMs make it possible to deliver ordnance without visually acquiring the target or the friendly forces. U.S. bombers are currently performing "CAS" missions using IAMs from very high altitude over Afghanistan. Stephanek points out that this procedure is not doctrinally correct and cannot be considered either positive direct or indirect control. Not only can the pilot not see the target, but the TAC cannot see the aircraft and has no way to confirm visually that the aircraft is attacking the correct target (1998, 44). Stephanek concludes that IAMs can safely be used in a CAS scenario if confidence in the accuracy of the target coordinates is high and if either friendly forces are not in close proximity to the target or an independent source of situational awareness is available to both pilot and TAC (1998, 76). Joint Pub 3-09.3 states, "When supplied with GPS coordinates by terminal controllers, computed deliveries can be extremely accurate" (1995, IV-18).

## Summary

A review of the literature reveals a number of relevant sources that are necessary to create a foundation of understanding for each of the elements under study. This understanding is critical in deriving conclusions and answers to the research questions. This literature review has also revealed the need for this thesis. No research yet exists that addresses the future tactical employment of the Air Force's primary CAS platform, or how it will support and integrate with the Army's interim force. This thesis attempts to fill that research void.

# CHAPTER 3

# RESEARCH METHODOLOGY

## Introduction

This chapter examines the research methods used to translate research begun in chapter 2 into the analysis of chapter 4. This analysis will provide answers to the research questions presented in chapter 5. This thesis will determine if next year's technologies and procedures are adequate for military operations conducted in the next decade. These questions must be answered today if U.S. armed forces are to be ready tomorrow.

According to Weber, content analysis is a research method that uses a set of procedures to make valid inferences from text. Content analysis is used to systematically evaluate many items of data to determine their relevance and interrelationship. This technique is useful because this study seeks to take information from multiple locations and sources, analyze it for content, and then synthesize these analyses into meaningful conclusions. Content is then organized into categories that will answer each of the research questions (1990, 9).

## Research Plan

The major parts of the research questions (airspace, A-10, Army, and CAS) were introduced in chapter 2, along with a brief background and an introduction to future capabilities. With this foundation, the employment and integration of these future systems may now be analyzed. In order to arrive at satisfying conclusions to the research questions, a conceptual battle space of the future will be built, based upon previous research findings, joint exercises, experiments, and the author's own experience.

First, the airspace of 2010 will be defined. This airspace will include the various air and space components available at that time, with a discussion of how these elements will integrate information and employment. Next, the upgraded A-10 with its future capabilities will be incorporated into this airspace. Finally, the Army's IBCT will then be introduced into a digital battlefield beneath this airspace. This battle space study will focus on the capabilities of the forces in question, and not be oriented toward a particular threat or a specific piece of terrain.

A notional TTP will be developed to integrate the air and land battles together. This integration will focus on the most likely A-10 missions in the future: CAS, forward air control-airborne (FAC[A]), AI, and CSAR. The TTP will include the essential tasks the A-10 must be able to perform in the future. The author will then conduct a subjective evaluation to determine if the developed TTP is effective for each of these missions. This evaluation will be used to answer the research questions and determine if A-10 employment will be possible and effective in future conflicts. The evaluation will judge the effectiveness of each tactic, technique, or procedure using the following four-point scale:

1. <u>Ineffective</u>. TTP had prohibitive limitations that would result in unsuccessful mission accomplishment.

2. <u>Marginally ineffective</u>. TTP had limitations that would require alterations to execution and usually resulted in unsuccessful mission accomplishment.

3. <u>Effective</u>. TTP had limitations that required alterations to execution but usually resulted in successful mission accomplishment.

4. Very effective. TTP had minor limitations that required no alterations to execution and nearly always resulted in successful mission accomplishment.

In order to obtain the required background information and knowledge to satisfactorily conduct the evaluation, the research will focus on future airspace, A-10 employment, IBCT operations, and CAS.

## Future Airspace

Tactical data link has the possibility of having a greater impact on airspace control than any factor since the introduction of radar. The air and space medium of tomorrow will contain new command and control assets, new procedures, new capabilities, and a new level of situational awareness by all players. Legacy systems, such as the A-10, will be upgraded to meet the new demands of this increasingly complicated airspace, but doctrine and TTP must also be updated to handle the additional information available to insure that new capabilities enhance operations rather than detract from them.

## Future A-10 Employment

The hardware and software available to the A-10 in 2010 are well known. How these systems will be used on tomorrow's battlefield has not been identified. Adding future PE capabilities to current A-10 TTP will produce an approximation of future procedures. Using TTP from other aircraft that employ similar systems in similar roles (the F-16C for SADL, targeting pod, and precision weapons; the F-15E and F-16CJ for inertially aided munitions) will help make these projections as accurate as possible. While not a perfect method, the results should be satisfactory for the purposes of this thesis.  The most pressing question and the greatest unknown at this time is:  How will the A-10 be employed in the future?

### The Interim Force

Similar questions exist for the IBCT.  The organization and equipment are established, but the development of TTP is still underway.  The IBCT features a very different organization and mission and consequently, must develop a very different way of doing business.  Those areas that deal directly with air support and joint integration areas are of special interest.

The primary area of emphasis in this area is the TTP for the Air Force TACP currently assigned to the first ICBTs at Fort Lewis, Washington.  These units must develop procedures for leveraging the advance technologies and capabilities of the ICBT they support, and their input to the process is critical.

### Future CAS

The analysis in this area will be focused on the integration of the A-10 and the IBCT for joint fire support.  An evaluation of the suitability of current CAS TTP for use on a digital battlefield will form the foundation for this part of the thesis.  Once the individual parts of the equation are defined and analyzed, developing proposed TTP for their integration will be the next step.

Of primary interest are digital fire support coordination and the digital integration of joint fires.  New organizations (such as the fires and effects coordination cell) and equipment (such as AFATDS) have the possibility of improving and perhaps even automating fire support.  How these elements will be used is critical to understanding of ICBT operations from an air perspective.  Other areas of interest include the RSTA

Squadron, and how targeting location and reporting will be accomplished. The limited history of digital CAS will be incorporated into this part of the analysis. Several questions must be answered: Can digital CAS be accomplished safely with the IBCT, and if so, how? Can the A-10 obtain the necessary situational awareness from the digital battlefield using onboard sensors? Can fixed-wing assets provide additional situational awareness to the ground battle?

## A-10 Mission Essential Tasks

In determining the feasibility and acceptability of the A-10 on the future battlefield, a qualitative analysis of the TTP developed in chapter 4 will be conducted. This analysis will determine the effectiveness of each capability and task required in 2010. If the A-10 cannot perform these critical tasks, then it will be unsuitable for use in the environment that it will be tasked to fly in during future operations.

## Summary

By taking what is known today (in-depth review of literature currently available, procedures and practices now being developed, and the researcher's personal knowledge and experience) and combining it with what is known about the future, the research questions may be answered and a reasonable projection for the future of the A-10 may be satisfactorily obtained.

# CHAPTER 4

# ANALYSIS

## Introduction

This thesis focuses on two future systems on the battlefield of the year 2010--the USAF A-10A Thunderbolt II aircraft and the U.S. Army's interim force as represented by the IBCT--and how they will interact with one another and with the battle space around them. The purpose of this chapter is to determine if these two diverse systems can integrate into an effective fighting force in the future and how this integration would be accomplished.

The primary research question of this thesis is: Can the PE-modified A-10 operate effectively on the battlefield of 2010? Before this question can be answered, three subordinate questions must be investigated: (1) Can the A-10 integrate into the airspace above the battlefield of 2010? (2) Can the A-10 integrate with other fires and effectively support the U.S. Army's interim force on the digital battlefield of 2010? and (3) Do current joint doctrine and TTP effectively address CAS fires on a digital battlefield, or are changes required to make digital close air support possible and effective?

In order to answer these questions, a conceptual battle space of the future will be used as a framework for analysis. Each element of this battle space--the airspace, the upgraded A-10, and the IBCT--will be examined individually, followed by a detailed analysis of the integration of the air and land battles. Since this thesis deals with the future, the analysis treats each element of the battlefield and its interaction as it exists in the year 2010. Discussion, findings and information will be given in the present tense, as if this were the year 2010. Since no research yet exists on the interface between these future combat elements, this projection of future capabilities will be based upon previous research findings, joint exercises, experiments, and the author's own experience. The analysis will conclude with an examination of the TTP for probable A-10 missions in the future. Using this future battle space and TTP, a subjective qualitative evaluation of essential A-10 tasks will determine if employment in 2010 is feasible, acceptable, and suitable for each of these missions. Following the lead of the 2001 Quadrennial Review, this analysis will be a capabilities-based, rather than a threat-based, assessment.

## Battle Space of the Future

### The Airspace

The first element of this future battle space extends from the earth's surface to the reaches of space. Air and spacecraft today operate in a more dynamic and complicated world than ever before. Air operations do not differ drastically from those in the past, but new technologies will drive changes to procedures while increasing effectiveness.

#### Data link

The most obvious and significant change in the near term will be the universal introduction of data link to U.S. aerospace forces. In 2010, all aircraft are linked together digitally in a near real time network. This system gives operators and controllers almost complete situational awareness of all friendly and many threat assets, with information shared automatically between forces. In the past, aircrews combined information obtained from sources within the cockpit (physical senses and onboard sensors) and from external sources (radio calls from other aircraft and sensors) and then mentally processed and synthesized the information in order to build a picture of the battle space. Today, data link systems depict this information (and much more) graphically within each cockpit and workstation, in a manner that can be interpreted quickly and easily. This information is passed over a secure, jam-resistant, low probability of intercept network and provides the unprecedented ability to almost instantly gain or regain situational awareness with a single glance.

Operators in 2010 have greatly increased battle space awareness. Deconfliction between aircraft is now much easier, especially at night and in bad weather. Aircrew can generally provide their own safe separation from other aircraft in high-density combat areas without having to rely on ground and airborne radars. Information between sensors is automatically shared; the situational display in an F-22 not only depicts those targets tracked by its own radar, but also those being tracked by other aircraft or ground radar stations. Surface and air threat information, obtained from a variety of sources, is also displayed graphically, providing earlier and more complete warning of enemy activity. Each member in the network uses the same common operating picture and shares the same view of the battlefield, reducing the need for often-misunderstood voice radio communication. Information previously passed over communication channels is now available through data link. By simply tagging a symbol on the display, information on that aircraft’s altitude, airspeed, direction, type, and weapons status is obtained. Preplanned and free-text messages are used to pass more detailed information between assets.

The Department of Defense was slow to exercise control over data link technology in the past, and as a result, each service (and sometimes individual organizations within a service) developed and introduced similar but incompatible systems during the 1990s. One system, Link-16, was established late in the 20th Century as the “standard” data link for all services. By 2010, most major aircraft and airborne command and control systems have a Link-16 system on board to provide two-way communication with the joint network. Unfortunately, ground forces took a different track in the past, and the Army’s tactical internet uses a completely different system. This network will eventually be replaced by a Link-16 compatible system in the future, but for a now, a two-way gateway (developed in 1995) translates information between the two systems. This gateway has worked successfully for years, but adds another layer of complexity and additional moving parts to an already complicated and fragile network, and it must be continuously available and in a position to provide line of sight with both systems.

In the late 1990s the interoperability issue drove the A-10 community to acquire the SADL instead of Link-16, against the wishes of Air Force leadership who desired a common data link. SADL ties directly into the tactical internet using the same radio used by ground forces. A-10 pilots and staff officers reasoned that it was more important to have direct communication between the A-10 and its primary customer (friendly ground forces) without reliance on a gateway. Link-16 could not represent the complete ground picture, and data latency between the two systems was of a concern to CAS pilots. Air National Guard units tasked with the CAS mission also have SADL installed in their F-16 Block 30 aircraft. The gateway operates between the ground battle--the Army and primary CAS aircraft operating on a common network--and the air battle above, where all players are now linked together through Link-16. Basic information, such as aircraft and threat positions, is shared between the two networks, along with all basic message formats.

This solution works best from an air support and ground perspective, but has been problematic in actual employment in the airspace of 2010. There is some data latency through the gateway, and not all Link-16 information can be displayed properly. However, the nature of today's battlefield has mitigated some of these problems. More information is now available over data link than can be assimilated by a pilot in a single-seat aircraft, and only mission essential information is displayed in order to keep a manageable number of symbols on the screen. Continued air supremacy in all theaters has reduced the need for air-to-ground aircraft to always have a complete air-to-air picture available. While in the target area, a CAS pilot routinely deselects friendly aircraft information coming over the gateway, and only displays threat aircraft, surface threats, and friendly ground force information. Even more information is filtered out during a complicated ground battle, so that only friendly and enemy ground forces are displayed. The most difficult problems arise when the SADL gateway is not working.

The first is the loss of integration into the friendly air picture. Since data link is now the primary means of air identification, a nonoperational gateway forces ground and air early warning radar platforms to revert to backup methods to control SADL aircraft. Using identification-friend or foe and verbal communication, SADL aircraft can be positively identified and deconflicted, but at the cost of increasing the workload for weapons controllers. In addition, without a gateway SADL aircraft and Link-16 aircraft do not "see" each other displayed over the data link and must rely on internal or external sources for friendly deconfliction. This is especially difficult for the PE A-10, which still has no on board radar or identification systems. Without a gateway, air-to-air pilot workload increases dramatically, who must integrate their own data link picture with verbal position reports from incompatible aircraft. Experience has shown that this increases the number of friendly radar locks on SADL aircraft, while confusing the current air picture. It should be noted that when single point network failure occurs, such as one aircraft in a four-ship of F-15s that cannot connect to the link, that aircraft almost becomes a liability to the flight, rather than an asset. With such a decreased level of situational awareness compared with the rest of the flight, the pilot is reduced to a "welded wingman" role, providing additional weapons to shoot at targets found by other aircraft.

The second problem associated with the loss of the data link gateway is the lack of real-time threat information. Information on threats located by counterair, surveillance, electronic warfare, and suppression of enemy air defense aircraft, as well as by national assets and other intelligence collectors, now automatically appears on the display of everyone on the link. Since threat information is passed over the Link-16 net, SADL aircraft do not have access to this information without an operating gateway. The only threat information visible to SADL aircraft will be those manually input by another SADL aircraft (a tedious process that occurs infrequently) or those that are available on the Army net. Like other aspects of information access, once operators get used to the wealth of knowledge available, they struggle when this information becomes temporarily unavailable.

New Capabilities

Several new technologies that appeared near the turn of the century are now fully integrated into the airspace of 2010. Unmanned aerial vehicles (UAVs), are now commonplace, providing real-time intelligence, reconnaissance, and surveillance feeds to commanders and intelligence analysts. Unmanned combat aerial vehicles conduct strategic attack in heavily defended areas, suppression and destruction of enemy air defenses, armed reconnaissance, and time sensitive air interdiction. While not fully integrated into strike packages, these pilotless aircraft support these packages by saturating air defenses, conducting decoy and deception operations, and providing around-the-clock flexible targeting against emerging and mobile targets. UAV and weapons technology has not yet progressed to the point where attacks against targets in close proximity to friendly forces are allowed. Equipping unmanned vehicles with data link has also greatly reduced airspace deconfliction problems. As late as 2004, manned aircraft were restricted from areas and altitudes used by UAVs, greatly reducing flexibility and employment. Today, UAVs positions are shown on the data link picture, and aircrew deconflict the airspace in real time.

Older aircraft are also being used in new ways. For example, the E-8C joint surveillance target attack radar system (JSTARS) is now often used as an airborne command and control platform. In theaters where CAS is used extensively and an airborne extension of the theater air control system is required, JSTARS or airborne warning and control system (AWACS) aircraft are used to control the flow and tasking of aircraft, replacing the C-130 airborne battlefield command and control center (or ABCCC) that was retired years ago. JSTARS shares its ground picture with other air control elements and Army intelligence organizations via data link, increasing the situational awareness of the entire theater. Since JSTARS and AWACS both share the common operating picture with the air support operations center and other elements of the theater air control system, any of these agencies can command and control air support assets, providing mutual support and redundancy within the system (Koven 2000, 25).

Intelligence fusion is also becoming a reality. Many different airborne and spaceborne sensors (including nonconventional collectors, such as specially equipped tanker aircraft) provide radar, electronic emission, visual, multispectral imaging, communications, and signal intelligence data to a common information fusion center. There, the data is synthesized with information obtained through unconventional means (such as electronic signals and cockpit video collected by fighter aircraft) via data link and other transmission means, into a common operating picture available to all agencies and platforms.

With additional intelligence information feeding the targeting process, the time between locating a target and bringing ordnance to bear has decreased dramatically. When sensors locate a possible target, the information is quickly processed and analyzed, a targeting decision is made, a precise location is determined, and then passed digitally to loitering aircraft, which then release the weapons on the confirmed target. This cycle can now occur in just a few minutes. Strict rules of engagement may require that all weapons be delivered with precision or near-precision guidance to reduce collateral damage.

This airspace picture is complicated by the mix of cutting edge technology and systems with older procedures and legacy platforms. The integration of third, fourth, and fifth generation technology has proved to be a difficult challenge to all twenty-first century players.

## The A-10

Into this new airspace comes the venerable A-10, now in its thirty-second year of active service. All Warthogs have now been updated with the PE modification, and all pilots are experienced with the new systems. This upgrade has significantly improved the aircraft, bringing many new capabilities relevant to today's battlefield.

Capabilities

Situational Awareness Data Link

As already discussed, data link greatly increases the situational awareness of the pilot in the cockpit. SADL provides a direct digital link to friendly ground forces through the Army's tactical internet. These ground forces know the exact location and condition of the aircraft supporting them, and A-10s in the CAS role know the exact location of all friendly vehicles equipped with an operational EPRLS radio. A quick look at the TAD, displayed in color on the cockpit monitor, gives the pilot information on all other aircraft in the area, friendly locations, targets, threats, and any other information available on the net or provided from other data links via the gateway. Preformatted CAS nine-line briefings or free text messages are sent digitally between aircraft and to and from the FAC. This feature eliminates one of the weaknesses of traditional CAS procedures: long and unsecure radio transmissions. These communications can be identified by enemy forces or misunderstood by friendly forces, and often require several follow-on transmissions. Target coordinates may be passed more accurately into the aircraft's navigation system automatically, reducing the possibility of data entry errors.

While primarily designed as an air-to-ground system, the air-to-air capabilities of SADL also greatly increase situational awareness. This is especially true for the A-10, which has no radar or any other means to maintain positional awareness between aircraft or to positively identify flight members. Prior to PE, pilots relied solely on visual and verbal means to maintain this awareness, and especially difficult task in poor weather or at night. A single glance at the SADL TAD provides the pilot an overall view of the aircraft's position in relation to the battlefield. The TAD displays a wealth of information on all aircraft on the same net, including flight position, altitude, airspeed, direction of flight, fuel remaining, and weapons status. Information on other friendly aircraft and enemy air-to-air and surface-to-air threats through the SADL gateway. To determine the position of a wingman not in sight, a quick look at the TAD takes the place of a challenge and response conversation over the radio.

Targeting Pod

Since its introduction, A-10 pilots had been forced to acquire targets, threats, and friendly forces using the unaided eye. The only sensors available in the past were binoculars, which are very difficult to use in a cockpit environment, and the Maverick air-to-ground missile. The Maverick is somewhat helpful in target acquisition because of its increased magnification, and until the introduction of NVGs to the A-10 in 1995, the IR version of this missile was the only sensor available to acquire targets at night without artificial illumination--a tactic used extensively during Desert Storm. Visual acquisition was perfectly appropriate for an aircraft designed to kill moving tanks while flying low and slow over the battlefield. As employment altitudes and standoff ranges increased after the Cold War, the ability to acquire targets at long ranges and high altitudes, day and night, became very challenging for A-10 pilots. In the FAC(A) role, the ability to obtain the accurate target coordinates required by high speed fighters employing precision weaponry was also nearly impossible. The introduction of the TGP increases the A-10's capability to find, identify, and mark targets for themselves and for other aircraft.

The TGP's integrated laser designator is used: (1) to provide accurate target ranging to improve the computed solution for the gun and for freefall bombs; (2) to covertly mark targets for any aircraft equipped with a laser spot tracker, without any advance warning to the enemy; and (3) to terminally guide laser guided bombs (LGBs), instead of depending upon an external laser source. These new capabilities allow the A-10 to deliver accurate freefall ordnance from medium altitude level passes (rather than the steep diving deliveries of the past), reducing overall exposure to surface-to-air threats and making it possible to employ under even the most conservative altitude restrictions. Also inherent in the TGP is an IR pointer that is visible to NVGs, providing an easily discernible mark to ground forces and other aircraft that do not have laser detection capabilities.

The TGP provides the FAC(A) an unlimited supply of marking rounds. The TGP sensors can obtain precise target coordinates to pass to other IAM capable platforms, the laser can provide sensor cueing to targets for visual acquisition and identification and to terminally direct laser-guided weapons on target, and the IR pointer can visually cue NVG-equipped fighters. A-10s can provide terminal control without being limited by the number of marking rockets or illumination flares on board. When tanker assets are available, the on-station time of the A-10 FAC(A) is only limited by pilot endurance. This increased time on station has proven to be a combat multiplier, since every aircraft used in the FAC(A) role reduces the number of A-10 assets available for the fighter role.

The advanced TGP now carried by the A-10 allows a much greater standoff range during target acquisition and identification. Using both the highly magnified third-generation forward-looking IR and electro-optical sensors, the A-10 can locate and identify a tactical sized target and direct laser guided weapons to it while remaining outside the range of tactical surface-to-air missiles and anti-aircraft artillery. In addition, once a target is located and designated, accurate coordinates may be obtained for other aircraft's smart weapons. The need for these capabilities became apparent in 1999 during the air war over Kosovo, when aircraft could not positively identify enemy targets from medium altitude using the current sensors.

Inertially Aided Munitions

PE gives the A-10 the ability to drop the "smart" bombs that now dominate the U.S. weapons arsenal. The aircraft is currently certified to carry and employ all varieties of JDAM and WCMD munitions. These weapons steer toward a previously preprogrammed location through the use of an onboard inertial navigation system, updated with inputs from an internal GPS receiver (the GPS receiver was added to the WCMD in 2004). The result is a weapon that can land within a few meters of the selected aim point regardless of weather or visibility. The main limitation of IAMs is obtaining accurate target coordinates. Target location error still accounts for the majority of weapons miss distance. These munitions are highly accurate when mensurated coordinates are obtained from satellite photos before takeoff. Unfortunately, because of the nature of their mission, A-10 pilots seldom have the luxury of obtaining such information and must locate targets and obtain accurate target coordinates while in flight. The TGP has the ability to obtain accurate coordinates of located targets while maintaining reasonable standoff distances. A pilot can now be cued to a location, either visually or by other sources, locate and identify the target in the TGP, designate the target, automatically send the resulting coordinates directly to the JDAM, and release the weapon, all within a matter of seconds. By selecting the optimum impact angle and attack axis, pilots can minimize the risk of fratricide and comply with any restrictions for that particular target area.

IAMs work well in many situations, but do have some limitations. Since these munitions guide to a specific impact point, they are not appropriate for moving targets or for targets of uncertain location. The accuracy of the weapon is almost entirely dependent on the fidelity of the programmed target coordinates. If accurate coordinates cannot be obtained or if large target location errors are possible, these weapons may not be effective. Target location errors are somewhat less critical for WCMD, which distributes submunitions over an area measured in hundreds of feet. One frustrating scenario, common in a CAS situation, occurs when a moving target is located while temporarily stationary, and insufficient time is available to generate accurate coordinates for use by IAMs. To counter this limitation, PE includes a target of opportunity mode that allows pilots to locate a target visually, place the bombing reticle on the target, and release the weapon. The onboard computer calculates the target coordinates based on the aircraft's GPS position and the relative position of the selected aimpoint, and transfers these coordinates to the weapon before release.

Another limitation of IAMs is the long time of fall required for accurate employment. The weapon's GPS receiver does not activate until after release from the aircraft, and the process of searching for satellites, obtaining current position, and updating the inertial navigation system takes several seconds.  Until these inputs are received, the weapon relies on inertial guidance alone, which becomes increasingly inaccurate as the time of fall increases.  A delivery above 20,000 feet is required to obtain full GPS guidance, which limits employment options.  Lower altitude releases (below 5,000) have a much shorter time of fall, and thus less inertial drift, but may not allow enough time guidance time to correct towards the target coordinates.

Other Enhancements

With the increased complexity of cockpit systems, the new HOTAS functionality has been essential for PE employment.  All weapons delivery related functions are now accomplished without moving the pilot's hands from the throttle or control stick.  This capability, in combination with the new DSMS, allows the pilot to change both the selected weapons and the desired delivery parameters with the actuation of a single switch on the control stick.  Prior to the modification, this same action could take up to ten switch changes, very few of which could be accomplished HOTAS.  The system requires more preflight planning, but saves a great deal of time in the air and reduces the need for the pilot to go "heads down" in the cockpit while in the target area.  Any data that must be entered in flight, such as target coordinates, is now input using the up front controller, located just below the HUD.  Before PE, data entry was accomplished using the keyboard located beside the pilot's right knee.

The new multi-function color displays have radically transformed the way information is presented to the pilot.  Prior to PE, pilots used an unreliable four-by-four-inch monochrome television monitor to display either the Maverick missile video picture or a repeat of the control display unit.  The new five-by-five-inch high resolution liquid crystal displays are 25 percent larger, fully NVG compatible, readable even in direct sunlight, and are much more reliable. The pilot can choose to see Maverick video, TGP video, TAD, DSMS, or a repeat of the control display on either display, and can switch between displays using a stick-mounted switch. The addition of color greatly enhances data interpretation, especially for the TAD.

Limitations

Even though the new capabilities of the A-10 are impressive, it is still an old aircraft with many of the same limitations and lacks many of the capabilities of newer aircraft. The aircraft continues to struggle with a significant thrust limitation. The A-10 was underpowered from inception, and the added weight and drag of subsequent modifications have only added to this problem. All combat loads include the TGP and ECM and IR countermeasures pods, which greatly increases baseline drag. The proposal to acquire new engines for the A-10 has been discussed for decades, but the multibillion dollar price tag continues to rule out a propulsion upgrade. The aircraft continues to struggle off the runway and climb to employment altitude, but new employment tactics help alleviate some of the thrust limitations in the target area. PE makes possible the accurate delivery of all weapons (except the gun) in level flight above 20,000 feet with greatly improved accuracy. Prior to the modification, steep-diving deliveries were required to insure visual target acquisition and to achieve the desired accuracy. These deliveries exposed the aircraft to more surface-to-air threats at lower altitudes, especially during the agonizingly slow climb back to altitude, with no excess energy available to perform evasive maneuvers. Reducing the need to perform these tactically risky deliveries has lessened the impact of the A-10's thrust deficiency. The A-10's slow speed continues to provide advantages while working at low altitude and in bad weather, especially when visually identifying targets and friendlies, but this slower speed also prevents it from integrating with other aircraft in strike packages.

The A-10 also cannot take advantage of some available technologies. Real-time video from UAV and other collection assets is available to other users, but cannot be broadcast directly into an A-10 cockpit as is possible in other aircraft. SADL does not have the communications bandwidth for such transmissions, although still pictures are a possibility in the future. Even though SADL is new to the A-10, it is based on older technology and is not as robust as newer systems that have much more expandability. The A-10's finite computing power, limited data link, and aging electrical system greatly reduce the possibility of taking advantage of other emerging technologies in the future.

SADL is also heavily dependent on the gateway to integrate into the battle space. During certain situations the loss of the gateway can prevent mission success, such as when controlling Link-16 fighters, when being controlled by a Link-16 FAC in the air or on the ground, when working with coalition aircraft, or when operating in a high air or ground threat area. In these scenarios, the gateway is a single point failure item; a critical node to operations.

Two weapons-related issues must also be addressed. Two of the A-10's primary weapons in the past, the thirty-millimeter cannon and the CBU-87, have received a great deal of political criticism of late. Both are tactical weapons that can have strategic implications. The A-10 was designed around its gun, seen as the most cost effective means to destroy armor on the battlefield. To accomplish this task, five out of every six rounds in the standard combat mix of ammunition are armor-piercing incendiary, which utilize depleted uranium as a kinetic penetrator. This material is harmless when handled, but the uranium dust created after impact can be toxic in large quantities. Even more dangerous is the political fallout from reports of millions of rounds of "radioactive" ammunition littering the battlefield (Meilinger 2001, 16). The alternative is to exclusively use the other type of ammunition available, high-explosive incendiary. This ammunition is effective against more vulnerable soft-skin targets, but is almost completely ineffective against armored vehicles at long ranges. The gun is also far less accurate from the higher employment altitudes expected in future conflicts (Saridakis 2000, 15). It is probable that in the future the A-10 will not be permitted to use the gun in certain situations. New ammunition currently under development shows promise, such as armor-piercing rounds using a more environmentally friendly tungsten penetrator, but is currently unfunded. While the stockpiles of the current ammunition are large, reliability and maintainability problems will continue to increase, and it is unlikely that forty-year-old rounds will achieve the desired effectiveness in the future.

The CBU-87 is a large canister weapon containing 202 combined effects submunitions, each of which possesses armor piercing, fragmentation, and incendiary properties. The weapon opens prior to impact, dispensing the bomblets over a large area. Again, the most serious drawback to the weapon is its political implications. Some submunitions in every canister will not explode on impact, potentially littering the battlefield with unexploded bomblets that pose hazards similar to land mines. While technological advances have reduced the dud rate, the worldwide outcry against land mines may also prevent their use in the future, even when they are dispensed from the much more accurate WCMD (Meilinger 2001, 16). CBU munitions have three advantages over conventional bombs:  (1) minimizing bombing inaccuracies by covering a large area, often the size of a football field; (2) effectiveness against area targets, such as truck parks, troops in the open, assembly areas, or artillery batteries, resulting in multiple kills per pass; and (3) increased flexibility in carrying a single weapon that is effective against multiple target types.  Precision weapons have largely negated the first advantage when used against stationary targets.  Weapons accuracy no longer requires dropping four or six CBU on a single target to insure a kill.  The other two advantages CBU provides, area coverage and flexibility, make it a viable weapon today, but political sensitivities may negate their use in some situations.

One often overlooked aspect of the PE modification is the impact it has had upon A-10 training.  The PE upgrade was a very difficult transition for the A-10 community.  During the three-year upgrade process, A-10 squadrons had both modified and unmodified aircraft.  The upgrade is so extensive and affects so many aircraft systems that transitioning between modified and unmodified aircraft is difficult.  Air National Guard and Air Force Reserve pilots who do not fly every week had an especially difficult time.  A rigorous upgrade program was required to learn the new hardware, software, switchology, TTP, and information available in the cockpit.  The PE program was designed with the pilot in mind, and operating the actual equipment is very intuitive.  However, learning to employ these new systems effectively in a tactical environment has been challenging.  With mission complexity increasing, robust pilot training has become even more important.

Employment

The PE modification has not drastically altered the A-10's time-tested tactics, but the upgrade has significantly improved the effectiveness of those tactics, while adding many additional capabilities. The A-10 has always been capable of the "targets per sortie" concept now used by heavy bomber forces. The aircraft's superior weapons load, long loiter time, and unique visible presence has long made it a favorite of ground troops, who still depend on it to accomplish the missions for which it was designed--visually identifying friend from foe in a close in battle, locating isolated personnel, and delivering precise weapons effects close to friendly or neutral forces. The A-10 is now digitally connected to the battle space through data link, and can both pass and receive vital information to air and ground based assets. It can accurately acquire and identify tactical sized targets from almost anywhere in its flight envelope, and either destroy these targets with precision guided munitions, or pass accurate coordinates to other aircraft for engagement in both the CAS and AI roles. It can also perform its legacy missions of FAC(A) and CSAR, integrating digitally with the most advanced aircraft while still maintaining a voice and visual capability to work with joint or coalition aircraft. It can find and destroy moving targets, one of the most glaring weaknesses in Air Force capabilities today (Kosan 2000, 16).

Data link operations have enhanced interoperability with non-A-10 assets in the FAC(A) and CSAR roles, especially other SADL-equipped aircraft. The USAF's dedicated CSAR recovery platform, the HH-60G Pave Hawk helicopter, has also been modified with SADL. The rescue community recognized the need to become fully integrated with the A-10, the primary fighter platform specially trained and tasked to provide on-scene command for CSAR operations, and also recognized the increased "battle space management capability" provided by the SADL system (Foglesong 2002). Data link has greatly increased the situational awareness of the A-10 pilot acting as CSAR on-scene commander, who must know everything going on within an area of operations. HH-60G helicopters also have additional equipment on board to receive direct feeds from many different assets through Link-16, which can then be passed to the A-10s. The A-10 will work with Link-16 equipped CAS fighters and CSAR task force assets through the gateway. This integration is not completely transparent, but basic positional and target information may be shared without difficulty. Interoperability problems will persist when working with other aircraft and services for these gateway dependent missions.

A-10 capabilities have been further enhanced by the introduction of smaller munitions, such as the small diameter smart bomb, a 250-pound JDAM. Primarily designed to fit in the internal bomb bays of the F-22 and F-35 fighters and reduce the risk of collateral damage, the smaller size allows the A-10 to carry more munitions to attack more targets with less weight. The joint common missile, an extended range launch and leave guided missile similar to the Army's Hellfire, is less than one-half the size and weight of the Maverick it replaces. These smaller munitions allow the Warthog to carry a load of fourteen guided munitions (six missiles and eight IAMs) for a weapons load of just over 3,000 pounds, compared to the previous standard load of six guided munitions (four Maverick missiles and two 2000-pound JDAMs) weighing over 7,000 pounds. The PE A-10 brings more firepower to the battlefield while reducing gross weight, always a consideration for the underpowered aircraft. In addition to these munitions, the A-10 always brings its thirty-millimeter cannon to the fight, which is not reliant on technology or target coordinates.

## The Interim Brigade Combat Team

### Capabilities

The IBCT is a full-spectrum, strategically responsive combat force, providing theater commanders with a rapidly deployable, highly integrated, combined arms force that exploits the power of information technology (Department of the Army 2000, 5). The IBCT is optimized for deployment to small-scale contingencies in complex and urban terrain against lower and medium level threats, where it has already proven its worth. It is also capable of integrating with higher echelon forces during major theater of war operations, a potential yet to be demonstrated. While the IBCT is a motorized force, transported on the battlefield by a family of future combat vehicles, it mainly operates as dismounted infantry. The IBCT is linked together digitally through a tactical internet, giving commanders unprecedented battlefield awareness. The FBCB2 system provides near real-time information and command and control through a common tactical picture of the battle space. Friendly and enemy forces, unit graphics, airspace control measures, targets, and even supporting aircraft are graphically displayed on the FBCB2 screen. IBCT operations have once again proven that a picture is indeed worth a thousand words. Since this same picture is shared by all components of the unit, overall situational understanding is greatly enhanced, and the need for voice communication is greatly reduced.

Supporting this force is the RSTA Squadron, which seeks to see, know, and understand the operational environment in detail through organic ground sensors, tactical

UAVs, human intelligence, and other digitally shared information. The RSTA Squadron is much more than a long range reconnaissance unit. Organic intelligence personnel also analyze the collected data, giving the commander not only the “where” and the “what” of the battlefield, but also the “why.” Initially, the amount of data available to the IBCT commander was overwhelming, but experience, aggressive filtering, and pre-analysis has made the information load more manageable.

Leveraging these technologies, the IBCT has been able to choose its battles very carefully. The situational awareness available to these units allows the commander to use the available force for decisive operations by outthinking and outmaneuvering opponents. The IBCT has also supported its share of small-scale contingencies and humanitarian operations, where decisive maneuver has not been required. However, the ability to quickly transition from peacekeeping to peace enforcement to combat operations is one of the IBCT’s strengths. These capabilities have been in great demand by the regional combatant commanders since the IBCT’s inception.

Limitations

The IBCT is a compromise of capabilities. While strategically agile, it cannot rely on tons of armor, heavy organic firepower, and pre-positioned logistics to survive. It must fight and maneuver with more finesse than its traditional counterparts. These units are very vulnerable to enemy artillery, but because of deployment limitations, do not possess self-propelled cannon and rocket artillery. Fire support is provided by towed 155-millimeter howitzers and 120- and 60-millimeter mortars, augmented by division, corps, or joint fire support. While designed to operate independently, the IBCT must rely on augmentation for aviation, air defense, engineer, military police, and logistical support for sustained operations and cannot command and control any joint or multinational task force without help. Each tailor-made task force has required significant augmentation, which greatly reduces the IBCT's strategic mobility (Smith 2000, 41).

The IBCT is comparatively light and strategically agile compared to other units with similar capabilities, but it is still a large and heavy force. All equipment is designed to be airlifted by C-130, but is more commonly transported intertheater by the C-17, one of the most in-demand assets in the Department of Defense. After working through some of the initial growing pains, units can now meet their ninety-six-hour deployment goal, if it receives top strategic airlift priority and if no other contingencies are occurring at the same. The more common experience has been eight to ten days, a time frame that still strains U.S. Transportation Command's assets. Once in theater, continuous airlift is required to sustain IBCT operations. The IBCT is a first response force, often quickly deployed into hostile areas. What has not been tested is the unit's ability to quickly withdraw from a tactical or strategic situation gone bad.

The biggest limitation of the IBCT is its inherent "full-spectrum" mission. Even with the latest technologies and training methods, the IBCT struggles with preparing for missions ranging from humanitarian relief to peacekeeping to large force-on-force combat operations. The Department of Defense has routinely called on the unique characteristics of the IBCT, causing it to have one of the highest operations tempo rates in the Army. The unit undergoes tailored training when possible, but the continual cycle of preparation, deployment, and reconstitution severely limits desired training opportunities. Unless more IBCTs are created, the eight now in existence will continue to carry the lion's share of operational deployments until the objective force takes shape in the next decade.

## Integration

None of the elements already discussed operate in a vacuum. The integration of these battle forces is the key to present and future success. On today's high-technology battlefield, ground forces have the advantage of real-time intelligence feeds from numerous sources, around-the-clock surveillance, unprecedented situational awareness, and long-distance precision weaponry, yet still require external air support on a regular basis. Today's smaller and more mobile ground maneuver elements operate on a larger, more diverse, nonlinear battlefield, and CAS has often been the fire support method of choice in the close battle (Satterfield 1996, 1). AFDD 1 states it well: "CAS produces the most focused but briefest effects of any Counterland mission; by itself, it rarely achieves campaign-level objectives. However, at times it may be the most critical mission by ensuring the success or survival of surface forces" (1997, 50). CAS continues to provide decisive effects on the battlefield, one small unit and one battle at a time.

IBCT integration with the air battle was initially quite poor. In late 2002 when the IBCTs first became operational, they took to the field a modernized TACP that had not been transformed in the same way as the unit it supported. The USAF treated the IBCT like any other brigade, and equipment, manning, and organization changed very little at first. Fortunately, this situation has improved over the past eight years as both the Army and Air Force gained experience in transformational operations. TACP manning has been increased, and support is now provided to each fire support team down to company level. One of the most significant changes was to add a battalion-sized TACP to the RSTA squadron. After a long delay, digital ground stations were procured, allowing the TACP to tie into both the air and ground picture. Initially this system was only compatible with Link-16, the Air Force standard, leaving the A-10 and F-16 Block 30 aircraft out of the digital picture. This system also required an additional link through Army channels to obtain the ground picture. Eventually, this system became compatible with both SADL and the tactical internet, greatly increasing the situational awareness of the TACP.

## Air Support Doctrine

Air Force and joint CAS doctrine entering the twenty-first century had changed little since first developed during World War II, evolving only to meet the Army's need for direct support of large force armored battles during the Cold War. This communications intensive, cumbersome system was not responsive enough for the pace or fluidity of today's battlefield. The Army uses digitally linked forces to faces nonlinear conflicts, asymmetric warfare, and operations on urban terrain. CAS under these conditions is very different from that discussed in previous joint publications. The old standard of direct positive control, where the terminal controller has both the attacking aircraft and the target in sight, had become archaic and anachronistic in today's digital battle space.

Today, all CAS and some AI sorties (now called battlefield air support missions) are allocated to individual ground units. The commander not only uses these missions in close proximity to friendlies to not only affect the current battle, but also to shape the battle space throughout the unit's area of operations. This change has give then commander has more flexibility in coordinating and integrating air with other available fires (Taylor 2000, 3).

## Digital Fire Support

The Joint TTP procedures for CAS control, described in chapter 2 (see table 1), allow both the attacking aircraft and the TAC to exchange information digitally through a data link, reducing the reliance on voice communications. The data link is a more accurate and reliable method to control aircraft in a CAS environment than the visual and procedural methods used in the past. Using a data link display, the TAC can see the attacking aircraft's position, the target, and the supported friendly forces overlaid on a digital map of the battlefield. The TAC can determine an aircraft's position and attack axis to insure that the appropriate target is being attacked, even if the aircraft is beyond visual range.

Other data link tools are available to increase the TAC's situational awareness. SADL also transmits the aircraft's sensor point of interest (SPI) when selected by the pilot. The SPI is the point on the ground where the active sensor is looking. The SPI could be the target currently locked up in the TGP or Maverick missile, the bomb reticle in the HUD, or a selected waypoint. When the pilot chooses to transmit the aircraft's current SPI and the TAC has tagged the aircraft's symbol, the SPI is depicted as a unique symbol on the display. When the SPI overlays the target the TAC is certain that the correct target is being attacked and can clear the pilot "hot." This can all be accomplished without the TAC seeing the attack aircraft or the target.

In 2002, a test conducted by the JCAS JT&E demonstrated the effectiveness of data link positional awareness and the SPI tool. TACPs controlling SADL-equipped

F-16 aircraft used SADL ground equipment to provide situational awareness to facilitate Type II terminal control procedures. The aircraft made 65 scripted attacks, 30 percent of which were intentionally made against the incorrect target or the friendly position. In this test, the TACs were able to make the correct clearance call (“cleared hot” or “abort” as appropriate) in 98 percent of the attempts. This compares to a 52 percent success rate for a control group of TACs using visual only means of terminal control to determine the attacking aircraft’s intent. In addition, the TAC was able to abort the fighters every time an attack was attempted on the wrong target, and no cases of fratricide were reported. In comparison, a similar test conducted by JCAS using old positive direct control procedures to control slower, easier to see A-10 aircraft without SADL achieved only a 38 percent success rate (Office of the Secretary of Defense, 2002). In these tests, using SADL significantly increased mission success, highlighting the advantage of increased situational awareness through digital control.

The system is still only as accurate as the data it receives--errors caused by system or human mistakes or inaccuracies are still possible. The TAC makes decisions based on the information displayed, even if it is incorrect information; for instance if the pilot has selected the wrong SPI, entered the wrong coordinates, or does not release weapons at the directed time. The draft JP 3-09.3 states is well:

> While recent technological advances in weaponry and digital/data link systems have provided significant enhancements to the CAS mission, it is imperative that commanders and operators fully understand the capabilities and limitations of the systems being brought to the fight. Descriptive dialog between the TAC and aircraft will often provide the best means of mitigating risk and producing the desired effect on target. (1995, V-21)

One of the most important lessons to have been relearned is that reliance on a single source of information for targeting can be disastrous. Pilots and controllers must verify that targets, friendly positions, coordinates, and other information passes the "common sense" test prior to releasing ordnance, especially when weapons deliveries take place beyond the visual range of the target. Data link capabilities have greatly improved the situational awareness of the TACP. The TAC can digitally see the attacking aircraft, the desired target, the target the aircraft is looking at, current artillery missions, and other aircraft in the area, all overlaid on a digital battle map with unit boundaries and airspace control measures. When the TAC adds a visual description to the CAS brief, either digitally or via voice, the pilot has all the situational awareness necessary to successfully attack the target using any available means. The benefits of such a system are many: (1) higher overall level of situational awareness by all participants; (2) greater mutual understanding between air and ground assets through the sharing of a common picture; (3) reduced reliance on visual target marking; (4) increased probability of target detection; (4) greatly decreased risk of fratricide; (5) increased aircraft survivability; (6) decreased time from target acquisition to attack due to faster information flow; and (7) real-time airspace coordination and deconfliction. These benefits have increased both the timeliness and accuracy of air support, historically the two most important traits of effective CAS.

One possible drawback to such technology is the tendency to centralize the execution of air assets because of the increased availability of information. A commander who has real time battle space awareness and the means to communicate and influence a battle from higher echelons must resist the temptation to skip levels of command and micromanage the battle from the rear.

## Evaluation

### Previous Experience

Since this evaluation is subjective in nature and based mainly on future capabilities, reviewing the experience of another old, slow, rugged aircraft on a non-traditional battlefield may prove insightful. From 1994 to 1996, Russian forces battled a loose collection of rebels in the breakaway Republic of Chechnya. Although the results of the fighting were inconclusive and the performance of the Russian Air Force was well below expectations in this low intensity operation in urban terrain, some observations are applicable. One Russian analyst related that:

> The experience of air combat operations in the Chechen conflict demonstrated the increased role of close support to ground troops. The participation of attack helicopters in it was limited [statistics indicate 10 percent loss and 25 percent damage rates per sortie], and front line fighters and bombers could not operate effectively at low altitudes and so were not used due to their high airspeed and the shortage of time to search for targets, aim and employ weapons.…This is why the Su-25C--a small, subsonic, reliable and maneuverable aircraft of simple design with a good view from the pilot cockpit--basically was used to support ground troops and for ground-attack operations. . . .Moreover, it has powerful armament, rather reliable navigation and targeting avionics, and armor protection and can operate both from airstrips with an artificial surface as well as from dirt airstrips (Thomas 1997, 56-57).

Based on this experience, Russian experts indicate that in future low intensity conflicts and peace operations, attack aircraft should be used: (1) in direct fire support; (2) for selective and precise destruction of enemy pockets of resistance; (3) as emergency assistance and fire support for friendly subunits in ambushes or encirclements; (4) for air reconnaissance in real time; (5) to combat enemy combat helicopters; and (6) to block or destroy mobile enemy combat groups (Thomas 1997, 57).

Operation Enduring Freedom in Afghanistan gave the military its first indication of air support on a twenty-first century battlefield. Teams of special operations forces and small units of light infantry fought with coalition partners on a nonlinear battlefield against a determined but unsophisticated non-nation state foe. Because of the ruggedness of the terrain and the nature of the warfare, coalition forces had no artillery and only a few mortars, leaving CAS as the only means of indirect fire support. These battles presented a situation tailor-made for the A-10. As the first fighter aircraft to be stationed in Afghanistan itself, A-10s flew from an austere forward-operating base and provided close-in support for allied forces, using the gun, unguided bombs, and Maverick air-to-ground missiles. The ability to visually deliver precise effects in close proximity to friendly forces became as important in Afghanistan as it was on the plains of Germany during the Cold War; the mission the A-10 was designed for. While A-10s performed these missions, B-52, F-16, and F-18 fighters loitered overhead, delivering on-call precision firepower, primarily with JDAM weapons. This all-weather, beyond visual range, fixed target kill capability was also invaluable to operations in Afghanistan. These complementary missions proved to be a very successful combination in supporting the widely scattered friendly units. In 2010 the A-10, with its own TGP and precision weapons, is able to accomplish both of the missions on a single sortie. The marriage of precision targeting using advanced weapons under data link control and close-in visual support may very well be a perfect match for future operations (Bacon 2002, 8).

Attacking moving targets is still a challenge for many aircraft. AFDD 2-1.3, *Counterland,* highlights this problem:

> Although there is no single category of targets most suitable for CAS application, mobile targets and their supporting firepower (in general) present the most immediate threat to friendly surface forces and thus are prime candidates for consideration. This is especially true when supporting light forces, such as airborne or amphibious units, since they are not able to bring as much organic heavy firepower into battle as heavier mechanized or armored units. (1999, 35)

No matter how many GPS-guided weapons advanced fighter or bomber aircraft bring to the battlefield, they cannot employ these weapons against moving targets without external support, unless they stop and are fixed by other targeting means. These weapons have little to no utility against moving targets. Fighter aircraft effectively employ LGBs and Mavericks missiles against mobile targets with great success. Bombers are capable of dropping multiple LGBs, but each weapon must be guided individually to the target by an external laser designator. The need to deliver ordnance on moving targets, tracked either visually or by optical sensors, is still a required capability on today's modern battlefield.

## Tactics, Techniques, and Procedures

Operating in the conceptual battle space just described, A-10 aircraft are employed using the TTP found in Appendix A (table 3). This TTP shows that the A-10 pilot of 2010 has more tools to accomplish the mission than ever before, and also demonstrates how dramatically data link has changed A-10 employment. SADL now permeates all aspects of A-10 employment. The evaluation of this new TTP shows the effect of the PE modification in enhancing previous capabilities. While the techniques used to accomplish ordinary tasks are essentially the same as before, new capabilities can both enhance and simplify these techniques. For instance, target identification has always been a key element of A-10 employment. In 2002, pilots would use a combination of target coordinates, map study, visual descriptions, and sometimes just plain luck to visually acquire a target. Target identification would be made by using the naked eye alone while flying over the target, assisted by a Maverick missile seeker or binoculars, the only sensors available to the pilot. In 2010 targets that are digitally transmitted over data link appear as a SPI symbol in the HUD, TGP, Maverick video, and on the SADL TAD, making target acquisition much easier. The TGP can then be cued to the desired coordinates, and target identification is made using the TGP's highly magnified television or IR sensors.

One factor not readily apparent from table 3 is the relative threat exposure using the different TTPs. Since Desert Storm, the A-10 has executed medium-altitude tactics in almost every situation, usually restricted to employing above a certain altitude by the theater rules of engagement. In these medium-altitude scenarios, delivering accurate freefall ordnance in 2002 required climbing to almost the maximum combat ceiling of the aircraft, rolling in to make a steep diving delivery, releasing the ordnance, then pulling off target with a maximum rate turn, then struggling to climb back to a safe altitude at very slow speeds with no excess energy available to maneuver or to react to threats. In 2010 A-10s almost exclusively carry and employ LGBs and IAMs, which can be accurately delivered in level flight from over 20,000 feet above the ground. These weapons are delivered from greater standoff ranges, which also increases survivability. The TGP is used to locate and identify targets well beyond normal visual ranges, and then the laser is used to terminally guide LGBs or obtain coordinates for IAMs, delivering them well outside of tactical threat ranges at much higher altitudes. PE has also made the Maverick missile and its replacement fire-and-forget air-to-ground missile more capable in 2010. The TGP is used to identify targets from long standoff ranges, the Maverick is automatically slaved to the exact location of the target found in the TGP, locked on to the target, and then launched from maximum kinetic range. In 2002 the pilot was forced to acquire, identify, and lock on to the target while diving at the ground, continuously decreasing the aircraft's altitude and range from the target and associated threats. These capabilities significantly reduce threat exposure and greatly lessen the impact of the A-10's speed and thrust limitations.

Using the TTP found in Table 3, a typical CAS mission may occur as follows: A flight of A-10s take off, electronically check in with AWACS, and are tracked via data link. After electronically passing a status message to the ASOC, a preliminary target brief is electronically sent over SADL. The fighters then pass a status message and rendezvous with the FAC(A) using the SADL TAD. Using information obtained from the RSTA Squadron, a digitized TACP electronically sends a nine-line CAS briefing to waiting A-10s over SADL. The A-10s receive and acknowledge the message electronically, and automatically transfers the target coordinates into their JDAMs. The Ground FAC, who has been watching the position of the fighters on the digital map on a laptop computer, transmits a "cleared hot" message via SADL when the A-10s SPI symbol overlays the target. The fighters receive and acknowledge the message over SADL and employ IAMs from beyond visual range of both the ground FAC and any nearby threats. The ground FAC transmits a free-text battle damage assessment message following the attack, and the fighters egress. The entire sequence could easily be accomplished without a single radio transmission.

## Summary

This chapter has shown how A-10 operations may be conducted in the future. The presentation and discussion of this notional 2010 battle space provides a frame of reference for evaluating the A-10's acceptability for supporting the IBCT in the future. This discussion and evaluation of future tasks and capabilities lead to the conclusions and recommendations found in the final chapter.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

> If there is one attitude more dangerous than to assume that a future war will be just like the last one, it is to imagine that it will be so utterly different that we can afford to ignore all the lessons of the last one (Slessor 1936, x).

## Introduction

The battlefield of tomorrow poses difficult challenges for U.S. military forces, especially to those legacy systems that remain part of the force structure. The A-10 is a particularly good example of this reality. Designed for a different mission on a different battlefield, it now finds itself scrambling to remain viable in the high-technology battle space of the future. As the only USAF aircraft ever designed specifically for the CAS mission, it possesses unique capabilities and attributes not found in any other weapons system. Many of these capabilities will continue to remain relevant for many years to come. However, without the additional capabilities required to operate in tomorrow's battle space, employment in the future will become infeasible. As shown in this thesis, the PE modification brings the A-10 these capabilities.

## Findings

PE brings many new capabilities to the A-10 and enhances most present ones. PE does not solve all of the A-10s problems or limitations, but it does add many significant new capabilities which are required to operate in tomorrow's battle space. Those capabilities and limitations that directly affect future battle space operations include:

1. Increased situational awareness through data link connectivity
2. Increased interoperability using common systems (data link, TGP, and IAMs)
3. Improved target acquisition using TGP sensors and data link targeting

4. Improved target identification ability using TGP sensors and data link

5. Greater standoff ranges during target acquisition using TGP sensors

6. Greater standoff ranges during target identification using TGP sensors

7. Precision weapons delivery using LGBs and IAMs

8. Longer weapons employment ranges using LGBs, IAMs, and Maverick missile

9. Increased weapons delivery altitudes using LGBs, IAMs, and Maverick missile

10. More efficient and accurate weapons delivery through DSMS capabilities and increased HOTAS functionality

11. Increased friendly force identification capability and battlefield awareness through SADL, decreasing the risk of fratricide

12. Increased surprise, security, and targeting accuracy through secure data link communications

13. Increased target marking capability using TGP laser and IR pointer

14. Increased interflight and intraflight mutual support through data link positional awareness

15. Increased visual lookout through greatly improve vehicle-pilot interface, HOTAS functionality, and up front control of many data entry functions

16. Increased CSAR task force interoperability through common data link.

17. A-10 missions are now more difficult because of increased complexity in the cockpit due to the new hardware and mission tasks

18. The transition to PE modified aircraft will require detailed integration for training and conversion purposes.

19. Data link gateways become a critical, single point failure node for operations

20. A-10 pilots will find it more difficult to remain proficient in all mission areas due to complexity and training limitations.

Operations currently being conducted in Afghanistan in support of Operation Enduring Freedom may provide a preview of the battlefield the A-10 could face in the future. Special operations teams and small infantry units fight with coalition partners on a nonlinear battlefield against a non-nation state threat. With very little organic artillery support, CAS has become the only means of indirect fire support. Flying from Afghanistan itself, A-10s provide close-in support using the gun, unguided bombs, and Maverick air-to-ground missiles. In this twenty-first century battle, the ability to visually deliver precise effects in close proximity to friendly forces is as important as it was during the Cold War. PE will bring the A-10 the additional capability of delivering standoff, all-weather precision munitions, controlled by digitally connected TACPs. The combination of these old and new capabilities, along with a superior weapons load out, will keep the A-10 useful and relevant throughout its service life.

## Conclusions

The purpose of this thesis is to determine if the PE-modified A-10 operate effectively on the battlefield of 2010. In order to answer this question, this thesis focused on three subordinate research questions:

1. Can the A-10 integrate into the airspace above the battlefield of 2010? The key to this question is the introduction of data link technology. Data link provides an enormous increase in capability to military forces, and the USAF will become increasingly dependent on this technology in the future. Without the SADL modification, the A-10 would not be able to integrate into tomorrow's battle space. With a robust data

link and an operational gateway, the A-10 can integrate into this increasingly complicated airspace.

2. Can the A-10 integrate with other fires and effectively support the U.S. Army's interim force on the digital battlefield of 2010? With SADL, the situational awareness of the aircraft and the FAC or TAC is greatly enhanced. This enhancement, as has been shown in recent tests, makes controlling fighter aircraft much more accurate than relying on visual procedures alone. It also brings the unprecedented capabilities of beyond visual range and all-weather CAS to the battlefield. With a more complete understanding of the ground situation, A-10s will be able to better support the ground commander's scheme of maneuver and fire support tasks. SADL also reduces the risk of fratricide and helps the ground commander better understand the capabilities and limitations of fixed-wing air support. Precision engagement also brings the A-10 more employment options. A greater variety of weapons will be available, including IAMs and LGBs, providing greater accuracy and more precise weapons effects. The ability to deliver these munitions from higher altitudes, longer standoff ranges, and shallower dive angles, also greatly increases the survivability of the velocity-challenged A-10. Not only do these types of deliveries bring greater safety to the pilot, but they also protect scarce air assets and also allow the A-10 to employ in higher threat areas, providing air support to ground forces under a wider variety of circumstances. For these reasons, the A-10 should have no difficulty providing even better support of the digital IBCT in the future than it can for conventional forces today.

3. Do current joint doctrine and TTP effectively address CAS fires on a digital battlefield, or are changes required to make digital close air support possible and

effective? Current CAS doctrine and TTP do not address digital CAS procedures or the capabilities new technologies bring to the battlefield. Fortunately, changes are already being made to incorporate data link and other situational awareness enhancements into the CAS operations. The new terminal control procedures now contained in the draft Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS),* replace positive direct and indirect means of control with three new categories (see table 1). Type II procedures allow terminal attack controllers to pass and receive information, clear fighters "hot" either verbally or digitally while maintaining positional awareness of the aircraft through data link or visual means. This removes the requirement for the controller to see both the aircraft and the target before providing attack clearance, which is becoming impossible with the employment altitudes and standoff ranges of today's weapons and aircraft. These draft procedures are being used today in Afghanistan in support of Operation Enduring Freedom. If these draft procedures are implemented, no further changes are required until data link technology becomes more prevalent and more experience is gained in its use. In order for these procedures to be used effectively, air and ground FACs need to have the equipment necessary to display both aircraft and ground vehicle data link information, and must train to these new procedures.

As has been shown in this research, each of the three subordinate questions can be answered affirmatively. Based on these answers, the A-10, following its PE modification, can indeed be effective on the battlefield of 2010. Its employment is both feasible and suitable, based on the conditions set forth in the research. The question remains: Is the A-10 the most suitable aircraft to accomplish these missions? The A-10 still has significant limitations, including speed, employment altitude, and survivability, and will certainly not always be the *most* suitable aircraft to perform every mission in every situation. However, its inherent capabilities, coupled with future enhancements, broaden its spectrum of operations and brings significant capabilities to the theater commander.

## Recommendations

As this thesis has shown, the PE modification will not turn the A-10 into a Joint Strike Fighter, but it will give the Warthog the minimum capabilities required to accomplish its mission until at least 2010. The following recommendations are based on the conclusions of this study:

1. The PE modification must continue to be funded and fielded as scheduled. This upgrade is absolutely essential to the continued viability of the A-10. The unique capabilities of this aircraft will make its continued presence on the battlefield of the future a “must have” for future theater commanders.

2. A TGP that meets the A-10 operational requirements document must be funded and acquired coincidental with PE fielding. A TGP is required to provide the A-10 with the necessary capabilities set forth in this thesis. Not only will a TGP enhance A-10 capabilities, but it will also improve the effectiveness of other aircraft operating in the same battle space by quickly and accurately acquiring, identifying, and precisely locating targets for other shooters.

3. Munitions suitable for visual and beyond visual range employment against moving and CAS targets must be procured. Even with these new capabilities, A-10 pilots must have the proper weapons available to properly support the ground forces of the

future. The increased reliance on IAMs could present serious problems for future CAS operations. These smart weapons have proven very effective under certain conditions, but are of little value against moving or emerging targets, two very prevalent target sets for A-10 missions. Laser guided bombs and missiles, fire-and-forget air-to-ground missiles, and smaller GPS-guided weapons are a necessity for successful employment in the future, and will greatly enhance A-10 effectiveness.

4. Future aircraft, ground forces, and TACPs must be integrated from development through deployment. In the decade of the 2020s, the U.S. Army's objective force will begin to be a reality, bringing a very different force structure and new equipment to the battlefield. This force will be supported primarily by the F-35 Joint Strike Fighter, which will also bring new cutting-edge capabilities to this future battle space. These two new systems cannot be developed independently of one another. The individual services cannot afford to wait until the equipment is fielded before integration discussions take place. Hopefully this is one of the lessons learned during the IBCT development process. Even at this time, no clear vision exists on how Air Force TACPs will provide air support to the Army's IBCT, and with what equipment.

5. In the near term, TACP modernization must be closely coordinated with further IBCT development and deployment. The ground FAC must have the right equipment to integrate into the Army's digital battlefield, especially the fire support nets. FBCB2 or an equivalent tactical displays are mandatory for all TACP vehicles and workstations. The ALO must also have a position in the IBCT's fire support vehicle to seamlessly incorporate joint and organic fires. The TACP must have the proper hardware and software to control data link fighters. By the year 2007, all primary USAF CAS

platforms, A-10s and Block 30 F-16s will be equipped with SADL. TACPs must possess the capability to digitally link with these aircraft through the tactical internet to obtain aircraft position information and to send and receive digital messages. Maintaining awareness of Link-16 aircraft will also be required, either through a separate system or through a gateway. TACPs and RSTA squadrons also need some method to quickly and accurately derive coordinates and elevations of desired targets out to maximum range of available sensors, such as a GPS and laser rangefinder combination a GPS/laser rangefinder combination.

6. Joint doctrine and TTP must continue to be updated to take advantage of new capabilities. The new draft JP 3-09.3 has made the important first step in updating terminal control procedures for compatibility with new technologies. These updated control procedures must be implemented in the next draft of this publication and must continue to be refined in the future as more experience is gained in digital CAS procedures. A five-year doctrine revision cycle will not keep up with technological advances in the future.

## Recommendations for Further Research

As the PE modification is developed, tested, and fielded, much more will be known about its capabilities, limitations, and optimum employment. This thesis is somewhat speculative in nature, dealing with battlefield elements that have not been operationally tested together or combat proven. The ideas presented here need to be continuously updated as more experience is gained and the new technologies are fielded. The TTP presented in this thesis is only an estimate of how the A-10 will be employed in the future. Specific procedures for each mission area need to be developed and tested. The following areas should be addressed in further research.

1. How should CAS be integrated with legacy, objective, joint, and allied ground forces, using data link and non-data link means. How should TTP be updated to address employment with different types of air and ground forces?

2. What are the optimum methods and programs for PE conversion training? How should commanders integrate existing and upgraded aircraft and pilots while maintaining unit readiness?

3. How should data link gateways be integrated into the battle space, and where is the optimum location for gateways?

4. What equipment should be included in the TACP modernization program? How should this equipment be integrated into the CAS command and control systems?

5. What changes must be made to A-10 employment and equipment to counter increasingly sophisticated air defense threats?

## Summary

The A-10 has long been a favorite of friendly ground forces, perhaps for no other reason than it represents a tangible Air Force commitment to the CAS mission. In its current form, the A-10 will continue to fall behind the technological revolution that is occurring in military operations. The PE modification will add twenty-first century capabilities to this twentieth century aircraft, making it a viable and effective battlefield for future battlefields. The complementary nature of old and new capabilities and missions make the A-10 a unique tool for the commanders of tomorrow.

# APPENDIX A

## A-10 TACTICS, TECHNIQUES, AND PROCEDURES

Table 3 summarizes a notional set of tactics, techniques, and procedures (TTP) for A-10 close air support (CAS) in the year 2010. The TTP is broken down by mission area for ease of discussion. That TTP which is common to all mission areas is listed first under General Employment. The author conducted a subjective evaluation of each task listed, using the following four-point scale:

1. Ineffective. TTP had prohibitive limitations that would result in unsuccessful mission accomplishment.

2. Marginally ineffective. TTP had limitations that would require alterations to execution and usually resulted in unsuccessful mission accomplishment.

3. Effective. TTP had limitations that required alterations to execution but usually resulted in successful mission accomplishment.

4. Very effective. TTP had minor limitations that required no alterations to execution and nearly always resulted in successful mission accomplishment.

Table 3.

A-10 Tactics, Techniques, and Procedures

| Required Task | 2002 TTP | ER | 2010 TTP | ER |
|---|---|---|---|---|
| **General Employment** | | | | |
| Integrate into AO | Voice<br>External Radar contact | E | Data link or Voice | VE |
| Airspace check-in | Voice<br>External Radar contact | E | Data link, digital message<br>Voice | VE |
| Receive flight member status (fuel, weapons) | Voice | E | Data link | VE |
| Maintain flight integrity/ mutual support (Day) | Visual | E | Data link<br>Visual | VE |
| Maintain flight integrity/ mutual support (Night) | Visual<br>NVG | MI | Data link<br>Visual, NVG | VE |
| Positional mutual support (Day) | Voice<br>Visual | E | Data link<br>Visual | VE |
| Positional mutual support (Night) | Voice<br>NVG | MI | Data link<br>Voice, NVG | VE |
| Controlling agency check-in | Voice | E | Data link digital message<br>Voice | VE |
| Receive initial tasking | Voice | E | Data link digital message<br>Voice | VE |
| Integrate with strike package | Adjacent, not within package | MI | Adjacent, not within package | MI |
| **Weapons Employment** | | | | |
| Employ freefall ordnance below 10,000 feet | Computed<br>Manual | VE | Computed<br>Manual | VE |
| Employ freefall ordnance above 10,000 feet | Computed<br>Manual | E | Computed<br>Manual | E |
| Employ freefall ordnance above 15,000 feet | Computed<br>Manual | E | Computed<br>Manual | E |
| Employ freefall ordnance above 20,000 feet | Computed<br>Manual | MI | Computed<br>Manual | MI |
| Employ air-to-ground missiles below 10,000 feet | Visual | E | Visual<br>TGP/TAD assisted | VE |
| Employ air-to-ground missiles above 10,000 feet | Visual | VE | Visual<br>TGP/TAD assisted | VE |
| Employ air-to-ground missiles above 15,000 feet | Visual | E | Visual<br>TGP/TAD assisted | VE |
| Employ air-to-ground missiles above 20,000 feet | Visual | MI | Visual<br>TGP/TAD assisted | VE |
| Employ gun below 10,000 feet | Computed<br>Manual | VE | Computed<br>Manual | VE |
| Employ gun above 10,000 feet | Computed<br>Manual | E | Computed<br>Manual | E |
| Employ gun above 15,000 feet | Computed<br>Manual | MI | Computed<br>Manual | MI |
| Employ gun above 20,000 feet | Computed<br>Manual | I | Computed<br>Manual | I |

| Required Task | 2002 TTP | ER | 2010 TTP | ER |
|---|---|---|---|---|
| Employ LGBs below 10,000 feet | Pave Penny<br>External laser | MI | TGP<br>Pave Penny | E |
| Employ LGBs above 10,000 feet | Pave Penny<br>External laser | E | TGP<br>Pave Penny | VE |
| Employ LGBs above 15,000 feet | Pave Penny<br>External laser | E | TGP<br>Pave Penny | VE |
| Employ LGBs above 20,000 feet | Pave Penny<br>External laser | E | TGP<br>Pave Penny | VE |
| Employ IAMs below 10,000 feet | None | I | Preplanned<br>Target of opportunity | E |
| Employ IAMs above 10,000 feet | None | I | Preplanned<br>Target of opportunity | VE |
| Employ IAMs above 15,000 feet | None | I | Preplanned<br>Target of opportunity | VE |
| Employ IAMs above 20,000 feet | None | I | Preplanned<br>Target of opportunity | VE |
| Employ precision weaponry | Gun, Maverick<br>LGB | E<br>E | IAMs, LGBs<br>Gun, Maverick | VE<br>VE |
| All-weather weapons delivery | GPS coordinates only | I | IAMs | VE |
| Beyond visual range weapons delivery | Maverick missile | MI | IAMs, LGBs<br>Maverick | VE |
| **CAS** | | | | |
| Receive tasking | Voice | E | Data link digital message<br>Voice | VE |
| Fighter check-in | Voice | E | Data link digital message<br>Voice | VE |
| FAC rendezvous | Visual | E | Data link<br>Visual | VE |
| Receive FAC-fighter brief | Voice | E | Data link digital message<br>Voice | VE |
| Identify known threats | Voice, visual | MI | Data link<br>Voice, visual | E |
| Receive CAS briefing from Ground FAC | Voice | E | Data link digital message<br>Voice | VE |
| Receive CAS nine-line briefing from FAC(A) | Voice | E | Data link digital message<br>Voice | VE |
| Enter target coordinates | Manual entry | E | Automatic entry | VE |
| Targeting briefing from FAC | Voice<br>Visual talk on | E | Data link digital message<br>Voice, visual talk on | VE |
| Acquire targets | GPS coordinates<br>Visual voice talk on | E | TGP<br>GPS coordinates, talk on | VE |
| Identify targets | Visual<br>Maverick | MI | TGP<br>Visual, Maverick | VE |
| Send target information intraflight | Voice | E | Data link<br>Voice | VE |
| Send target information interflight | Voice | E | Data link, digital message<br>Voice | VE |
| Identify friendly position | Visual<br>Verbal description | E | Data link<br>Visual, verbal description | VE |

| Required Task | 2002 TTP | ER | 2010 TTP | ER |
|---|---|---|---|---|
| Troops in contact weapons delivery | Gun<br>Maverick | E | Gun<br>Maverick | E |
| **FAC(A)** | | | | |
| Mark targets (day) | Verbal description<br>Rockets | E | TGP Laser<br>Verbal, rockets | VE |
| Mark targets (night) | IR pointer (in cockpit) | E | TGP Laser<br>Air commander pointer | VE |
| Terminally guide laser weapons | None | I | TGP | VE |
| Interoperability | GPS | E | Data link, TGP<br>GPS | VE |
| Receive CAS briefing from Ground FAC | Voice | E | Data link digital message<br>Voice | VE |
| Receive fighter-FAC briefing | Voice | E | Data link digital message<br>Voice | VE |
| Send CAS briefing | Voice | E | Data link digital message<br>Voice | VE |
| Maintain situational awareness of fighters | Visual, voice | E | Data link<br>Visual, voice | VE |
| Targeting briefing to fighters | Voice<br>Visual talk on | E | Data link digital message<br>Voice, visual talk on | VE |
| Acquire targets | GPS coordinates<br>Visual voice talk on | E | TGP<br>GPS coordinates, talk on | VE |
| Identify targets | Visual<br>Maverick | MI | TGP<br>Visual, Maverick | VE |
| Identify friendly position | Visual<br>Verbal description | E | Data link<br>Visual, verbal description | VE |
| Pass IAM coordinates to fighters | GPS mark | MI | TGP designation | E |
| **CSAR** | | | | |
| CSAR task force Situational awareness | Voice<br>Visual | E | Data link<br>Voice, visual | VE |
| CSAR task force deconfliction | Visual<br>Voice | MI | CSAR task force<br>Situational awareness | E |
| Receive survivor location | Voice | E | Data link digital message<br>Voice | VE |
| Helicopter rendezvous | Visual<br>Voice | E | Data link<br>Visual, voice | VE |
| Helicopter escort | Visual<br>Voice | E | Data link<br>Visual, voice | VE |
| CSAR briefing | Voice | E | Data link digital message<br>Voice | VE |
| Obtain survivor location | Visual<br>Electronic | E | TGP<br>Visual, electronic | VE |
| **Effectiveness Rating (ER)**<br>**I - Ineffective** **MI - Marginally Ineffective** **E - Effective** **VE - Very Effective** | | | | |

REFERENCE LIST


A/OA-10 Prime Team. 2002. A/OA-10 precision engagement (PE) pilot vehicle interface (PVI) design description document (DDD). Owego, NY: Lockheed-Martin Systems Integration. 14 January.

Air Combat Command. 1999. Final CAF operational requirements document CAF 401-91-I/II/III-D for A/OA-10 aircraft multi-staged improvement program (MSIP). HQ ACC/XRA10, Langley AFB, VA, 19 October.

Bacon, Lance. 2002. Saving the day: A-10s at Baghrem Air Base are the first U.S. fighter jets based in Afghanistan. *Air Force Times*, 1 April, 8-9.

Baumgardner, Neil. 1999. New brigades to rely on joint forces for fire support. *Defense Daily*, 17 December, 1-3.

Boller, Michael J. 2000. A common understanding for transformation brigades. *Military Review* 80, no. 5 (September-October): 29-38.

Brown, David R. 2001. Joint Close Air Support (JCAS) Joint Test and Evaluation (JT&E) tasking. *USAF Weapons Review*, summer, 9-11

Brown, David R. 2002. Rethinking close air support. *Armed Forces Journal International*, February, 20-21.

Bush, George W. 2001. Speech given at The Citadel, Charleston, South Carolina, 11 December. Available from http://www.whitehouse.gov/news/releases/2001/12/20011211-6.html. Internet. Accessed on 11 January 2002.

Campbell, Douglas N. 1999. Plane in the middle: A history of the U.S. Air Force's dedicated close air support plane. Ph.D diss., Texas Tech University.

Department of the Army. 2000. *Interim Brigade Combat Team organization and operational concept, v.4.0*. Washington, DC: Government Printing Office. 18 April.

_________. 2001a. Field Manual 3-0. *Operations*. Washington, DC: Government Printing Office, June.

_________. 2001b. United States Army white paper: Concepts for the Objective Force. Washington, DC. Available from http://www.objectiveforce.army.mil/oftf/pages/ObjectiveForceWhitePaper.pdf. Internet. Accessed on 10 November 2001.

_________. 2002. Field Manual 7-20 (Draft). *The infantry battalion*. Washington D.C.: Government Printing Office.

Deptula, David A. 2001. Air Force transformation: Past, present, and future. *Aerospace Power Journal* 15, no. 3 (fall): 86-91.

Dubik, James. 2000. Interview with Major General James Dubik. Interview by Frontline, 24 October 2000. Available from http://www.pbs.org/wgbh/pages/frontline/shows/future/interviews/dubik.html. Internet. Accessed on 30 January 2002.

Feldhausen, Thomas J. 2000. A/OA-10 precision engagement: A better way. Briefing, ACC/DRA10, Langley AFB, VA, 28 September.

Foglesong, Robert H. 2001. Personnel recovery technology working group reply. Memorandum from HQ USAF/XO to Chief of Staff of the Air Force John P. Jumper, 22 October. Copy in author's possession.

Gourley, Scott R. 2001. DCX spotlights US Army 'legacy force' upgrades. *Janes Defence Upgrades.* 1 June. Database on-line. Available from http://online.janes.com. Internet. Accessed on 22 August 2001.

Hall, Mike. 1998. Close air support: Technology fighting tradition. *Aviation Week & Space Technology*, 17 August, 94.

Hansen, Ralph S. 2000. A-10 PE baseline pilot-vehicle interface briefing. Briefing, 422TES/DOA, Nellis AFB, NV, 15 August.

Hoppe, Glenn M. 2001. Current close air support doctrine: Out of step with new technology and urban combat requirements. Thesis, Naval War College, Newport, R.I.

Isby, David C. 2001. United States: A-10 upgrade may be expanded. *Jane's Defence Upgrades.* 16 January. Database on-line. Available from http://online.janes.com. Internet. Accessed on 22 August 2001.

Jumper, John P. 2001. Global strike task force: A transforming concept, forged by experience. *Aerospace Power Journal* 15, no. 2 (spring): 24-33.

Keithly, David M. Revamping close air support. 2000. *Military Review* 80, no. 2 (March-April): 14-22.

Kipp, Jacob W., and Lester W. Grau, 2001. The fog and friction of technology. *Military Review* 80, no. 5 (September-October): 88-97.

Kosan, Keith J. 2000. United States Air Force precision engagement against mobile targets: Is man in or out? Thesis, United States Air Force School of Advanced Airpower Studies, Maxwell AFB, AL.

Koven, Alexander L. 2000. Joint surveillance target attack radar system (JSTARS) direct support of close air support (CAS) operations. *USAF Weapons Review,* winter, 24-32.

Larsen, Henry S., and Michael T. Walsh. 2001. Transforming fire support for the ICBT: Supporting the maneuver commander. *Field Artillery,* March-April, 7-11.

Mehaffey, Michael. 2000. Vanguard of the objective force. *Military Review* 80, no. 5 (September-October): 6-16.

Meilinger, Phillip S. 2001. Precision aerospace power, discrimination, and the future of war. *Aerospace Power Journal* 15, no. 2 (fall): 12-20.

Office of the Secretary of Defense. 1999. *Joint close air support (JCAS) day CAS mini-test results.* Eglin Air Force Base, FL: OSD, February.

_________. 2000. *Joint close air support joint test and evaluation interim report* [CD-ROM]. Eglin AFB, FL: OSD, October.

_________. 2002. *Joint close air support (JCAS) mini-test II report*. Eglin Air Force Base, FL: OSD, May.

Putney, Douglas R. 2001. Close air support and the digitized division: An airman's perspecitve. *The Air Land Sea Bulletin* 2-3 (December): 7-9.

Perkins, Roy E. 2001. V Corps FECC. *Field Artillery*, September-October, 15-20.

Saridakis, Mike. 2000. Updated tactics for GAU-8 employment. *USAF Weapons Review,* summer, 12-19.

Serres, Todd J. 2002. New CAS doctrine: Getting control of emerging technology and advanced concepts. Thesis, United States Army Command and General Staff College, Ft. Leavenworth, KS.

Shinseki, Eric K. 1999. Army transformation. Briefing to Association of the United States Army, USA/COS, 12 October.

Satterfield, Jeffery A. 1996. Traditional classic close air support in the age of information. Thesis, United States Marine Corps Command and Staff College, Quantico, VA.

Situational awareness data link (SADL). 2000. *Jane's Military Communications 2001-2002.* 7 September. Database on-line. Available from http://online.janes.com. Internet. Accessed on 22 August 2001.

Slessor, J.C. 1936. *Air power and armies.* London: Oxford University Press.

Smallwood, William L. 1993. *Warthog: Flying the A-10 in the Gulf War.* Washington, D.C.: Brassey's.

Smith, Scott F. 2000. Boots in the air: Moving the new Army brigade. Thesis, United States Air Force School of Advanced Airpower Studies, Maxwell AFB, AL.

Steele, Richard V. 2001. Air Warrior 01-10 situational awareness data link (SADL) integration after action report. Memorandum from 9 ASOS/B Flt CC to 9 ASOS/CC, 28 September. Copy in author's possession.

Stephanek, Kenneth T. 1998. The utilization of inertially guided weapons in performing close air support. Thesis, United States Army Command and General Staff College, Ft. Leavenworth, KS.

Taylor, Lynn D. 2000. Battlefield air support: An evolved concept for integrating airpower on the battlefield. Unpublished paper, Air Ground Operations School, Nellis AFB, NV. Copy in author's possession.

Thomas, Timothy L. 1997. Air operations in low intensity conflict: the case of Chechnya. *Air Power Journal* 11, no. 4 (winter): 51-59.

Turabian, Kate L. 1996. *A manual for writers of term papers, theses, and dissertations.* 6th ed. Revised by John Grossman and Alice Bennett. Chicago: University of Chicago Press.

U.S. Air Force. 1997. Air Force Doctrine Document 1, *Air Force basic doctrine.* Washington, DC: Government Printing Office, September.

_________. 1999. Air Force Doctrine Document 2-1.3, *Counterland*. Washington, DC: Government Printing Office, September.

U.S. Department of Defense. 1995. Joint Publication 3-09.3. *Joint tactics, techniques, and procedures for close air support (CAS).* Washington, DC: Government Printing Office, 1 December.

_________. 2001. *Quadrennial defense review report.* Washington, DC: Government Printing Office, 1 December.

U.S. General Accounting Office. 2001. Defense acquisition: Army transformation faces weapon systems challenges. Report to Congressional committees. Washington, DC: Office of the Comptroller General.

Walsh, Guy M. 2002a. Initial Brigade Combat Team (IBCT) TACP assessment. Briefing, 1 ASOG/CC, Ft. Lewis, WA, 29 January.

_________. 2002b. White paper on TACP C2 modernization vs. IBCT transformation. 1 ASOG/CC, Ft. Lewis, WA, 27 March.

Warden John A. 2000. *The air campaign.* New York: toExcel.

Weber, Robert P. 1990. *Basic content analysis.* Newbury Park, CA: Sage Publications.

Williams, Alford J. 2001. Air support functionality in AFATDS. *Field Artillery,* May-June, 20-23.

Wood, David. 2001. Bombs awry: Air-support debacle. *Air Force Times,* 10 December, 16.

## SELECTED BIBLIOGRAPHY


Campbell, Scott C. 2000. Inertially aided munitions: Do they make sense for CAS? Student paper, USAF Weapons School, Nellis AFB, NV.

Costello, Peter A. 1995. A matter of trust: Close air support apportionment and allocation for operational level effects. Thesis, United States Air Force School of Advanced Airpower Studies, Maxwell AFB, AL.

Elsarelli, Leon E. 1998. From Desert Storm to 2025: Close air support in the 21st century. Thesis, United States Air Force Air Command and Staff College, Maxwell AFB, AL.

Enhanced position location reporting system (EPLRS). 2000. *Jane's Military Communications 2001-2002.* 4 January. Database on-line. Available from http://online.janes.com. Internet Accessed on 22 August 2001.

FBCB2 takes a major step forward. 2000. *International Defense Review.* 21 December. Database on-line. Available from http://online.janes.com. Internet. Accessed on 22 August 2001.

Haun, Phil M. 2001. Air power versus a fielded army: A construct for air operations in the 21st century. Thesis, United States Air Force Air Command and Staff College, Maxwell AFB, AL.

Kniep, Scott A. 1999. A-10 targeting pod. Student paper, USAF Weapons School, Nellis AFB, NV.

Lewis, Michael. 1996. Lt. Gen. Ned Almond, USA: A ground commander's conflicting view with airmen over CAS doctrine and employment. Thesis, United States Air Force School of Advanced Airpower Studies, Maxwell AFB, AL.

Metzger, Louis S., and Donald R Erbschloe. 2001. Who's got the big picture? *Aerospace Power Journal* 15, no. 3 (fall): 86-91.

Mueller, Karl P. 2000. Politics, death, and morality in US foreign policy. *Aerospace Power Journal* 14, no. 2 (summer): 12-16.

Murphy, Todd A. 1999. F-16 JDAM accuracy vs. terminal threats. Student paper, USAF Weapons School, Nellis AFB, NV.

Nordwall, Bruce D. 1998. Fighters to tap the 'infosphere.' *Aviation Week & Space Technology*, 3 August, 67-74.

Norwood, John D. 2001. The objective force: Are we on the right track? Strategy research project, United States Army War College, Carlisle Barracks, PA.

Pengelly, Rupert. 2001. The US Army's FBCB2 makes progress: Is more needed? *Jane's Defence Upgrades.* 29 January. Database on-line. Available from http://online.janes.com. Internet. Accessed on 22 August 2001.

Scheel, Lynn I. 1999. Improving FAC-A effectiveness in a killer scout/armed recce scenario with collateral damage concerns. Student paper, USAF Weapons School, Nellis AFB, NV.

Scheer, Jon P. 2001. Targeting pods for the A-10. Student paper, United States Air Force Weapons School, Nellis AFB, NV.

Scott, William B. 2000. New targeting pods deliver 'Litening' strikes. *Aviation Week & Space Technology*, 21 August, 56-60.

Shelton, Henry J. 2000. *Joint vision 2020.* Washington, DC: Government Printing Office.

Southwest Research Institute. 1998. *System description document for the A/OA-10 situational awareness data link (SADL) with television monitor (TVM)/tactical awareness display (TAD) and signal processor.* San Antonio, TX: SWRI, 31 December.

Unterreiner, Ronald J., Jeffrey A. Brelsford, Richard J. Findlay, John F. Hunnell, and Michael F Wagner. 1996. Close air support (CAS) in 2025: Computer, lead's in hot. Research paper presented to Air Force 2025. Air University: Maxwell AFB, AL.

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