

REPLICATING THE AC-130'S URBAN CLOSE AIR SUPPORT
CAPABILITIES AROUND THE CLOCK

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ABSTRACT

REPLICATING THE AC-130'S URBAN CLOSE AIR SUPPORT CAPABILITIES AROUND THE CLOCK, by Maj J. Michael Nardo, 95 pages.

Given that half of the world's populace currently resides in urban environments, the United States armed forces find themselves at odds with the challenges urban combat imposes. For example, dense terrain features, noncombatants interspersed with enemy forces, and restrictive rules of engagement combine making urban operations problematic. To meet current and future urban combat demands the USAF must develop an airframe or system specifically designed for urban close air support situations. The central question is therefore: Given the current urban operating environments, what capabilities would be required to replicate the AC-130's ability around the clock? The study analyzes the AC-130's capabilities and defines them in terms of desirable urban battlefield effects. Using the AC-130 as an urban close air support effects benchmark other USAF close air support aircraft are qualitatively compared to determine which could best replicate the AC-130's effects during times when the gunship is not available. This study contends that no single aircraft can currently replace the AC-130, however, a combination of airframes can adequately encompass the AC-130's ability to provide persistence, precision low collateral damage on call fires, integrated command and control, and exceptional intelligence, surveillance, and reconnaissance support to ground forces in the urban environment.

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ACRONYMS

AFDD	Air Force Doctrine Document
AFSOC	Air Force Special Operations Command
AFSOF	Air Force Special Operations Forces
AO	Area of Operation
ATI	Ambient Temperature Illuminator (AN/AAT-3A)
C2	Command and Control
CAS	Close Air Support
CD	Collateral Damage
CDE	Collateral Damage Estimate
COIN	Counterinsurgency
CSAR	Combat Search and Rescue
DoD	Department of Defense
EWO	Electronic Warfare Officer
FCO	Fire Control Officer
HUD	Heads-Up Display
IFF	Identification Friend or Foe
IP	Instructor Pilot
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
IZLID	Infrared Zoom Identification
LANTIRN	Low Altitude Navigation and Targeting Infrared for Night
LNO	Liaison Officer
LOAC	Law of Armed Conflict

LOS	Line of Sight
MOOTW	Military Operations Other Than War
MOUT	Military Operations on Urban Terrain
NAV	Navigator
NVG	Night Vision Goggles
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ROE	Rule of Engagement
SDB	Small-Diameter Bomb
SF	Special Forces
SOC	Special Operations Command
SOF	Special Operations Forces
SPA	Stabilized Platform Assembly
TTP	Tactics, Techniques, and Procedures
TV	Television (sensor)
USAF	United States Air Force
USSOCOM	United States Special Operations Command (Commonly “SOCOM”)
WIC	Weapons Instructor School

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CHAPTER 1

INTRODUCTION

Introduction

Urban warfare, fighting in cities, war in complex terrain. To the casual observer, the words seem detached, almost pristine. However, the words are strikingly real to military professionals who have seen the images of great destruction and excessive casualties in cities such as Berlin, Stalingrad, Hue, and Beirut. Urban warfare, a subject that many military professionals would prefer to avoid, is still with us. Moreover, it may be the preferred approach of future opponents.¹

Major General Robert H. Scales, Jr., USA

Combat operations in urban environments have been steadily increasing for decades. While this type of warfare is not entirely new, its frequency is increasing. Study after study identifies the global trend toward urbanization.² Despite the increase in military operations in urban terrain doctrine and literature, little has been done in the way of airframe development specifically designed for close air support in an urban environment.

Nearly five years after the terrorist attacks of 11 September 2001, and in the midst of the longest declared war in US history, urban combat operations are ongoing and promise to continue for the foreseeable future. The increase in urban combat is due to an increasing global populace and increasing globalization as identified in appendix A. The US Census Bureau estimated the annual global population growth rate at 1.2 percent while the world's population increased from 6 billion to 6.2 billion people in the 1999-2002 time frame.³ As the world's populace expands, urbanization naturally follows. Urbanization is the "growth in the proportion of a population living in urban areas."⁴ In

fact current estimates indicate a staggering 47 percent of the world's populace reside in urban areas, which has been steadily increasing for two hundred years.⁵

In a world where nearly half its population currently resides in urban areas, conflicts will increasingly involve urban combat.⁶ There are other factors that drive combat into urban arenas. Imagine you are a combatant (either an insurgent, freedom fighter, or a member of a conventional force) fighting against a numerically superior, better-equipped, better-trained foe with excellent resupply capabilities. When fighting in open terrain, your forces are decimated nearly every time. The occasional tactical victory may be yours, but even then you are almost certainly met with overwhelming force in retaliation. How can your forces survive and remain relevant? How can the playing field be leveled? One answer is to take the fight into the urban environment. If this scenario sounds eerily similar to combat occurring in the Middle East today, it should. Recent examples can be seen in battles in Afghanistan and Iraq. In many ways, urban combat is becoming the norm displacing the large open field, conventional, fights of the past with high-intensity battles in and around cities. US forces must be ready to respond to the complexities of urban combat or risk creating a Grozny-type scenario, such as the one faced by the Russians in 1995.⁷ During this battle Russian forces entered the city of Grozny to expel an armed group of Chechen fighters. Although the Russians were a numerically superior force they paid a high cost in both men and equipment while gaining little ground. The Chechens used the urban environment to their advantage and inflicted a high toll upon the Russian forces. They realized the value of urban tactics and understood that by turning to the urban environment they could, “negate Russian advantages of firepower in the open from helicopters, fixed-wing aircraft, and tanks, and

they could blend in with the local population to their advantage. This not only continued to make it difficult to distinguish combatants from civilians, but it also helped the Chechens get the local population on their side. This was usually the result when Russian forces entered a city, destroyed property and buildings, and killed or wounded civilians while searching for their armed opponent.”⁸ The poorly trained Russian forces resorted to an artillery barrage of the city that ultimately destroyed the vast majority of the city in just over three weeks. The lesson, “preparation for urban combat must begin in peacetime. . . . [T]here is no ‘standard urban combat operation.’ Each is unique to the opponent, the city, specific operational and tactical issues, and geopolitical considerations. . . . Understanding the elements and ramifications of urban combat is a difficult but crucial task.”⁹ The US Air Force must therefore be ready to support ground personnel with urban close air support.

To meet the demands of close air support in an urban environment, the USAF must develop an airframe or system specifically designed for use in urban close air support situations. The AC-130’s capabilities appear to be suited to this environment. Originally conceived and developed in 1965 for night personnel interdiction and air base defense in Vietnam, the Douglas AC-47, fashioned from a converted C-47 cargo aircraft, was highly successful.¹⁰ This precursor to the modern day AC-130 variant evolved quickly, striking fear amongst enemy forces in the jungle environment.¹¹ The AC-130 gunship has maintained its position as an exceptional close air support fires platform and has evolved into an excellent urban close air support asset capable of fulfilling most of the roles specifically required in this environment. The gunship’s Achilles heel, however, is its slow speed, large size, and exceptional vulnerability to ground fire. Surprisingly,

there has there been little focus on developing an airframe, system, or system of systems capable of providing the same highly precise on call fires, ISR, C2, or persistence capabilities employed by the AC-130 on a sustained basis. The AC-130's superior nocturnal capabilities must be replicated for use in urban close air support environments and employed during daylight and high-illumination periods.

Problem Statement

Given the trend toward urban combat operations, what capabilities are required to provide continuous accurate urban close air support? In order to adequately understand the project, it is necessary to define urbanization and identify the effects urbanization will have on future battlefields. Since close air support is an extremely critical battlefield capability, a significant effort will be placed on describing its various subtypes while simultaneously identifying the ground commanders close air support asset requirements. With a suitable understanding of urban close air support completed and with the understanding that there is a need for a specifically designed airframe to support anticipated objectives in an urban environment, the project uses the AC-130 as a benchmark urban close air support asset. A brief historical overview of its development and an in-depth study of the AC-130's capabilities and weaknesses as a close air support platform is presented paying particular attention to the AC-130's use in the urban environment. Finally, an analysis of available systems required to replicate the AC-130's close air support capability during daylight hours is provided.

Research Questions

The primary research request is: Given the current urban operating environments, what capabilities would be required to replicate the AC-130's ability to provide accurate air delivered close air support fires around the clock?

The secondary supporting request questions are:

1. What is close air support in an urban environment?
2. What qualities, both lethal and nonlethal, make an airborne platform ideal for the urban close air support mission?
3. What strengths does the AC-130 contain for use in urban close air support scenarios?
4. What weaknesses hinder the AC-130's ability to operate in urban environments?

Purpose

This project will identify the increasing trends towards urban combat operations and the dangerous art of urban close air support. The goal is to determine what capabilities make the AC-130 gunship particularly suited for this combat environment, while identifying its weaknesses. The intent is to analyze the strengths and weaknesses this airframe contains and to suggest a viable system or system of systems that could replicate the AC-130's precision urban close air support effects.

Facts and Assumptions

The scope of this research has the potential to be exceptionally large; therefore, for the purposes of this study, the following assumptions will be made:

1. Only current technological capabilities will be used. No future or notional weapon systems are utilized.
2. For the purpose of this study, the terms urban close air support and close air support in urban environments are used interchangeably, both referring to the performance of close air support operations in any type of urban environment. There may be discussion elsewhere as to the significance of these terms and their usage; however, they are not germane to this study.
3. Numerous studies regarding daylight use of the AC-130 platform exist, but they will not be used in order keep this study unclassified. The overall assumption will be that the AC-130 does not normally fly combat missions during daylight hours and this study is attempting to identify a suitable daylight replacement.

Background

Doctrine pertaining to close air support originated in an environment much different than we find ourselves in today. During World War II, initial attempts at creating aircraft and tactics for close air support were confined to the early Air Corps Tactical School ultimately leading to the formation of a gap between air and ground officers.¹² “As many Air Corps Officers after 1935 began to identify independence with strategic bombing, interest in attack aviation lessened.”¹³ During World War II, the gap diminished as a renewed interest in attack aviation grew, eventually leading to the development of the first close air support field manual. This document addressed important issues dealing with command and control, communication and even rudimentary close air support tactics. Interestingly, out of all the advancements in close air support airmen looked upon, “the autonomy they achieved from ground control as the

most beneficial influence on the close air support mission.”¹⁴ This in no way mirrors the current manner in which current close air support is employed. The trend towards integration with ground forces can be seen doctrinally in JCS Publication 1, 1964, which further defined close air support as: “Air action 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.”¹⁵

Current post-major regional contingency operations increasingly require the movement of forces from an open field fighting environment, where targets can be engaged with relative certainty of minimal collateral damage, to a more complex urban operating environment. This environment provides many benefits and presents numerous obstacles for both friendly and hostile forces. Urban areas provide excellent concealment, protection, and freedom of movement. Unfortunately, with these advantages come ambush positions, urban canyons, confined fighting areas, decreased communications, restricted weapons flight paths, decreased ability for identification, and, of course, the presence of noncombatants on the battlefield. Every urban environment is unique.

Urban operations do not occur in a homogenous type of terrain or place. The setting varies greatly across a given city, and obviously cities in themselves vary. The terrain and structures that we often envision and speak of are the urban canyons of the city core, which typically comprise only three percent of the urban area. Urban operations can involve other locations within an urban area, where some of the salient features found in the city core, such as obscuration from tall buildings, may not be the driving issues. There are other important factors to consider, such the population and industrial sites. It is important to emphasize that the urban environment is a complex collection of terrains for military operations.¹⁶

The USAF Scientific Advisory board further identified numerous types of environments located within a typical urban area, such as “commercial ribbon, urban sprawl and city core to name a few.”¹⁷ The nature of urban combat, with all its

constraints, requires the employment of highly precise weapons producing both lethal and nonlethal effects while causing minimal collateral damage.

Air Force doctrine identifies seventeen operational functions including Counterland, which includes the subset of close air support.¹⁸ USAF doctrine uses the term “close air support” as a catchall phrase including any operation requiring “the use of aerospace assets to directly support the ground force . . . flown against targets that are in close proximity to friendly forces . . . requires detailed integration between CAS missions and the fire and movement of surface forces.”¹⁹

Most urban close air support operations, both in training and in combat, include highly restrictive operational requirements, extreme weapon system accuracy, and detailed force integration in order to prevent fratricide and ensure minimal collateral damage. Even in the most benign training environments this kind of accuracy can be hard to achieve. In combat it requires special tactics, training, equipment, and doctrine. Often success or failure is dictated in terms of capturing or killing one specific person on an objective; minimal collateral damage; minimized fratricide; intricate intelligence, surveillance, and reconnaissance (ISR); and precise command and control (C2).

The AC-130 gunship effectively provides all these capabilities in one airframe. Unfortunately, it is used primarily at night. The AC-130 units’ motto: “You can run but you will only die tired” is accurate, but like many night predators this low-density, high-demand asset is hard pressed to operate in periods of high illumination or in daylight. Gunship crews routinely train in daylight hours; however, their operational preference is during low-illumination periods of darkness, which drastically enhances their survivability. AC-130 gunship capabilities are discussed in greater detail in chapter 4.

Given the AC-130's nighttime capabilities, considerations for replicating its effects during daytime operations are appropriate. Ongoing operations in Iraq, Operation Iraqi Freedom (OIF), and Afghanistan, Operation Enduring Freedom (OEF), reflect the desire for similar capabilities in high-illumination environments.

Given the likelihood of urban close air support operations increasing, coupled with the ground force commanders requirements for the employment of AC-130-like urban close air support capabilities during all-light conditions, a viable system replicating the gunship's effects during the day must be developed. Initially, there does not appear to be one, all encompassing, asset capable of filling this void. In lieu of a single airframe, a system of systems appears to be a viable option. It is precisely this system of system this study will attempt to identify.

Limitations

The foremost limitation is the necessity to ensure this document remains unclassified. To that end this project will rely heavily on open source data, publications and documents. This should not hinder the ability to come to a feasible conclusion.

Scope and Delimitations

This study will identify strengths and weaknesses in the AC-130 gunship and will make relevant suggestions for replicating its effects during high-illumination conditions. It will not presume to create, nor implement doctrine, tactics, techniques, and procedures (TTPs), or design airframes capable of fighting around the clock in the urban environment, this requires greater assets and further study than feasible to include herein. Furthermore, this thesis will not include classified material of any kind. Should classified

material become necessary a supplement will be created and placed on file in an appropriate manner.

This thesis is limited to close air support assets and will not delve into the field artillery arena to any great extent. This thesis does not presume to discount field artillery use in support of urban combat operations, rather it is meant to confine the scope to systems which can provide significant combat support to ground personnel. While artillery can provide highly accurate firepower, it simply cannot provide necessary items such as, command and control and ISR support, to ground personnel.

Significance, Summary, and Conclusions

Combatant commanders are frequently presented with a series of conditions requiring sustained highly accurate ISR, C2, and aerial-delivered fires in urban environments. With only 21 AC-130s available worldwide and given its propensity to operate primarily during darkness, a system must be developed to replicate its effects while diminishing its weaknesses. It is possible for certain mission sets, such as extremely high-value targets, to simply employ the AC-130 during daylight. This is the exception rather than the rule. It is likely that no single aircraft can provide low-yield, highly accurate, consistent firepower in an urban environment while minimizing collateral damage. It may be possible to use a package of aircraft in order to accomplish the same purpose. The ultimate goal is to provide the ground force with the effects of an AC-130 around the clock. A system, such as this could, bridge the current capabilities gap until the Department of Defense (DoD) can develop a suitable aircraft. The outcome will also enhance the ground forces ability to fight in urban environments and more importantly provide an increased level of safety, C2, ISR, and air-delivered fires.

¹Joint Chief of Staff, JP 3-06, *Doctrine for Joint Urban Operations* (Washington, DC: GPO, 2002), I-1.

²Evidence showing that by the year 2010, nearly 75 percent of the world's population will be living in urban areas is in Michael C. Desch's, *Soldiers in Cities: Military Operations on Urban Terrain* (Carlisle, PA: Strategic Studies Institute, 2001), 4.

³This information was available from the US Census Bureau, Global Population Profile: 2002, Washington, DC, www.census.gov/ipc/wp02.html, 3. Some of the more relevant data is reproduced in figures 14-16.

⁴Population Today, *Patterns of World Urbanization* (Washington, DC: Population Reference Bureau, 2006), terms.

⁵"In 1800, only 3 percent of the world's population lived in urban areas. By 1900, almost 14 percent were urbanites. . . . In 1950, 30 percent of the world's population resided in urban centers. The world has experienced unprecedented urban growth in recent decades. In 2000, about 47 percent of the world's population lived in urban areas, about 2.8 billion. There are 411 cities over 1 million. More developed nations are about 76 percent urban, while 40 percent of residents of less developed countries live in urban areas. However, urbanization is occurring rapidly in many less developed countries. It is expected that 60 percent of the world population will be urban by 2030, and that most urban growth will occur in less developed countries." For more information see figure's 14-16.

⁶Wallace J. Hoff, *Air Force Operations in Urban Environment*, Vol. 1, *Executive Summary and Annotated Brief* (Washington, DC: United States Air Force Scientific Advisory Board, 2005), 2, the author states "As cities increase in number and importance, the population of the world is rapidly gravitating toward these centers of commerce, culture, and society."

⁷The Battle for Grozny took place in 1995 whereby a numerically superior, although poorly equipped and trained, Russian force entered Grozny and after an intense three-week urban battle seized the city from a Chechen force who eventually retook the city in 1996. For more information see Timothy Thomas's, *The Battle of Grozny: Deadly Classroom for Urban Combat* (Carlisle, PA: US Army War College, 1999), 87-102.

⁸Ibid.

⁹Ibid.

¹⁰Philip D. Chinnery, *Any Time Any Place, Fifty Years of the USAF Air Commando and Special Operations Forces* (Annapolis, MD: Naval Institute Press, 1994), 99.

¹¹Ibid., “The gunship’s were allocated the callsign ‘Spooky’, and earned the nickname ‘Puff the Magic Dragon’, from those who witnessed its nocturnal display of firepower. The roar of the guns and the sight of twenty tracer bullets per second reaching out towards the ground struck fear into the Viet Cong. Being a superstitious people, the Vietnamese took the name literally. Captured Viet Cong documents told of orders not to attack the Dragon, as weapons were useless and it would only infuriate the monster.”

¹²John Schlight, *Help from Above: Air Force Close Air Support of the Army, 1946-1973* (Washington, DC: Air Force History and Museums Program, 2003), 2.

¹³Ibid.

¹⁴Schlight, 2.

¹⁵Ibid., xi.

¹⁶Hoff, 6.

¹⁷Ibid., figures 9 and 10 further illustrate the urban environment.

¹⁸D. Robert Poyner, Air Force Doctrine Document (AFDD) 1, *Basic Doctrine* (Maxwell AFB, AL: Air Force Doctrine Center, 2003), 449 (hereafter cited as AFDD1).

¹⁹Department of the Air Force, USAF, Air Force Doctrine Document 2-1, *Air Warfare* (Maxwell AFB, AL: Air Force Doctrine Center, 2000), 19 (hereafter cited as AFDD2-1).

CHAPTER 2

LITERATURE REVIEW

Introduction, Purpose, and Organization

The purpose of this study is to identify a system capable of replicating the AC-130's effects in urban close air support environments during high-illumination periods. Research for this thesis contained voluminous information that could easily have filled several authoritative works on pertaining to urban close air support. For this reason, the focus had to be narrowed from a purely urban close air support focus to the more specific topic of replicating the AC-130's effects in urban combat environments. The intent is to derive a system that could assist ground commanders in the accomplishment of their mission under the unusual strains of urban combat during times where AC-130 support is unavailable.

Current State of Publications

Unfortunately, at the time of this writing, there has been little work done directly relating to the primary question. While this ensures the study's relevance in the field, it promises greater difficulty in deriving a straight forward conclusion. The answer to the primary question will be derived from literature encompassing the secondary questions, available airframe technical manuals, and interviews. To that end this chapter will focus primarily on writings relating to each of the secondary questions. Fortunately, the majority of available information pertaining to the secondary questions is contained in readily available open source areas.

Literature for the Primary Question

Currently, the best information regarding the primary questions lies within airframe technical manuals. These manuals can be voluminous and provide a large amount of nonclassified information. Unfortunately, they are not easily obtainable in all circumstances. For this reason and in order to make sense of items, such as airframe capability and employment not related to specific manufacturer requirements, selective participants provided background information. The author will act as the primary source for AC-130 related topics with locally available airframe instructors providing expertise in their airframes as needed. Aircraft information from these sources is provided in appendixes B and C.

Literature for the Secondary Questions

Several secondary questions have been identified and will be addressed in order.

The answer to the first secondary question lies within AFDD-1 and JP-3-09.

AFDD-1 contains the accurate definition while the joint publication's focus is on close air support in the joint arena. These manuals accurately describe the urban environment and close air supports role on the battlefield. More intriguing literature on the complexities of the urban environment, however, can be found in studies produced by the Rand Corporation, namely *Marching Under Darkening Skies: The American Military and the Impending Urban Operations Threat* and *The Changing Face of Urban Operations*. To be certain, these are not the only works in the field, they simply represent excellent examples of the performance of close air support in urban environments. Throughout this report numerous Rand Corporation studies were examined for their relevancy, and although not all were utilized, the quality of its projects were consistently excellent. Of

course, this is to be expected from an organization routinely called on by senior governmental agencies to produce high-caliber examinations and trend analysis for emerging conflicts.

Identifying patterns in urban growth was accomplished using an exceptional article written by the Population Reference Bureau entitled, “Patterns of World Urbanization.” The article provided shocking identification of the global increase in urban populations and included several authoritative supporting references in support.

Information regarding secondary questions 2 through 5 was obtained primarily through airframe technical manuals and interviews. Some important work in the field of early close air support platform development is covered in Douglas Campbell’s *The Warthog and the Close Air Support Debate*, which chronicles the advent of an aircraft whose sole purpose is the performance of close air support. As expected, it only includes single- or two-seat, fighter aircraft, leading to the development of the A-10.

Many ground commanders have written about their close air support requirements, and Bruce Don’s work entitled *Future Ground Commanders’ Close Support Needs and Desirable System Characteristics* provides an interesting look at close air support requirements in response. Sometimes, however, the view from the ground and the air differs, as Michael Lewis writes in “Lt Gen Ned Almond, USA: A Ground Commanders Conflicting View with Airmen over CAS Doctrine and Employment.” In his dissertation he discusses the historical viewpoints and friction between Army and Air Force with regard to his “four CAS sub issues.”¹ Lewis’ arguments regarding priorities in the employment of airpower, close air support ownership and apportionment, command

and control, and single or multipurpose aircraft are interesting, but a bit out of date. These issues, while still discussed, have been overcome in today's joint environment.

It is intriguing that the changing battle space finds the Air Force investing in a joint strike fighter in an environment where close air support development for the urban environment should, in the author's opinion, supersede other requirements. After the attacks of 11 September, former Secretary of Defense Donald Rumsfeld acknowledged the lethality and terror gunships dealt on their enemy, yet the budget provided funding for only four new aircraft. The addition of these four aircraft, only one of which has been fielded some five years later, increases the total gunship inventory to only twenty-one worldwide! There still are not enough airframes to fulfill the ground force commander's requirements. According to Patrick Allen's book, *US Special Operations Command in Action*, new studies for more maneuverable gunships and associated weapons are underway, yet none are in actual development.

Trends in Literature

The literature regarding close air support is growing. Articles regarding close air support's use in the war on terror are prevalent as after-action reports (AARs) and studies are being accomplished on close air support's role in the ongoing war on terror. Many of the articles are from the ground commanders' viewpoint and identify their individual use of close air support assets in particular engagements. While these were of some value, they were not specific enough to be applicable in all circumstances and therefore not entirely relevant to the effort contained herein. The RAND Corporation studies utilized in this thesis point to the complexity of urban combat, its continued emergence, and the importance of training to fight in these environments. The trend toward increased urban

combat in the literature regarding this subject is abundant, but it does not specifically deal with the primary question.

Summary and Conclusions

There is an abundance of information regarding close air support as a topic and copious reporting from those who have utilized close air support assets in war. This is undoubtedly the result of the evolution in warfare whereby the enemy, in order to maximize combat effectiveness, has moved into the urban environment. Battles, such as those in Panama, Chechnya, Afghanistan, and most recently the Battle for Fallujah, indicate a definite change in the urban close air support environment. As technology increases, the battle space defined for close air support is compressing. Books, such as, *We Were Soldiers Once and Young* by retired Lieutenant General Moore and Joseph L. Galloway and *Not a Good Day to Die* by Sean Naylor indicate just how close to friendly forces close air support fires have encroached as close air support techniques, and technology, continue to improve. To be certain there will always be close air support in nonurban terrain as these writings indicate. Increasingly, however, urban terrain has become the battleground, and research in the area has grown as a result. Numerous Rand Corporation reports have focused on operations in the urban environment. "A modern U.S. force possessing extraordinary maneuverability and firepower that is unable to fight and win in the city is of dubious value."² This feeling is echoed in *Mars Unmasked: The Changing Face of Urban Operations* by Sean Edwards. Numerous cited works document the changing close air support environment, yet none are dedicated to determining which aircraft or aircraft characteristics are uniquely suited for this environment. The void will be bridged by this work.

¹Michael Lewis, "Lt Gen Ned Arnold, USA: A Ground Commander's Conflicting View with Airmen over CAS Doctrine and Employment" Ph. D. diss. (School of Advanced Airpower Studies, Maxwell Air Force Base, AL, 1997), 69.

²Russell W. Glenn, *Heavy Matter: Urban Operations' Density of Challenges* (Santa Monica, CA: Rand Corp., 1996), 38.

CHAPTER 3

RESEARCH DESIGN

The immediate intent is to locate and identify any works, electronically or in print, that focus on the Air Force's support for the urban environment. This is no small undertaking, especially due to the vast amount of literature dedicated to close air support. Following the initial search the material was screened for relevancy to the questions posed and included with the findings. With respect to defining a system capable of replicating the AC-130's combat capabilities, the initial effort will be at describing the AC-130's strengths and weaknesses. Once this is accomplished, other close air support airframe characteristics was compiled and examined in a quantitative manner to define which airframe can adequately reproduce the AC-130's effects.

Questionnaires were compiled on a limited basis with personnel locally available. In each case, an aviator from the designated platform was identified from within the student and instructor populace located at the US Army Command and General Staff College. Once identified these personnel were asked to assist by providing background information regarding their airframe and its capabilities in the close air support environment. Aviators selected were all Air Force officers with at least 1,000 hours of time in their respective airframes. Where possible, weapons instructor course (WIC) graduates and instructor pilots were sought out for their expertise. There were no UAV pilots available, therefore, information regarding UAVs was obtained from readily available unclassified sources. In some cases, WIC personnel and the authors experience with UAVs in combat were used.

CHAPTER 4

ANALYSIS

Introduction

This chapter defines the AC-130's unique urban close air support capabilities and provides background data from other USAF airframes in order to answer the primary research question. Urban close air support is defined and described, followed by an evaluation of the AC-130's strengths and weaknesses performing close air support in the urban environment. Similar information is provided for the F-15, F-16, A-10, and armed and unarmed UAVs. The intent is to identify the capabilities and effects that make the AC-130 a formidable weapon in the urban environment, particularly at night. These capabilities provide a baseline to compare and assess other contemporary close air support platforms in order to identify what platforms, or packages, should be used to develop an all-weather, day-night urban close air support capability.

Evaluation of the Secondary Questions

What is close air support in an urban environment?

What qualities, both lethal and nonlethal, make an airborne platform ideal for urban close air support?

Close air support is defined as air action against targets that are in close proximity to friendly forces requiring detailed integration.¹ The essence is providing on call fire support to friendly personnel who are in close proximity with enemy forces. "In this context, forces in close proximity are close enough to engage one another with organic weapons such as artillery."² When this type of support is provided to friendly personnel

in an urban environment, it is termed urban close air support and brings with it a host of additional complexities not normally associated with standard close air support operations.³

There are many unique characteristics for planning and executing urban close air support missions, for example: “(1) operations in urban canyons, (2) deconfliction in confined airspace, (3) restrictive [ROEs], (4) difficulty in threat analysis, (5) an overload of visual cues, (6) the presence of noncombatants, (7) the potential for collateral damage, and (8) the increased risk of fratricide. . . . These items suggest two broad tactical problems: the difficulties of properly identifying (1) potential targets (target ID) and (2) friendly vehicles and positions (combat ID), both of which are especially critical for urban CAS.”⁴ Urban close air support requires some atypical skill sets and training not normally associated with standard close air support missions. Accepted standards for effective close air support require “thoroughly trained personnel with well developed skills, effective planning and integration, effective command, control, communications, computer systems [C4], air superiority, target marking and acquisition, streamlined and flexible procedures, and appropriate ordnance.”⁵ Late in 2005, urban close air support considerations appeared in joint doctrine. “CAS planners must be aware of the special considerations regarding urban terrain. These considerations include, but are not limited to: target acquisition, munitions effects, observation and terminal attack control, SEAD [suppression of enemy air defenses] requirements, limited visibility and adverse weather effects, visual employment, system-aided employment, time considerations, and civil considerations.”⁶ From these requirements, the answers to the secondary questions can be derived. The ideal urban close air support platform should be able to positively affect, or

aid the ground force in affecting, the doctrinally required close air support considerations. The current airframe of choice for these missions is the AC-130 gunship. The AC-130 provides precise aerial-delivered munitions, timely persistent ISR, command and control capabilities, and lethal-nonlethal response options to support ground personnel in a single platform.

The AC-130 Gunship

A recent study identified the AC-130 as a “star performer” in the urban close air support arena.⁷ This study explored areas, such as “timely and persistent ISR [and] lethal and non-lethal attack,” options while examining close air support in urban environments.⁸ Certainly the AC-130 can perform these functions well, but the study did not provide enough detailed information regarding how or why the AC-130 did so well in this environment. In order to fully appreciate what capabilities the AC-130 brings to the urban close air support environment, the following questions must be answered:

What strengths does the AC-130 contain in the performance of urban close air support?

What weaknesses hinder the AC-130’s ability to operate in urban close air support environments?

The answers determine the critical capabilities potential airframes, or systems, must include in order to provide similar coverage during times when AC-130s are unavailable or inappropriate. These answers provide the framework to analyze the suitability and viability of other close air support platforms.

AC-130 Overview

The AC-130 is built around the standard C-130 Hercules airframe manufactured by Lockheed Martin. Its basic airframe components are similar to most C-130s currently in operation. Figures 1 and 2 identify the visible similarities between these aircraft.



Figure 1. Standard C-130

Source: Military Analysis Network, AC-130H and U Gunship [web site on-line]; available from <http://www.fas.org/man/dod-101/sys/ac/c-130.htm>; Internet; accessed 16 August 2006.



Figure 2. AC-130H

Source: Military Analysis Network, AC-130H and U Gunship [web site on-line]; available from <http://www.fas.org/manand/dod-101/sys/ac/c-130.htm>; Internet; accessed 16 August 2006.

Based on the Lockheed airframe, both aircraft employ identical airframe and engine structures. Both are built around an “all metal, high-wing, long-range, land-based monoplane . . . divided into the cargo compartment and the flight station.”⁹ Each employs four Allison T56-15 turbo-prop engines, dual-wheel construction, steerable nose gear, two tandem-mounted main retractable landing gear, are the same in height and length, and utilize four Lockheed-Fowler type high lift flaps.¹⁰ Many of the basic subsystems, such as fuel and pneumatics, still have commonalities, while others, such as electronics and hydraulics, have been extensively modified to support specific AC-130 close air support mission requirements. The cargo compartment, for example, has been extensively modified in order to convert from a cargo carrying aircraft into an aerial fires platform. From this basic construct, the AC-130 has transformed from a cargo-carrying role into a lethal close air support platform.¹¹

External similarities, particularly when looking at the right side of the aircraft, can make aircraft identification difficult. When viewing the AC-130 from the left side as shown in figure 3 or when peering into the cargo compartment, the differences are extremely evident.

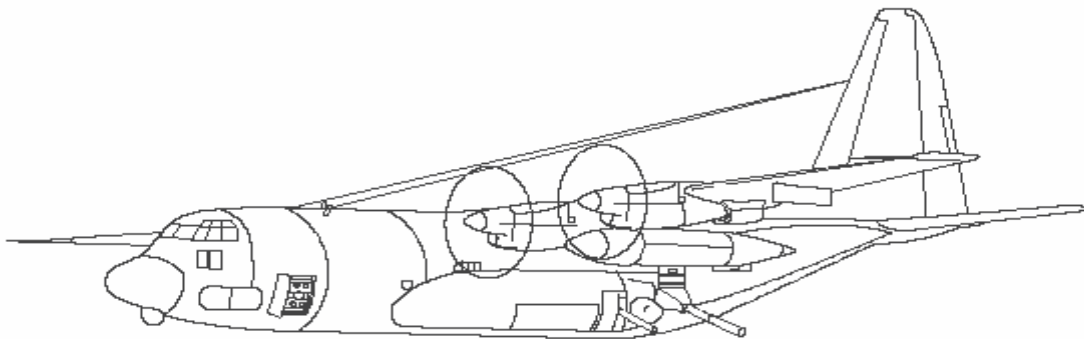


Figure 3. AC-130 H Aircraft

Source: Warner Robbins, ALC, TO 1C-130(A)H-1, *AC-130(A)H-1 Aircraft* (Warner Robbins AFB, GA: WR-ALC and LUTD, 2004),1-1.

The C-130 airframe has been extensively modified and includes the addition of a 105-millimeter Howitzer, 40-millimeter L60 Bofors cannon, and a 25-millimeter GAU-12 Gatling gun (AC-130U-model only) which protrudes from the left side of the aircraft. The H-model has a sensor platform located in place of the forward crew entrance door, which contains a Stabilized Platform Assembly (SPA) comprised of the low light level television (LLTV), infrared zoom laser illuminator designator (IZLID), and ambient temperature illuminator (ATI) systems. An infrared sensor ball hangs from the nose of the AC-130H. The U model, however, maintains its crew entrance door utilizing separate housings for the IDS and ALLTV systems that hang underneath the aircraft's forward section. During combat operations heat shields are installed on each engine in order to reduce the extensive heat signature produced by its four engines.

The cargo compartment has undergone numerous, extensive, modifications as well. Figure 4 provides an excellent visual overview of the AC-130 cargo compartment. When viewing the cargo compartment from the aft section of the aircraft the armament system can be readily identified. Ammunition storage racks are located within easy reach of the weaponry, and additional storage locations are located in the forward cargo compartment. This arrangement eases the complexity of weapons loading during blacked out combat conditions. The aircraft's hydraulic systems have been modified in such a manner as to enable the operation of the large hydraulic gun mounts while providing essential hydraulic power in case of an emergency. A sensor operator booth has been installed in both models, but differs slightly in each. The H-model contains three crew positions including a low-light television set (TV) operator, the infrared detection set operator (IR), and the electronic warfare operator (EWO).¹² The AC-130U contains a

Battle Management Center (BMC), which contains the IR, TV, and EWO in addition to the navigator and fire control officers positions.

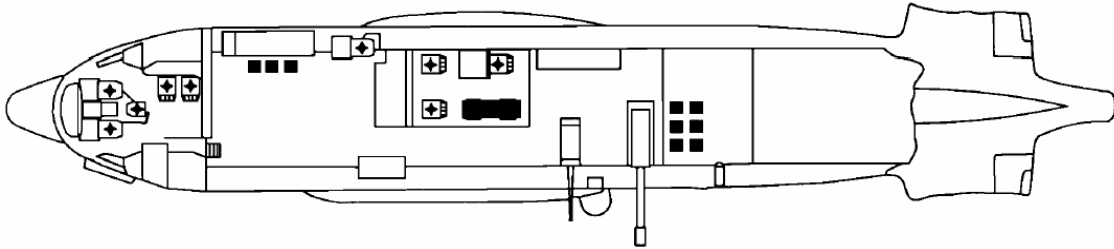


Figure 4. AC-130H Gunship

Source: Warner Robbins, ALC, TO 1C-130(A)H-1, *AC-130(A)H-1 Aircraft* (Warner Robbins AFB, GA: WR-ALC and LUTD, 2004), 1-205.

Forward of the booth, BMC, extensive electronics racks have been installed to support the highly technical communications and mission computer suite. The electronics rack extends from the forward, right side, of the booth in the cargo compartment to the aft side of the aircrew flight station. This arrangement allows the additional electronics to support the enhanced communications suite necessary to provide the complex command, control, and communications required in close air support environments.

The flight station has been extensively modified in both variants; each will be identified separately beginning with the H-model. The AC-130H has an extended flight deck, shown in figure 5, allowing expansion of the navigator station to include a fire control officer's (FCO's) position. This position includes additional instrumentation, an overhead fire control panel, and an isolated communication system for use between the navigator, FCO, and booth personnel. Extensive coordination is required between the navigator and fire control positions during combat, and this crewmember arrangement

facilitates that coordination. The navigator's position has been modified to include precision navigation information systems that can easily feed into the fire control and mission computer systems. Overhead screens enable both crewmembers to view sensor information for target tracking and identification during target engagement.

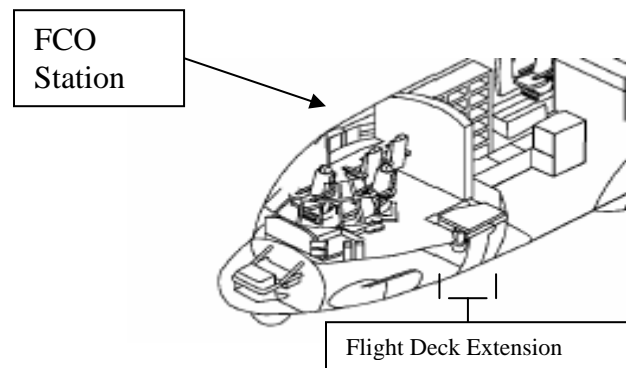


Figure 5. AC-130H Flight Deck Layout

Source: Warner Robbins, ALC, TO 1C-130(A)H-1, *AC-130(A)H-1 Aircraft* (Warner Robbins AFB, GA: WR-ALC and LUTD, 2004),4-515.

The pilot's crew station contains a yoke-mounted trigger switch for weapons firing and a unique side-mounted HUD. The head-up display (HUD) receives computer-generated symbols from digital generation units and "reflects them off a combiner glass enabling the pilot to prosecute an attack by viewing the fire control solution symbology and simultaneously viewing the outside world."¹³ Separate information is displayed on the pilot display units (PDUs) for both the pilot and copilot. Off nominal airspeed and altitude are displayed on the PDUs providing constant feedback enabling the pilot to maintain exact specifications for optimal firing solutions based on mission computer inputs.

In the tactical environment the AC-130 is the only aircraft in the world where both pilots actually control the aircraft at the same time. In this environment duties are divided with the pilot in command operating the ailerons in order to maintain specific geometry requirements displayed in the HUD and engaging targets with the aircrafts' weapons, while the copilot maintains the altitude and airspeed, operates the communications system, scans the horizon for threats, and assists the pilot and engineer in monitoring the engine instruments.¹⁴

The flight deck on the AC-130U includes crew station seating for the pilot, copilot, and an engineer. The navigator and FCO positions have been relocated into the BMC contained in the cargo compartment. An updated electronics and flight control instrumentation panel has been installed providing easier manipulation of information and screens that enable either pilot to view sensor and navigation information. A similar HUD and PDU system is employed on the U-model as well.

The engineer's position has changed little. Most C-130 aircraft are not refuelable during flight; however, the AC-130 has been modified with an in-flight refueling system that is controlled from an overhead air-refueling panel operated by the flight engineer. This single addition drastically increases loiter time, which is a significant improvement and a desirable close air support effect. The electrical system has been modified to enable the aircraft to provide adequate power in response to the drastically increased power requirements necessary for the sensor, electronic warfare, and mission computer systems contained in the AC-130. Numerous circuit breakers have been added enabling the AC-130's enlarged electric system to safely power the substantially increased electrical requirements of the AC-130. Four 90 KVA AC engine generators provide the bulk of the

aircraft's electrical requirements during flight. Each generator provides 200/115 volt, three phase electrical power. In flight, 28-volt DC power is provided via six transformer-rectifier units.

A gun control panel has been added to the engineer's position. From this position the engineer can arm or safe the guns as required by the pilot or in response to gun malfunctions. The guns can also be safed by switches located at the FCO and gunner's positions. The weapons systems on both models are oriented out the left side of the aircraft.¹⁵ Both utilize a 105-millimeter Howitzer and a 40-millimeter Bofors cannon; the U-model also contains a 25-millimeter Gatling gun. A diagram of the weapons layout is provided in figure 6. The guns are hydraulically operated responding to signals supplied from the mission computers.

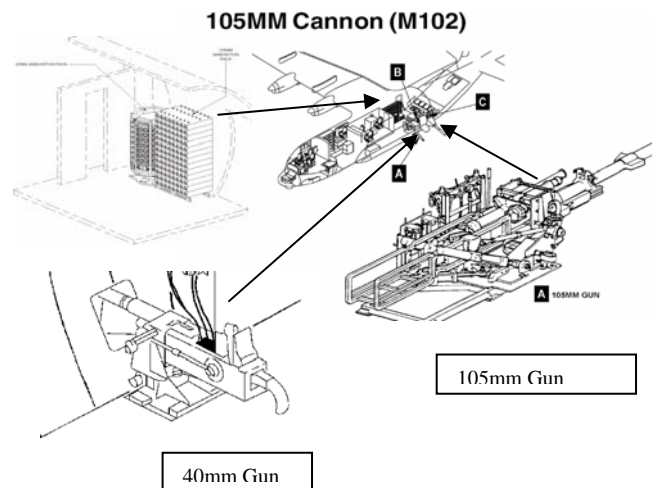


Figure 6. AC-130H Weapons Layout

Source: Warner Robbins, ALC, TO 1C-130(A)H-1, *AC-130(A)H-1 Aircraft* (Warner Robbins AFB, GA: WR-ALC and LUTD, 2004), compilation of figure from 4-463, 4-457, 4-466.

Data from the onboard sensor systems, airspeed, pressure altitude, barometric corrected altitude, true airspeed, calibrated airspeed, indicated airspeed, Mach number, air pressure, air density ratio, static air temperature, total and impact air pressures, and total temperature all combine in the air data management computers. This information interfaces with GPS and INS systems in the onboard mission computers, and in concert with time of fall and ballistic wind data calculations aims the guns through hydraulic gun mounts.¹⁶

Firing solution errors can be immediately determined and manually corrected by the FCO from the flight station. “AC-130 firing altitudes depend on terrain, threat environment, and weather. Gun selection depends on target type and desired effects. The gunship’s weapons do not have a hard-kill capability against heavy armor or bunkers. However the 105-millimeter has . . . fuses with both point detonation and 0.05 second delay, concrete penetrators, and proximity fuses for airburst . . . 25-millimeter, and 40-millimeter have point detonate fuses.”¹⁷ While engaging targets the gunship can make use of several ammunition types and fuses to ensure desired effects are achieved.¹⁸ The ability to moderate the types of ammunition and fusing based on the desired effects reduces overall CD and is a distinct advantage in the urban environments.

The AC-130 electronic warfare system is quite extensive. In general, the aircraft has been modified to include an AN/ALE-40V countermeasures dispenser system capable of dispensing chaff and flares in response to hostile radar and infrared threats. The system responds to manual crew inputs derived from any combination of visual cues, three radar, or one infrared, warning receiver system(s). Radar warning is provided via the ALR-69, QRC 84-05, and an AAN/APR-46 wideband receiver. Infrared protection is

provided via an AN/AAR-44 system. Additional automatic aircraft threat protection is provided via the ALQ-172 radar system, or a DIRCM (AN/AAQ-24(V)6) infrared protection system.¹⁹

With the preceding understanding of the AC-130 gunship completed, attention can now be turned toward specifically answering the following secondary questions: What capabilities, or strengths, does the AC-130 offer in the performance of urban close air support and what are the AC-130's weaknesses while performing urban close air support missions?

The AC-130's mission set identifies its close air support capabilities. Advertised missions include: "Close Air Support, Interdiction, Armed Reconnaissance, Point Defense, Escort (Convoy, Naval, Train, Rotary Wing), Surveillance, Combat Search And Rescue, Landing and Drop Zone Support Limited Airborne Command and Control."²⁰ Among its superb capabilities is the AC-130's ability to deliver highly accurate munitions while maintaining exceptional battlespace awareness in urban environments. The following OIF account accurately depicts the AC-130's advantages.

The AC-130 is very, very user friendly because of the number of eyes, that is, the large crew vice a tactical jet or gunship, so it worked out extremely well The AC-130 at nighttime was the king. It was a phenomenal capability and was outstanding because of the weapons to target match and the three munitions. It can engage multiple targets simultaneously and can do it surgically, and of course, you're also danger close down to 125 meters for 40 millimeter . . . and the last thing was the psychological effect that it had on not only the enemy, but on our Marines. It was an absolute force multiplier that terrified the enemy.²¹

A combination of attack geometry, highly precise sensor suites, selectable ammunition types and rates of fire, and an advanced communications suite enable the gunship to diminish the characteristics that make fighting in urban environments so dangerous.

The attack geometry, which can be manipulated by the FCO in response to specific target requirements, is a significant factor enabling gunship crews to maintain superior awareness in urban environments while delivering highly accurate ordnance effects in support of ground force objectives. The gunship delivers ordnance using a highly effective maneuver known as the pylon turn. The pylon turn allows the gunship to orbit its target enabling the crew to keep its sensors trained on a target area throughout the entire engagement. This tactic assists in providing a stable platform, alleviates the need for run in headings, and allows the gunship to continuously engage targets throughout the entire orbit enabling it to provide effective on call fires for troops in contact.²² Once over a target the extended loiter time, facilitated by the air refueling capability, ensures extensive target coverage is available in order to provide ground personnel the required ISR and on call fires support. Reducing the amount of sorties required for ground support minimizes fratricide incidents by enabling a single aircrew to spend significant time over an engagement area. The result is improved situational awareness of the battlespace to include friendly force location and disposition.

The AC-130's ability to provide highly accurate on-call fires, ISR support, and exceptional target area awareness is derived from extensive aircrew training and precision onboard targeting equipment. The H-model gunship contains an AAQ-26 infrared detection system (IDS), a LLLTV, and the APQ-150 beacon tracking radar for limited all-weather targeting operations. The AC-130U employs an IDS, an all-light level television system (ALLLTV), and an APQ-180 Strike Radar which allows increased all-weather targeting capabilities.

Although each model has slightly different sensor systems, they provide roughly the same support. The IDS system has four fields of view (FOVs) including wide, medium, narrow, and two times (2X) narrow FOVs. Wide-angle FOV is 1.8 magnification and generally aides in low-altitude flight and area search to include road, river, and bridge recognition. Medium FOV, 10.8 magnification, provides immediate target orientation and target detection. Narrow FOV, 42.9 magnification, enables small-target identification and precision line of sight angular adjustments.²³ Two-times narrow FOV, 85.8 magnification, is an electronic magnification of the selected target environment.²⁴ Both models' sensor and targeting systems can be employed to provide significant ISR capabilities.²⁵

Available ISR and targeting information can be transmitted through onboard secure communications radio systems, directly to properly equipped ground force personnel. During transmission gunship crews can utilize any of the seven separate communication radios, three UHF, three VHF, and a SATCOM radio, to verbally transmit ISR information including troop strength, location, and in many instances troop disposition. Most gunship's can receive real-time video from unmanned predators and other gunship's, which dramatically improves target area orientation and situational awareness prior to arriving on station. In many instances real time target surveillance video can be transmitted directly to ground force personnel. This single capability dramatically enhances ground personnel target area awareness and can reduce fratricide events from occurring. A distinctive capability offered by AC-130's is the ability to reduce fratricide and target identification through precision onboard marking devices. Onboard marking devices, "expedite identification of friendly forces, improve fire

support responsiveness . . . [and] limit the exposure time for the gunship. Beacons provide a rapid means to identify and update the friendly position in poor visibility conditions. The Ambient Temperature Illuminator (ATI), and the Infrared Zoom Laser Illuminator and Designator system (IZLID), provides an enhanced ability to identify personnel, identify, and track targets during low illumination periods. The ATI provides additional illumination in the range of .86 microns over large areas during periods of low illumination and enables the television system to see in total darkness. The ATI also provides ground personnel equipped with the proper night vision equipment the ability to see in total darkness while offering a way for gunship crews to identify friendly forces.”²⁶

The IZLID is an active, trainable, laser system used “to illuminate and designate specific targets with a narrow beam of infrared light.”²⁷ The IZLID can be effectively operated to determine or confirm target area orientation and can be used as a nonlethal means of identifying and tracking targets and personnel of interest in the area of operations.²⁸ Ground personnel requesting illumination of an area of operations request the aircraft “burn” the target. If the use of the IZLID is preferred to identify a specific building, corner of a building, vehicle, or person, ground personnel request the aircrew to “sparkle” the target. This method of marking a target area is highly effective and reduces battlefield confusion by providing a nonlethal mark that can be adjusted by ground personnel prior to engaging the target with live munitions. Figure 7 identifies the sensor and marking system locations for the AC-130H.

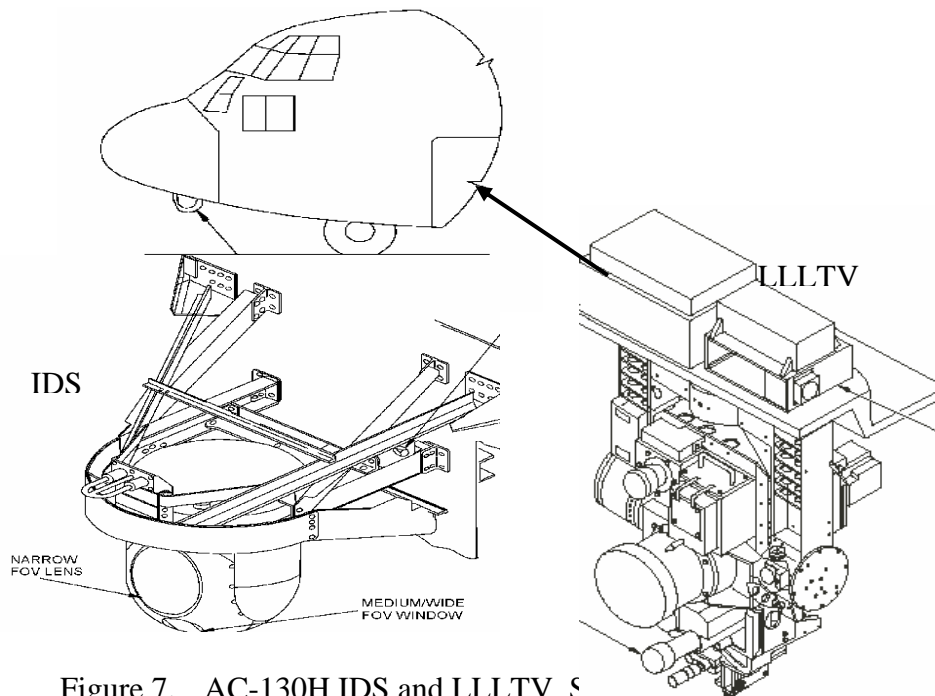


Figure 7. AC-130H IDS and LLLTV

Source: Warner Robbins, ALC, TO 1C-130(A)H-1, *AC-130(A)H-1 Aircraft* (Warner Robbins AFB: WR-ALC and LUTD, 2004), 4-331 and 4-345.

Strengths

All major units involved in *Just Cause* used the AC-130. It provided precise direct fire, night surveillance and navigation assistance. . . . The AC-130 is an excellent fire support system. Precision fire control and accurate weapons systems fit well within restrictive ROE and reduction of collateral damage.

Operation Just Cause Lessons Learned

Recent combat operations reinforce this statement. Ground forces in urban environments require an airframe that can provide ISR, command and control (C2), precision fires (both lethal and nonlethal options), and persistence. The AC-130's sensors, numerous communications systems, exceptional command and control capabilities, and the ability to place precision fires rapidly on a target are necessary

capabilities required in an urban close air support platform. Despite its strong points, like any other fielded system, it has several weaknesses that must be discussed.

With any system there are inherent weaknesses and limitations that dictate where aircraft safety and successful mission accomplishment meet. Despite many superb qualities the AC-130 is hindered by its size, agility, noise signature, and lack of hard target kill capability. These constraints make safe operation in nonpermissive environments extremely difficult; therefore, AC-130s tend to operate at night, maximizing their strengths and minimizing their weaknesses.

Gunships that operate during daylight hours in nonpermissive environments do so at their own peril.

At 0600 hours on the morning of January 31, “Spirit 03” was the last of three AC-130 Spectre gunships on station to provide close air support for the embattled Marines on the ground. Spirit 03 was due to end its patrol when it received a call from the Marines - they needed an enemy missile battery destroyed. Despite the risk of anti-aircraft artillery fire, and the greater danger of the morning sun casting light on the circling gunship, the crew of “Spirit 03” chose to remain and destroy the position requested. Soon after eliminating the target designated by the Marines, a lone Iraqi hoisted an SA-7 “Grail” man portable surface-to-air missile to his shoulder. In the dawn of the early morning light, the form of the large AC-130 slowly became visible in the skies over Khafji. The decision to remain behind to support the Marines cost the pilots and crew of Spirit 03 their best defensive weapon - darkness. The Iraqi pointed the weapon at the aircraft, and fired. The missile found its target and at 0635 hours the aircraft sent out a “mayday” distress call and then crashed into the waters of the Persian Gulf. All 14 crewmembers were killed.²⁹

Despite an upgraded electronic warfare system, the AC-130 is extremely vulnerable to enemy surface and air attack. Surface-to-air missiles and antiaircraft systems are consistently upgraded and easily obtained on the black market.³⁰ Gunship engagement altitudes are determined by a combination of threat environment and optimum IDS and LLLTV system limitations. The result is that the aircraft’s large size,

relatively poor agility, numerous engines, and a large noise signature make target engagement in nonpermissive areas hazardous. In general, as altitude decreases the target visibility, ISR capability, and weapons accuracy increase. Operating during darkness therefore enables the employment of reduced orbit altitudes while minimizing enemy detection. Standard gunship tactics therefore stress the importance of optimizing low illumination periods in order to increase aircraft survivability. For this reason standard missions will be performed during hours of darkness. Operations during high illumination periods, in nonpermissive environments, will typically not be undertaken without the existence of extenuating circumstances deeming mission success crucial and requiring a unique gunship capability.

One final argument regarding armament and the AC-130's limited hard target kill capability must be discussed. In recent battles, the joint directed attack munition (JDAM) has been effective in urban scenarios, and this kind of weaponry simply is not available on the gunship. In order for an AC-130 to destroy a standard single-story wood building, it requires the expenditure of a large number of 105-millimeter rounds.³¹ Missions requiring this type of effects-based destructive power should be given to aircraft capable of carrying munitions necessary for this type destruction. AC-130 munitions are low yield and precise, capable of destroying a room while leaving the building standing. This capability is a significant effect enabling low CDE in urban environments.

Effects-based operations (EBO's) have become vitally important to the Air Force's conduct of combat operations; therefore, the determination of a system that can substitute for the AC-130 will be determined comparing its effects with that of other systems in order to determine a suitable urban close air support substitute. EBO is

defined as, “actions taken against enemy systems designed to achieve specific effects that contribute directly to desired military and political outcomes.”³² The AC-130 can provide many effects desirable for fighting in urban areas, chief among them are integrated ISR and C2 capabilities, precision low CD munitions for on call fires, and persistence. In order to determine a suitable substitute, these desirable effects are used as comparison points. The effects encompassed in the A-10, F16, F15, and the UAV are defined following a brief description of these aircraft.

Aircraft Overview

A-10 Warthog

The A-10 Warthog is the first Air Force aircraft specifically designed for close air support of ground forces. Developed in the late 1960s, this aircraft suffered through some lean years, survived possible extinction, yet remains an exceptional close air support platform. During its conception and design, only four guidelines were stressed: lethality, simplicity, survivability, and responsiveness.³³ All were achieved. The A-10’s “primary mission is to provide day and night close air combat support for friendly land forces and to act as a forward air controller (FAC) to coordinate and direct friendly air forces in support of land forces.”³⁴ The aircraft is essentially a low-winged, single-seat, pressurized aircraft that utilizes two General Electrics TF-34-100 turbofan engines mounted above and aft of the wings. The cockpit is armored with titanium, the windscreen is bulletproof, the flight controls are redundant and can revert to manual control if the hydraulic systems are damaged, and the fuel tanks are self-sealing. These characteristics, combined with the aircraft’s twin tails and high engine placement, enable the A-10 to survive antiaircraft fire up to 23-millimeter, and provide a superior ability for

the pilot to safely return to base if the aircraft is damaged in combat.³⁵ The A-10 has excellent slow-speed characteristics and maneuverability, performs well at low or high altitudes, and has extended range capability for loitering near the combat environment. Combining these characteristics with the General Electric Aircraft Armament Subsystem A/A49E-6 (30-millimeter gun system) capable of firing 3,900 rounds per minute and the ability to carry numerous types of aerial dropped munitions, this aircraft is a formidable close air support platform.³⁶ The aircraft has undergone numerous modifications including the addition of night vision imaging systems, electronic warfare upgrades, and improvements to its targeting systems. This aircraft has proven its usefulness consistently over the last decade, and the effects it brings to the urban battlefield are significant.

The A-10's ability to provide accurate on call fires, enhanced by PGM's deliverable from eleven pylons located under the aircraft, and exceptional survivability are its most noteworthy urban close air support characteristics. Aircrews are specifically trained for close air support operations, but not specifically for the urban environment. This aircraft has a useful reconnaissance capability; however, the ability to provide surveillance and intelligence is reduced due to limited on-station time. Some aircraft have the ROVER modification currently being put to use on the AC-130. This modification enables properly equipped ground personnel to receive and view real-time video, greatly enhancing target area situational awareness. Unfortunately, the A-10 has a minimal communications suite consisting of only one UHF secure capable radio and two VHF radios.³⁷ During flight only one radio can be used in the secure mode, and only two total radios can be monitored. One of the VHF radios is capable of transmitting and receiving in the FM range, a frequency used frequently by ground forces.

F-15E Strike Eagle

Developed as an air superiority fighter aircraft, the F-15A took to the skies in late July 1972. Initially, its motto was “not a pound for air-to-ground,” but, as time passed, its mission evolved along with the versions produced, and now the F-15E Strike Eagle is a formidable air-to-ground asset.³⁸ The F-15E Strike Eagle version first flew in 1987 with a mission, “as succinct as that of its air-to-air cousin: to put bombs on target.”³⁹ While this statement errs to the simplistic, it identifies the fighters foray into the air-to-ground arena. The F-15E was “specifically configured for the deep strike mission, venturing far behind enemy lines to attack high value targets with a variety of munitions.”⁴⁰ Although designed for deep-strike missions, the close air support role has only evolved over the last five years, and with the development of new precision strike munitions, this aircraft has been able to adapt to its new role nicely.⁴¹

The Strike Eagle maintains the F-15’s air superiority capabilities and adds to them a weapons systems officer (WSO) and updated air-to-ground avionics enabling deep strike and close air support mission accomplishment. This two-seat, dual-role fighter is capable of speeds up to mach 2.5 and is able to deliver munitions during “day and night all weather air-to-air and air-to-ground missions including strategic strike, interdiction, OCA and DCA.”⁴² Close air support was not included in the initial mission subset during this period. In the performance of its mission, the aircraft is capable of carrying a massive array of munitions including a 20-millimeter cannon, precision (laser, electro, and infrared) guided munitions (PGMs), cluster bombs, and retarded munitions. Night precision-guided munitions missions are enhanced by the addition of the low-altitude navigation and targeting infrared for night (LANTIRN) system.⁴³ Munitions are carried

on hard points located beneath the aircraft. Heavy munitions and multiple ejector racks, for the new small-diameter bomb (SDB) munitions, are carried on inboard hard points while the outboard hard points are reserved for lighter weight munitions allowing weapons load flexibility based on mission requirements.⁴⁴ While employing these munitions, today's Strike Eagle aircrews make use of Sniper pods and synthetic aperture radars to perform nontraditional ISR, target detection and engagement.⁴⁵ Their communication system is limited to two UHF secure voice capable radios, however, only one is secure capable at any given time. The fleet is currently being retrofitted with an UHF and VHF and FM radio system in order to provide increased communications capability with ground forces that routinely use FM communication sets, however, funding constraints have prevented this retrofit from occurring. To date, no satellite communications capabilities exist on this airframe.

Performing close air support missions require long loiter times, and although the aircraft is air refuelable, additional conformal fuel tanks (CFTs) were included on the F-15E. CFT's are designed to, "minimize the effect on aircraft aerodynamics, [and] much lower drag results than if a similar amount of fuel is carried in conventional external fuel tanks. This lower drag translates directly into longer aircraft ranges, a particularly desirable characteristic of a deep strike fighter like the F-15E."⁴⁶ CFT's fit close to the fuselage of the aircraft and are not jettisonable in case of an emergency during flight.

Deep strike aircraft must have exceptional electronic counter measures systems and the F-15E is no exception. "The F-15E Strike Eagle's tactical electronic warfare system [TEWS] is an integrated countermeasures system. Radar, radar jammer, warning receiver and chaff and flare dispensers all work together to detect, identify and counter

threats posed by an enemy.”⁴⁷ Updates to this system enable it to detect and jam enemy threats in the high, mid, and low frequency range.⁴⁸

The F-15’s most notable close air support effect is its ability to locate and destroy a target using Sniper, Litening II, or LANTIRN pods coupled with PGMs. When combined with qualified joint terminal attack controllers (JTACS), or accurate GPS coordinates, these system’s provide limited all weather precision weapons delivery options desirable in urban scenarios. The LANTIRN systems ability to designate targets at distances up to 10 miles allows the aircraft to remain outside a threat environment while engaging targets. The aircraft’s APG-70 radar system allows targets, such as bridges and buildings, to be identified at distances up to 80 miles. At close range the systems acuity is increased, allowing aircrews to identify targets as small as individual vehicles. There is no doubt that performing urban close air support from excessive distances is not practical, but this system enables aircrews to orient themselves with an engagement area prior to arriving on station and to remain outside potential threat environments until necessary to enter. During target engagements, Strike Eagle aircrews can manipulate the munitions fusing in order to minimize CD in many of their munitions. The ability to reprogram weapons delays during flight is a significant advantage enhancing their urban close air support capability. The F-15E’s 20-millimeter M-61A1 multibarrel internal cannon provides a minimal ground point targeting capability, and with only 512 rounds available its area saturation capability is also reduced. The M-61A1 cannon presents only minimal light armor piercing capabilities based on ammunition type and availability.

Two of the most desired qualities in the urban battlespace are persistence and extensive integrated ISR and C2 capabilities capable of overcoming the negative affects associated with the urban environment, unfortunately these are not incorporated in the F-15E. The aircraft's CFT's provide acceptable loiter times, but this capability is not significant enough to provide the lengthy on station times provided by the AC-130 without air refueling, therefore, planned urban close air support missions requiring persistent fires, or lengthy ISR missions, should include numerous airframes. Unfortunately, the F-15E does not have the ability to track multiple ground targets moving about an engagement zone and is not capable of acting as both hunter and killer during close air support engagements. The aircraft targeting pods are capable of adequately performing "nontraditional" ISR missions and route reconnaissance.⁴⁹ The additional WSO position makes maintaining target area awareness easier by enabling one set of eyes to be constantly trained on the objective. The Strike Eagles limited communication suite hinders its ability to provide adequate C2 in urban environments.

F-16CG Falcon

Lockheed Martin's F-16 Falcon is an exceptional aircraft designed as a lightweight air-to-air day fighter. The subsequent addition of "[a]ir-to-ground responsibilities transformed the first production F-16s into [a] multirole fighter."⁵⁰ Designed in the early 1970s, the first operational model entered service in 1978 as, "the first operational fighter to employ fly-by-wire flight controls, relaxed static stability, high-g cockpit, bubble canopy, variable camber wings, blended wing-body design, modular construction, and integrated digital avionics."⁵¹ Like the F-15E, there are numerous models, each designated with a sequential alpha designator. While the original

design did not include a close air support role, its strike capability easily morphed to include close air support.

Aircraft configurations, or Blocks, are important F-16 designators incorporated by the manufacturer to allow purchasers to select a package suiting their specific needs. For example: Block 30 versions have different engine choices available, the Block 40 version adds a night attack capability, and the later Block 50 and 52 version also known as the CJ adds a lethal SEAD capability.⁵² Active duty Air Force units primarily fly Block 40/42 and 50/52 variants while the Air National Guard and Reserve primarily fly Block 30 and 32 versions.

In years past not all models were capable of using precision munitions, however, advancements in technology, and a significant refit program, have enabled nearly all models to incorporate this capability. In order to assure its superiority, this aircraft has been designed to carry a wide array of air-to-air and air-to-ground munitions in concert with its M-61A1 multibarrel internal cannon. The F-16's 20-millimeter M-61A1 multibarrel internal cannon provides a minimal ground point targeting capability, and with only 512 rounds available its area saturation capability is also reduced. The M-61A1 cannon presents only minimal light armor piercing capabilities based on ammunition type and availability. External stores are contained on hard points and are configurable based on each mission's parameters, improving mission flexibility.⁵³ This flexibility was extremely useful in 1991 when the F-16's air-to-ground role capabilities proved invaluable while engaging in Iraqi combat operations, but the transition from a strike to a close air support role has only received emphasis in the recent past.⁵⁴ Upgraded sensor pods, including Litening II and SNIPER, provide limited "nontraditional" ISR capability

and aid in providing accurate target area orientation and target acquisition. Many newer munitions have selectable fuzes that can be set to provide varying delay times prior to detonation, and munitions impact angles can be modified prior to employment. These qualities combine to minimize CD in the urban environment.⁵⁵

The F-16's combat range and loiter time is extended via drop tanks, and with a "choice of two 29,000-pound-class engines: the Pratt and Whitney F100-PW-229 or the General Electric F110-GE-129," the aircraft has more than enough thrust to weight ratio to provide exceptional acceleration, climb rates, and weapons load carrying capacity.⁵⁶

Sophisticated electronics counter measures systems have been installed on all U.S. F-16 models. The aircraft's small signature aids in threat detection avoidance and when coupled with the AN/ALR 56M threat warning receiver, or the AN/ALR 69 radar warning system on some models, increased survivability through a varied array of threat environments results.⁵⁷

The F16 CG has adapted nicely to its recent close air support role. In many ways the F-16's effects are similar to that of the F-15E. It employs the same M-61A1 cannon and has the same minimal armor piercing capability. Typical gun employment uses a low angle of attack trajectory requiring a relatively unrestricted straight line of sight to accurately employ this weapon, however, even with a high angle dive of 30 degrees the urban canyon effect restricts the cannon's use.⁵⁸ The wide array of PGMs available provides positive urban close air support affects, and when coupled with Litening II, or SNIPER, targeting pods, the F-16's weapons accuracy is exceptional. Using GPS coordinates and PGMs, or by enlisting the services of a ground observer, the F-16 is capable of improved all weather attack capability as well.

The F-16's small size affords little extra fuel storage capacity, reducing its loiter time. Having a limited sensor suite and only one pilot reduces situational awareness and prevents tracking of multiple targets without additional airframes. Currently, no capability for sending real time video images to ground forces exists, although video can be recorded in the targeting pod and returned for future analysis. The F-16's communication suite is minimal when compared to the AC-130, containing only one UHF, and one VHF, secure capable radio. In flight only one is capable of being secure, however, both can be monitored simultaneously.

Unmanned Aerial Vehicles

Unmanned aerial vehicles (UAVs) are increasingly dominating the current battlespace. UAVs are "remotely piloted or self-piloted aircraft that can carry cameras, sensors, communications equipment or other payloads."⁵⁹ The UAV idea itself is not a new concept owing its origins to a November 1939 U.S. Army Air Corps project where a Radioplane Model RP-4 was designated the OQ-1.⁶⁰ Though not ready for combat, the idea was valid, but the program was fleeting and until "interest in UAV's later in the twentieth century sparked a resurgence, the Radioplane drones were merely a forgotten footnote to World War II."⁶¹ By the mid-1990's the idea had again gained popularity, except amongst pilots, and UAVs were coming of age.⁶² Today there are UAV squadrons with missions as varied as the UAVs they employ. UAV use has increased over the last decade, and in the last five years they have proven exceptionally adept at performing their ISR and attack missions without endangering aircrew lives.⁶³ In general, there are three tiers of UAVs, which are listed below:

Tier 1 UAVs operate at altitudes up to 15,000 feet with a range up to 150 miles and a 5-24 hour endurance (i.e. RQ-2 Pioneer);

Tier II UAVs operate from 3,000-25,000 feet with ranges up to 550 miles and endurance exceeding 24 hours (i.e. RQ-1 Predator). Tier II plus versions operate up to 65,000 feet with 3,000-mile range and endurance exceeding 40 hours (i.e. RQ-4 Global Hawk);

Tier III minus UAVs are strategic high altitude UAVs that include low observable, or stealth, characteristics.

The tier system refers to the entire package, not specifically the UAV itself.⁶⁴ Within each tier there are many UAVs ranging both in size and mission, our focus will be on two general versions; armed (MQ) and unarmed (RQ) UAVs.

Unarmed UAVs are generally coded with an RQ identifier identifying their role as a reconnaissance aircraft.⁶⁵ UAVs provide unique capabilities to the twentieth century battlespace including a combination of exceptional ISR systems, long-range endurance, low visibility, and in the case of the armed predators the ability to perform precision air strikes. “The primary Predator missions still include ISR tasks such as preparation of the battlespace, reconnaissance along lines of communication, and the stake out of high value targets . . . [although they are] being increasingly used for close air support and other armed missions.”⁶⁶ UAV sensor arrays are exceptional, providing detailed ISR capabilities for the joint force commander and ground forces alike. The MQ-1’s sensor array, for example, provides “remarkably clear, magnified, digitally scanned forward looking infrared (FLIR) images that are available in eight different fields of view (magnification) and seven views in electro-optical (EO) low-light TV. In certain

configurations, synthetic aperture radar is installed.”⁶⁷ When coupled with Hellfire missiles, urban close air support missions can be accomplished.

Some UAVs are equipped with advanced communications capabilities. Typical ground force communications occur via UHF, VHF-AM and VHF-FM frequencies, while UAV operation and real time video down links are sent via KU-band frequencies.⁶⁸ UAV operators are capable of using a networked infrastructure to transmit data between “aircraft, ground units, and C2 nodes . . . [to] present real-time aircraft, ground positions, and enemy locations onto graphics displays inside the ground control station.”⁶⁹ Many UAVs are capable of transmitting real-time target area video to ROVER equipped ground forces. Advances in technology provide UAVs an increased ability to employ lasers and target marking devices, enhancing the fusion between air and ground forces. Using infrared target markers and laser designators capable of providing non-mensurated coordinates gives both armed and unarmed UAVs the ability to accurately steer laser-guided munitions or mark potential targets prior to engagement.⁷⁰

The UAVs effect on today’s battlefield has largely been positive. These platforms provide exceptional persistence with some airframes capable of loiter times in excess of twenty four hours. Integrated ISR and improved C2 capabilities enhance the overall battlefield awareness for ground forces and geographically separated commanders alike. Quiet engines and exceptional sensor suites provide substantial standoff capability while providing adequate target area ISR. If timely, accurate, precision munitions are required an armed UAV has the ability to strike targets using PGMs, and in many cases can act as both hunter and killer. The ability to provide persistent fires are reduced due to the limited numbers of munitions UAVs carry, with some versions only carrying one Hellfire

missile. Although its sensor suite is advanced, its single axis field of view capability reduces its ability to track multiple, or fleeing, targets.

Despite the overall positive battlefield effects provided by UAVs, it would be erroneous to assume that all UAVs contain the systems necessary to provide adequate close air support in the urban environment. Many UAVs, for example, are designed solely for long-range ISR missions and are not capable of delivering munitions or performing C2 functions for the ground force. For this reason this study will focus on the MQ-9 Reaper, also called the Predator B. The MQ-9 Reaper is a UAV capable of providing ISR, persistence, precision guided munitions strikes, and a limited command and control capability. This airframe has demonstrated the ability to “destroy ground targets from a UAV and the capability to find, fix, track, target, destroy, and conduct battle damage assessment.”⁷¹ The MQ-9 includes an upgraded sensor suite improving its ISR capabilities and has an increased payload capable of carrying 800lbs internally, and an additional 3,000lbs of munitions externally.⁷² Despite the MQ-9s many improvements, its air-to-ground communication suite leaves much to be desired.

An examination of the MQ-9s equipment and capabilities, located in figure 25 of Appendix B, provides evidence of its limited communications capacity. The communications suite only contains two airborne relay radios, one UHF, and one VHF, for communicating with ground personnel. There are, however, significant additions to the aircraft’s ability to transmit real time video to properly equipped ground, and airborne, personnel as well as the capability to transmit images to its ground control station using updated KU-band satellite data links.⁷³ This system has the additional ability to laser designate targets for precision-guided munitions delivery. The

improvements in weapons delivery and video transmission capability, while significant, do not overcome the limited number of radios capable of communicating with ground personnel. While airborne UAVs must maintain contact with airborne controllers for collision avoidance and mission control purposes just as any other airborne platform. Maintaining an airborne control frequency reduces the airframe's ability to communicate with ground personnel under most circumstances. Many urban operations require the monitoring of numerous communications frequencies and the MQ-9 is only capable of monitoring two frequencies at any given time, as a result this aircraft is not entirely suited to perform the C2 portion of the urban close air support mission.

Effects Synthesis

The AC-130's large size provides it the ability to independently fulfill the ground force commander's urban close air support requirements. Its ability to loiter approximately five hours over a target while maintaining consistent target area awareness is without compare.⁷⁴ The ability to provide sustained persistence attribute allows AC-130 crews to provide ISR, C2, and precision on call fires at a standard level that is above that of any fighter or UAV aircraft currently in the Air Force inventory.⁷⁵ When engaging targets in an AO, the AC-130 has the ability kill personnel and damage structures discreetly, and effectively, while simultaneously minimizing CD, a particularly valuable characteristic in the urban environment. For these reasons it appears that no single aircraft can adequately perform the AC-130's complete urban close air support mission set in a comparable manner. While there is no indication that a single aircraft can perform in a similar manner to the AC-130, there is promise in combining airframes in an effects based approach to achieve the same results. Using the ground personnel's desired urban

close air support effects, in concert with the listed aircraft capabilities, an aircraft force packaging analysis can be done to identify the appropriate number, and type, of aircraft required to perform the urban close air support mission.

Ground personnel in urban environments require close air support assets capable of providing precision real time ISR capabilities. Outside of the MQ-9, the remaining airframes in this study were not designed for providing ISR and, as a result, their capabilities are limited. Most, if not all, are now using SNIPER pods, which provide a limited nontraditional ISR capability. Targeting pods such as SNIPER, however, were designed primarily for precision target engagement, not for the specific purpose of performing long term ISR coverage over the battlefield. Some target pod systems are equipped with the ability to take, and store, limited amounts of video, but the images obtained are not currently downloadable in real time to ground forces. The technology required to fulfill this capability is currently available, however, it remains in the acquisition process and will be some time before it is fielded to all close air support platforms.⁷⁶ Using a system similar to ROVER enhances user access to real time ISR images providing increased battlespace awareness for properly equipped ground force personnel. The MQ-9 Reaper makes effective use of its video downlink capability in the same manner as the AC-130, making it a remarkable ISR platform. The only possible hindrance in using the MQ-9 Reaper for urban ISR coverage resides in the minimal number of sensors it contains. The Reaper's "multispectral targeting system (MTS) . . . includes a day television, electro-optical infrared camera and a laser ranger/designator,"⁷⁷ but its dual sensor capacity contains system restrictions prohibiting the use of more than one sensor at any given time. Providing timely ISR to the user, however, is only one

critical capability required in the urban environment, the ability to use real time ISR information to C2 the battlespace is another.

The MQ-9 Reaper does not provide the robust C2 capability included in the AC-130. In general, listing the communications capability of the aircraft studied in terms of radio capacity provides the following order: A-10, F-16, F-15, MQ-9. The A-10 is typically the more robust airframe while the MQ-9, with its limited communication capacity, comes in last.⁷⁸ Adequately replicating the AC-130's C2 capability therefore requires a combination of several aircraft. Fighter TTPs generally call for one radio per aircraft to remain tuned to an inter flight frequency allowing communications between cockpits without hindering mission communications on the primary command and control frequency. This procedure's arguable outcome is a further reduction in an already minimal C2 capability due to limited number of available radios per aircraft. Typical urban operations utilize primary, secondary, tertiary, air-to-air, air traffic control, and even over the horizon command and control satellite frequencies. None of the airframes studied, other than the AC-130, are capable of monitoring this many frequencies. This does not indicate that communications intense missions cannot be accomplished, it simply means that airmen must find suitable options to ensure the proper support is provided to the ground force. A four-ship package of fighter aircraft, for example, could divide communications amongst cockpits to maintain one inter-flight frequency while sharing communication monitoring responsibilities between pilots for monitoring air traffic control, air command and control, and several ground force frequencies. In many instances the current pilot technique is to simply "check-off" secondary frequencies in order to monitor the primary tactical air-to-ground, and inter-flight, frequencies in the

engagement area. In some cases other aircraft are contacted for assistance, enlisting their services to pass messages to communications limited aircraft unable to monitor all the appropriate frequencies. The outcome is that using MQ-9s, or fighter aircraft, to C2 the urban battlespace is problematic. When determining which aircraft is optimally suited to perform a C2 intensive urban close air support mission the A-10 provides the most capability.

The ability to remain on station for extended periods of time improves situational awareness of the battlespace and creates synchronicity among air and ground forces reducing targeting time during engagements. In terms of persistence, the MQ-9 is the most persistent aircraft included in this study, having the ability to remain airborne in excess of 30 hours. Their ability to remain airborne over the battlefield exceeds the AC-130's persistence capabilities. The average two-ship F-15E, and F-16 CG, fighter package located less than 100 miles from the engagement area plans to remain on station for approximately one hour and twenty minutes prior to departing for an air refueling. A-10 aircraft, using the same distances and circumstances, plan to remain on-station for approximately two hours prior to refueling. Using this information to rank the airframes studied based on ability to remain in the engagement area prior to refueling provides the following order: MQ-9, A-10, F-15, F-16.⁷⁹ Assuming air-refueling assets are available, the answer is to provide a four-ship package whereby two aircraft remain over the objective while the remaining pair depart for an aerial refueling. Allocating the force in this manner achieves persistence but requires aviators to constantly update each other on the status of ground forces and the movements that occurred while they were off-station refueling. Although this requires additional inter-cockpit coordination time, it improves

situational awareness and ultimately prevents fratricide events from occurring. While MQ-9s offer superiority in terms of providing ISR, and persistence, they are not adequately suited for providing extensive on-call fires support in the urban close air support role.

Despite its many positive attributes, the MQ-9 is not exceptionally prepared for conducting urban close air support fires when compared to the other airframes in this study. The ability to carry precision-guided munitions in itself makes all the aircraft studied acceptable in the precision fires role, however, the MQ-9 is the least robust in terms of total munitions carrying capacity. When combining airframes specifically for the urban close air support precision fires role, based solely on weapons type and desired effects, the A-10 is the most agile. The A-10's total weapons load out is not as robust in terms of overall munitions carrying capacity, but, when combined with a 30-millimeter cannon capable of piercing armor, the A-10 becomes the most effective close air support provider. The A-10 has the ability to carry munitions capable of producing the same destructive effects as both the F-15 and F-16. The A-10's 30-millimeter cannon is superior, in both destructive capability and ammunition carrying capacity, to the 20-millimeter M-61A1 cannon used on both the F-15 and F-16. The 30-millimeter cannon has a robust armor piercing capability when compared to that of the smaller 20-millimeter cannon, and, although both weapons are effective for short burst area saturation events, the A-10's larger ammunition carrying capacity enables more total engagements.

In the urban environment it is conceivable based on the ROEs for the ground force to require an aircraft to engage enemy armor in a highly constrained area without

severely damaging nearby buildings. All the aircraft studied, except the MQ-9, provide some type of constrained area strafing capabilities, however, only the A-10's 30mm cannon includes an armor piercing capacity. Airspeed, distance from the target, and altitude are all factors influencing strafing. Of the aircraft studied the A-10 engages targets at a slower airspeed than either the F-15 or F-16 aircraft, and therefore is capable of performing a high-angle strafing engagement for a longer duration placing more ammunition in the target area.⁸⁰ In this scenario the A-10, despite carrying less total munitions weight, contains an increased weapons employment capability making it the best option of the aircraft studied.

In urban areas ground based fires are particularly lethal to aircraft, making survivability an extremely important quality. Aircraft survivability is a pervasive A-10 design characteristic not found in the other airframes. Many surface-to-air weapons can be ballistically fired from well within the urban environment, effectively reducing the pilot's detection and evasion capabilities. Anti-aircraft guns are easily hidden in the urban environment as well, therefore, aircraft operating at mid-level altitudes and below are prone to acquiring damage in this environment and must be inherently able to sustain damage and safely return its aircrew to base. Neither the F-15 nor the F-16 has the same level of systems redundancy as the A-10.

There are, however, some mitigating arguments to this analysis. Without including classified information it is safe to say that the majority of anti-aircraft fire employable from urban areas is not capable of reaching the altitudes typically flown by any of these aircraft and hardening the aircraft structure against this threat would diminish its overall ability. The counter point is that employing weapons from increased

distances precludes the use of the cannon for strafing engagements and assumes only precision munitions use. It can also be argued that the increased altitudes and airspeeds flown by the F-15 and F-16 aircraft reduces their susceptibility to anti-aircraft fire. While this logic is intuitive, neither aircraft has the necessary systems redundancy to maintain flight if AAA damage were to occur. Of the two platforms, the F-15 Strike Eagle is more capable of sustaining damage in a typical AAA engagement and safely returning its aircrew to base than the smaller F-16.

¹AFDD2-1, 11.

²Ibid.

³An example of the additional requirements in urban CAS is complex command and control issues, and increased situational awareness necessary to avoid fratricide and minimize non-combatant casualties.

⁴This information comes from a paper written by Lt Col Kemper at Maxwell AFB Alabama. In this document he quotes the ALSA study that is cited herein. For more information see Todd G. Kemper, *Aviation Urban Operations: Thesis “Are We Training Like We Fight”* (Maxwell AFB, AL: Air University Press, 2004), 13.

⁵US Marine Corps, *Joint Tactics, Techniques and Procedures for Close Air Support (CAS)*: (Suffolk, VA: GPO, 2005), 14.

⁶Joint Chiefs of Staff, JP3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS)* (Washington, DC: GPO, 2003), III-17. In this publication each factor is delineated and expanded, based upon the characteristics unique to urban CAS operations.

⁷Hoff, 10.

⁸Ibid., 14.

⁹Warner Robbins, ALC, *TO 1C-130(A)H-1, AC-130(A)H-1 Aircraft* (Warner Robbins AFB: WR-ALC and LUTD, 2004), 1-1 (hereafter cited as TO 1C-130 (A)H-1).

¹⁰Ibid., 1-1, 1-153, 1-157.

¹¹For more aircraft information see figure 11 contained in this document.

¹²TV, IR, and EWO are crewmember designations that do not necessarily identify technical equipment identifiers. For example: the IR operator uses the IDS system identified later in this text.

¹³TO 1C-130(A)H-1, 4-230.

¹⁴Both gunship models employ the same HUD and utilize the same modes of fire. The HUD operates in numerous modes of fire, and based on the mode of fire being employed displays different symbology. For a complete breakdown of HUD symbology and HUD operation see TO 1C-130(A)H-1, 4-265.

¹⁵The figure shown is a compilation of two figures located in TO 1C-130(A)H-1, Figure 4-148 and 4-156 and is intended to show the 40mm and 105mm gun systems along with aft ammunition storage area. On U model aircraft an additional 25mm Gatling gun is placed in the forward cargo compartment.

¹⁶This information can be found in greater detail throughout TO 1C-130(A)H-1, sections 2 and 4.

¹⁷Global Special Operations, AC-130 Gunship; [web site on-line] available from <http://www.globalspecialoperations.com> and, Internet; accessed 11 September 2006, 1.

¹⁸For more information regarding ammunition and fusing see MIL-HDBK-145B (5-13-94), and AFI 11-2-AC-130 Vol 3 chap 15.

¹⁹Detailed information can be found in the individual system manuals, and TO 1C-130A(H)-3 aircraft manual. Due to the sensitive nature of the electronic warfare equipment only general information is provided in this text.

²⁰Global Special Operations, 1.

²¹US Marine Corp Center for Lessons Learned, *Urban Close Air Support (Urban CAS); A Summary Of Collected Lessons, Observations, Interviews, After Action Reports And Relevant Documents from OEF, OIF-I, and OIF-II* (Suffolk, VA: GPO, 2005), 12.

²²Ibid. Troops in contact is defined in JP 3-09.3, V-14 as personnel engaged within 1 kilometer of enemy forces. Typical engagements for gunship crews routinely require "Danger Close" minimums be applied. Danger close is specifically .1% probability of incapacitation occurring due to the close proximity to the mean impact area. Gunship danger close minimums are 200m (105mm Howitzer), 125m (40mm Bofors Canon), and 125m (25mm Gatling gun). These reflect 2005 distances and may have been refined in 2006. For more information relating to risk estimate distances see figure 12. More detailed information can also be found in JP-3.09.

²³This information is derived from an unpublished student handout provided to AC-130 personnel during their initial aircraft training. More information can be obtained by calling the 19 Special Operations Squadron at Hurlburt Field, Florida.

²⁴TO 1C-130(A)H-1. 4-345.

²⁵For additional information on camera specifics, sensor, and targeting system capabilities refer to TO 1C-130(A)H-1 and TO 1C-130U.

²⁶More specific information regarding the ATI can be obtained in applicable aircraft TO's, and in JP-3.09.

²⁷TO 1C-130(A)H-1, 4-295.

²⁸The IZLID is not currently available on the AC-130U gunship.

²⁹Special Operations.Com, Spirit 03 and the Battle for Kafji [web site on-line] available from <http://www.specialoperations.com/memorial/spirit.html>; Internet; accessed 21 Sept 2006.

³⁰There is a plethora of information regarding the Black Market weapons trade worldwide. The ability to acquire weapons of any caliber and type to those capable of paying inordinate amounts of money can be considered common knowledge, however, the information contained herein was obtained in an article written by Margaret Coker entitled *Illegal Small Weapons Pose Global Threat*, [web site on-line] available from <http://www.commondreams.org/headlines01and0709-03.htm>. accessed on 8 November, 2006.

³¹See figure 11 for munitions types and JP-3.09 for other munitions effects. The AC-130's ability to damage and, or, or destroy building depends on the size and construction of the facility in question. Obvious fortified building and bunkers may be unaffected by 105mm rounds using delayed fusing for penetration. There has been discussion regarding weaponry that could provide this type of destructive capability, however, to date nothing has been fielded in this regard. The information contained herein is from the experience of the author.

³²AFDD1, 98.

³³Douglas N. Campbell, *The Warthog and the Close Air Support Debate* (Annapolis, MD: Naval Institute Press, 2003), 69.

³⁴Military Analysis Network, *A-10/OA-10 Thunderbolt II* [web site on-line]; available from <http://www.fas.org/man/dod-101/sys/ac/a-10.htm>; Internet; accessed 30 September 2006.

³⁵Ibid.

³⁶For more information on the A-10 munitions availability refer to figure 11.

³⁷Some A-10 models have been modified to include an additional UHF radio. An additional modification currently being tested is the addition of a SATCOM radio as well.

³⁸Military Analysis Network, *F15 Eagle* [web site on-line]; available from <http://www.fas.org/man/dod-101/sys/ac/f-15.htm>; Internet; accessed 3 October 2006.

³⁹Ibid.

⁴⁰Ibid.

⁴¹As late as 2001 the F-15E AFTTP 3-1, Vol. 17 did not include CAS as a mission performed by this aircraft. During OEF, CAS and night ISR mission importance gained and today it is a primary mission. For more information see questionnaire from Maj Michael Biorn.

⁴²Ibid.

⁴³Additional F-15E ordnance types can be found in figure 11.

⁴⁴Military Analysis Network, *F15 Eagle* [web site on-line]; available from <http://www.fas.org/man/dod-101/sys/ac/f-15.htm>; Internet; accessed 3 October 2006.

⁴⁵For the purposes of this thesis, nontraditional ISR missions are defined as ISR missions flown by aircraft whose primary mission is not ISR.

⁴⁶Ibid.

⁴⁷Ibid.

⁴⁸Ibid. Additional information can be found in the aircrafts tactical manuals and will not be include herein.

⁴⁹This information was obtained from questionnaire answers provided from Maj Biorn; the summary is provided in appendix C.

⁵⁰Military Analysis Network, *F15 Eagle*, 1.

⁵¹Lockheed Martin Corp., *F-16 Fighting Falcon, Background*, [web site on-line] available from <http://www.lockheedmartin.com/wms>; Internet; accessed 03 October 2006

⁵²Military Analysis Network, *F15 Eagle*, 1.

⁵³Military Analysis Network, *F16 Fighting Falcon* [web site on-line]; available from <http://www.fas.org/man/dod-101/sys/ac/f-16.htm>; Internet; accessed 3 October 2006. For more information on the F-16's armaments see appendix B.

⁵⁴Lockheed Martin Corp, 1. Maj Clark Quinn provided important information regarding the F-16's CAS role. He indicated the role of the F-16 has morphed to include CAS in the recent past, and without PGM's this capability would not be possible and the aircraft would have remained primarily a multirole deep strike fighter aircraft.

⁵⁵Minimal CDE are readily identifiable in the destruction of a compound containing Abu Musab Zarqawi (AMZ) in Iraq in mid 2006. During this attack two-F-16s employed precision munitions, which destroyed the house containing AMZ while leaving the rest of the compound relatively undamaged.

⁵⁶Lockheed Martin Corp., 1.

⁵⁷Ibid. More countermeasures information can be found in the aircraft's technical manuals or by contacting Lockheed Martin through their website at <http://www.Lockheedmartin.com>. Additional information will not be provided.

⁵⁸Joint Chief of Staff, Joint Pub 3-06, *Doctrine for Joint Urban Operations* (Washington, DC: GPO, 2002), I-1. In urban areas, airspace is broken up at low levels by manmade structures of different heights and densities in addition to the irregularities in natural terrain. This produces an "urban canyon" effect that can adversely impact operations.

⁵⁹Military Analysis Network, Unmanned Aerial Vehicles [web site on-line]; available from <http://www.fas.org/irp/program/collect/uav.htm>; Internet; 3 October 2006.

⁶⁰Bill Yenne, *Attack of the Drones: A History of Unmanned Aerial Combat* (St. Paul, MN: Zenith Press, 2004), 16.

⁶¹Ibid.

⁶²Ibid.

⁶³The first active squadron in the US Air Force was the 11th Reconnaissance Squadron, who operated the Predator. Its first overseas operational use was in Operation Nomad Vigil between July and November 1995 in support of Operation Provide Promise. See Yenne, 63, for more information.

⁶⁴Yenne, 74.

⁶⁵Lockheed's RQ-3 Darkstar, and Northrop Grumman's RQ-4 Global Hawk are examples of unarmed UAVs. An Armed UAV example is the MQ-9A Predator built by General Atomics Aeronautics systems.

⁶⁶Bill Sweetman, "US Air Force Predator UAV's Have Moved Into a More Overt Strike Role," *Air Land and Sea Bulletin*, (Langley, VA: GPO, 2006), Issue No. 2006-2, 6.

⁶⁷Steve Colby, Lt Col, USAF, "UAV'S Support to Combat Search and Rescue (CSAR) Operations," *Air Land and Sea Bulletin*, (Langley, VA: GPO, 2006), Issue No. 2006-2, 13.

⁶⁸Ibid.

⁶⁹Sweetman, 9.

⁷⁰Ibid.

⁷¹Global-Defense.com, Predator Starts UAV Revolution [web site on-line]; available from <http://www.global-defence.com/2003/index.html>; Internet; 18 November 2006.

⁷²Ibid.

⁷³Ibid.

⁷⁴Loiter times listed assume available air refueling assets in close enough proximity to allow the aircraft to depart a AO, arrive at an air refueling rendezvous point (ARIP), and divert to an alternate airfield and land with the required fuel reserves as dictated in the applicable Air Force regulations.

⁷⁵Typical aircraft employment tactics dictate the packaging of two or more airframes in order to provide mutual support. For this thesis, a minimum of two airframes will be considered for every operation. Specific numbers of airframes will only be listed if there are more than two in a flight.

⁷⁶ From background information located in Appendix C.

⁷⁷Global-Defense.com, 1.

⁷⁸This listing is based in terms of communications capacity per airframe and not based on the intrinsic variables as pilot capability. The F-15 and F-16 currently have the same number of radios per airframe; however, the F-15 fleet is undergoing a modification to add an additional UHF, VHF, or FM radio and is therefore placed higher in rank than the F-16. The A-10's single UHF, and two VHF radio's provide additional capabilities. There is an additional SATCOM capability being added to A-10s, which will significantly add to their ability to provide battlespace C2.

⁷⁹See figure 11 for specific aircraft information. Thesis committee member Colonel David M. Neuenswander, USAF, provided the on-station time discussed.

⁸⁰This conclusion is based on an extremely dense urban environment requiring a strafing engagement minimizing collateral damage to the area's infrastructure.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

It appears that there is no single aircraft capable of performing the entire gamut of AC-130 missions when the ground forces desires are arrayed with the individual aircraft's capabilities. The information provided in the preceding chapters identifies the AC-130's inherent urban close air support qualities and puts forth the following idea: It is possible to replicate the AC-130's capabilities with other aircraft such as MQ-9, the A-10, F-15E, or F-16CG aircraft using a force packaging approach. The problem arises when determining which airframe is best suited to fulfill the AC-130's urban close air support role when coupled with the effects it provides and those desired by the ground forces. In order to determine how this mission set can be accomplished during times when the AC-130 is not available a decision matrix can be applied using the available airframes to identify an appropriate aircraft package. This will be done by taking the figures below and ranking each aircraft in order to from one to four in each category. Once this is done the decision matrix will be populated with the appropriate rankings and the best urban close air support package can be determined.

The resultant figures, therefore, represent the compilation of the capabilities contained on the aircraft studied with the goal of determining how to replicate the AC-130's urban close air support effects during the day. Each represents the assessed number of aircraft required to fulfill the capabilities encompassed in a typical AC-130 mission, beginning with persistence.¹

Figure 8 represents a five-hour typical AC-130 orbit and the number of sorties each aircraft would require providing the same capability to the ground force. In general, based on the information contained in chapter four of this study, and the specifications in appendix B, the aircraft providing the greatest persistence is the MQ-9, followed by the A-10, F-15E and F-16CG airframes.²

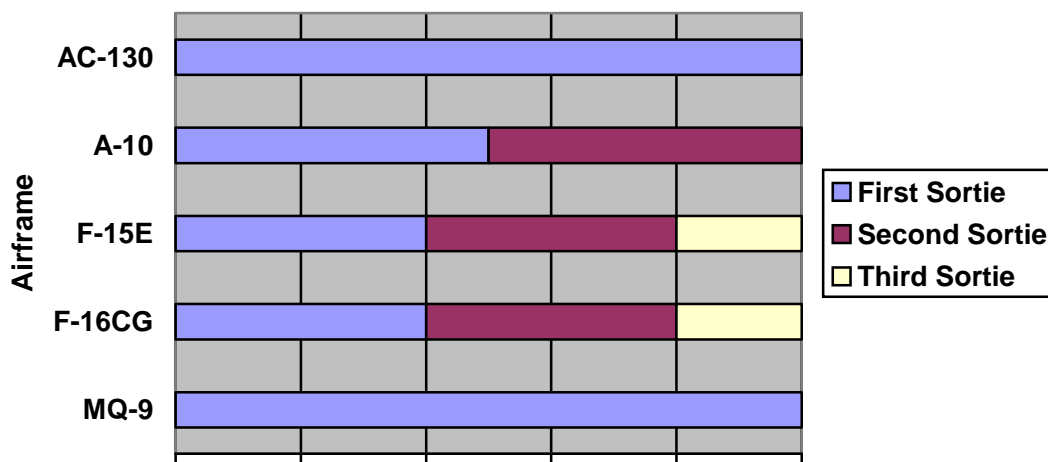


Figure 8. Persistence

In the ISR role, the AC-130 brings two trainable sensors with numerous adjustable fields of view, both capable of independent targeting. Figure 9 graphically represents the number of aircraft sorties required to provide this capability. The MQ-9 is the more robust ISR platform. The other airframes do not advertise true ISR capability, stating instead that they are capable of performing non-traditional ISR missions. Each airframe uses similar targeting pods making differentiation among them difficult.

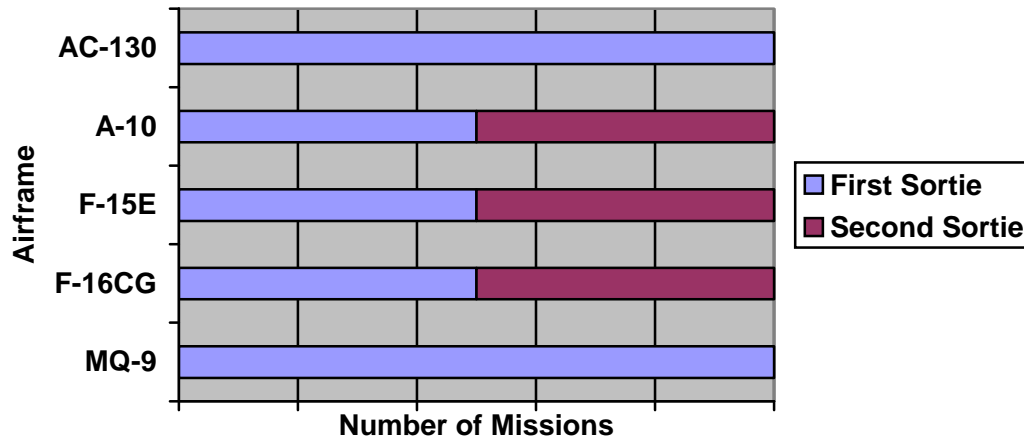


Figure 9. Intelligences, Surveillance and Reconnaissance (ISR)

The C2 capability of the listed airframes, based on the number of communications radios with respect to the seven radios on the AC-130s, is shown in figure 10.³ Once again the A-10 is the most robust airframe containing three communications radios and an additional satellite communications capability currently being added to the fleet, The F-15E, F-16CG, and MQ-9 aircraft all contain only two radios.

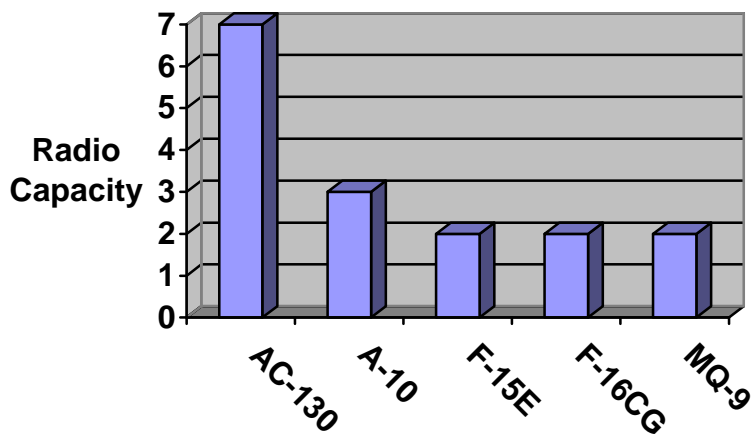


Figure 10. Command and Control Capability

Figure 11 compares the precision fires capability of the identified airframes. The aircraft studied are all capable of engaging targets using PGM's, and therefore will be compared against each other to determine which provides the best urban close air support fires effects based on the total number of munitions carried. Positive urban close air support fires effects are represented as a bar graph with zero indicating minimal, and one-hundred representing exceptional, urban fires capability. The chart indicates the F-15E carries the largest payload of munitions followed by the A-10, F-16CG, and lastly the MQ-9. The A-10 carries less total munitions but includes illumination flares and rockets that typically provide positive kinetic and nonkinetic effects in the urban environment. The strafing column represents the particular airframes strafing capabilities and indicates that the A-10 contains a greater number of total rounds while including a robust armor piercing capability.

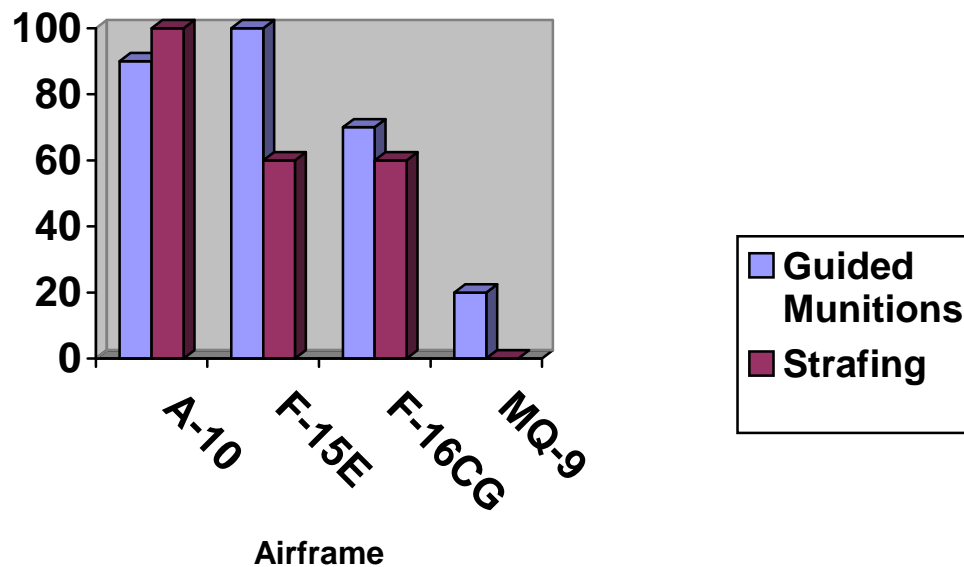


Figure 11. Precision Fires Capability Based on Effects

By combining airframes, a synergistic battlefield effect can be obtained in the AO. Most fighter aircraft only perform nontraditional ISR missions based on the limited number of sensors they can employ. Including an MQ-9 fulfills the ISR and persistence requirements. By adding two pairs of fighter aircraft to an MQ-9, nearly the entire AC-130 mission set can be performed. Figure 12 identifies this compilation and can be converted into the aforementioned decision matrix, shown in table 1, to determine the best force packaging arrangement is the A-10 and the MQ-9.

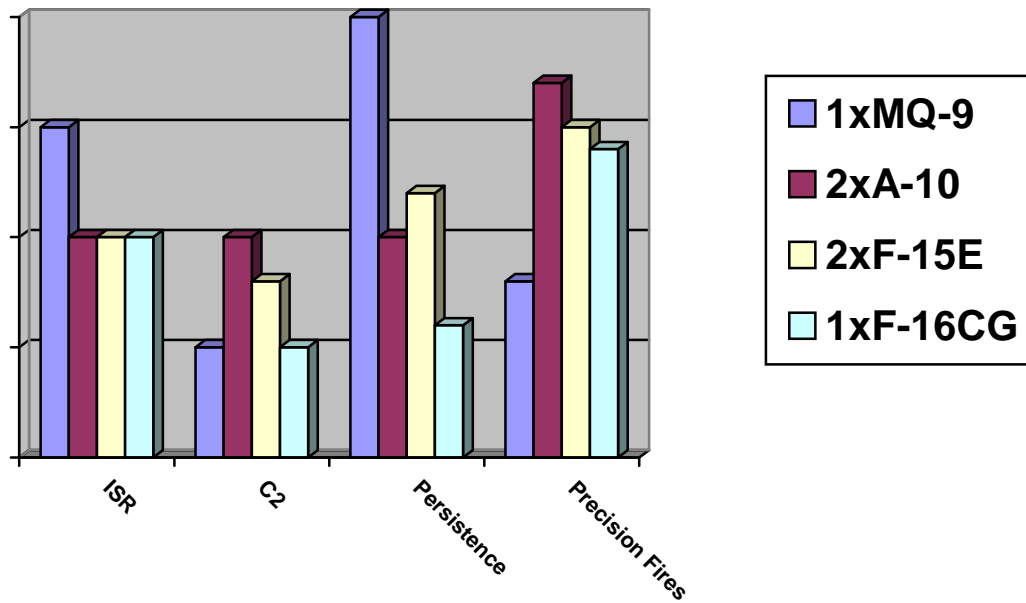


Figure 12. Airframe Effects Compilation

Table 1. Airframe Decision Matrix

Airframe	ISR	Persistence	C2	Precision Fires	Total
A-10	3	3	4	4	14
F-15E	2	2	2	3	9
F-16CG	1	2	3	2	8
MQ-9	4	4	1	1	10

In a notional urban close air support scenario the evidence suggests the combination of an MQ-9 Reaper UAV system with two pair of A-10 Warthogs would provide the optimum effects required to replicate the AC-130s capabilities during daylight hours. A typical urban close air support scenario could unfold in the following manner.

A ground force is given the mission of searching for a group of enemy combatants who have taken hostages and are suspected to frequent an urban market place for supplies during the busy late afternoon shopping period. The time is mid afternoon and there are many non-combatants roaming the market attending to their daily regime. While preparing for this mission, planners requested and received a four-ship flight of A-10 aircraft to supply on call fires and C2 capacity, and an MQ-9 to supply ISR, persistence, and limited fires if necessary. The A-10s are to rotate air-refueling times to ensure at least two remain on station at all times in a standoff position to prevent mission compromise. The MQ-9 is to orbit the market place at a high altitude while using its sensors to scan for a particular automobile entering the market. The mission time frame is expected to last several hours throughout the course of the day and includes primary, secondary and tertiary air-to-ground frequencies, an air-to-air frequency, and air traffic control

frequency. Located nearby in a concealed position a Special Forces team holds up in a building they entered under the cover of darkness and monitors the Reaper's video downlink system. Around late afternoon the suspect's automobile arrives and the Special Forces team begins moving to capture the hostage takers alive in order to determine the location of the hostages. While moving into position, they are discovered by lookouts and attacked from a small building on the edge of the market place. The MQ-9 maintains contact with the enemy automobile while simultaneously the A-10s begin suppressing the enemy fire using low-CD munitions to prevent the loss of innocent life to the greatest extent possible. Throughout the engagement the MQ-9 is able to maintain target area awareness to ensure the suspect vehicle, and, if identified by the ground force commander, the actual hostage takers, do not escape the engagement area. Once suppressing the enemy fires, the A-10s remain overhead using their target pods to search for combatants while the ground force moves to and captures the hostage takers.

This scenario is similar to the type missions currently being performed in OIF and OEF. Properly packaging aircraft in an effects-based manner ensures the proper asset is available, and capable of performing the required mission, using the decision matrix as a force-packaging tool to meet the mission's requirements. Using the decision matrix indicates, in general, that an A-10, MQ-9, package provides the greatest urban close air support capability.

¹Since fighter aircraft are usually scheduled in pairs, a sortie represents two aircraft throughout the graphs. For AC-130s and MQ-9s one sortie equals one aircraft.

²Figure 8 assumes readily available air-refueling assets and appropriate nearby divert airfields to enable each aircraft to maximize their fuel burn rate and on station time while maintaining their required fuel reserves.

³This only includes the useable ultra high frequency (UHF), very high frequency (VHF), frequency modulation (FM), and SATCOM radio equipment onboard each AC-130. It does not include any other communications devices, such as high frequency (HF) radios.

APPENDIX A

ILLUSTRATIONS

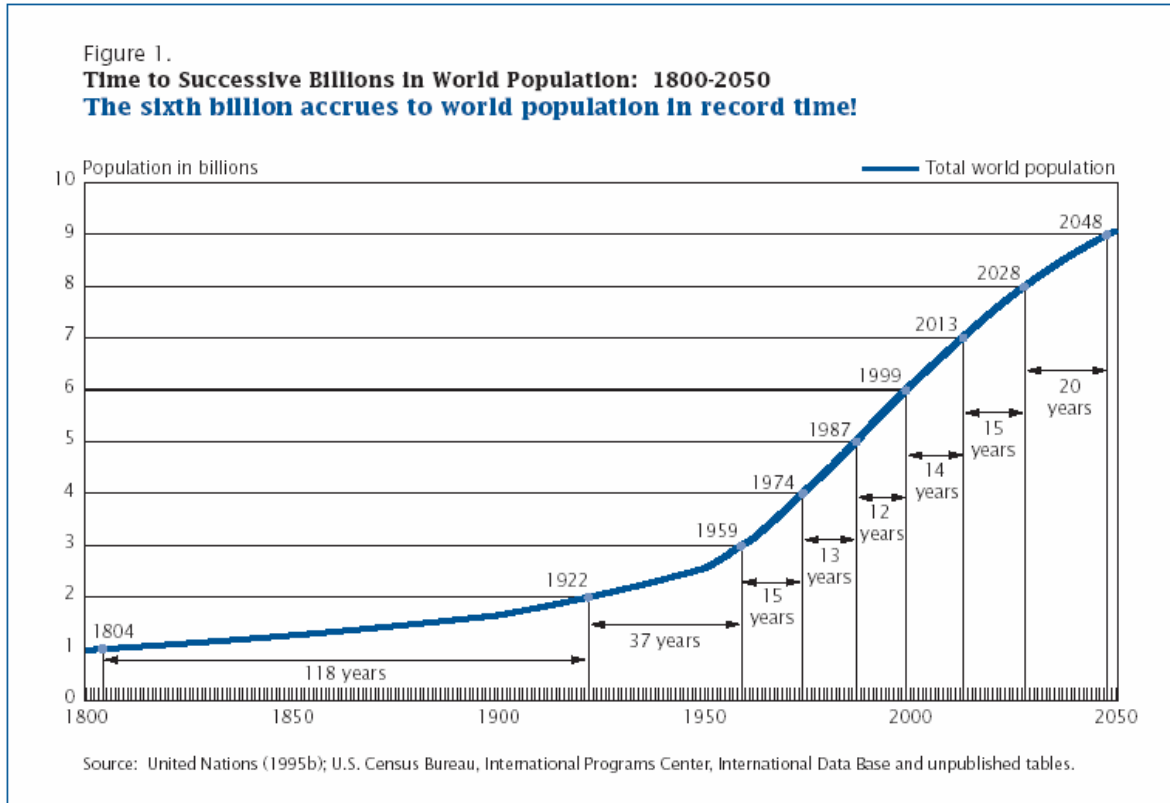


Figure 13. Time to Successive Billions in World Populations

Source: US Census Bureau Global Population Profile: 2002, Global Populations Growth [US Census Bureau web page]; available from <http://www.census.gov/ipc/prod/wp02/wp-02003.pdf>; Internet; accessed on 15 June 2006.

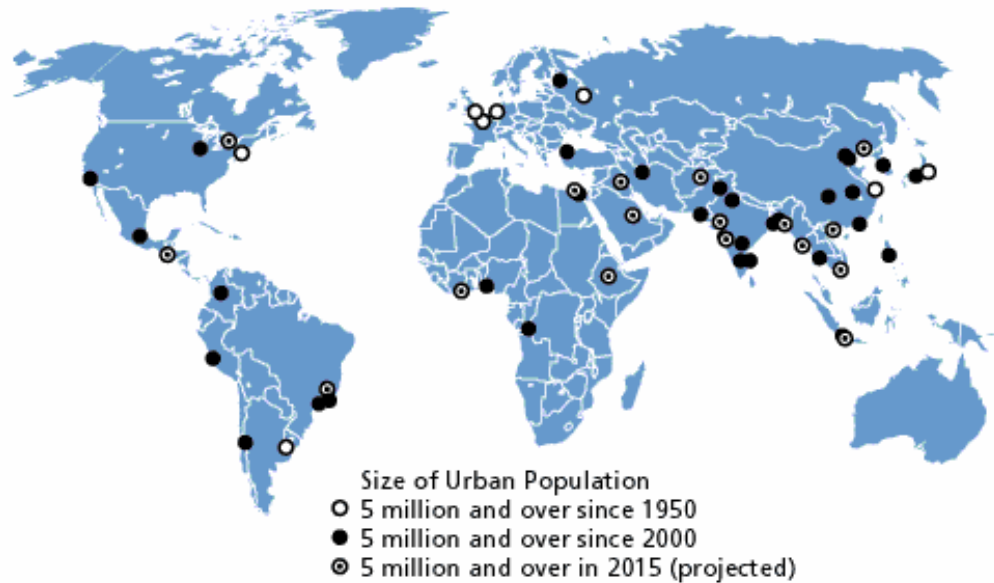


Figure 14. Largest Urban Agglomerations, 1950, 2000, 2015

Source: United Nations, *World Urbanization Prospects, The 1999 Revision* [Population Reference Bureau web page]; available from http://www.prb.org/Content/NavigationMenu/PRB/Educators/Resources_Guides/Human_Population/Urbanization2/Patterns_of_World_Urbanization1.htm; Internet; accessed on 15 June 2006.

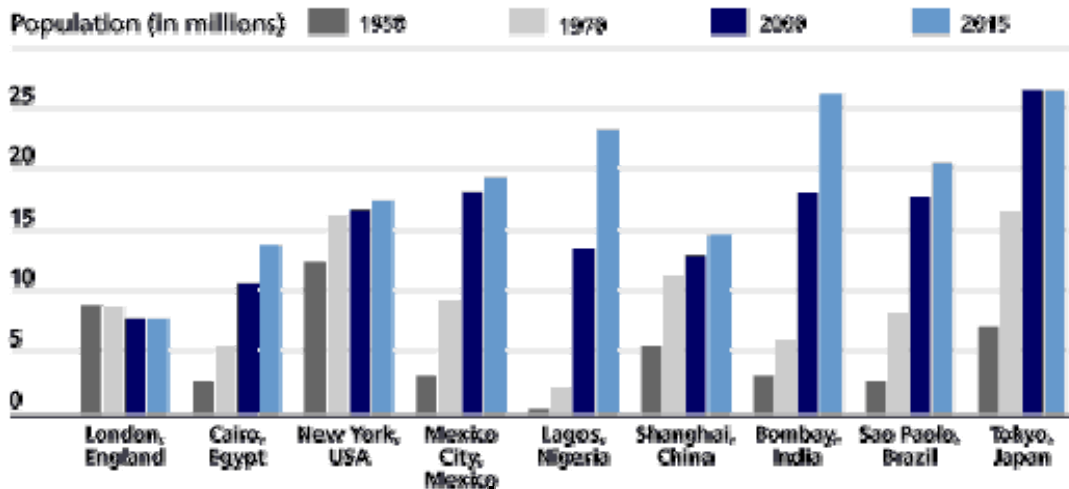


Figure 15. Growth of Urban Agglomerations, 1950–2015

Source: United Nations, *World Urbanization Prospects, The 1999 Revision* [Population Reference Bureau web page]; available from http://www.prb.org/Content/NavigationMenu/PRB/Educators/Resources_Guides/Human_Population/Urbanization2/Patterns_of_World_Urbanization1.htm; Internet; accessed on 15 June 2006.

Urban Operations Environment



Figure 16. Urban Operations Environment

Source: United States Scientific Advisory Board, *Report on Air Force Operations in Urban Environments; Executive Summary and Annotated Brief* (Washington, DC: OMB, 2005), 6.

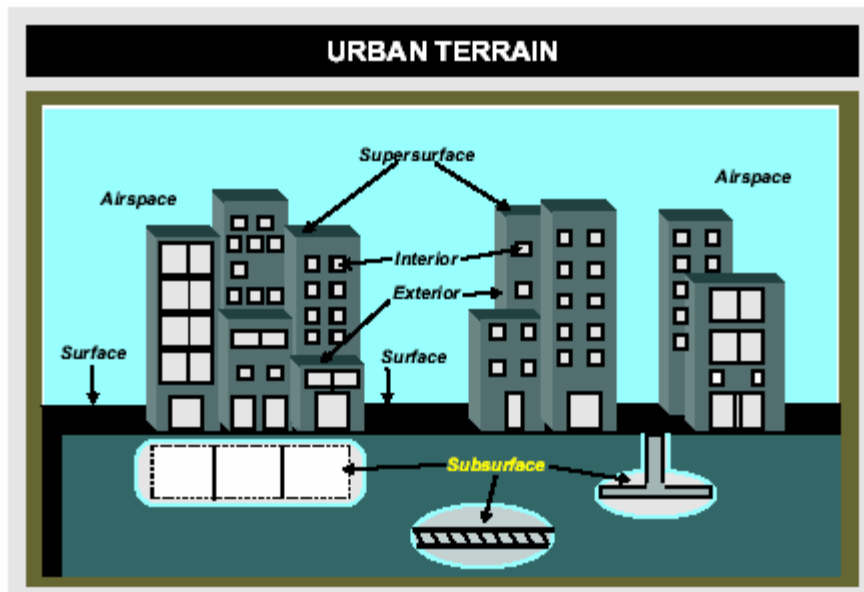


Figure 17. Urban Terrain

Source: *Joint Pub 3-06; Doctrine for Joint Urban Operations*, 16 September 2002, I-5.

APPENDIX B

AIRCRAFT SPECIFICATIONS

AC-130 Gunship

General Characteristics

Primary Function: Close air support, air interdiction and force protection

Builder: Lockheed/Boeing Corp.

Power Plant: Four Allison T56-A-15 turboprop engines

Thrust: 4,910 shaft horsepower each engine

Length: 97 feet, 9 inches (29.8 meters)

Height: 38 feet, 6 inches (11.7 meters)

Wingspan: 132 feet, 7 inches (40.4 meters)

Speed: 300 mph (Mach .4) (at sea level)

Range: Approximately 1,300 nautical miles; unlimited with air refueling.

Ceiling: 25,000 feet (7,576 meters)

Maximum Takeoff Weight: 155,000 pounds (69,750 kilograms)

Armament: **AC-130H** and **U:** 40-millimeter cannon and 105mm cannon; **AC-130U:** 25-millimeter gun

Crew: **AC-130U** - Five officers (pilot, copilot, navigator, fire control officer, electronic warfare officer) and eight enlisted (flight engineer, TV operator, infrared detection set operator, loadmaster, four aerial gunners)

Deployment Date: **AC-130H**, 1972; **AC-130U**, 1995

Unit Cost: **AC-130H**, \$132.4 million; **AC-130U**, \$190 million (fiscal 2001 constant dollars)

Inventory: Active duty: **AC-130H**, 8; **AC-130U**, 13; Reserve, 0; ANG, 0

Source: Global Special Operations, AC-130 gunship [Global Special Operations web page]; available from <http://www.globalspecialoperations.com/ac130.html>; Internet; accessed 11 September 2006.

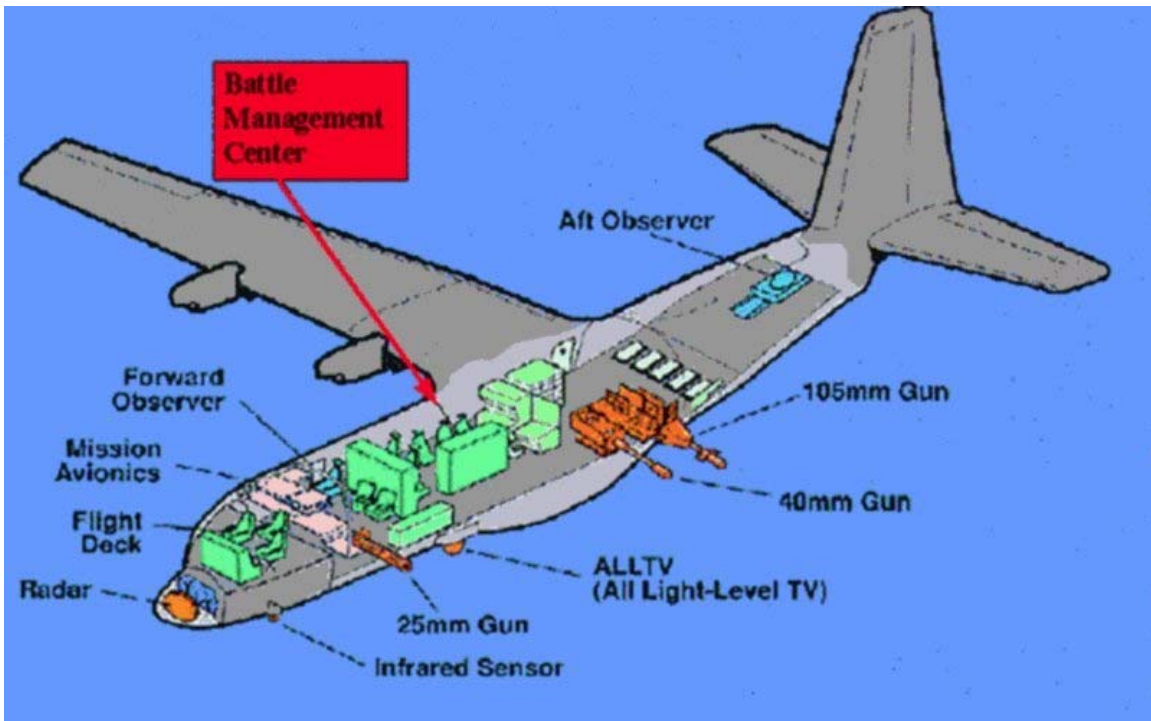


Figure 18. AC-130 U

Source: Global Security, AC-130 Pictures [Global Security.org web page]; available from <http://www.globalsecurity.org/military/systems/aircraft/ac-130-pics.htm>; accessed on 15 August 2006.

Aircraft Armor/Ballistic Curtains

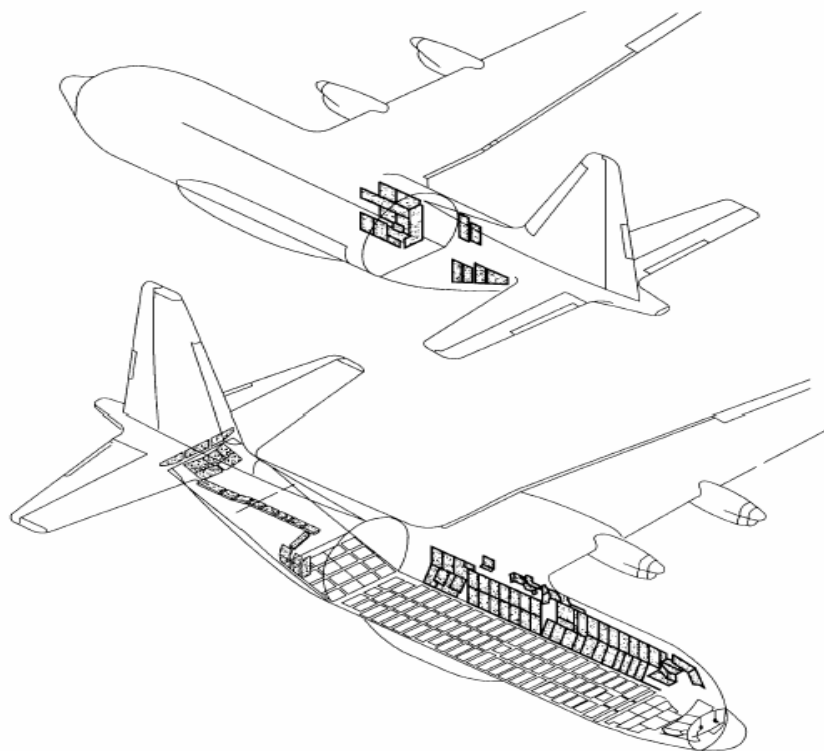


Figure 19. Aircraft Armor/Ballistic Curtain Locations

Source: Warner Robins ALC, *TO 1C-130(A)H-1; AC-130H Aircraft* (Warner Robbins:WR-ALC, 2004), 1-207.

A-10 Warthog:

Primary Function A-10 -- close air support, OA-10 - airborne forward air control
Contractor Fairchild Republic Co. **Power Plant** Two General Electric TF34-GE-100 turbofans **Thrust** 9,065 pounds each engine **Length** 53 feet, 4 inches (16.16 meters) **Height** 14 feet, 8 inches (4.42 meters) **Wingspan** 57 feet, 6 inches (17.42 meters) **Speed** 420 miles per hour (Mach 0.56) **Ceiling** 45,000 feet (13,636 meters) **Maximum Takeoff Weight** 51,000 pounds (22,950 kilograms) **Range** 800 miles (695 nautical miles)
Armament One 30 mm GAU-8 and A seven-barrel Gatling gun; up to 16,000 pounds (7,200 kilograms) of mixed ordnance on eight under-wing and three under-fuselage pylon stations, including infrared countermeasure flares; electronic countermeasure chaff; jammer pods; 2.75-inch (6.99 centimeters) rockets; illumination flares and:
MK-82 (500 pound bomb)
MK-84 (2000 pound bomb)
MK77 incendiary

10 MK20 Rockeye II (4 - 6 standard load)
 10 CBU-52 (4 - 6 standard load)
 10 CBU-58 (4 - 6 standard load)
 10 CBU-71 (4 - 6 standard load)
 10 CBU-87 (4 - 6 standard load)
 10 CBU-89 (4 - 6 standard load)
 CBU-97
 10 BL755 (4 - 6 standard load)
 AGM-65 Maverick missiles
 GBU-10 laser-guided bomb
 GBU-12 laser-guided bomb
 AIM-9 Sidewinder missiles

MK	AGM	CBU	CBU	CBU	2.75	GBU	AIM	LUU	LUU	30
82	65	87	89	97	RX	12	9	1	2	MM
12							2			1000
	4						2			1000
6	2						2			1000
	2	4					2			1000
		6					2			1000
	2		4				2			1000
			6				2			1000
				6			2			1000
	2				14		2	8	8	1000
	4				14		2	8	8	1000
	2					4	2			1000

Systems

- AN/ALE-40
- AN/ALQ-119

Source: Military Analysis Network, A-10and OA-10 thunderbolt II [Military Analysis Network web page]; available from <http://www.fas.org/man/dod-101/sys/ac/a-10.htm>; Internet; accessed 24 September 2006.

F-15 Strike Eagle:

Primary Function Tactical fighter. Contractor McDonnell Douglas Corp. Power Plant Two Pratt & Whitney F100-PW-100 turbofan engines with afterburners. Thrust (C/D models) 25,000 pounds each engine (11,250 kilograms). Length 63 feet, 9 inches (19.43 meters). Height 18 feet, 8 inches (5.69 meters). Wingspan 42 feet, 10 inches (13.06 meters) Speed 1,875 mph (Mach 2.5-plus) at 45,000 ft. Ceiling 65,000 feet (19,697 meters). Maximum Takeoff Weight (C/D models) 68,000 pounds (30,600 kilograms). Range 3,450 miles (3,000 nautical miles) ferry range with conformal fuel tanks and three external fuel tanks. Armament 1 - M-61A1 20mm multibarrel internal gun, 940 rounds of ammunition

4 - AIM-9L and M Sidewinder and

4 - AIM-7F and M Sparrow missiles, or combination of AIM-9L/M, AIM-7-F/AIM-120 missiles.

Weapon Loads:

12 CBU-52 (6 with wing tanks)

12 CBU-59 (6 with wing tanks)

12 CBU-71 (6 with wing tanks)

12 CBU-87 (6 with wing tanks)

12 CBU-89 (6 with wing tanks)

20 MK-20 (6 with wing tanks)

AGM	AGM	CBU	CBU	CBU	GBU	GBU	GBU	GBU		AIM	AIM	20
65	130	87	89	97	10	12	28	15	JDAM	9	120	MM
4											4	500
	1										4	500
		8									4	500
			8								4	500
				8							4	500
					4						4	500
						8					4	500
							2				4	500
								1			4	500
									4		4	500
										4	4	500
										2	6	500

Systems

- AN/APG-63 X-b/pulsed-Doppler radar [Hughes]
- AN/APG-70 X-b/pulsed-Doppler radar [Hughes]
[on F-15E, F-15C/D, F-15A/B MSIP]
- AN/APX-76 IFF interrogator [Hazeltine]

AN/ALQ-135(V) internal countermeasures system
 AN/ALQ-128 radar warning [Magnavox] suite
 AN/ALR-56 radar warning receiver (RWR) [Loral]
 AN/ALE-45 chaff/flare dispensers [Tracor]
 AN/AVQ-26 Pave Tack
 AN/AXQ-14 Data Link System
 LANTIRN Crew F-15A/C: one. F-15B/D: two. Unit cost \$FY98

Source: Military Analysis Network, F15 Eagle [Military Analysis Network web page]; available from <http://www.fas.org/man/dod-101/sys/ac/f-15.htm>; Internet; accessed 3 October 2006.

F-16 Falcon:

Primary Function Multirole fighter Builder Lockheed Martin Corp. Power Plant F-16C/D:
 one Pratt and Whitney F100-PW-200/220/229 or one General Electric F110-GE-100/129 Thrust F-16C/D, 27,000 pounds(12,150 kilograms) Length 49 feet, 5 inches (14.8 meters) Height 16 feet (4.8 meters) Wingspan 32 feet, 8 inches (9.8 meters) Speed 1,500 mph (Mach 2 at altitude) Ceiling Above 50,000 feet (15 kilometers) Maximum Takeoff Weight 37,500 pounds (16,875 kilograms) Combat Radius [F-16C]

- 740 nm (1,370 km) w/2 2,000-lb bombs + 2 AIM-9 + 1,040 US gal external tanks
- 340 nm (630 km) w/4 2,000-lb bombs + 2 AIM-9 + 340 US gal external tanks
- 200 nm (370 km) + 2 hr 10 min patrol w/2 AIM-7 + 2 AIM-9 + 1,040 US gal external tanks Range Over 2,100 nm (2,425 mi; 3,900 km) Armament One M-61A1 20-millimeter multibarrel cannon with 500 rounds; external stations can carry up to six air-to-air missiles, conventional air-to-air and air-to-surface munitions and electronic countermeasure pods.

MK	MK	AGM	AGM	CBU	CBU	CBU	GBU	GBU	AIM	AIM	20
82	84	65	88	87	89	97	10	12	9	120	MM
6									2	2	500
	2								2	2	500
		2							2	2	500
			2						2	2	500
				4					2	2	500
					4				2	2	500
						4			2	2	500
							2		2	2	500
								6	2	2	500
									2	4	500
										6	500

Systems

AN/APG-66 pulsed-Doppler radar
AN/AAQ-13 LANTIRN NAVIGATION POD
AN/AAQ-14 LANTIRN/SHARPSHOOTER
AN/AAQ-20 PATHFINDER NAVIGATION POD
AN/AAS-35 PAVE PENNY LASER SPOT TRACKER POD
AN/ASQ-213 HARM TARGETING SYSTEM POD
AN/ALQ-119 ECM POD and AN/ALQ-131 ECM POD
AN/ALQ-178 INTERNAL ECM
AN/ALQ-184 ECM POD
AN/ALR-56M THREAT WARNING RECEIVER [F-16C/D Block 50and 52]
AN/ALR-69 RADAR WARNING SYSTEM (RWR)
AN/ALR-74 RADAR WARNING SYSTEM (RWR) [replaces AN/ALR-69]
AN/ALE-40 CHAFF/FLARE DISPENSER
AN/ALE-47 CHAFF/FLARE DISPENSER Unit cost \$FY98

Source: Military Analysis Network, F16 Fighting Falcon [Military Analysis Network web page]; available from <http://www.fas.org/man/dod-101/sys/ac/f-16.htm> Internet; accessed 3 October 2006.

MQ-9 Predator B

Dimensions

Wing span	48.7ft (14.84m)
Length	27ft (8.23m)
Wing span (Predator B)	66ft (20.1168m)
Length (Predator B)	36ft (10.9728m)

Weights

Weight fully loaded	<2,300lb (1,035kg)
Weight payload	450lb (202.5kg)
Weight (Predator B)	10,000lb (4,536kg)
Internal payload (Predator B)	800lb (363kg)
External payload (Predator B)	3,000lb (1,361kg)

Engines

Predator A	Rotax 4-cylinder engine
Predator B	Honeywell TPE 331-10T

Performance

Altitude	25,000ft (7,620m)
Range	400 nautical miles
Cruise speed	>70kt (129km/h)
Endurance	>40 hrs
Conventional launch and recovery	Approximately 2,000ft (600m)
Altitude (Predator B)	50,000ft (15,240m)
Endurance (Predator B)	30+ hr
Airspeed (Predator B)	Over 220kt (407km/hr)

Communications

Two-colour DLTV television	Variable zoom, 955mm Spotter
High resolution FLIR	Six fields of view, 19mm to 560mm
Synthetic aperture radar	All weather surveillance, 1ft resolution
Optional payloads	Laser target designator and rangefinder, ECM/ESM, moving target indicator, communications relay
Datalinks	C-band LOS, UHF and Ku Band Satellite Datalink
Radio relay	UHF and VHF radio
Data distribution system	Trojan Spirit II or Global Broadcast System for dissemination
Vehicles	Two HMMWV transports
Ground data	5.5m dish for Ku-band Ground Data Terminal
Data dissemination	2.4m dish for data dissemination

Ground Station

Trailer	30ft x 8ft x 8ft (9.14m x 2.44m x 2.44m)
Air transportability	C-130 and C-141 transportable

Table 2. Risk-Estimate Distances for Aircraft-Delivered Ordnance

RISK-ESTIMATE DISTANCES FOR AIRCRAFT-DELIVERED ORDNANCE			
Weapon	Description	10% PI meters	0.1% PI meters
Mk-82 LD ¹ contact	500-lb bomb	145	325
Mk-82 LD ^{1,2} airburst	500-lb bomb	175	390
Mk-82 HD ³ contact	500-lb bomb/retarded	110	290
Mk-82 HD ^{2,3} airburst	500-lb bomb	135	350
Mk-83 LD ¹ contact	1,000-lb bomb	175	385
Mk-83 LD ^{1,2} airburst	1,000-lb bomb	195	405
Mk-83 HD ³ contact	1,000-lb bomb/retarded	130	330
Mk-83 HD ^{2,3} airburst	1,000-lb bomb/retarded	160	375
Mk-84 LD ¹ contact	2,000-lb bomb	175	430
Mk-84 LD ^{1,2} airburst	2,000-lb bomb	190	510
Mk-84 HD ³ contact	2,000-lb bomb/retarded	115	350
Mk-84 HD ^{2,3} airburst	2,000-lb bomb/retarded	140	460
CBU-87 ⁴ , CBU-89 ⁴	CEM or GATOR	165	220
CBU-99 ⁴ , 100 ⁴	CBU-87/89 w/kit	100	145
Mk20 ⁴	Rockeye	100	145
M151, M229, M261 ⁵	2.75" Rockets med alt	255	440
	2.75 " Rockets low alt	145	240
Zuni - all warheads ⁵	5" Rockets	220	340
M61A1, M197	20 mm gatling	80	125
GAU-12	25 mm gatling	40	50
GPU-5A, M230A1	30 mm gatling/chain	25	40
GAU-8 (A-10)	30 mm gatling	40	65
	25mm	35	65
	40mm	25	75
AC-130	105mm	65	165
	500-lb LGB	95	300
	1,000-lb LGB	105	350
GBU-10/24	2,000 lb LGB	90	340
GBU-38	500-lb JDAM	95	300
GBU-32	1,000-lb JDAM	105	350
GBU-31	2,000-lb JDAM	90	340
AGM-130	2,000 lb TV guided	90	335
BLU-97	JSOW	Not Available	Not Available
AGM-158A	JASSM	55	235
AGM-65	Maverick (All)	25	95
AGM-114	Hellfire	40	105
BGM 71	TOW Anti-tank	Not Available	Not Available

NOTES:
^{1,2} - LD=low drag airburst fusing (DSU-33)
³ - HD=high drag/air inflatable retarder (AIR)
⁴ - Not recommended for use with troops in contact
⁵ - Fixed-wing only. Helicopter numbers not available

Source: Joint Chiefs of Staff, JP 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS)* [web site on-line]; available from http://www.dtic.mil/doctrine/jel/new_pubs/jp3_09_3.pdf; accessed on 18 July 2006, Appendix D.

APPENDIX C

ADDITIONAL INFORMATION

Background Information

The following background information was prepared for and for use by J. Michael Nardo, Maj, USAF. This information may be included in whole, or in part in the final product. This product may be published and otherwise used for continued research in the field of close air support.

At the conclusion of each area you may clarify or expand your answer using the space provided.

F-16CG

Biographical Data:

Name: QUINN, Clark J. Date: 16 Aug 06
Rank: Maj Service: USAF Crew Position: Pilot
Highest Crew position attained (i.e. PIC/IP/WIC/ other): SEFE
Primary Airframe: F-16 Other airframe experience: F-15E
Total Aircraft flight hours: 2000 Total Combat hours: 100
Total hours in Primary Airframe: 1200
Date of most recent combat experience (flying only): Aug 2001
Do you have combat experience performing CAS in urban environments? No

Primary Aircraft Data:

1. Is the aircraft designed for CAS? Y or N: Yes, designed as multi-role fighter, not specifically for CAS though.
2. Is CAS a primary mission for this type of aircraft? Y or N: Yes, it is now!
3. Is CAS included in the overall mission set for this aircraft? Y or N: Yes
4. Is Urban CAS a mission set for this type aircraft? Y or N: Yes
5. Is ISR a mission set for this airframe? Y or N: No – I think an ANG unit does it though.
 - a. If no, is this airframe equipped for ISR mission? Intel often uses pod video (Litening, Sniper) as source of imagery but it isn't downloadable in flight yet.

Airframe Capabilities: (Unclassified information only)

A. Communications:

1. How many UHF communication radios does this airframe have? 1
 - a. Are these radios capable of secure voice? Yes

- b. Are they capable of switching from secure to non-secure voice in flight? Yes
- c. How many can be simultaneously monitored during flight? 1
- 2. How many VHF communication radios does this airframe have? 1
 - a. Are these radios capable of secure voice? Yes
 - b. Are they capable of switching from secure to non-secure voice in flight? Yes
 - c. How many can be simultaneously monitored during flight? 1
- 3. How many Satellite communication (Satcom) radios does this airframe have? 0
 - a. Are these radios capable of secure voice? N/A
 - b. Are they capable of switching from secure to non-secure voice in flight?
 - c. How many can be simultaneously monitored during flight? _____
- 4. Does this aircraft carry any other specialized communications equipment? (Explain)
Can only be secure on 1 radio at a time – either UHF or VHF.
- 5. Does this aircraft have the ability to take, view, and send real time video during flight to properly equipped ground forces? (i.e. Rover feeds etc) No.

B. Aircraft Munitions loads:

- 1. What munitions can this aircraft employ? The list is too long to include here, I recommend searching the internet for comprehensive listing.
- 2. What are the standard munitions load for CAS missions? In general, 20mm, (4xGBU-12) or (2xGBU12 + 2xGBU-38), possibly 2 x AGM-65 Maverick, but these are not commonly used for CAS missions.
- 3. Is there a different munitions load for urban CAS? No – the pilot adjusts fuzing (delay) and impact angle (steep) for the IAMs before firing.
- 4. Which munitions are guided? GBU & Maverick
 - a. Do they require terminal guidance? IAMs do not, others do
- 5. What is the required standoff for CAS engagements? Prefer a 3-5nm orbit for older TGP, and 8-10nm for the newer ones (Sniper, etc.)
- 6. What is the typical “advertised” weapons accuracy? Approximately 30m – not sure if that’s the party line though.
- 7. Does this aircraft employ any non-lethal weapons? Only the ability to perform leaflet drops.
- 8. Are these munitions capable of being employed when engagement distances are minimal? (i.e. TIC with minimal friendly to enemy distance) Yes – we use the standard danger close criteria listed in the JFIRE publication. The ground commander may authorize dropping munitions closer than the listed safe distance based on the situation.
- 9. Are the kinetic weapons employed capable of maneuvering in urban environments, or do they require a clear path from aircraft to target. IAMs are pretty good with steep impact angles programmed in. LGBs and the TGPs each have masking issues with vertically developed urban areas. We generally use low angle strafe, and even our high angle strafe is about a 30-degree dive, so it may be tough to get 20mm into a vertically shielded area.

C. Aircraft Sensors:

For this question sensors are defined as any system capable of identifying ground targets such as personnel, vehicles or buildings. For example, targeting pod with video, Infrared Detection sets, Low Level Television sets etc.

1. What sensor suite does this aircraft typically carry? NVGs, and some type of TGP – anything from the old TGP to the new Sniper pod.
2. What are the unclassified capabilities of these systems? TGP is IR only, requiring only a temperature delta. Newer pods have CCD (similar to a TV camera) for daylight use. I'm not sure of the specific "zoom" capabilities of them. For example – it is very difficult to ID a specific type of vehicle with the TGP – newer pods have much better resolution and allow an easier self-ID capability for the pilot.
3. With these systems can pilots ID enemy personnel in urban environments? I would have to say No. The ability to identify a specific person as an enemy without direction from ground personnel is difficult, especially in urban environments.
4. Can friendly personnel be identified? Most ANG jets have SADL (situational awareness data link). SADL will display the position of "friendlies" equipped with EPLARS radios – unfortunately not many ground units have these.
5. Can a pilot utilizing this sensor suite perform timely, persistent ISR? Yes, to the timely part if the aircraft is nearby and has the newer pod. No to the persistent part, due to fuel considerations.
6. Can these sensors be effectively utilized in urban environments? Yes
7. Can these sensors be employed during low and high illumination conditions? Yes

D. General information:

1. Are pilots specifically trained to perform CAS missions? Yes
2. Is urban CAS training required? Yes
3. What is the general length of a combat sortie? 4 to 6 hours assuming current operational conditions. Dedicated strike sorties will probably be much shorter based on distance to target and munitions availability.
 - a. Does the duration include refueling? Yes
 - b. If yes, how many? 2 – 4
4. Is this system capable of acting as both hunter and killer in urban CAS engagements while maintaining persistent surveillance on another target? No
5. Does this system offer reduced sensor-to-shooter chain of custody? No, the bottom line is that during CAS missions there will be a JTAC on the ground that decides ii, and when munitions will be employed. In most the pilot will not be able to positively ID something as hostile – the JTAC will ensure that ROE is met.
6. Is this aircraft capable of providing persistent fires on a target, or are several airframes required? About 4 bombs and the gun per jet. CAS will normally get a 2 ship. In order to obtain persistence more airframes must be added in an overlapping manner.
7. In your opinion how many airframes would be required for a planned urban CAS mission? Two should work, based on the desired on station time. Urban CAS does not normally present an environment that requires large numbers of 500lb bombs.
8. Does this aircraft have a ground marking system/pointer? (i.e. IZLID, ATI, etc) The basic jet does not. FAC(A)s will carry WP rockets. The Litening pod has an NVG

capable marker and the ability to lock on to a laser designation, I am not sure about the Sniper pod, but I assume it does as well.

Additional Comments: (please any comments you feel necessary for inclusion in the final product.)

F-15E

Personal Biographical Data:

Name: BIORN, Michael Date: 21 September 2006
Rank: Maj Service: USAF Crew Position: Pilot
Highest Crew position attained (i.e. PIC/IP/WIC/ other): 4 Flight Lead (4FL)
Primary Airframe: F-15E Other airframe experience: T-38
Total Aircraft flight hours: 2100 Total Combat hours: approx. 400
Total hours in Primary Airframe: 1080
Date of most recent combat experience (flying only): September – December 2005
Do you have combat experience in performing CAS in urban environments? Yes

Primary Aircraft Data:

1. Is the aircraft designed for CAS? Y or N: No. Until five years ago the 3-1 volume. 17 did not include CAS. This function has developed since that time.
2. Is CAS a primary mission for this type of aircraft? Y or N: Yes, since OEF.
3. Is CAS included in the overall mission set for this aircraft? Y or N: see above
4. Is Urban CAS a mission set for this type aircraft? Y or N: No-CAS terrain types not delineated.
5. Is ISR a mission set for this airframe? Y or N: No, however non-traditional ISR is a mission set.
 - a. If no, is this airframe equipped for ISR mission? With SNIPER or LITENING pods we are a pretty good ISR source.

Airframe Capabilities: (Unclassified information only)

A. Communications:

1. How many UHF communication radios does this airframe have? 2
 - a. Are these radios capable of secure voice? Yes, only one at a time.
 - b. Are they capable of switching from secure to non-secure voice in flight? Yes
 - c. How many can be simultaneously monitored during flight? 2
2. How many VHF communication radios does this airframe have? None, but fleet is being retrofitted to one.
 - a. Are these radios capable of secure voice? Yes
 - b. Are they capable of switching from secure to non-secure voice in flight? Yes
 - c. How many can be simultaneously monitored during flight? 2
3. How many Satellite communication (Satcom) radios does this airframe have? 0
 - a. Are these radios capable of secure voice? 0
 - b. Are they capable of switching from secure to non-secure voice in flight? N/A

- c. How many can be simultaneously monitored during flight? _____
4. Does this aircraft carry any other specialized communications equipment? (Explain) Datalink allows C2 messages to pass some messages to the aircraft.
5. Does this aircraft have the ability to take, view, and send real time video during flight to properly equipped ground forces? (i.e. Rover feeds etc) Not typically. It is possible if we are carrying the AXQ-14 RTS. Information can be sent to the ground forces. Cards for the SNIPER pods are in acquisition to allow downlink of video in flight.

B. Aircraft Munitions loads:

1. What munitions can this aircraft employ? See aircraft specifications.
2. What is the standard munitions load for CAS missions? 9 x GBU's or 2/4 xGBU-12's and 2 x JDAMS
3. Is there a different munitions load for urban CAS? More GPS guided munitions.
4. Which munitions are guided? GBU-10/12/24/28/, GBU-15, AGM-130, GBU-31/38
 a. Do they require terminal guidance? Only the following: GBU-10/12/15/24/28 /31/38
5. What is the required standoff for CAS engagements? N/A
6. What is the typical "advertised" weapons accuracy? Approximately 10m
7. Does this aircraft employ any non-lethal weapons? No
8. Are these munitions capable of being employed when engagement distances are minimal? (i.e. TIC with minimal friendly to enemy distance) Yes, especially with the JPF. Fuzing can be set in flight; gun is fine in close. Standard J-FIRE minimums are used.
9. Are the kinetic weapons employed capable of maneuvering in urban environments, or do they require a clear path from aircraft to target. Clear path required.

C. Aircraft Sensors:

For this question sensors are defined as any system capable of identifying ground targets such as personnel, vehicles or buildings. For example, targeting pod with video, Infrared Detection sets, Low Level Television sets etc.

1. What sensor suite does this aircraft typically carry? SNIPER pod and synthetic aperture radar.
2. What are the unclassified capabilities of these systems? 15K track enables small object identification.
3. With these systems can pilots ID enemy personnel in urban environments? Yes
4. Can friendly personnel be identified? Not without a ground controller.
5. Can a pilot utilizing this sensor suite perform timely, persistent ISR? Yes
6. Can these sensors be effectively utilized in urban environments? Yes
7. Can these sensors be employed during low and high illumination conditions? Yes

D. General information:

1. Are pilots specifically trained to perform CAS missions? Yes
2. Is urban CAS training required? No, it is beneficial but not required.
3. What is the general length of a combat sortie? 8 hours

- a. Does the duration include refueling? Yes
- b. If yes, how many? 3 – 4
4. Is this system capable of acting as both hunter and killer in urban CAS engagements while maintaining persistent surveillance on another target? No
5. Does this system offer reduced sensor-to-shooter chain of custody? Yes
6. Is this aircraft capable of providing persistent fires on a target, or are several airframes required? Yes as long as several different airframes are used and refueling is available.
7. In your opinion how many airframes would be required for a planned urban CAS mission? 4
8. Does this aircraft have a ground marking system/pointer? (i.e. IZLID, ATI, etc) Yes
- Additional Comments: (please any comments you feel necessary for inclusion in the final product.) None

A-10

Personal Biographical Data:

Name: Robert M. Chavez, Jr. Date: 20 Aug 06

Rank: Major Service: USAF Crew Position: Pilot

Highest Crew position attained (i.e. PIC/IP/WIC/ other): IP / Evaluator / WIC IP

Primary Airframe: A-10 Other airframe experience: None

Total Aircraft flight hours: 2500 Total Combat hours: 37

Total hours in Primary Airframe: 2200

Date of most recent combat experience (flying only): None

Do you have experience in performing CAS in urban environments? Yes

Primary Aircraft Data:

1. Is the aircraft designed for CAS? Y or N: Yes
2. Is CAS a **primary** mission for this type of aircraft? Y or N: Yes
3. Is CAS included in the overall mission set for this aircraft? Y or N: Yes
4. Is Urban CAS a mission set for this type aircraft? Y or N: Yes
5. Is ISR a mission set for this airframe? Y or N: Yes, reconnaissance
- a. If no, is this airframe equipped for ISR mission? Yes

Airframe Capabilities: (Unclassified information only)

A. Communications:

1. How many UHF communication radios does this airframe have? 1 (2 on LARS-equipped aircraft)
- a. Are these radios capable of secure voice? Yes
- b. Are they capable of switching from secure to non-secure voice in flight? Yes
- c. How many can be simultaneously monitored during flight? 1 (2)
2. How many VHF communication radios does this airframe have? 2
- a. Are these radios capable of secure voice? 1 of them is
- b. Are they capable of switching from secure to non-secure voice in flight? Yes

- c. How many can be simultaneously monitored during flight? 2 (only one secure)
3. How many Satellite communication (Satcom) radios does this airframe have? 0
- a. Are these radios capable of secure voice? _____
- b. Are they capable of switching from secure to non-secure voice in flight? _____
- c. How many can be simultaneously monitored during flight? _____
4. Does this aircraft carry any other specialized communications equipment? (Explain) No
5. Does this aircraft have the ability to take, view, and send real time video during flight to properly equipped ground forces? (i.e. Rover feeds etc) Yes, if ROVER-equipped

B. Aircraft Munitions loads:

1. What munitions can this aircraft employ? Virtually all in the USAF inventory except INS/GPS-guided weapons (A-10C will be able to employ those as well)
2. What are the standard munitions load for CAS missions? Theater-dependent; most sorties during OIF I carried 1150 rounds 30mm Combat Mix, 7 x 2.75" WP Rockets, 7 x M257/M278 Overt or Covert Illume Rockets, 2 x Maverick A/G Missiles (1 x EO and 1 x IR day or 2 x IR for night), and either 6 x Mk-82 bombs or, if TGP-equipped, 3 x Mk-82s and 3 x GBU-12 LGBs.
3. Is there a different munitions load for urban CAS? In practice no, although the Urban CAS TD&E conclusions, and many theoretical discussions, center on lighter weapons such as 30mm TP and more rockets. There is some discussion of getting laser-guided rockets and Hellfires tested and approved for carriage.
4. Which munitions are guided? Mavericks and GBUs
- a. Do they require terminal guidance? Mavericks do not; GBUs do (laser)
5. What is the required standoff for CAS engagements? None required, although the threat level may encourage some standoff for survivability
6. What is the typical "advertised" weapons accuracy? Each weapon is different and many of the numbers are classified.
7. Does this aircraft employ any non-lethal weapons? Y or N Yes. M129 leaflet bomb drops.
8. Are these munitions capable of being employed when engagement distances are minimal? (for example TIC with minimal distance from friendly to enemy) Y or N Yes.
9. Are the kinetic weapons employed capable of maneuvering in urban environments, or do they require a clear path from aircraft to target. All require a clear field-of-fire.

C. Aircraft Sensors:

For this question Sensors are defined as any system capable of identifying ground targets such as personnel, vehicles or buildings. For example, targeting pod with video, Infrared Detection sets, low level television sets etc.

1. What sensor suite does this aircraft typically carry? F4949G NVGs, Pave Penny Target Identification Set Laser (TISL) laser spot tracker, Maverick missiles, and Litening II TGP on most A-10s in theater
2. What are the unclassified capabilities of these systems? N/A due to classification.
3. With these systems can pilots ID enemy personnel in urban environments? Yes and no; if you mean: can these systems allow pilots to see a human – yes; if you mean: can these systems “positively” ID enemy personnel – no (and anyone who says their system can is lying). The crux of this issue is PID in the A/G environment or, combat ID, which is a better term since PID came from the counter-air world and has limited, sometimes negative, utility in the air-to-ground world. There’s no perfect PID in the air-to-air world but it is a much cleaner and more permissive environment in that regard than is the A/G world.
4. Can friendly personnel be identified? Yes, through battlefield situational awareness and if friendlies are using marking devices such as VS-17 panels, IR strobes, IR pointers, etc.
5. Can a pilot utilizing this sensor suite perform timely and persistent ISR? Y or N Reconnaissance – yes; surveillance is limited based on relatively limited station time; intelligence only insofar as the pilot has the knowledge and ability to analyze observed information in the cockpit (varies greatly based on ability, knowledge, and desire of individual pilots)
6. Can these sensors be effectively utilized in urban environments? Y or N Yes
7. Can these sensors be employed during low and high illumination conditions? Y or N Yes, except NVGs, which can’t be used in the daytime

D. General information:

1. Are pilots specifically trained to perform CAS missions? Y or N Yes
2. Is urban CAS training required? Y or N No specific AFI or syllabus requirement that I know of although it is often done
3. What is the general length of a combat sortie? Anywhere from 1.5 hours (no refueling – low altitude) to ten hours (which would include 4-5 refuelings)
 - a. Does the duration include refueling? Y or N: See above.
 - b. If yes, how many? See above
4. Is this system capable of acting as both hunter and killer in urban CAS engagements while maintaining persistent surveillance on another target? No
5. Does this system offer reduced sensor-to-shooter chain of custody? Yes
6. Is this aircraft capable of providing persistent fires on a target, or are several airframes required? Depends on your definition of persistent, but on balance I would say yes.
7. In your opinion how many airframes would be required for a planned urban CAS mission? Too many potential variables in this question to give you a good answer.
8. Does this aircraft have a ground marking system/pointer? (i.e. IZLID, ATI, etc) – Yes - hand-held IR pointers from 100mW up to 1 Watt; laser and IR pointer on the Litening II TGP; and, WP 2.75” rockets.

Additional Comments: (please any comments you feel necessary for inclusion in the final product.) None

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