THE RISE OF THE UNMANNED AERIAL VEHICLE AND
ITS EFFECT ON MANNED TACTICAL AVIATION

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Unmanned aerial vehicles (UAVs) are not new concepts. Their history dates back to the Civil War with hot air balloons and has evolved into a crucial combat tool for commanders in the modern battlespace. The increased demand for unmanned systems has placed a corresponding strain on manned tactical aviation and the airspace control system. This paper seeks to answer the questions surrounding the growth in the number of UAVs and their effects on the current structures in place. Current UAVs have a wide range of capabilities from the large Global Hawk high-altitude system to the hand-launched Raven. The US Army's transformation to a modular concept has increased the number of UAVs to approximately 300 per division. This increase has the potential to saturate the airspace command and control systems causing delays in the application of aerial delivered fires and identifying hostile UAVs. The analysis highlights the critical points and concludes the current airspace structure can support the growth in the number of UAVs but with time delays caused by the amount of coordination required. The ability to defend against threat UAVs will remain doubtful until all blue UAVs can either be tracked or respond to air defense interrogations.

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ABSTRACT

THE RISE OF THE UNMANNED AERIAL VEHICLE AND ITS EFFECT ON MANNED TACTICAL AVIATION, by Major James P. Meger, 91 pages.

Unmanned aerial vehicles (UAVs) are not new concepts. Their history dates back to the Civil War with hot air balloons and has evolved into a crucial combat tool for commanders in the modern battlespace. The increased demand for unmanned systems has placed a corresponding strain on manned tactical aviation and the airspace control system. This paper seeks to answer the questions surrounding the growth in the number of UAVs and their effects on the current structures in place. Current UAVs have a wide range of capabilities from the large Global Hawk high-altitude system to the hand-launched Raven. The US Army's transformation to a modular concept has increased the number of UAVs to approximately 300 per division. This increase has the potential to saturate the airspace command and control systems causing delays in the application of aerial delivered fires and identifying hostile UAVs. The analysis highlights the critical points and concludes the current airspace structure can support the growth in the number of UAVs but with time delays caused by the amount of coordination required. The ability to defend against threat UAVs will remain doubtful until all blue UAVs can either be tracked or respond to air defense interrogations.

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ACRONYMS AND GLOSSARY

A2C2	Army Airspace Command and Control
AADC	Area Air Defense Commander
AAGS	Army Air Ground System
ABCS	Army Battle Command System
ACA	Airspace Control Authority
ACM	Airspace Coordination Measures
ACMREQ	Airspace Control Means Request
ACO	Airspace Control Order
ACP	Airspace Control Plan
ACS	Airspace Control System
ADAFCO	Air Defense Artillery Fire Control Officer
ADAM/BAE	Air Defense Airspace Management / Brigade Aviation Element
ADSI	Air Defense System Integrator
AESA	Active Electronically Scanned Antenna
AETACS	Airborne Element Theater Air Control System
AFDD	Air Force Doctrine Document
AGL	Above Ground Level
AIM	Air Intercept Missile
ALO	Air Liaison Officer
AMD	Air and Missile Defense
AMDWS	Air and Missile Defense Workstation
AMRAAM	Advanced Medium Range Air to Air Missile
ARFOR	Army Forces

ASOC	Air Support Operations Center
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BAE	Brigade Aviation Element
BAO	Brigade Aviation Officer
BCD	Battlefield Coordination Detachment
BCT	Brigade Combat Team
BFT	Blue Force Tracker
BN	Battalion
BOS	Battlefield Operating System
CALL	Center for Army Lessons Learned
CAP	Combat Air Patrol
CAS	Close Air Support
CO	Company
COA	Course of Action
COCOM	Combatant Commander
COMMINT	Communications Intelligence
COP	Common Operational (or Operating) Picture
CRC	Control Reporting Center
CRE	Control Reporting Element
DASC	Direct Air Support Center
DCA	Defensive Counter Air
DoD	Department of Defense
ECCORD	Effects Coordinator
ELINT	Electronic Intelligence

ER/MP	Extended Range / Multipurpose
FAC(A)	Forward Air Controller (Airborne)
FBCB2	Force XXI Battle Command, Brigade and Below
FECC	Fires and Effects Coordination Cell
FEZ	Fighter Engagement Zone
FCS	Future Combat System
FM	Field Manual
FPASS	Force Protection Aerial Surveillance System
FSCM	Fire Support Coordination Measures
GPS	Global Positioning System
GTACS	Ground Theater Air Control System
GWOT	Global War on Terror
HIDACZ	High Density Airspace Control Zone
IFF	Identification Friend or Foe
ISR	Intelligence, Surveillance, and Reconnaissance
JAOC	Joint Air Operations Center
JEZ	Joint Engagement Zone
JFACC	Joint Forces Air Component Commander
JFC	Joint Force Commander
JIADS	Joint Integrated Air Defense System
JOA	Joint Operations Area
JSTARS	Joint Surveillance Targeting and Attack Radar System
JTAC	Joint Terminal Air Controller
MDMP	Military Decision Making Process
MEZ	Missile Engagement Zone

MFD	Multifunction Display
MRR	Minimum Risk Route
MTI	Moving Target Indicator
NATO	North Atlantic Treaty Organization
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PSYOPS	Psychological Operations
RAP	Recognized Air Picture
ROE	Rules of Engagement
ROZ	Restricted Operating Zone
RSTA	Reconnaissance, Surveillance, and Target Acquisition
SAAFR	Standard use Army Aircraft Flight Route
SIF	Selective Identification Feature
SPINS	Special Instructions
SUAV	Small Unit Unmanned Aerial Vehicle
TACP	Tactical Air Control Party
TAGS	Theater Air Ground System
TACS	Theater Air Control System
TAIS	Tactical Airspace Integrations System
TBMCS	Theater Battle Management Core System
TDL	Tactical Data Link
TOC	Tactical Operations Center
TPIO	TRADOC Program Integration Office
TRADOC	Training and Doctrine Center
TTP	Tactics Techniques and Procedures

TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
WMD	Weapon of Mass Destruction
VID	Visual Identification

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CHAPTER 1

INTRODUCTION

> We are entering an era in which unmanned vehicles of all kinds will take on greater importance in space, on land, in the air, and at sea.
>
> President Bush, Address to the Citadel, 2001

Background

Since the first battle, commanders and soldiers have longed to see what is over the next hill. Today the unmanned aerial vehicle (UAV) has become the platform of choice, allowing observation of the enemy and increasing situational awareness with real-time intelligence. UAVs have undergone rapid growth in numbers and capability since Operation Allied Force and are here to stay. Proliferation in both numbers and capabilities of emerging UAVs is rapidly overwhelming the ability to detect, track, and deconflict from friendly UAVs, while defending against the potential threat UAV platforms.

Although there has been an exponential increase in UAVs in today's operating environment, the history of the UAV dates back to the American Civil War. Both Union and Confederate troops employed balloons laden with explosives, intending for them to land on the enemy side of the lines and cause damage to infrastructure in the area.[1] The Japanese attempted a similar technique during World War II by launching incendiary balloons into the Pacific Northwest with the intent of causing panic in the United States.[2] Although pioneering, the inability to control the delivery of the explosives, other than by wind currents led, to marginal success and abandonment of these ideas.

During World War II the United States took UAV technology to a new level with Operation Aphrodite. Aphrodite began as a hybrid manned UAV sortie in which a pilot took off in an explosive laden B-17 and then bailed out at altitude after giving positive radio control to a mothership.[3] The unmanned B-17 was then guided and crashed into its intended target causing the destruction of both the target and the B-17.[4] This method is more in line with today's cruise missile and it was not until the Vietnam Conflict that UAVs began to expand their roles.

During the 1960s several events stunned the aviation world including the shoot down of the Francis Gary Powers over the Soviet Union in May of 1960, and the loss of a second U-2 during the Cuban Missile Crisis in 1962.[5] With the vulnerability of pilots brought to the forefront, the need to reduce the overall risk was the driving factor in the development of the first operational UAV, the AQM-34 Lighting Bug. During the Vietnam Conflict the Lighting Bug flew over 3,400 sorties with an 84 percent successful return rate.[6] The majority of missions tasked to the Bug were photographic reconnaissance, but also included Electronic Intelligence (ELINT), Communications Intelligence (COMINT), as well as Psychological Operations (PSYOPS) executing leaflet drops.[7] With the highly successful Bug came the drawback of rigid mission planning and no ability to retask the vehicle once airborne.[8]

After Vietnam, the UAV maturation was apparent during Operation Desert Storm. The United States Navy used an Israeli designed UAV, the Pioneer, to provide support for naval gunfire and for battle damage assessment. Pioneers also scouted potential minefields and landing areas for amphibious operations, amassing over 300 sorties and 1,000 flight hours for various operations.[9] The Pioneer recorded several firsts, including the surrender of enemy troops to a UAV. On the island of Faylaka, Iraqi troops recognized the presence of the Pioneer UAV as the precursor to a naval bombardment and surrendered to the UAV by waving white flags, T-shirts, and handkerchiefs.[10]

Operations Allied Force, Enduring Freedom, and Iraqi Freedom have seen large changes in UAV capability, doctrine, and participation. During Allied Force the Predator UAV made its combat debut and was able to provide long-duration intelligence surveillance and reconnaissance (ISR) over the Kosovo engagement zone. Capabilities and missions are changing rapidly in the UAV regime from the strategic to tactical with systems, such as the high-altitude RQ-4 Global Hawk and the small unmanned aerial vehicle (SUAV), such as the Raven.

With the transformation of the US Army to a modular concept there is a dramatic increase in the number and type of UAVs in the battlespace. This increases the potential conflict with manned aircraft and also opens a potential seam in defending against enemy UAVs. One of the premises of the modular concept is the reduction in the overall weight of a brigade making it more deployable. Reducing organic fires by cutting artillery tubes reduces the overall footprint, but increases the reliance on fires delivered from joint platforms including air assets. A second change in the overall structure of the BCT includes the addition of large numbers of SUAVs starting at the company level.[11] By increasing situational awareness at the lowest level, commanders can mass their combat power at the decisive point on the battlefield. Other services in the Department of Defense (DoD), US allies, and potential coalition partners are also going through force structure changes, including the addition of greater numbers of UAVs to their inventory.

The UAV while providing valuable information they do so at a cost of increasing the amount of air traffic in the battlespace.

The US and its allies are not the only countries interested in the procurement and fielding of UAVs. Terrorist groups have demonstrated the ability to operate UAVs. On 7 November 2004, Hezbollah operated a UAV that flew in Israeli airspace for nearly one-half-hour, later releasing the footage taken by the UAV.[12] According to the London *Independent* newspaper, a British national held at Camp Delta, Guantanamo Bay, Cuba, confessed to being part of an Al Qaeda plot to acquire a UAV to attack the House of Commons with anthrax.[13] The growth of UAVs, both friendly and enemy, as airspace users and potential lethal delivery devices leads to the primary research question.

Thesis Intent and Primary Research Question

The growth and prevalence of UAVs on the battlefield has outpaced the current airspace structure leaving operators in a precarious situation. The desire for more UAVs may directly impact the ability to put fires on target due to airspace constraints. Furthermore, the possibility exists for a potential adversary to exploit a gap in the defensive counterair (DCA) coverage with UAVs. The primary question this thesis seeks to answer is whether or not the growth in UAVs will have a negative impact on manned tactical aviation. Addressing secondary and tertiary questions will offer a more thorough review of the topic. Secondary questions include: How will close air support (CAS) be deconflicted to prevent a midair collision or prevent delays in employment? Will the proliferation of UAVs, both friendly and enemy, prevent the JFC from achieving air superiority? Tertiary questions include: What is the maximum and sustained number of UAV sorties a division can generate in a twenty-four hour period? What is the proposed level of control and authority to regulate airspace in a modular division? Is there a way to determine if a UAV is enemy or friendly? Will Tactical Air Control Parties (TACPs) have access to a common operating picture to know where UAVs are located?

Assumptions

There are several key assumptions which will keep the paper focused on the primary question. First is the change in the US Army to a modular concept with the Brigade Combat Team (BCT) as the central fighting force. With the change to modularity also comes a change in number of UAVs and the associated airspace control cells. This thesis researches the A2C2 cell and UAV structure for the modular Army.

The assumption that an unmanned platform contains a human in the loop at all times is not necessarily valid. The author will explore possibilities of UAV technology in a cruise missile type profile, that is, a one way trip with an offensive payload, versus the return of the vehicle as in an ISR platform.

As shown in figure 1 the notional division contains a total of seven brigade combat teams, each with approximately 300 organic UAVs. An assumption is that SUAVs will operate below the altitude of 3,000 feet above ground level (AGL) and that tactical UAVs (TUAVs) will operate above that altitude. Due to the rapidly changing technology and performance characteristics of the UAVs, this thesis will assume the Raven will be the primary SUAV until the future combat system (FCS) is fielded.

Technological advances in the radar field have dramatically increased the probability of detection of low radar cross-section platforms. Active electronically scanned antenna (AESA) radar platforms currently fielded include the F-22A, F-15C, and the F/A-18.[14] With the rapid fielding and improving technology this thesis will assume radar detection of UAVs, to include SUAVs is possible.

Joint Definition

There are several definitions of the UAV available on the internet. This thesis uses the Joint Publication 1-02 definition, "A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles."[15] Further defining the UAV, the author has excluded lighter-than-air platforms, such as balloons and blimps.

Limitations

This thesis will remain unclassified through the use of open source materials. New radar technologies in the Airborne Warning and Control System (AWACS), Patriot missile systems, and fighter aircraft, such as the F-22A, are sensitive and sourced with open materials. Official publications, such as *Air Force Tactics Techniques and Procedures (AFTTP) 3-1 Volume 15, F-15 Operations,* contain tactics, techniques, and procedures (TTPs) on defending against UAVs but are classified. There is, however, a large amount of open source data available to answer the primary question.

The transformation to a modular concept is a stepping stone for the US Army's vision of fielding the FCS. This thesis will limit the scope of investigation to the current transformation and will not research FCS potentials. Keeping pace with transformation, the US Army Training and Doctrine Command (TRADOC), has been prolific in the output during the transformation process. The author has made every attempt to use the latest data from TRADOC but set a deadline of December 2005 as a cutoff for the assimilation of new information.

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[1]Jeffery Goldfinger, "The Pilotless Eyes in the Sky," *The Hook: Journal of Carrier Aviation*, (summer 2002), 34.

[2]Christopher A. Jones, "Unmanned Aerial Vehicles (UAVs): An Assessment Of Historical Operations And Future Possibilities" (Thesis, USAF Air Command and Staff College, 1997), 3-4.

[3]Ibid.

[4]Ibid.

[5]Ibid.

[6]Ibid., 4.

[7]Ibid., 8.

[8]Ibid., 11.

[9]Ibid.

[10]Goldfinger, 36.

[11]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[12]Eugene Miasnikov, "Terrorists Develop UAVs" (Moscow Institute of Physics and Technology Center for Arms Control, Energy and Environmental Studies, 6 December 2004) [document on-line] available from http://www.armscontrol.ru/uav/mirsad1.htm; Internet; accessed 30 October 2005.

[13]Dennis M. Gromley, "Testimony Before the Subcommittee on National Security, Emerging Threats, and International Affairs Of the U.S. House of Representatives Committee on Government Reform" (Monterey Institute's Center for Nonproliferation Studies, 9 March 2004) [document on-line];available from http://cns.miis.edu/research/congress/testim/testgorm.htm; Internet; (accessed 28 October 2005).

[14]Global Security Organization, “E-3 Sentry (AWACS) Radar System Improvement Program (RSIP)” (Global Security .org, Reliable Security Information, 16 May 2005) [document on-line]; available from http://www.globalsecurity.org/military/systems/aircraft/e-3-rsip.htm; Internet; accessed 22 May 2006.

[15]Chairman, Joint Chiefs of Staff, Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington DC: GPO, 31 August 2005), 563.

CHAPTER 2

LITERATURE REVIEW

Overview

> The gravest danger to freedom lies at the crossroads of radicalism and technology. When the spread of chemical and biological and nuclear weapons, along with ballistic missile technology--when that occurs, even weak states and small groups could attain a catastrophic power to strike great nations. Our enemies have declared this very intention, and have been caught seeking these terrible weapons. They want the capability to blackmail us, or to harm us, or to harm our friends--and we will oppose them with all our power.
>
> President Bush, Graduation Address

From chapter 1, the congestion of airspace over the modern and future battlefields is clearly visible. Users will demand more time and greater volumes of airspace with increasing capabilities of unmanned vehicles and their sensor suites. With the increase in quality having an effect, the increase in the quantity will drive airspace demands to new levels. The desire to have UAVs ready for an almost immediate launch presents formidable challenges for all users. The purpose of this thesis is to examine the integration of UAVs into the battlespace and determine if there are areas that have a negative impact on manned fixed wing tactical aviation.

This chapter contains four main sections which review information relating to the primary research question. The first section examines the growth of UAVs in the Army's BCTs and the growth of enemy unmanned aerial vehicles. Section two will focus on the doctrine involved with the control of airspace in a combat zone. Review of the associated doctrine begins with Joint publications, with additional research into service specific doctrine. Section three focuses on the actual control of airspace and how the transformation of the Army to BCTs integrate with the Joint Air Operations Center (JAOC). The final section in the literature review encompasses the material on the integration of CAS and DCA sorties into the battlespace, and their relationships with the JAOC and A2C2 centers.

The Number and Capabilities of UAVs: US and Theirs

As chapter 1 illustrates the use of unmanned platforms is not a new concept or tool in warfare. The rapid explosion in UAV numbers and capabilities is driving a revolution in military operations. Commanders at all levels possess the ability to task and employ organic UAV platforms. While the numbers are rising, capability is also on the rise with high loiter times and increasing sensor capabilities. The US has been the most recent user of UAVs, but many nation states and nonstate actors are developing and acquiring unmanned technology. The military's appetite for the live UAV feed has grown dramatically in a short time. To meet this need the US Army is increasing the number of TUAVs and SUAVs in the modular structure. Using the transformed division with two maneuver brigades as an example as shown in figure 1, the number of UAVs available has increased over 300 times from the legacy division.[1]

As shown in figure 1, the number of UAVs in the notional division is 320, 268 belonging in the SUAV category.[2] Due to maintenance requirements, channel deconfliction, ground control station availability, and operator limitations, the maximum number of UAVs flyable at one time is 105.[3] Surge capability exists, as well as task organization, to increase the number of friendly UAVs in the battlespace.

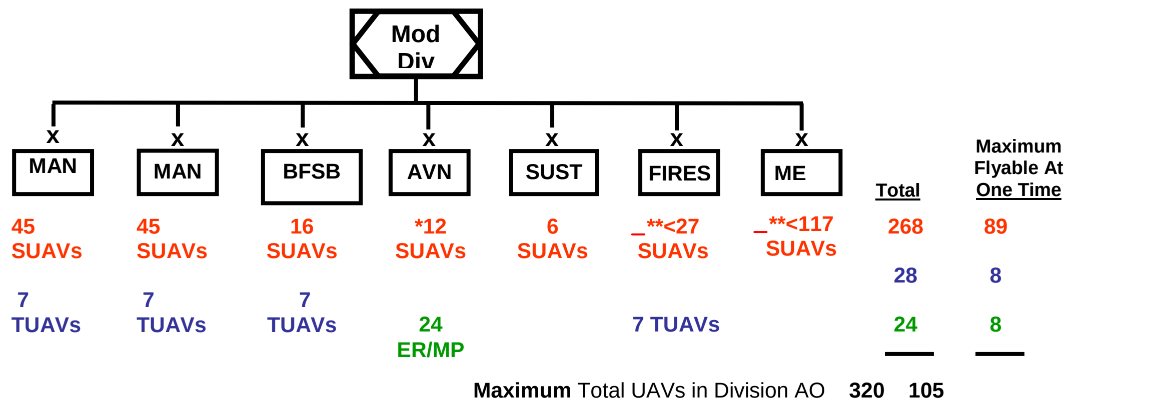

Figure 1. Example Modular Division
Source: TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

The US is not the only user of airspace on the battlefield; future enemies will likely have some form of manned and unmanned platforms. Estimates of the world's UAV inventory include more than 600 types of UAVs in over forty countries, with nearly 80 percent having the ability to fly over 300 kilometers one way.[4] With dual use technologies available from a foreign government or private firm, a terrorist organization can acquire the ability to create an off-the-shelf UAV with payload capacities capable of delivering weapons of mass destruction (WMD) for as little as $50,000.[5]

What is Joint, Army, and Air Force Doctrine?

The word doctrine often brings to mind lofty goals with dry carefully worded phrases written by someone detached from the realities of a combat environment. [6] Doctrine is the sanctioned beliefs and principles describing the application of combat power, shaping the organization, training, and fighting principles of military forces.

When there is a conflict between joint and service doctrine the following quotation best explains the precedence.

> If conflicts arise between the contents of this joint publication and the contents of service publications, joint publications will take precedence for the activities of joint forces unless the Chairman of the Joint Chiefs of Staff, normally in coordination with the other members of the Joint Chiefs of Staff, has provided more current and specific guidance.[7]

Joint publication 3-52, *Airspace Control in a Combat Zone*, released in August 2004, with the previous edition dating back to July 1995 sets the stage for the review in section one.

Fundamental Considerations of Airspace Control

Controlling airspace in a combat zone requires three major components: coordination, integration, and regulation. Ultimately, the synchronization of airspace control fosters the application of combat power from aerial platforms with air or surface launched weapons to achieve the joint force commander's (JFC) intent. To accomplish this integration the JFC normally designates an airspace control authority (ACA) and defines the relationship between the ACA and component commanders.[8] The ACA does not retain power to deny combat operations, and when a conflict between operational commanders and airspace requirements arise the JFC will resolve the issue. This method ensures unity of effort and the application of combat power in accordance with the JFCs intent. Figure 2 from JP 3-52 shows the responsibilities delegated to the ACA.

AIRSPACE CONTROL AUTHORITY RESPONSIBILITIES

- Coordinate and integrate the use of the airspace.
- Develop policies and procedures of airspace control and for the coordination required among units within the operational area.
- Establish an airspace control system that is responsive to the needs of the joint force commander, provide for integration of the airspace control system with that of the host nation, assist in establishing a civil structure where none exists, and coordinate and deconflict user requirements.
- Develop the airspace control plan and, after joint force commander approval, distribute it throughout the operational area. Implement the airspace control plan through the airspace control order.
- Provide necessary facilities and personnel for airspace control functions in assigned areas and identify these facilities and personnel for inclusion in the airspace control plan.

Figure 2. ACA Responsibilities
Source: Joint Chiefs of Staff, JP 3-52, *Joint Doctrine for Airspace Control in a Combat Zone* (Washington DC: GPO, 30 August 2004), II-3.

The JFC will also normally designate a joint force air component commander (JFACC) whose duties and responsibilities include: planning, coordinating, monitoring, and ensuring the proper allocation of joint air resources to meet the JFCs decisions and intent. According to JP 3-52, the JFACC will also normally act as the Area Air Defense Commander (AADC) and the ACA.[9] The AADC is responsible for defensive counterair, including both air and missile systems. The AADC has responsibilities including the development and execution of a sensor plan for the identification and engagement of enemy air and ballistic assets.[10] In addition, the AADC is responsible for the dissemination of information on possible air and missile attacks.[11] As the AADC and ACA, the JFACC is in a unique position to maintain unity of command to maximize the deconfliction of joint air operations and prevent fratricide, or friendly fire incidents.[12]

JP 3-52 presents an overview on engaging enemy threats traveling through the air and stresses the need for a central agency to coordinate engagements. The JAOC synchronizes this process ensuring economy of force, reduction in simultaneous engagements, and minimizing fratricide potential. Enhancements to the engagement process include airspace coordination measures, such as joint engagement zones (JEZ), fighter engagement zones (FEZ), and missile engagement zones (MEZ).[13] JEZ operations involve the simultaneous use of fighters and missile systems integrated in an operational area. By using each system's strengths, for example using a Patriot to target a ballistic missile, a synergistic effect is achieved. This integration relies on detailed, quick, correct identification of friendly, neutral, and enemy systems and doctrinally operates under positive versus procedural control. The FEZ is normally located beyond the range of surface-based systems and is dependant on other elements of the aerial control system (ACS), such as AWACS aircraft. The FEZ gives the AADC the ability to respond to air threats across a large operational area due to the range and speed of modern fighter aircraft. The MEZ presents unique characteristics to the AADC with the ability to target the full range of enemy air threats from UAVs to ballistic missiles. Each of the engagement zones has the same objective, to deny the enemy the use of airspace and to accomplish these tasks; the ACS uses two different types of control, positive and procedural.

Objectives and Methods of Airspace Control

JP 3-52 lays out several key objectives for airspace control directly relating to the primary question. Objectives include: the prevention of mutual interference, facilitation of air defense identification, safe accommodation, and expeditious flow of air traffic in the operational area.[14] To accomplish these objectives, the ACA employs two levels of control, positive or procedural control of the airspace. Positive control relies on hard data or inputs, such as radar, identification friend or foe (IFF) / selective identification feature (SIF), digital data links, or other sensors.[15] The use of positive control assumes there is two way radio communications and the controlling agency has the authority to direct the aircraft. This allows the ACA and AADC to identify, track, organize, and direct air assets to meet the defensive counterair requirements and the JFC's objectives.[16] Procedural control is the second method employed to direct an orderly flow of air assets in a combat zone. Procedural control as defined by JP 1-02 relies on a combination of previously agreed and promulgated orders and procedures.[17] Procedural control uses airspace coordination measures (ACM) such as air defensive identification maneuvers at preplanned locations (listed in the airspace coordination plan (ACP)), minimum risk routes (MRR), fire support coordination measures (FSCM), coordinating altitudes, and restricted operating zones (ROZ). These measures function to reserve a set column of airspace for weapons systems, deconflict air operations from surface-to-surface fires, and facilitate the integration of unmanned systems into the ACP.[18] Figure 3 summarizes the differences between positive and procedural control.

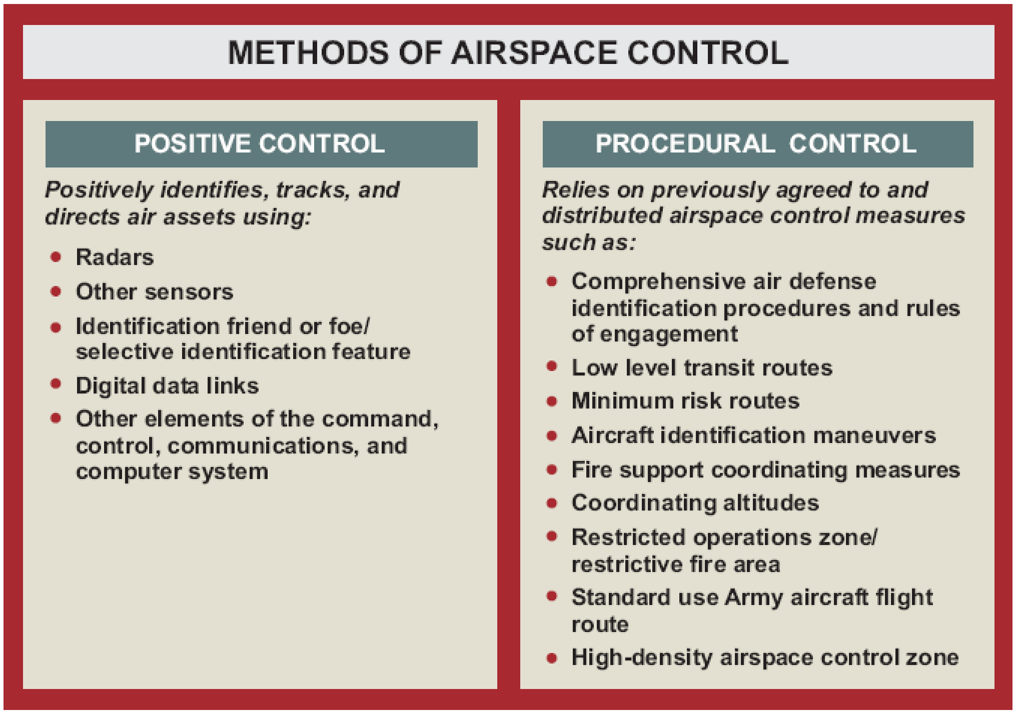

Figure 3. Positive versus Procedural Control
Source: JP 3-52, *Joint Doctrine for Airspace Control in a Combat Zone*, 30 August 2004, II-4.

By using a combination of positive and procedural control, the airspace control structure can remain flexible and adaptable to both the enemy and friendly situations. The primary method separating rotary-wing and fixed-wing assets is the use of the coordinating altitude. The coordinating altitude as defined by JP 1-02 is

> an airspace control method to separate fixed-wing and rotary-wing aircraft by determining an altitude below which fixed-wing aircraft will normally not fly and above which rotary-wing aircraft normally will not fly. The coordinating altitude is normally specified in the airspace control plan and may include a buffer zone for small altitude deviations.[19]

The coordinating altitude may vary from theater to theater or be different with in the same theater of operations at different locations. The coordinating altitude is not a hard altitude where fixed wing, rotary wing, or UAVs shall not cross. To penetrate from procedural to positive airspace requires coordination with the appropriate agency. Figure 4 shows a visual depiction of the coordinating altitude.

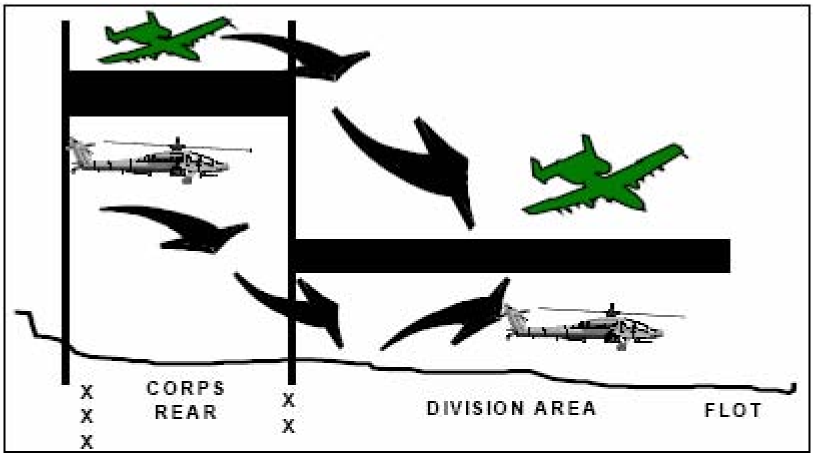

Figure 4. Coordinating Altitude Depiction
Source: FM 3-52, *Army Airspace Command and Control in a Combat Zone,* August 2002, 4-3.

As shown by figure 4 the use of the coordinating altitude allows Army and Air Force planners the flexibility to execute missions quickly with little coordination, if all operations are to remain below or above the predetermined altitude.

The Joint View on UAV Airspace Coordination

Although JP 3-52 addresses UAV operations for airspace control, it leaves much up to the services to issue guidance and procedures. The doctrine states each service may operate its respective UAVs using the fundamentals behind manned operations for airspace coordination. For example, the Army may launch a SUAV remaining below the coordinating altitude with little or no input to the JAOC. However, if the SUAV is required to penetrate above the coordinating altitude into positively controlled airspace, the appropriate agency, such as an AWACS, must be contacted. Joint doctrine acknowledges certain types of UAVs are very difficult to detect both visually and with electronic sensors and may present a hazard to manned operations. To mitigate this risk, the airspace control order (ACO) must include volumes of detailed information dealing with UAVs. In addition the ACO should contain activation times and locations of UAV operations to integrate manned and unmanned operations ensuring a flexible airspace structure. [20] How this airspace structure develops requires inputs from each of the services or users of airspace.

Army Airspace Command and Control (A2C2) Doctrine

Field Manual 3-52, *Army Airspace Command and Control in a Combat Zone*, provides the guidance to integrate, coordinate, synchronize, and regulate the Army's use of airspace. It focuses on how the Army uses airspace in planning and executing the commander's intent. The review of FM 3-52 will focus on Army specific topics and the Army's relationship in the theater air-ground system (TAGS) to support the JFC's overall objective. Figure 5 is a notional depiction of the Army Air-Ground System (AAGS).

Figure 5, while representative of the AAGS, is under revision with the ongoing transformation of the Army. As the figure shows the A2C2 cell at the brigade level contains ad hoc personnel as no formal organization exists in units which have yet to transform. In the transformed Army, BCTs will have a much more robust ability to coordinate airspace through the Air Defense Airspace Management (ADAM) and the Brigade Aviation Element (BAE). The function of the ADAM and the BAE is to: provide the air picture to the BCT, manage and deconflict BCT airspace, plan aviation employment to include organic UAVs, provide command and control for air missile defense, support airspace coordination measures, and receive and integrate subordinate A2C2 requirements.[21]

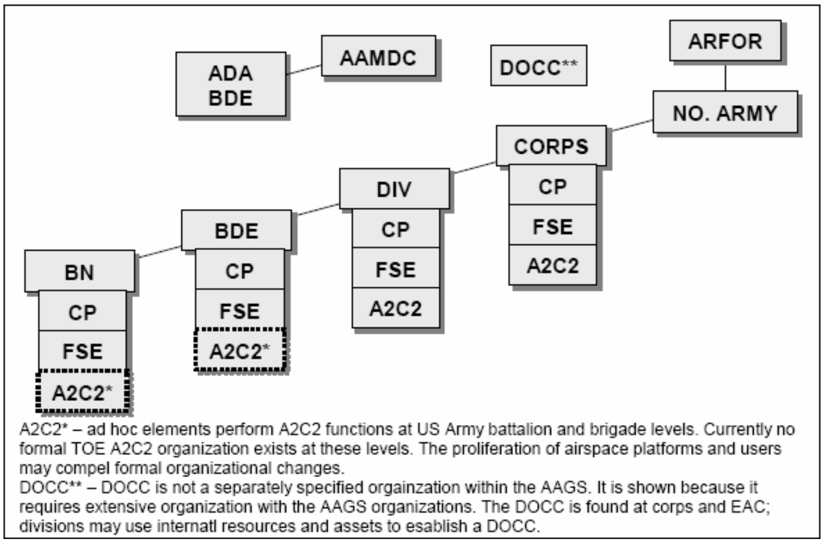

Figure 5. Army Air-Ground System
Source: Source: FM 3-52, *Army Airspace Command and Control in a Combat Zone*, August 2002, 1-15.

A2C2's overall aim is the integration and synchronization of air and ground schemes of maneuver to maximize combat power. The main functional areas of A2C2 include: identification, coordination, integration, and regulation. Identification is the use of positive or procedural means to classify friendly and hostile air threats including manned and unmanned systems. Timely identification allows for maximum and favorable engagement parameters of enemy threats. Coordination is the central focus of the A2C2 system, integrating all airspace users to achieve a flexible airspace structure. The integration of airspace ultimately begins at the lowest level in theater. By starting at the lowest level of command, planners can assure a synchronized, safe, flexible airspace plan with sister services and coalition partners. After achieving the functional tenants, the five basic principles of A2C2 are possible which include: command, control, air defense, fire support coordination, and airspace management.[22]

The Birth of the Transformed A2C2 Structure

The structure examined in this thesis will fall under the modular Army which centers around the BCT. The major difference noted earlier is the function of the ADAM/BAE which provides for a robust A2C2 cell at the brigade level. Figure 6 shows a visual depiction of the transformed A2C2 structure.

The senior level of the A2C2 function resets at the JAOC with the Battlefield Coordination Detachment (BCD). The BCD is the Army Forces (ARFOR) liaison element located within the JAOC. The primary purpose of the BCD is to monitor and interpret the land battle and provide interface with the appropriate cells in the JAOC.[23] The BCD does not make command decisions or take part in the commanders estimate but, as a liaison element, coordinates in the following areas: battle command, intelligence, fires, airspace management, and air and missile defense. As the senior ARFOR element in the JAOC for airspace management, the BCD is responsible for coordinating the use of airspace for ARFOR rotary-wing and fixed-wing platforms, ISR assets, including both manned and unmanned platforms.[24]

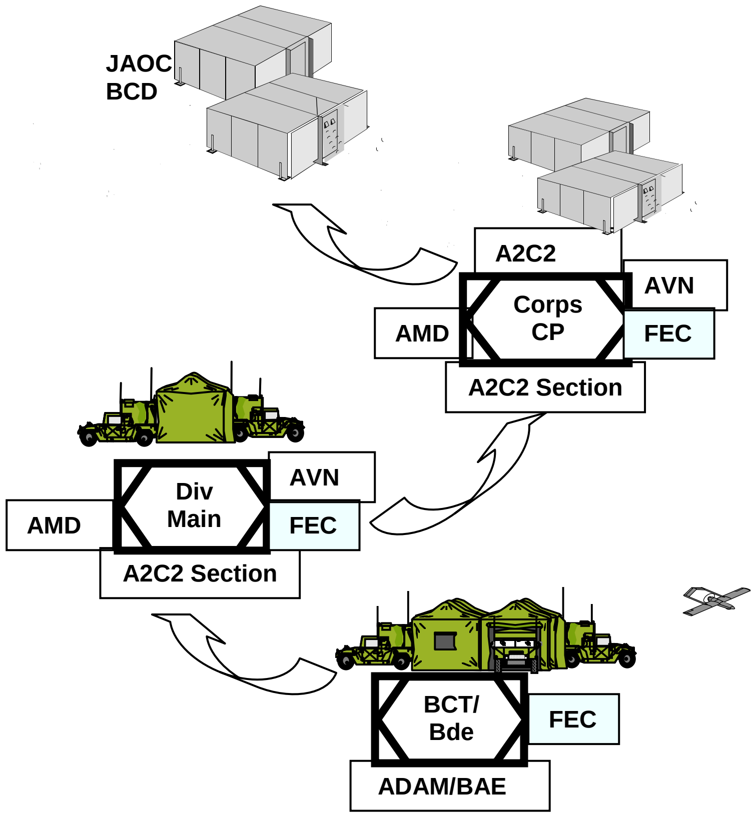

Figure 6. Transformed A2C2 Structure
Source: Briefing for Army Airspace Command and Control in the Modular Force, TRADOC Program Integration Office, Battle Command – A2C2, 29 April 2005.

For air and missile defense, the BCD provides the AADC the channel to incorporate Army air defense assets into a joint integrated air defense system (JIADS). The engagement authority for Army assets lies with the air defense artillery fire control Officer (ADAFCO). The ADAFCO is responsible for the defense of critical assets through coordination, monitoring of command, and tracking of individual AMD unit information. With the ADAFCO located within the JAOC, rapid coordination and engagement of manned or UAV threats is possible while minimizing the potential for fratricide.[25] The current data link structure to support AAMD, shown in figure 7, is overseen by the ADAFCO. This data link architecture allows for the rapid exchange of information from the ADAFCO to the Fire Control Center and is visible to the appropriate personnel within the JAOC.

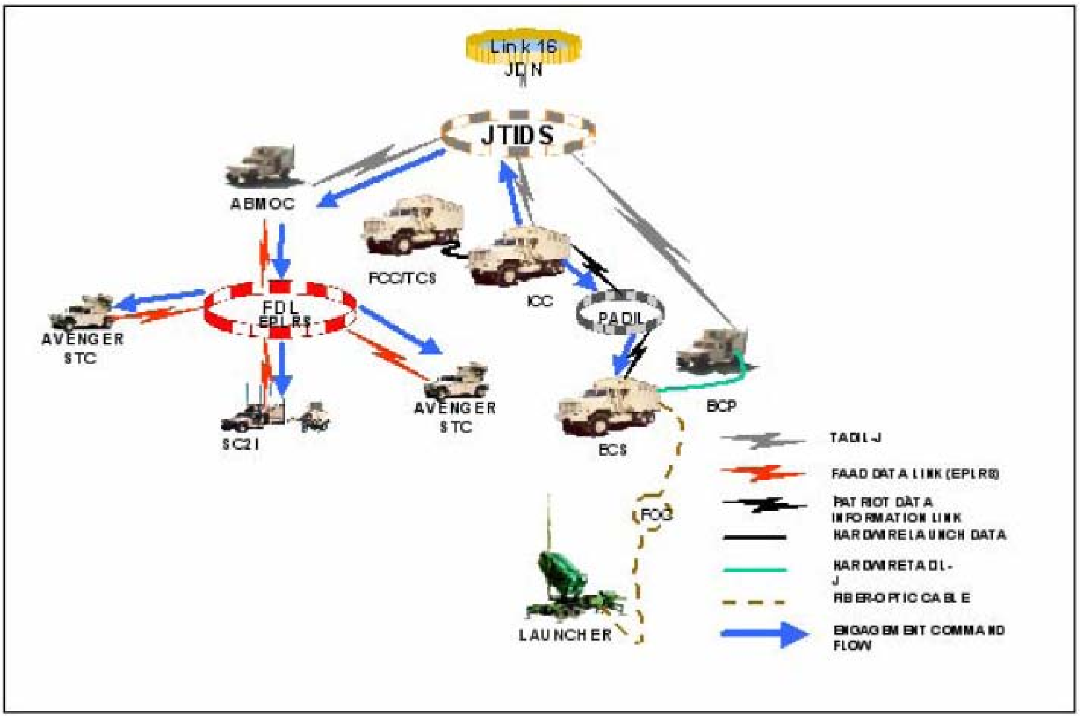

Figure 7. AMD Battalion Data Link Architecture
Source: Department of the Army, Field Manual Interim 3-01, *Air and Missile Defense Battalion Operations*, November 2005. 3-2.

The BCD relies on a series of digitized networks, in addition to voice, to allow integration with Air Force systems in the JAOC for the A2C2 and AMD cells. To assist with A2C2, the BCD uses the Air Forces theater battle management core system (TBMCS) along with the Army’s tactical airspace integration system (TAIS) to integrate ACMs for fires, manned, and unmanned platforms. The air defense system integrator

(ADSI) and the Air and Missile Defense Workstation (AMDWS) support the DCA portion of the BCD in close coordination with the JFACC.[26]

Falling under the BCD, the corps level A2C2 function is responsible for the synchronization of all subordinate units across the area of operations. The corps A2C2 cell digitally receives all airspace requests through the TAIS to determine requirements and make changes in the current operations section. The Air Support Operations Center (ASOC), normally located at the corps level, is an Air Force component of the Theater Air Control System (TACS), directly subordinate to the JAOC.[27] At the corps level, the ASOC and A2C2 cell are in a position to quickly deconflict CAS from other airspace users to include: fires, rotary-wing, and unmanned platforms.

Moving to the division, the A2C2 structure focuses on conducting the close battle over a smaller area. With the high tempo of land combat and introduction of UAVs, airspace requests from subordinate units have increased significantly. The division A2C2 cell reviews requests to ensure airspace requirements and concepts are transmitted to the corps level A2C2. In the modular division, the locations of the A2C2 cells include the main and tactical command posts allowing for redundant airspace planning and control.[28]

ADAM/BAE – A2C2 at the Brigade Level

Before the Army's transformation to BCTs, the division was the lowest level where the A2C2 cell had dedicated personnel. Under the transformed system, a BCT has the ADAM and BAE to conduct airspace management functions. The ADAM/BAE combines air and missile defense, aviation personnel, and enhanced digital connectivity providing the BCT with the ability to perform A2C2 and maintain a near real-time air picture.[29] The brigade aviation officer (BAO) is the lead integrator among the staff to coordinate A2C2 functions. The BAO, working for the BCT commander maintains a relationship with the aviation brigade commander, ensuring information is exchanged to facilitate A2C2 support. The BAE is also responsible for the integration of both rotary-wing and UAVs with the submission of airspace control measures requests (ACMREQ) to the next higher A2C2 element.[30] When the BCT works directly for a Joint Task Force (JTF) the ADAM/BAE is capable of interfacing directly with the BCD at the JAOC.[31]

At the battalion level and below there is no formal A2C2 element, rather this function is given to the battalion S3 who maintains the overall responsibility for managing airspace within the battalions AO. Without an A2C2 element at battalion level the ADAM/BAE at the BCT helps minimize the airspace workload on the battalion staff, especially when dealing with company level SUAV operations. With the majority of SUAV sorties originating at the battalion level, table 1 shows the key A2C2 tasks the battalion staff must execute within its AO.

Table 1. Battalion Key A2C2 Tasks
1. Receive and disseminate SUAV airspace request approval/changes/disapprovals
2. Review planned and immediate airspace requests and resolve conflicts within the battalion
3. Monitor and analyze aviation, SUAV, fires, air defense, and maneuver operations to resolve conflicts
4. Communicate deviations from pre-planned missions to the ADAM/BAE immediately
5. Ensure no SUAV flies without prior airspace coordination through the ADAM/BAE or higher
6. Monitor rotary/fixed-wing aircraft in the battalion AOR to aid in deconflicting SUAVs and other air traffic

Source: Department of the Army, Field Manual 3-04.155, *Army Unmanned Aerial Vehicle System Operations, Final Draft,* August 2005, E-6.

US Air Force Doctrine in the Control of Airspace in a Combat Zone

> Air control can be established by superiority in numbers, by better employment, by better equipment, or by a combination of these factors.
>
> General Carl A. "Tooey" Spaatz

As the nation's only full-service air and space force, the US Air Force is the primary user of airspace over the joint operations area. The Air Force airspace command and control system is a reflection of the air and space power tenet of centralized control and decentralized execution. The Air Force TACS provides the air component commander with the means to achieve this tenet.[32] Air Force doctrine describes three fundamentals which address key requirements to enhance combat operations: unity of effort, common procedures, and simplicity.[33]

Unity of effort relies on a central clearing agency whose power is vested from the ACA, and a central organization for defensive air operations, the AADC.[34] Although each of these functional areas may be a different person, the JFACC is normally responsible for these areas. By making the JFACC the central authority, a single air component commander provides the leadership and power of decision over assigned forces achieving unity of effort.[35] Common procedures throughout the joint operating area allow for integration of airspace users with a shared understanding. With a common airspace language, air traffic can safely transit airspace expeditiously, prevent fratricide, and facilitate air defense identification. The third area, simplicity, is important when considering stressors to aircrew and airframe capabilities during combat. Easily understood procedures are paramount when dealing with manned and unmanned systems of all services.

The US Air Force Theater Air Control System

The Air Force command and control system of airspace reflects upon the central tenant from Air Force Doctrine Document (AFDD) 1 *Air Force Basic Doctrine*, the notion of centralized control decentralized execution. The TACS is the execution mechanism which facilitates the ACP, the ACO, and the Area Air Defense Plan (AADP).[36] The centralized command center for all airspace operations resides in the JAOC. From the centralized location of the JAOC, coordination of operations throughout the entire joint operations area (JOA) are controlled in real time.

The JAOC is the senior element in the TACS and is a weapon system in the Air Force known as the Falconer. The JAOC provides the JFACC the ability to plan, execute, and assess air operations consistent with major combat operations. The JAOC organization consists of five divisions: strategy, combat plans, combat operations, ISR, and air mobility.[37] In addition to Air Force personnel there are liaison officers from all services and coalition partners involved in the use of airspace at the JAOC. Figure 8 shows a notional JAOC layout which the JFACC may modify based on the local environment, resource availability, and operational demands.

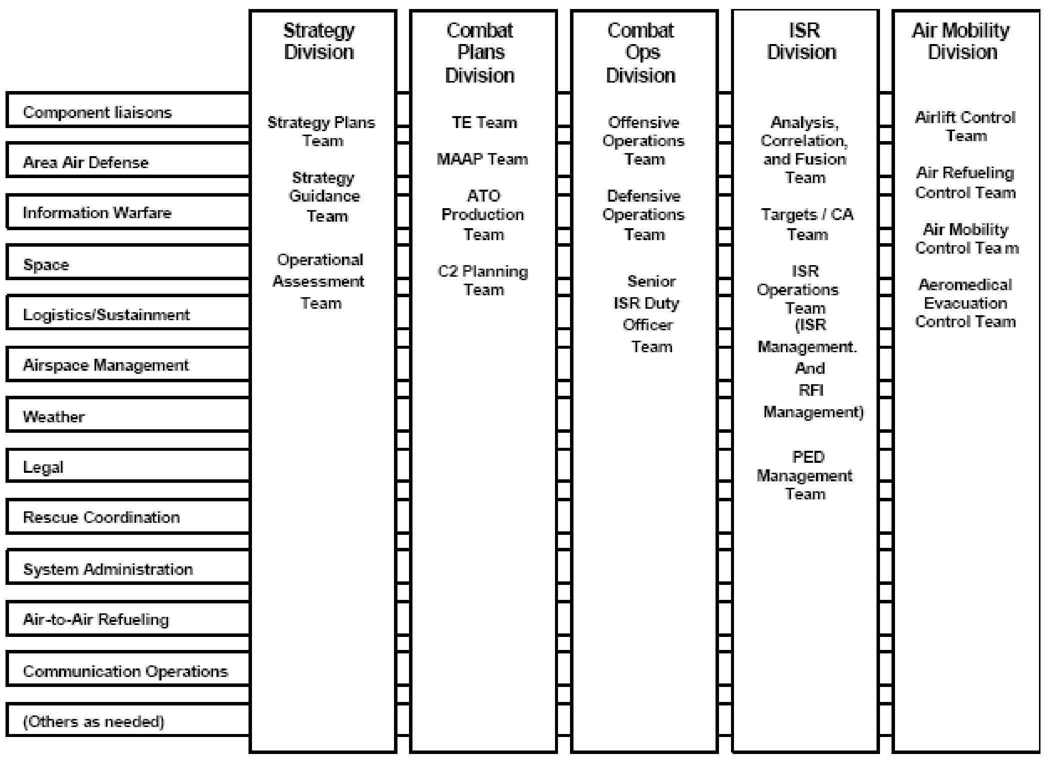

Figure 8. Notional AOC Layout
Source: Air Force Doctrine Document 2-1.7, *Airspace Control in the Combat Zone*, 13 July 2005, 30.

Airspace management, as seen in figure 8, is an integral function of the JAOC. Integrated into the combat plans, combat operations, and air mobility divisions within the JAOC, airspace managers plan and execute the ACAs combat airspace control plan.

Within the combat plans and air mobility divisions, team members, write the ACP and the ACO for the ACA, with combat operations responsible for real time implementation of the ACO.[38] With the ACO developed the TACS is now able to execute the airspace plan.

Elements of the TACS

The TACS is divided into two major sections, ground and airborne components. The ground TACS (GTACS) is composed of the control and reporting centers (CRC), the ASOC, and Tactical Air Control Parties (TACP).[39] The airborne elements of the TACS (AETACS) include the AWCAS, the Joint Surveillance Targeting and Attack Radar System (JSTARS) and the forward air controller-airborne (FAC(A)).[40] Each of the elements links directly to the JAOC as the executor of the ACP and ACO.

The CRC is a deployable system employed at the tactical level to support air operations planning and execution. Directly subordinate to the JAOC, the CRC is capable of directly interfacing with all other tactical airspace systems and is normally assigned a geographic area of responsibility to manage activities. The CRC provides battle management, weapons control, surveillance, identification, and data link management. In airspace control, the CRC provides real-time management of airspace in support of theater air operations.[41]

The ASOC, also directly subordinate to the JAOC, is normally located with the army senior level of tactical command. The ASOC provides the corps with a direct conduit for air support and integration of air power into future plans. The ASOC plays a major role in airspace control, through the execution of joint airspace coordinating measures, such as high-density airspace control zones (HIDACZ) and MRR. It deconflicts airspace with the Army's fire and effects coordination cell (FECC), G-3 air, and Army A2C2. The ASOC also establishes fire support coordinating measures when necessary and is responsible for delivering the air tasking order (ATO) and ACO to the TACPs.[42] The TACPs are liaison elements located from the battalion level up. They are responsible for direct coordination with Army airspace and fire support elements to ensure deconfliction between fires, manned and unmanned systems through formal or informal coordination measures.[43]

The airborne elements of the TACS include AWACS, JSTARS, and FAC(A) platforms. The AWCAS is an airborne radar control element tasked with tactical command and control providing early warning, surveillance, battle management, combat ID, and weapons control functions. It has the ability to detect and control aircraft below and beyond the coverage of ground-based radars and enables a more accurate air picture through various tactical data links (TDLs). The AWACS platform is directly subordinate to the JAOC and is capable of performing the same functions as the CRC.[44] Augmenting the AWACS is the JSTARS, a command and control battle management system optimized for the detection, and tracking of ground targets.[45] The JSTARS system, with a moving target indicator (MTI) can locate both rotary-wing and small, slow aircraft, such as SUAVs. The JSTARS also has a limited capability to act as a reporting point to procedurally deconflict airspace in a focused area. To facilitate the close-in fight the FAC(A) provides the airborne coordination between the TACP and fighter aircraft to rapidly put effects on target. The FAC(A) is capable of working procedural control in the immediate target area using altitude and geographic deconfliction.

It is the responsibility of the JFACC to fuse all of the data provided in the TACS system into a recognized air picture (RAP) enabling joint and coalition partners the ability to rapidly assess any situation. The JAOC combines and translates all data link feeds from the TACS into a common operating picture (COP), used at all levels of command for mission planning and execution.[46]

Air Force Doctrine on UAVs

AFDD 2-1.7 addresses concepts on UAVs in the combat zone. Principally UAVs operate in, and therefore are subject to, the same airspace control plan which manned aircraft operate. Pilots and operators must be familiar with the ACP and procedures within a specific AOR. Regardless of size, UAV operations require special considerations in terms of airspace control and usage. Specific volumes of planned airspace for UAVs need to be included in the ACO, and UAV information must be part of the ACP and special instructions (SPINS).[47] The AF position from AFDD 2-7.1 is that UAV missions prior to launch require coordination with the appropriate command and control agency. Although coordinated, small UAVs are not necessarily included in the ATO or SPINS. Deconfliction with these UAVs must occur on a real-time basis with the appropriate airspace control agency. If UAV operations are not deconflicted properly, unsafe flying conditions may result, or prevent airspace users from accomplishing their mission. Thorough coordination not only decreases the risk between UAVs and manned aircraft but also prevents engagement by friendly forces.[48]

The SUAV: Mission Planning to Mission Complete

The primary user of SUAVs in the battlespace is the US Army. The purpose of the SUAV is to provide reconnaissance, surveillance, and target acquisition (RSTA) day or night to increase situational awareness. The Center for Army Lessons Learned (CALL) Handbook, *Leader's Guide to A2C2 at Brigade and Below*, outlines the current guidance for SUAV mission request, guidance, and flow. Similar to other air support requests there are two types, immediate and preplanned. Preplanned SUAV flights should, when possible, appear on the ACO and ATO for maximum visibility to the JAOC, enabling identification and deconfliction from weapons effects or manned platforms. If the SUAV is operating below the coordinating altitude, the division is responsible for airspace deconfliction internally from additional SAUV sorties, CAS, and fires.[49] Immediate requests, while time sensitive in nature, must still coordinate for airspace. Rehearsed events or battle drills, help ensure proper coordination with the ADAM/BAE to safely deconflict manned platforms, and prevent inadvertent engagement of the SUAV by friendly air defense forces.[50]

The process of planning a SUAV sortie begins with determination of the need by the battalion commander, the immediate staff, or the company commander. With the need identified, the battalion operations officer (S-3) determines if there are any internal conflicts with other airspace users and passes the information to the company to begin planning. Simultaneously the battalion staff will submit a mission request to the BCTs ADAM/BAE for review and approval. Upon receipt of the digital or voice message, the ADAM/BAE digitizes the information, if required, and enters the data into the TAIS determining if there are airspace conflicts.[51] If a conflict exists, the ADAM/BAE provides a recommended change based on mission priority and the commander's guidance to the battalion S3 or commander. Once the mission requirements are satisfied between the ADAM/BAE and the battalion, the ADAM/BAE digitally forwards this information to the division A2C2 cell while the battalion refines the mission details.

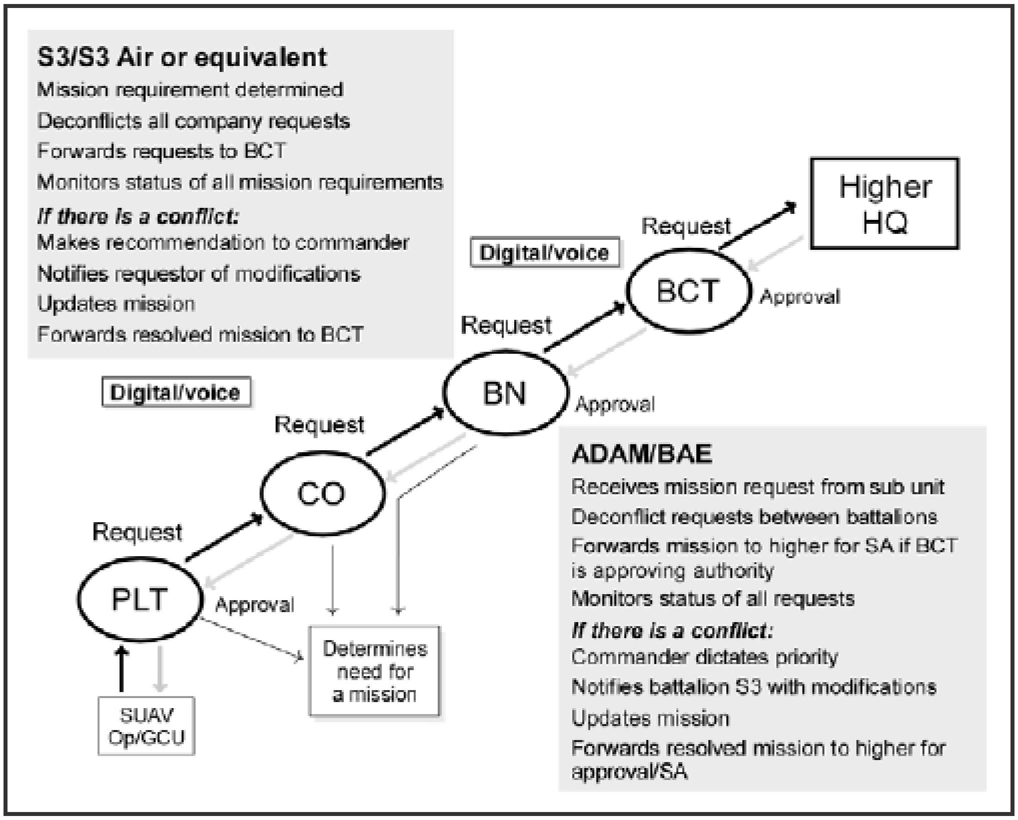

Figure 9. SUAV Mission Flow
Source: Department of the Army, Field Manual 3-04.155, *Army Unmanned Aerial Vehicle System Operations, Final Draft,* August 2005, E-16.

The division A2C2 cell reviews the mission for conflicts in the same manner as the ADAM/BAE and approves the mission with modifications if required. The approved mission is forwarded to all subordinate BCTs for coordination and safety purposes. Figure 9 shows a typical SUAV mission flow.

Normally accompanying the approved mission request is the associated airspace coordination measure. Examples include a restricted operating zone (ROZ) or a blanket of airspace where the UAV has a defined horizontal and vertical area to move freely without further coordination.[52] If the UAV operator determines, for mission requirements, the need to exit the confines of the ROZ, coordination with the next senior A2C2 element must occur first. Recent operations in OIF/OEF have seen a trend by UAV planners to make the dimensions of this type of ROZ over half the size of the country.[53] The rationale, to account for any contingency or mission change, dramatically affects other operations by blocking out large pieces of airspace.

Tracking and Identifying the UAV

> There have already been two mid-air collisions between Raven SUAVs and Army helicopters in theater and at least one near miss recently. These incidents could have been avoided if the helicopter aircrews and Raven operators had a common SA link capable of reporting and displaying the other aircraft's position data.
>
> Major General Thomas Turner,
> Operational Needs Statement 21 July 2005

With UAVs located across the entire battlespace, the problem of tracking unmanned platforms for deconfliction and identification emerges. Larger UAVs, such as the Predator or Hunter, contain an IFF/SIF system designed to supplement radar returns. With the IFF/SIF, the TACS can populate data link networks with the UAV position to the JAOC and air defense networks. Current SUAV technology does not support the capability to carry an IFF/SIF system due to size and weight constraints. This leaves a large number of airspace users not visible to other platforms on the COP. Recent technological advances promise an increase in the visibility of SUAVs across the battlespace through the integration of the Global Positioning System (GPS) and Blue Force Tracking (BFT) mechanisms.

During Operation Iraqi Freedom there were many lessons learned in the airspace control and air defense communities. One of the primary concerns to commanders was the potential delivery of chemical or biological weapons by either a cruise missile or UAV platform. Significant air assets were devoted to defense against this threat, including twenty-four-hour manned DCA coverage against likely launch locations. Complicating the problem was a significant number of unidentified air tracks which persisted in the joint air picture for lengthy amounts of time.[54] Lessons learned on the joint data link network, Link 16, noted not all friendly fixed wing aircraft, Army rotary-wing, and UAV platforms were included in the air picture. This might have prevented the TACS from identifying a potential cruise missile or enemy UAV threat.[55] Even though not all manned platforms were on the data link network, the ability to carry an IFF/SIF and have direct two way radio communications with a component of the TACS allowed detailed integration and responsiveness to the DCA plan.

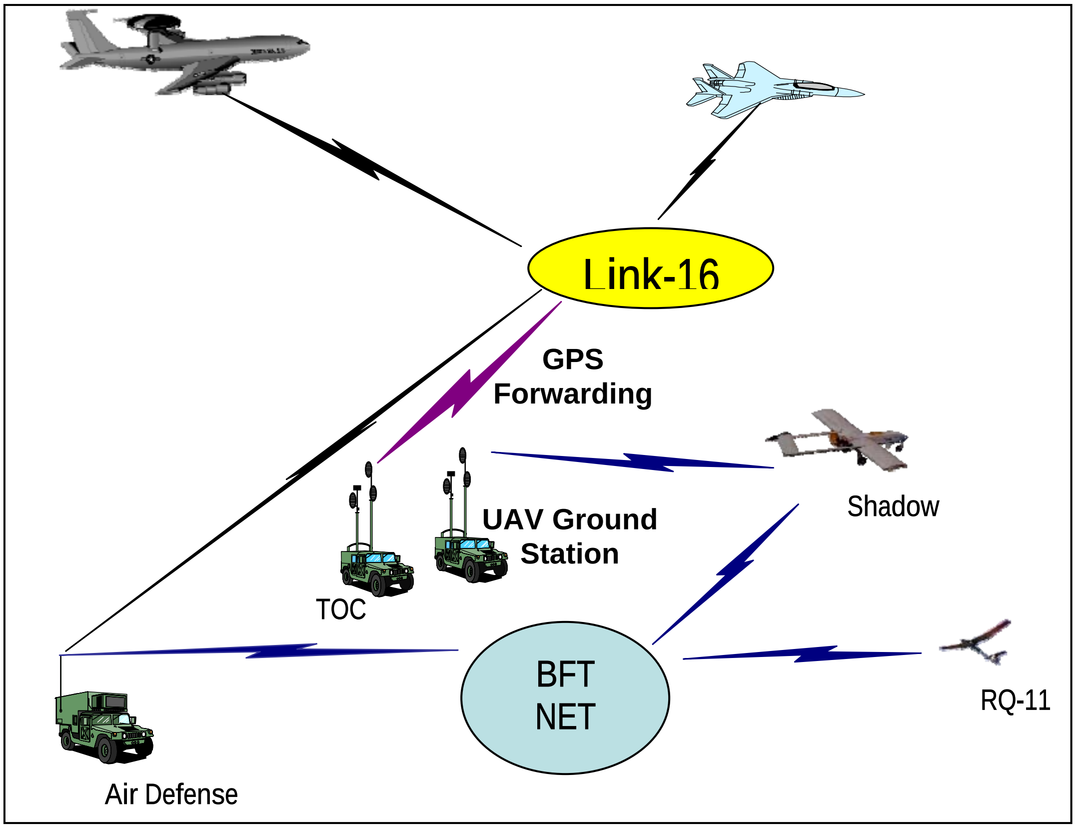

Figure 10. UAV Tracking with Blue Force Tracker
Source: Mike Eison, Presentation on Friendly UAV Identification, Program Interoperability Division, Missiles and Space, 2 February 2006.

UAVs with limited payload capacity have recently been able to enter the air picture through the Blue Force Tracking (BFT) system.[56] Currently UAVs report their GPS derived position back to their respective ground control stations. By manipulating the data with a time stamp and software modification, the UAV GPS position is then forwarded to data link networks, allowing for a common reference within the TACS. With the addition of a Force XXI Battle Command, Brigade and Below (FBCB2) module attached to the UAV ground control station, the GPS derived position is reported to the FBCB2 module for broadcast onto the BFT network.[57] Figure 10 shows the network architecture required to introduce a UAV without IFF/SIF into the current and future joint air picture data links. Integration of this capability is ongoing while units deploy to OIF. As of Feb 2006 the GPS forwarding message stops at the BFT level, with the plans to integrate BFT participants into a joint data link network in the future.[58]

Close Air Support and the UAV

CAS is air action by fixed-wing and rotary-wing aircraft against hostile targets in close proximity to friendly forces requiring detailed integration of each mission.[59] Although normally thought of at the tactical level, the air apportionment and allocation process links CAS to the operational level. CAS planning and execution accomplishes the ground commanders objectives of tactical units or joint task forces.

Command and control of CAS sorties occurs through the JFACC's staff located at the JAOC. Reliable, secure communications are required to exchange information between all participants in a CAS sortie.[60] The JFACC exercises control over CAS sorties through the TACS. In the execution of a CAS sortie, both air and ground components of the TCAS are used, with attack clearance from a joint terminal air controller (JTAC) completing the final step of the CAS process. To achieve the desired effect on the battlefield with CAS, there are many factors which warrant consideration. Several factors outlined in JP 3-09.3 applicable to the thesis include: detailed planning and integration, C4, and streamlined flexible procedures.

The CAS planning and integration model is broken into 5 steps:

Table 2. CAS Planning Model
1. Receipt of Mission
2. Mission Analysis
3. Course of Action (COA) Development
4. COA Analysis/Wargame
5. Orders Production

Source: Joint Chiefs of Staff, Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS)*, 2 September 2005, III-3.

The first major input from the TACS system through the TACP occurs in step two, mission analysis, and is based on initial guidance and the desired end state. By considering the effect on battlefield operating systems by CAS, the TACP contributes to the development of essential fire support and reconnaissance tasks. During COA development, TACPs contribute CAS overlays and sketches, showing how the aircraft will enter and exit the battlespace, and deconfliction options for artillery and UAVs.[61] Wargaming, step four in the process, tests the proposed COA to determine if the assumptions used in development were correct and ensure is it feasible, acceptable, suitable, and complete. Assumptions might include CAS operating altitudes based on the threat, weather, and the status of UAV and rotary-wing activity. During this stage of CAS planning the development of airspace coordination measures occurs in order to maximize airspace flexibility. Figure 11 highlights the CAS planning cycle.

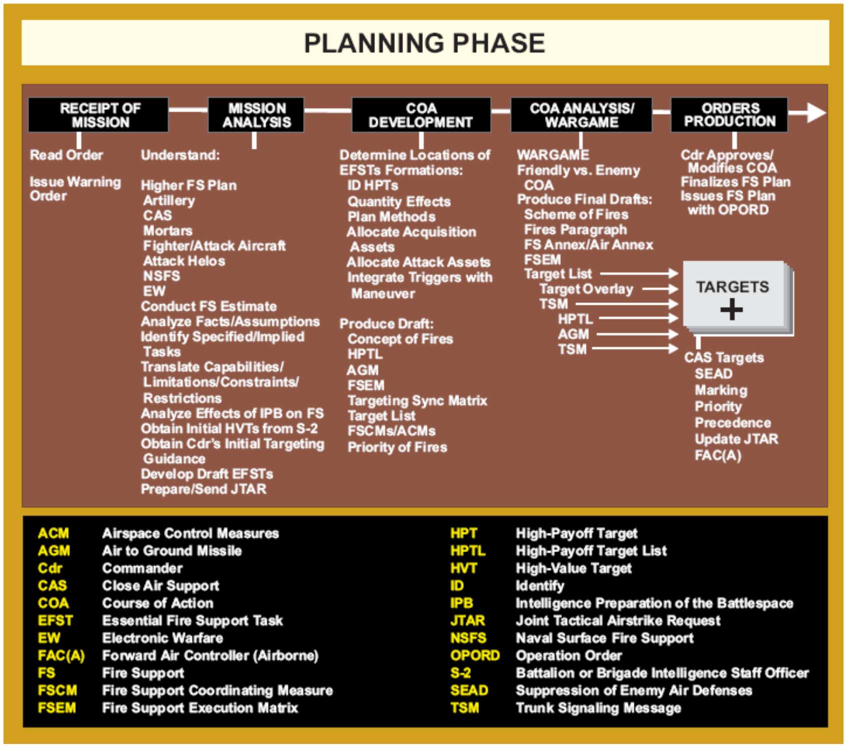

Figure 11. Joint CAS Planning
Source: Joint Chiefs of Staff, Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS),* 2 September 2005, III-4.

During OIF and OEF CAS aircraft operated well above the coordinating altitude. However, external pressures, such as weather or threats, may force fixed wing aircraft into the same environment as the UAV. It is critical for JTACs and staff elements to coordinate their efforts prior to each CAS engagement. Key issues include target nomination, airspace deconfliction and coordination, synchronization, weapons release authority, tactical risk assessment, types of terminal attack control, and which JTAC party will provide terminal attack control.[62] Airspace deconfliction during CAS sorties must allow for the manned aircraft to enter and exit the airspace safely, while considering the impact to other airspace users by the JTAC. JTACs and fire support personnel should select separation techniques requiring the least coordination without adversely affecting the ability to safely complete the mission.[63] By maintaining a high degree of situational awareness on UAV locations, the JTAC on the ground becomes a critical input into the DCA network by helping the airborne TACS track friendly UAVs.

UAVs and Air Superiority

> If we lose the war in the air, we lose the war, and we lose it quickly.[64]
>
> Field Marshal Bernard Montgomery
> Joint Doctrine for Countering Air and Missile Threats

One of the primary objectives the JFC must achieve is air superiority. By reaching this goal quickly the JFC achieves the freedom to attack at the location and time of his choosing as well as freedom from enemy attack.[65] During the Cold War the major opponent to US and NATO air superiority was the Soviet Union's fighter force. With the end of the Cold War the air threat no longer emanates from large technologically advanced forces, rather from small threat nations who are often resource constrained when compared to the US.[66] Air superiority does not solely include dominance of manned threats, but includes unmanned as well. Since the proliferation of GPS technology, UAVs have become an attractive alternative to purchasing cruise missiles, or fielding a manned force capable of delivering weapons to a specific target. According to research conducted by the RAND Corporation, an attack of 60 ballistic missiles and 38 UAVs could achieve a 90 percent destruction rate of aircraft parked in the open at an airbase. To further the destruction, an attack on the corresponding tent city and supporting infrastructure would require the addition of a few more missiles and UAVs.[67] The use of chemical or biological agents, delivered by a UAV, would further complicate a difficult scenario. With as little as 500 kilograms of VX nerve gas or 5 to 10 kilograms of weaponized anthrax and appropriate atmospheric conditions, an area the size of an airbase or staging area is easily covered by a UAV.[68]

With the potential for a UAV to carry WMD, the ability to find and identify hostile threats has become increasingly important. Prior to engaging a threat, DCA assets must follow predetermined rules of engagement (ROE). ROE guidance allows the destruction of enemy targets at the greatest possible range while protecting friendly forces from fratricide.[69]

With the assumption of detection made, the most difficult portion for the DCA assets is proper identification. There are two types of identification, positive and procedural; both designed to allow flexible use of airspace by friendly forces.[70] Procedural control, as defined earlier, relies on preset coordination measures documented in the ACO or ACP. An example of procedural identification is a MRR, which is a corridor established to allow a friendly aircraft or UAV passage through an AO without being engaged. Positive identification relies on high confidence systems such as visual observation, radar tracking from point of origin, and other electronic means.[71] An example of positive identification is an AWACS which maintains a radar track of a target from takeoff at an enemy airfield, or an F-15 electronically identifying an airborne vehicle. If an electronic identification is not possible, often called “lack of friendly,” this does not constitute the authority to destroy a target. The possibility exists the target in question may be a friendly with an electronic malfunction or in the case of a UAV, not have the ability to respond to IFF interrogations. For DCA forces to engage a manned or unmanned vehicle, the theater ROE must be satisfied. The JFC and commanders at every echelon are responsible for establishing and implementing ROE, but their ROE cannot be less restrictive than that approved by a superior commander.[72]

With the numbers and capabilities in UAVs evolving faster than most doctrine, considerable attention and thought is necessary to ensure manned tactical aviation will not suffer. The birth of the SUAV has given ground commanders from the lowest level the ability to see over the next hill, but by placing these UAVs in ever increasing densities across the battlespace the potential impact on manned tactical aviation has increased. The danger for CAS aircraft lies in several areas, from delaying weapons effects due to a conflict with a UAV, to a catastrophic event caused by a midair collision between a 500 mile per hour aircraft and a four pound Raven SUAV.[73] There are promising technologies in BFT with a GPS forwarding message, but this technology has yet to reach the cockpit of either DCA or CAS aircraft to aid in deconfliction and identification. With the potential to mate WMD with a UAV and the problems with identification, the necessity to sort enemy from friendly UAVs is apparent.

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[1]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[2]Ibid.

[3]Ibid.

[4]Dennis M. Gromley and Richard Speier, "Controlling Unmanned Aerial Vehicles: New Challenges," *The Nonproliferation Review 10,* no. 2 *(*2003): 2.

[5]Ibid.

[6]Department of the Air Force, Air Force Doctrine Document 1, *Air Force Basic Doctrine* (Washington, DC: GPO, 17 November 2003), 1.

[7]Chairman, Joint Chiefs of Staff. Joint Publication 3-52, *Joint Doctrine for Airspace Control in a Combat Zone,* (Washington, DC; GPO, 30 August 2004), i.

[8]Ibid., vii.

[9]Ibid.

[10]Ibid.

[11]Department of the Army, Field Manual 3-52 *Army Airspace Command and Control in a Combat Zone,* (Washington, DC: GPO, August 2002), 1-20.

[12]Ibid., II-1.

[13]Ibid., II-2.

[14]Ibid., II-3.

[15]Ibid.

[16]Ibid., III-4.

[17]JP 1-02, 427.

[18]JP 3-52, III-4.

[19]JP 1-02, 124.

[20]JP 3-52, III-6.

[21]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[22]FM 3-52, 2-3.

[23]Ibid., 3-2.

[24]Department of the Army, Field Manual 3-09.13 *Battle Field Coordination Detachment (Final Draft),* (Washington, DC: GPO, April 2003), 2-3.

[25]Department of the Army, Field Manual Interim 3-01.9, *Air and Missile Defense Battalion Operations,* (Washington, DC: GPO, November 2005), 3-5.

[26]Ibid.

[27]Department of the Air Force, Air Force Doctrine Document 2-1.7, *Airspace Control in the Combat Zone,* (Washington, DC: GPO, 13 July 2005), 35-36.

[28]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[29]Center for Army Lessons Learned, Handbook *05-25, The Leader's Guide to A2C2 at Brigade and Below,* (Fort Leavenworth, KS, June 2005), 5.

[30]Ibid., 6.

[31]Ibid.

[32]AFDD 2-1.7, 28.

[33]Ibid., 29.

[34]Ibid.

[35]Ibid., 2.

[36]Ibid., 29.

[37]Ibid.

[38]Ibid., 32.

[39]Ibid., 34.

[40]Ibid.

[41]Ibid., 35.

[42]Ibid., 36.

[43]Ibid.

[44]Ibid.

[45]Air Force Link, "Factsheets; E-8C Joint Stars" (Air Force Official Information Site, October 2005) [document on-line]; available from http://www.af.mil/factsheets/factsheet.asp?fsID=100; Internet; accessed 22 May 2006.

[46]AFDD 2-1.7, 12.

[47]JP 3-52, III-6.

[48]AFDD 2-1.7, 27.

[49]Ibid.

[50]Center for Army Lessons Learned, Handbook *05-25*, *The Leader's Guide to A2C2 at Brigade and Below,* (Fort Leavenworth, KS, June 2005), Page 12.

[51]Ibid.

[52]Ibid., 13.

[53]Department of the Army, Field Manual 3-04.15, *Army Unmanned Aerial Vehicle System Operations, Final Draft*, (Washington, DC: GPO, August 2005), D-13

[54]Mike Eison, "Friendly UAV Identification" Program Interoperability Division, Missiles and Space, Presentation dated 2 February 2006.

[55]Ibid.

[56]Ibid.

[57]Ibid.

[58]Chris Boetig, TRADOC Program Integration Office Battle Command – A2C2, interview by author, 7 Feb 2006.

[59]Chairman, Joint Chiefs of Staff, Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS),* (Washington, DC: GPO, 2 September 2005), IX.

[60]Ibid., X.

[61]Ibid., III-7

[62]Ibid., V-1.

[63]Ibid., V-2.

[64]Chairman, Joint Chiefs of Staff, Joint Publication 3-01, *Joint Doctrine for Countering Air and Missile Threats, Revision First Draft,* (Washington, DC: GPO, 14 September 2005), I-1

[65]AFDD 1, 76.

[66]Davis S. Nahome, "A Joint Approach to Air Superiority," (Masters of Military Arts and Science Thesis, Fort Leavenworth, Kansas), June 2001. 1.

[67]Thomas G. Mahnken, "The Cruise Missile Challenge," *Center for Strategic and Budgetary Assessments*, March 2005, 37.

[68]Ibid.

[69]JP 3-01, xi.

[70]Ibid., V-6.

[71]Ibid.

[72]Ibid., III-21.

[73]FM 3-04.155, 2-7.

CHAPTER 3

RESEARCH METHODOLOGY

The rapid growth in unmanned systems and capabilities has changed the battlespace forever, providing new levels of situational awareness. The transformation of the Army has embraced the unmanned system and increased the density of such systems significantly when compared to the legacy force. The purpose of this chapter is to describe the research methodology to answer the primary question: Will the growth in the number of unmanned platforms have a negative impact on manned tactical aviation? The two major areas of concern for manned tactical aviation include the servicing of targets by CAS sorties and the protection of friendly forces by DCA systems. The increase in the number of UAVs in the battlespace puts into question the ability to deconflict manned and unmanned aircraft and our ability to defend against enemy unmanned threats.

The methodology used to answer this question is broken into three major portions. The first section analyzes the number of unmanned systems in the division shown in figure 1 with relation to the amount of battlespace owned by the division. Derivation of UAV densities is determined by initially assuming UAVs are equally spaced across the division boundaries. Using these densities and the assumption that UAVs will be located at the critical points on the battlefield, the updated or relative densities are calculated. With the updated calculations the research method directly translates to the second and third sections, integration of CAS and DCA sorties.

The initial focus on CAS sorties will analyze A2C2 doctrine and the integration of the TACS with manned tactical aviation. The analysis of CAS and UAV platforms focuses on where, what system, the method of control, and finally where the critical points originate. The DCA sortie will follow a similar approach to the CAS example with a review of the guiding doctrine and integration of the UAV and manned DCA coverage into the TACS. With relevant scenarios, critical analysis of the ability to defend against the unmanned threat is possible.

The author has taken the following approach to obtain the necessary information for review of the topic, researching joint and service specific doctrine, including draft doctrine which contains the most current information. Since the US has yet to fight an adversary with a credible UAV threat, doctrine contains the majority of information regarding defense against UAVs. With the limited number of SUAVs currently fielded the amount of information available has led the author to the Center for Army Lessons Learned website to obtain information on integration of the unmanned platform into operations. Research of relevant publications from the Air Land Sea Application Center (ALSA), a joint center for developing TTPs, and contact with the doctrine center at HQ AF was also established. Personal interviews with the TRADOC Program Integration Office (TPIO), where emerging A2C2 doctrine and TTPs originate, provides a unique level of insight and expertise to the analysis. The personal interviews were conducted through email, phone, and when possible in person allowing the individuals to freely flow their information on the subject.

The criterion used to analyze the data is qualitative, analyzed with the naturalistic inquiry and design flexibility methods.[1] The naturalistic inquiry method is a qualitative method of research in the study of real world situations as they naturally unfold. The lack of a predetermined outcome allows for research in a non-manipulative and noncontrolling manner.[2] Complimenting this is design flexibility which avoids rigid designs and pursues new paths of discovery from the research as they unfold.[3]

For a CAS sortie the soldier on the ground may see the need to destroy an enemy vehicle immediately, whereas a commander with a larger area of concern does not feel the urgency of the situation. The same principle applies in defending against enemy UAVs. A ten foot wingspan sized UAV may not be able to mass conventional firepower on a target but a SUAV with a WMD payload passing through the DCA coverage may have a catastrophic effect. With a qualitative approach the author uses scenarios, such as the ones above to help analyze the framework and doctrine with the current airspace structure in chapter 4.

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[1]Michael Quinn Patton, *Qualitative Evaluation and Research Methods* (Newbury Park: Sage Publications, 1990), 40.

[2]Ibid.

[3]Ibid., 41.

CHAPTER 4

ANALYSIS

> I will tell you that a commander without the proper C2 assets commands nothing except a desk. You must have the ability to communicate with the forces under your command. You must have the ability to exchange information with them freely, frequently, and on a global basis. It's one thing to have highly technical, sophisticated observation platforms, but if you can't use the information in a timely manner, it's wasted.
>
> General (ret) Ronald R. Fogleman

This chapter analyzes the use of manned and unmanned aviation in the same battlespace with the criteria and methodology laid out in chapter 3. Chapter 4 analyzes the primary, secondary, and tertiary questions listed below:

Primary Question: Will the growth in unmanned aerial vehicles have a negative impact on manned fixed wing tactical aviation?

Secondary Questions:

1. How will CAS be deconflicted to prevent a midair collision or prevent delays in achieved the desired effects?

2. Will the proliferations of UAVs both friendly and enemy prevent the JFC from achieving air superiority?

Tertiary Questions:

1. What is the maximum and sustained number of UAV sorties a division can generate in a 24 hour period?

2. What is the proposed level of control and authority to regulate airspace in a modular division?

3. Will Tactical Air Control Parties have access to a common operating picture and know where friendly UAVs are located in real time?

4. Is there a way to determine is a UAV is friendly or enemy?

Chapter 4 answers the research questions stated above starting with the tertiary and ending with the primary question.

Tertiary Questions

In addition to the primary question there were four tertiary questions generated for this thesis. The first question deals with the number of UAVs the modular division (represented in figure 1) can generate for steady state and surge operations. The total number of unmanned systems is 320 with 105 of those flyable at any one time. This is due to maintenance requirements, radio frequency deconfliction, personnel, and control terminal availability. If required, the ability exists to surge this number with a change in task organization, increasing control terminals, and expanding the number of available radio channels. With these changes a surge capability of an additional 20 percent is possible increasing the maximum number of UAV sorties in the division's airspace at any one time to approximately 125.[1] Based on interviews with armor and infantry officers a realistic amount of battlespace for a division with two maneuver BCTs is an area of 35 kilometers by 35 kilometers.[2] This equates to a density of one UAV every 9.8 square kilometers if the UAVs are spaced equally across the division's AO. Given that not all areas covered by the division require observation, UAV densities at key locations on the battlefield will increase.

Typical fighter holding patterns are approximately ten nautical miles in length before commencing a turn which may take an additional two miles. This creates a race track type pattern which may cover up to fourteen miles from end to end. With the UAVs perfectly spread across the battlespace a set of fighters holding could easily cross up to eight UAV orbits controlled by multiple brigades. If the threat or weather has driven fixed wing aircraft, which normally operate in mutually supportive formations of two or four aircraft, into using low-altitude tactics operating at or near the coordinating altitude, UAV orbits will require special attention for deconfliction. A typical fighter aircraft run in from low-altitude is approximately ten miles starting from an initial point and leading to the desired target. This distance does not take into account any maneuvers required to minimize or defeat potential threats. Given this set of conditions is it certain the fighters would cross multiple UAV orbits. With these factors it is imperative that the division A2C2 structure is prepared for steady state and surge operations in all weather and threat conditions.

The second question relates to the proposed level of control and authority to regulate airspace in a modular division. The A2C2 cell in the division has the authority and communication equipment to execute procedural control within the division's boundaries.[3] An area of concern within the A2C2 cell at the division is the number of personnel. Currently there are two officers and five enlisted personnel in the division A2C2 cell.[4] With twenty-four-hour operations and the requirement to review, modify, forward and approve large numbers of UAV sorties constantly, the potential for error is significant. The division A2C2 cell is only capable of exercising procedural control requiring the extensive use of ROZs and other ACMs to deconflict UAV from manned tactical aviation. The A2C2 cell has the required tools to integrate the airspace but how the airspace is used is personality driven. A division may elect to reserve large amounts of airspace for the future UAV operations planning for every possibility. This can quickly lead to an inflexible structure with contingency airspace requirements affecting current operations.

Technological advances for future UAV systems include the addition of blue force tracking and making current UAVs visible to the TACS.[5] The technological advances in the UAV region are impacting the battlespace in Iraq today. By tracking TUAVs on the BFT with the GPS forwarding message to a joint data link network, all levels of command will benefit from increased situational awareness. US Air Force personnel found at the lowest levels of Army command include the TACPs. The TACPs are the link in the GTACS system between the Army UAV and fixed wing manned aviation. With this function it is critical that the TACP have knowledge of all UAVs in their area of operation and have the means to deconflict these aerial platforms. This capability relates to the tertiary question of whether or not the TACP will have access to the COP to know where the UAVs are located. The lowest level where the TACP is located is the battalion. At this level the TACP will not have access to the A2C2 cell and COP located at the brigade.[6] However, through the TACS system the TACP is able to communicate with personnel who have access to the COP and are able to relay information to the TACP. When fixed wing assets check into the area with the appropriate ASOC, a picture of the COP and the most current tracking information on UAVs in the assigned airspace is available. By relaying this information to the fixed wing aircrew, their situational awareness builds over the planned operating area. The TACP located at the battalion level may or may not be in direct contact with the UAV operator but has a line of communication via the tactical operations center (TOC) to facilitate informal coordination measures at the battalion.

With the potential for large numbers of UAVs to be airborne at any one time, the ability to differentiate between friendly and enemy UAVs is daunting. Currently the only unmanned systems that are compatible with the current electronic means of identification are the larger platforms such as the Hunter TUAV. By using the GPS forwarding message, future software upgrades may allow all UAVs to populate the BFT network and eventually the joint common operating picture. However data link pictures alone will not suffice to determine if a UAV is friendly or enemy. The problem arises in the difference in refresh rates between real time and radar tracking over a congested battlespace. For example the a UAV is traveling at 60 knots and is sending a GPS forwarding message every 30 seconds to the ground station to the BFT network. The BFT network also has an approximately delay, or refresh rate, of 30 seconds, which is sent to the joint data link networks and eventually to the fighter cockpit. When the fighter aircraft locks this UAV with his radar, real time information on the exact location of the UAV is presented, this contrasts to the joint data link network which shows historic information up to a minute old. This leads to two tracks in the fighter cockpit for the same contact, one historic from the joint network and the second being actual location of the UAV from radar data. With the difference in the refresh rates and real time radar tracking the ability to quickly identify a UAV may be difficult.

If the aircrew is unable to acquire an electronic identification, a visual identification (VID) is the next course of action. While there have been no operational tests on visual identification of UAVs by interceptor aircraft, the author would equate this task to trying to determine the difference between a falcon, hawk, or osprey as the aircrew passes by with approximately of 200 miles per hour of overtake. With interceptor aircraft covering large volumes of airspace the potential to cross multiple divisional boundaries is certain. For the interceptor aircraft to safely descend to the altitude of the unknown UAV from distances ranging up to 60 miles, a large number of friendly UAV orbits must be crossed to reach the intercept point of the unknown system. The question of identification of a UAV as hostile depends on a large number of variables. For example, if detection of an unknown UAV occurs in an area where there are no friendly units with UAVs airborne, this alone may trigger the ROE to engage the UAV. A more likely scenario would be the detection of unknown air contacts by fighter aircraft located near friendly units. Before the engagement of these targets the controlling agency must ensure the UAV is enemy. This will require an intense amount of rapid communication to ensure the timely engagement of the threat UAV. The communication chain involved is the JAOC, BCD, the CRC or AWACS platform, and the senior A2C2 section. This communication architecture exists to help determine if the UAV is enemy or friendly but may require more time than is acceptable.

Secondary Questions

To answer the primary question on the impact UAVs have on manned fixed wing aviation generated two secondary questions. These questions correlate to deconfliction between aircraft and UAVs and the attainment of air superiority against the UAV threat. These questions when answered form the basis for answering the primary question.

To many it may seem the UAV's size and weight does not present a danger to fixed wing aviation. The current generation of SUAVs employed by US forces includes the Dragon Eye, Force Protection Aerial Surveillance System (FPASS), Pointer, and Raven with an average weight for these systems of just under six pounds.[7] These systems are each capable of flying above the coordinating altitude presenting a collision hazard to manned aviation. Even when the UAV remains below the coordinating altitude the fixed wing sortie may be required to share this airspace based on weather or threat. During Operation Anaconda a two ship of F-15E Strike Eagles was required to hold in airspace offset from a troops in contact situation to allow a UAV to observe the situation.[8] The propensity to desire a UAV over such locations increases the UAV density and collision potential with manned aircraft.

Still, does this present a threat to manned aviation for deconfliction? Since 1985 US Air Force aircraft have had 66,642 bird strikes resulting in over $715 billion in damage.[9] The SUAV lies in the same weight category as many of the bird strikes with one major difference: the SUAV carries much denser parts to include cameras, engines, and batteries.[10] The effect of hitting a six pound object with metallic parts while traveling at over 500 knots would most likely result in catastrophic damage depending on impact point.

The main link in the safe separation between the UAV and manned fixed wing aviation resides in two areas of the A2C2 and TACS system, these areas are planning and current operations. Reaching into the A2C2 planning structure, the responsibility for deconfliction at battalion level between the UAV and fixed wing air resides at the S-3 or operations officer. The TOC at the battalion is responsible for the tracking and communications with the ADAM/BAE to procure and clear airspace for UAV sorties, which is passes up the AAGS to the BCD located at the JAOC. FM 3.04.155 *Army*

Unmanned Aerial Vehicle System Operations recommends planning with a single point of contact to track all airspace requests and make recommendations based on the emerging situation for airspace involving CAS and UAVs.[11] Staff planners must monitor UAV airspace to ensure it does not conflict or prevent current and ongoing operations.[12] Changes in the allocation of CAS, artillery, Army aviation, and the dynamic retasking of UAVs will almost certainly cause conflicts in airspace usage. To address these changes, the supported unit must have a periodic A2C2 meeting with key players including the ADAM/BAE, ECOORD, S3 Air, and the air liaison officer (ALO) to address these issues. Actions may include the redirection of the UAVs to a different pre-planned ROZ or adjusting its current ROZ.[13] This process must be part of the battle rhythm and have surge capability for high tempo operations. During the planning phase for future operations the conduit to ensure visibility to all airspace users is the ATO. By placing the UAV sortie in the ATO, SPINS, or ACO the mission is coordinated with the ACA, AADC and the JFACC. This ensures separation from manned systems and prevents engagement by friendly air defense assets.[14]

During the execution of the ATO the TACS will block off the airspace unless the originating unit cancels the request. This has several implications to airspace users. If the airspace remains unused and is not cancelled, this specific portion of the battlespace will remain clear of manned aviation. This may prevent a timely response from air assets due to extra coordination to determine if the airspace is in use and then to open the airspace to all users. Since not all UAVs are visible to the TACS, delays caused by coordination are highly possible. Through war gaming in the military decision making process (MDMP) uncovering critical areas in the airspace structure will ensure the preservation of assets, both the unmanned and manned systems.

During the battle the ability to dynamically retask both the SUAV and manned fixed wing aviation in real time requires further safeguards for proper airspace deconfliction. Before retasking a SUAV mission at battalion level the TOC must contact the ADAM/BAE at brigade to begin the process of requesting the necessary airspace. The following information is required at the ADAM/BAE before clearing the mission:

Table 3. SUAV Immediate Request Format

1. Unit identification (call sign and frequency).
2. Launch and recovery site.
3. Restricted Operating Area location (includes GPS coordinates and operating altitude).
4. Ingress route, azimuth and distance.
5. Egress route, azimuth and distance.
6. Times and durations of mission.
7. SUAV operating channel.

Source: Department of the Army, Field Manual 3-04.155, *Army Unmanned Aerial Vehicle System Operations, Final Draft,* August 2005, E-10.

The ADAM/BAE receives the information and transfers it into the TAIS, making the request visible from the ADAM/BAE to the BCD located at the JAOC. TBMCS, the Air Force interface with TAIS completes the loop to the airspace cell located in the JAOC which reviews the request for the impact on current operations. The airspace approval routing is similar to that of a CAS request, in which the absence of an input equates to approval. Once approved the unit may move the UAV to the desired location.

UAVs may conduct operations above the coordinating, below the coordinating altitude or a combination of both. If the UAV operates below the coordinating altitude no additional inputs are required to the JAOC with internal tracking and approval by the division.[15] The primary emphasis when operating below the coordinating altitude is deconfliction from rotary-wing and fires effects.[16] In this example, the UAV remains below the coordinating altitude but due to the weather or threat CAS aircraft must also use the same vertical airspace levels. The TACS system remains relatively untasked in this example save for the joint terminal air controller (JTAC). The JTACs and TOC elements must coordinate their efforts prior to each CAS engagement. The key areas of concern which require understanding by all include battle tracking, target nomination, airspace deconfliction, and synchronization.[17] With the battle tracking information from the TOC the JTAC is able to make real time deconfliction decisions enabling fixed-wing effects at the location desired by the commander. If the JTAC is not collocated with the TOC, the passing of critical information can occur through any suitable means prior to the CAS platforms entering into occupied airspace. This requires the JTAC have either the ability to communicate with the unmanned system operator either directly or through the TOC. With this line of communication the ability to move the UAV either laterally or vertically is possible enabling CAS assets to enter the battlespace. While the communication links exist, the question of authority to move the unmanned asset requires coordination with the appropriate personnel, normally the S/G-3 or higher. The process of moving the UAV or restricting the run in of CAS aircraft occurs through the process of informal ACAs, designed to be an expedient method for JTACs to deconflict aircraft from other airspace users. These measures are usually short lived and designed to provide immediate deconfliction between systems. The deconfliction methods include lateral, vertical, time or a combination of all three. In the case of the UAV and manned system in the previous example lateral deconfliction is the best choice to allow rapid weapons effects while keeping the unmanned system in the area.

If the UAV penetrates above the coordinating altitude, additional tasking of the TACS occurs. The UAV, now located in airspace under positive control is required to be in radio communication with the controlling agency, either an AWACS or a CRC. Since many UAVS are difficult to detect by electronic means and may not have the GPS forwarding capability, a restricted operating zone (ROZ) is normally established. This coordination measure allows the UAV to perform its mission above the coordinating altitude as shown in the figure 12.

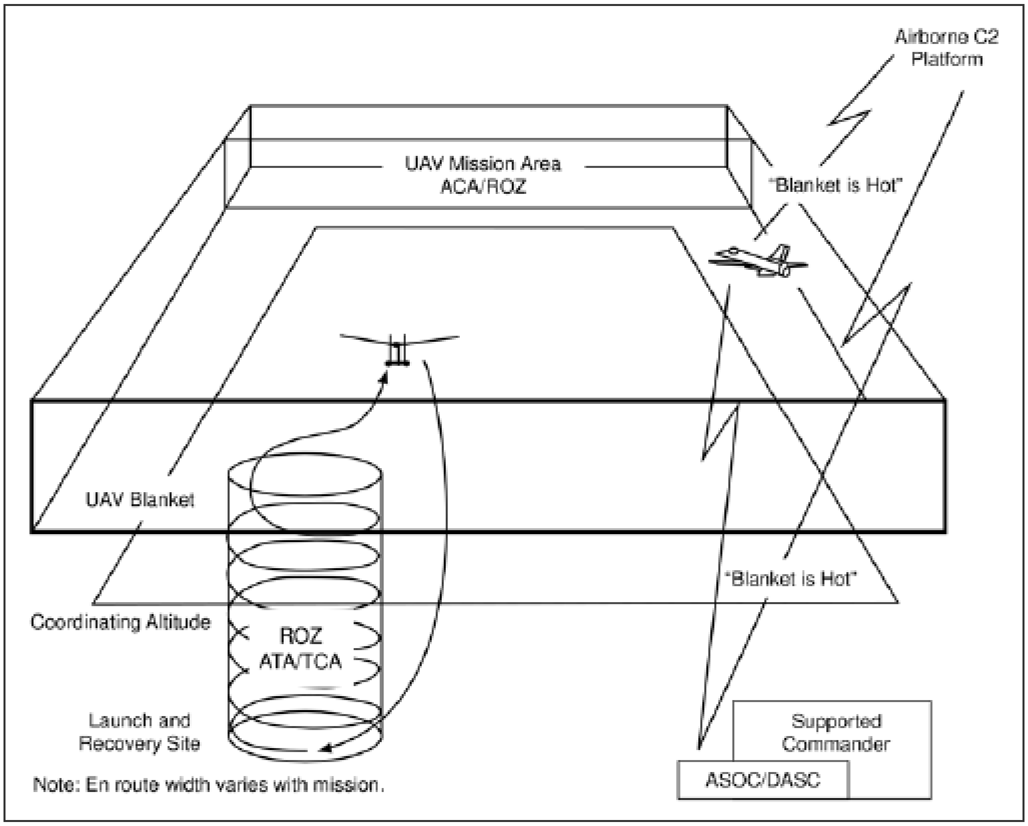

Figure 12. UAV Blanket ROZ
Source: Department of the Army, Field Manual 3-04.155, *Army Unmanned Aerial Vehicle System Operations*, *Final Draft*, August 2005, D-13.

While the UAV blanket ROZ seems like an easy solution there are many implications to this method of deconfliction. In ongoing operations in OIF and OEF there has been a trend in planners and operators to make the ROZ over one-half the size of the country.[18] The logic allows for almost any type of contingency and dynamic retasking of the UAV without further coordination. If an aircraft wishes or is required to enter this airspace it must do so under see and avoid conditions at their own risk. With the multiple unmanned systems flying it is easy to imagine an entire AOR blanketed with ROZs causing large delays in the application of air delivered effects. These effects may limit not only the close in battle but deep operations also as weapons dropped from altitudes above the ROZ need to be cleared to prevent loss of the unmanned system. Coordination for the ROZ and clearing airspace often takes time, and these delays may prevent the application of combat power at the necessary time.

The amount of time necessary before the destruction of an enemy by CAS assets is subjective to say the least. To the soldier in foxhole with an approaching tank seconds count, while at division level an isolated tank may not even meet engagement criteria for CAS. Areas which UAVs have the potential to cause time delays in the application of manned fixed wing aviation reside primarily in the following areas: coordination for airspace and the ability to make near real time decisions to move UAVs with informal ACAs. Specific points of friction include the electronic interface from the ADAM/BAE to the BCD at the JAOC. Due to the unique nature of airpower's ability to range large areas of battlespace, time sensitive targeting is affected. With ISR platforms such as the Global Hawk, the kill chain has shortened to minutes requiring immediate action from multiple sections. These actions must now deconflict from UAV operations to prevent delays in achieving the JFCs intent.

Weapons effects, time sensitive targeting and CAS requests are not the only implications of UAV operations. The US Air Force maintains air superiority as one of its key Air and Space functions.[19] The US Air Force has shown its commitment to US ground forces which have not been the subject to attack by enemy airpower since the Korean War. The addition of the UAV in large numbers to the battlespace raises the question of whether or not the US is capable of defending against UAVs. With the assumption in chapter 1 of the ability to detect UAVs with a new generation of AESA radar technology the question becomes that of proper identification. Currently all SUAVs in the US inventory do not have IFF/SIF capability which severely complicates the identification process. As noted in the tertiary questions the ability to determine if a UAV is friendly or enemy is in question. Population of data link networks increases situational awareness with the GPS forwarding message but this also has limitations. The ability to enter into the current air COP (Link 16) is limited to a finite number of participants and currently the BFT tracking message does not populate the Link 16 network.[20] The current Link 16 architecture works on time intervals where a participant enters and receives data from the network according to a defined time slot.[21] With the increase in the number of unmanned systems the potential exists to saturate the link 16 network. Airborne platforms also have a second limitation due to multifunction display (MFD) refresh rates and thus are limited the amount of symbols they are able to draw. During OIF the author was unable to use peacetime training patterns with the MFD due to the number of aircraft, with no UAVs, in the Link 16 network, causing the MFD to enter symbol overload failure mode.[22]

Does the US military even need to defend against enemy UAVs? Does a UAV possess the ability to mass effects on the battlefield? With the potential for a UAV to be a WMD platform the necessity to find, identify and engage this threat is clear. Even without WMD, the ability to crash a 15-pound warhead into a command post may have severe implications in an operation. The inability to identify a UAV as friendly or hostile either by electronic or visual means opens up a large seam in the air defense network which a potential enemy can exploit. For example, an enemy insurgent team has acquired a weaponized biological agent contained in a small aerosol can and mounted to a SUAV.

Using established lines of communication they are able to reach a population center within five miles the target area where US or coalition forces are conducting operations to include flying their organic UAV assets. With a speed of sixty miles per hour the AADC and TACS system would have less than five minutes to find, identify and engage the target SUAV before it is able to release its payload. The short flight times coupled with a limitless number of launch sites and complex terrain, such as urban environments makes the successful engagement of the SUAV analogous to finding a need in the haystack.

Primary Question

Is the growth in UAVs having a negative impact on manned fixed wing tactical aviation? This question is broken into two areas, the ability to rapidly deconflict from the UAV and the ability to find and engage enemy systems.

The ability to deconflict from friendly unmanned systems exists with the current AAGS and TACS in place. Through the use of airspace integration tools such as TBMCS and TAIS, deconfliction software is available down to the brigade level to facilitate deconfliction. The transformation of the US Army to the modular divisions also brings a greater capability to coordinate the battlespace. Dedicated personnel and equipment will increase the knowledge and expertise helping to minimize delays in the application of airpower. Due to the fog and friction of modern warfare, the potential exists for delays due to lost communications or lost link operations with UAV systems. Units must have well rehearsed battle drills to respond with the changing situation in the contemporary operating environment.

Currently the SUAV is not visible on a COP and therefore deconfliction must occur through procedural control. This relationship puts the TACS in a reactive mode and forces large amounts of coordination to open and close airspace. With aircrews and UAVs flying around the clock the airspace structure briefed before takeoff may be significantly different from the real time structure once airborne. The ability to integrate the unmanned system and prevent delays rests with the TACS ability to assimilate the information and transfer this into positive control. While the ability exists in the current structure, there are friction points which can slow the process down and prevent the timely application of fires.

The ability to rapidly acquire and engage enemy fighters as the US military has demanded is not yet feasible against the UAV with current systems. During Desert Storm US fighter aircraft oriented their patrol locations and sensors to detect and engage Iraqi aircraft immediately after takeoff. With the ability to cue sensors to specific locations, i.e. airfields, coalition aircraft could optimize their intercept of the enemy. The UAV and more specifically the SUAV have the ability to launch from virtually any location. In a nonlinear battlefield, ADA assets such as the US Army Patriot and fighter combat air patrols (CAP) could just as easily be oriented in the wrong direction. This places DCA platforms at a disadvantage since typical fighter radars only sweep +/- 60 degree in azimuth and +/- 30 degrees in elevation from the centerline of the aircraft and ADA assets also have set radar zones. Using the division shown in figure 1 and assuming half of their unmanned assets are airborne, a fighter pilot would have to sort over 50 contacts on a display of 6 inches by 6 inches, all which do not reply to friendly interrogations making successful engagement unlikely.

The UAV is here to stay and will change the battlespace forever. General Mosley, US Air Force Chief of Staff, in his address to the Senate on the fiscal year 2007 posture reiterates the US Air Force commitment to UAVs with expansion in current UAV programs and voiced concerns over increasing enemy UAV platforms.[23] The expansion of friendly UAVs will task the current air coordination system but it is not impossible to manage. Increases in the A2C2 structure and emerging technologies may alleviate many of the potential problems associated with deconfliction and identification. The ability to defend against enemy UAVs presents a much more challenging situation given the current UAV force. The lack of IFF/SIF on the vast majority of UAVs presents DCA assets with identification problems making successful engagements nearly impossible. The growth in UAVs has affected fixed wing manned tactical aviation. The structure is present to ensure deconfliction and engagement but requires more attention in the planning and execution phases to preserve the US airpower asymmetric advantage.

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[1]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[2]Major Douglas Keeler, US Army Armor officer, and Major Mark Read, US Army Infantry officer, interview by author, 18 November 2005.

[3]FM3-52, 1-20.

[4]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[5]Chris Boetig, TRADOC Program Integration Office Battle Command – A2C2, interview by author, 7 February 2006.

[6]This information came from the TRADOC Program Integration Office, Battle Command – A2C2 Cell Fort Leavenworth, Kansas, taken from a presentation titled "Army Airspace Command and Control in the Modular Force," 29 April 2005.

[7]Office of the Secretary of Defense, "Unmanned Aerial Systems (UAS) Road Map, 2005-2030" (Washington, DC: GPO, 4 August 2005), 26.

[8]Headquarters United States Air Force / XOL. "Operation Anaconda and Air Power Perspective" (Washington, DC: GPO, 7 Feb 2005), 76.

[9]Air Force Safety Center, "USAF Wildlife Strikes by Fiscal Year," (Air Force Safety Center, Aviation Division, 30 Sep 2005) [document on-line] available from http://afsafety.af.mil/SEF/Bash/web_year_stat.html; Internet; accessed 22 May 2006

[10]OSD UAS Road Map, 26.

[11]FM 3-04.155, 5-13.

[12]Ibid., 5-14.

[13]Ibid.

[14]Ibid., D-6.

[15]Ibid., E-9.

[16]Ibid., E-7.

[17]JP 3-09.3, V-1.

[18]FM 3-04.155, D-13.

[19]AFDD 1, 1.

[20]Chris Boetig, TRADOC Program Integration Office Battle Command – A2C2, interview by author, 7 Feb 2006.

[21]ACC/DOYJ. "Combined Joint Network AFBX/0011A Network Description," (Langley AFB, VA, 22 Mar 04), 3-15.

[22]This note is based on the author's personal experience during Operation Iraqi freedom.

[23]Department of the Air Force, "Presentation to the Armed Services Committee United States Senate, Fiscal Year 2007 Air Force Posture" (Washington, DC: GPO, 2 March 2006), 18.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

> The Air Force will exploit the technological promise of unmanned aerial vehicles and explore their potential uses over the full range of combat missions.
>
> Global Engagement: A Vision of the 21st Century Air Force

The transformation of the US Army to a modular force includes the procurement of unmanned systems from the corps down to the company level. These unmanned systems give Army commanders access to ISR platforms in large numbers. Will the increase of the ground commanders ISR capability have an unintended consequence of degrading the theater air control system? Can the US maintain air superiority and successfully engage the enemy's threat array of UAVs? The purpose of this thesis is to analyze the growth in unmanned systems and their impact on manned fixed wing aviation. This thesis was broken in two main areas, the integration of the unmanned systems into the A2C2 and TACS structure and the UAVs effect on the ability to achieve air superiority. Chapter 5 includes a brief summary of the findings from chapter 4 and looks at the potential implications of the results. Following the review the author will make recommendations for further study to include areas left for future action.

Review of Findings and Implications

Chapter 4 concludes that the rapid growth in UAVs will impact manned tactical aviation. The current A2C2 and TACS structure can support the growth, but with a price in time delays. Populating the battlespace with large numbers of UAVs controlled by multiple brigades and potentially multiple divisions limits the ability to rapidly clear airspace. CAS platforms may experience delays delivering desired effects while waiting on the status of multiple UAV tracks in order to facilitate the safe passage. Current technology might bridge the gap of the deconfliction by allowing UAVs to enter joint data link networks, but this is still years away from incorporating all classes of unmanned systems.

Currently the vast majority of UAVs operate under procedural control with 83 percent of the UAVs in a division lacking the ability to respond to identification requests. These factors coupled with the TACS coordination requirements on all UAV locations, will test the ability of air defense assets to quickly identify a UAV as friendly or enemy. The proliferation of UAVs also complicates friendly air defenses ability to locate a UAV due to the limitless number of launch site locations to include urban terrain. Historically air defense assets have been able to orient their sensors to known locations such as airfields. UAVs undermine this TTP launching from virtually anywhere. Assuming detection of a UAV, the inability to identify a UAV as friendly or enemy will most likely force the fighter interceptors into a VID mode. To accomplish this mission the interceptor aircraft will cross multiple friendly UAV orbits to reach the location where the unknown threat is located. With the interceptor aircraft originating above the coordinating altitude a large amount of synchronization is necessary to clear friendly UAVs along the intercept axis allowing a safe descent by the interceptor to the threat UAV altitude. With these considerations, manned air defense fighters will undoubtedly feel the growth in UAVs across the battlespace, potentially resulting in the inability to stop enemy UAVs.

Recommendations

Many of the technological innovations for the UAV focus on the ability to operate higher, fly longer, get there faster and collect in more spectra than previous models. Future generations of UAVs must also include the ability to populate joint data link networks and manned assets should have the ability to enter the network as well. This technology helps alleviate the stress points located in this thesis. The TACS and A2C2 elements benefit by having the ability to electronically see each unmanned system making real time deconfliction possible. The ability to deconflict, enabled by viewing the location and altitude of a UAV track on a multifunction display, allows aircrews and TACS elements to build situational awareness. Interceptor aircraft can rapidly correlate their radar information with the data link network to quickly sort the threat from the friendly UAV.

The addition of UAVs in the joint data link networks presents additional considerations which are beyond the scope of this thesis but merit consideration. The amount of additional information presented on small cockpit displays could quickly overwhelm the aircrew or mask a potential threat. As UAVs enter data link networks, development must also occur in fighter software suites to allow the filtering of information presented to the aircrew. The ability to select or deselect UAVs tracks allows the aircrew to manage the amount of information presented to acceptable levels.

Currently there is no program in place to have aircrew train against all classes of UAVs. Fighter aircrew should receive training on the visual identification features and capabilities of friendly and threat UAVs. This is crucial as VID is the final step when all electronic means to identify the UAV have failed. Currently the US Air Force trains to intercept against low and slow aircraft simulated by a fighter size aircraft. Using actual UAVs during intercept training and in large exercises such as Red Flag gives a realistic threat presentation to not only the pilots but the entire theater air control system.[1] Training against actual UAVs in peacetime will facilitate combat success in future conflicts.

Traditionally fighter aircraft have conducted DCA with aircraft such as the F-15 designed specifically for this purpose. The design of these aircraft allowed them to cover large volumes of airspace quickly to intercept an enemy fighter, not a hand launched UAV. By flying very low and slow the UAV increases its chances of escaping detection and identification by interceptors. However, also flying in this regime is a large number of rotary-wing assets which are better suited to engage UAVs. With similar speeds and operational altitudes, rotary-wing aircraft are prime assets to identify and engage the UAV threat. Currently attack rotary-wing training does not include the intercept, identification, and engagement of UAVs. However attack pilots manuals such as FM 3.04.111 *Aviation Brigades* and FM 3.04.140 *Helicopter Gunnery* provide the building blocks and recommendations for engaging aerial targets. These FMs contain basic sight computations, weapons selection, and engagement ranges for air to air encounters.[2] Combining these skills with the ability to communicate with the TACS lays the foundation for a rotary-wing DCA platform to defend against enemy UAVs.

Further Action

One of the major areas requiring further review is in the actual engagement of UAVs. The current generation of Air Force missiles include the Advanced Medium Range Air to Air Missile (AMRAAM) and the heat seeking Air Intercept Missile (AIM)-

9X while the US Army utilizes the Patriot and Stinger systems. Both services missile systems were designed to engage a fighter size target but also have the capability to target the larger class of TUAVs. However the SUAV presents unique problems to these systems due to its size and speed. To keep this thesis unclassified the targeting of SUAVs was not explored but is a critical portion of the intercept process. If the threat UAV is hostile and clearance to engage is given, the DCA system must be capable of eliminating the threat, especially with the potential of WMD on an SUAV.

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[1]Red Flag is a realistic combat training exercise involving US and allied air forces conducted on the Nellis AFB range complex. Red Flag uses the most realistic settings available with dissimilar aircraft that replicate threat weapons and tactics.

[2]Department of the Army, Field Manual 3-04.140, *Helicopter Gunnery*, (Washington, DC: GPO, July 2003), 7-11 thru 7-14.

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