Air University

Stephen R. Lorenz, Lt Gen, Commander

Air War College

Stephen J. Miller, Maj Gen, Commandant
Stephen Wright, Col, Dean
Lawrence E. Grinter, PhD, Series Editor
Jeff Hightaian, Col, Essay Advisor

Air University Press

Shirley B. Laseter, DPA, Director
Bessie E. Varner, Deputy Director
Demorah Hayes, Content Editor
Lula Barnes, Copy Editor
Vivian D. O'Neal, Prepress Production
Daniel Armstrong, Cover Design
Mary J. Moore, Quality Review

Please send inquiries or comments to
Editor
The Maxwell Papers
Air War College
325 Chennault Circle, Bldg. 1401
Maxwell AFB AL 36112-6427
Tel: (334) 953-7074
Fax: (334) 953-1988
http://www.au.af.mil/au/awc/awcgate/awc-mxwl.htm

AIR WAR COLLEGE
AIR UNIVERSITY

Integration of Weaponized Unmanned Aircraft into the Air-to-Ground System

DAVID B. HUME
Colonel, USAF

Air War College
Maxwell Paper No. 41

Air University Press
Maxwell Air Force Base, Alabama

September 2007

This Maxwell Paper and others in the series are available electronically at the Air University Research Web site http://research.maxwell.af.mil and the AU Press Web site http://aupress.maxwell.af.mil.

Disclaimer

Foreword

Unmanned aircraft (UA) now carry air-to-ground Hellfire missiles that give the operator the ability to not just find and track ground targets, but also strike them with great precision and lethality. Demand is high for the enhanced capabilities of armed UAs. However, there is currently no joint consensus on the development and employment of UAs. Within the Air Force, the ways intelligence, surveillance, and reconnaissance (ISR) and ground attack assets are doctrinally resourced, tasked, and flown in support of requirements are at odds with each other. Moreover, the Army's Warrior UA and the Air Force's Predator have some overlapping capabilities: they operate at similar altitudes, and both carry Hellfire missiles. Operators wrestle with competing operational employment concepts: is the armed UA a strike or an ISR asset? The answer to that question is fundamental to tasking and employment, which in turn must be shaped by consistent doctrine.

In this paper, Col David B. Hume, who served as an expeditionary air support operation group commander in Operation Iraqi Freedom, explores some of the mission employment and doctrinal issues associated with this emerging weapons system and argues that weaponized UAs should be commanded and controlled just like close-air-support (CAS) assets. He argues that the Army's Warrior program, while having many beneficial aspects, intersects a clearly defined Air Force mission area, which includes close air support, aerial imagery, tactical air reconnaissance, and tactical air interdiction. To avoid crowded airspace and redundant capabilities, he recommends that the Air Force be given the entire mission. He believes that whatever the outcome of the struggle over which service owns the mission area, much still must be accomplished to effectively command and control weaponized UAs in tomorrow's battlespace. To further that effort, the author also recommends joint employment standards for UA weapons, joint agreement on the conduct of terminal control, and detailed training requirements for UA personnel. Finally, Colonel Hume recommends improvements in joint air-ground command and control to bring airspace management into the near-real-time realm, which can simplify coordination procedures and truly integrate joint fires and tactical assets.

As with all other Maxwell Papers, this study is provided in the spirit of academic freedom and is open to debate and serious discussion of the issues. We encourage your response.

STEPHEN J. MILLER
Major General, USAF
Commandant, Air War College

About the Author

Col David B. Hume, USAF, is the commander of the 4th Air Support Operations Group supporting 5th Corps, US Army at Heidelberg, Germany. He is a career weapons systems officer, having flown the D, E, and G variants of the F-4 Phantom II and the F-15E Strike Eagle, with over 2,400 operational flying hours. He is also an experienced jumpmaster and air liaison officer with four tours supporting Army units such as the 75th Ranger Regiment and the 18th Airborne Corps. He has combat tours in Operations Desert Storm, Deny Flight/Joint Endeavor, Iraqi Freedom, and Enduring Freedom. He has commanded at the flight, detachment, squadron, and group levels and is a joint specialty officer, having served as a team chief at the Joint Warfare Analysis Center in Dahlgren, Virginia.

Colonel Hume graduated from the University of Virginia with a bachelor of science degree in aerospace engineering and earned a master of science degree in aeronautical science from Embry-Riddle Aeronautical University in 1997, as well as a master's degree in strategic studies from Air University in 2007. He is a graduate of the Armed Forces Staff College and the Air War College.

Abstract

Unmanned aircraft (UA) have changed the nature of warfare. Their persistence, economy, and utility make them indispensable on the battlefield, but the lines between the intelligence, surveillance, and reconnaissance (ISR) and ground attack missions of the UA are now blurred. Within the Air Force, the MQ-1 Predator does not fit seamlessly into the armed reconnaissance role. The ways ISR and ground attack assets are doctrinally resourced, tasked, and flown in support of requirements conflict with each other. The command and control (C2) structure of the theater air control system/Army air-ground system (TACS/AAGS) is not optimized to support the integration of UA operations required in tomorrow's battlespace. The Army is fielding the weaponized Warrior UA system, which crosses service lines into what is traditionally and clearly an Air Force mission. This study examines the issues of integrating weaponized UAs into the future battlespace from the standpoint of doctrine, operational concepts, and roles and missions. To address the disconnects in UA missions and systems, the Air Force must treat weaponized UAs like close air support and merge the Predator and Warrior requirements. Merging the programs will save money, and using the centralized control/decentralized execution tenant of airpower vice organic ownership can decrease the number of UAs required to support the mission effectively. This merger will require both services to establish firm acquisition numbers based on joint requirements. The services must establish a joint acquisition strategy for interoperability, airframe and spare part commonality, and cost savings. This study also recommends establishing joint employment standards and improving C2. Both services must evaluate how they command and control weaponized UAs. The TACS/AAGS system must be modernized along the lines of a joint air-ground C2 cell to allow for near-real-time C2 and dynamic retasking of UAs to maximize employment.

Introduction

The advent of unmanned aerial vehicles (UAV) has changed the nature of warfare. Their persistence, economy, and utility have made them indispensable on the battlefield. What began as an advanced concept technology demonstration (ACTD) in 1994 with the UAV that became the RQ-1 Predator has evolved into the armed MQ-1 Predator, with more weaponized UAVs on the way.[1] Soon the US Army will field the extended range/multipurpose (ER/MP) Warrior unmanned aircraft system (UAS), and the US Air Force will field the MQ-9 Reaper, both weaponized and lethal. As UAVs have evolved from an intelligence, surveillance, and reconnaissance (ISR)-only platform to one that can find, fix, and target, much debate has emerged over their best employment.

The lines blurred between the ISR and ground attack missions when the first AGM-114 Hellfire missile was test-fired from a Predator in February 2001.[2] In her article "Clash of the UAV Tribes," Rebecca Grant describes the debates over operational concepts as well as roles and missions, which are similar to debates that have engaged the services since the creation of an independent Air Force in 1947.[3]

Within the Air Force, the MQ-1 has not fit seamlessly into the armed reconnaissance role. Conflicts exist in how ISR and ground attack assets are doctrinally resourced, tasked, and flown in support of requirements. Between the services, the UAV missions of fixed-wing reconnaissance and ground attack create a debate over the traditional division of roles and missions between the Army and Air Force. Additionally, the command and control (C2) structure of the theater air control system/Army air-ground system (TACS/AAGS) is not optimized to support the integration of UAV operations required in tomorrow's battlespace.

The purpose of this study is to examine the issues of weaponized UAV integration into the future battlespace from the standpoint of doctrine, operational concepts, and roles and missions and to make recommendations on how best to employ this capability in the future. The study provides background information on the evolution and employment of weaponized UAVs and reviews relevant joint and service doctrine. After analyzing the issues associated with C2 of weaponized UAVs, it discusses the programs and points of view of the services and emerging doctrine. Finally, it offers recommendations and conclusions based on the current issues.

The discussion is limited to currently fielded or soon-to-be-fielded weaponized UAVs, specifically the MQ-1/MQ-9, the ER/MP Warrior UAS, and to a lesser extent the RQ-5 Hunter. Because the topic is somewhat technical, the discussion assumes an audience familiar with multiservice doctrine for air-to-ground C2, joint firepower integration, and UAVs. The term *unmanned aircraft* (UA) describes a single UAV, and *unmanned aircraft system* (UAS) refers to the aircraft and its associated C2 equipment that make up the system, as adopted by the 2005 Department of Defense (DOD) *Unmanned Aircraft Systems Roadmap*.[4]

Background on Unmanned Aerial Vehicle Employment

UAs are defined by the DOD as powered aerial vehicles that do not carry a human operator; they use 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.[5] UAs have been around for years and were used in Vietnam (e.g., AQM-34 Firebee) but did not gain favor as a tactical intelligence platform until the Israelis demonstrated their effectiveness with the Pioneer in Lebanon in 1982. Acquired by the US Navy from Israel, the Pioneer proved its worth at the tactical level during Operation Desert Storm, and its demonstrated ability opened up new UA research and development that led to the USAF Predator.[6] The Predator had its operational debut in Bosnia in 1995 and came to the forefront of aviation news during Operation Allied Force (OAF) in 1999.[7] The weaponized Predator was first employed in combat during Operation Enduring Freedom (OEF) in Afghanistan, and its use for air-to-surface attack in Iraq is now commonplace. In another Predator first, a UA armed with a Stinger air-to-air missile unsuccessfully attempted to engage a MiG-25 over the Southern Iraq No-Fly Zone in December 2002.[8]

USAF Predator

The Predator ACTD started in 1994 and transitioned to the USAF in 1997. The Predator, built by General Atomics, has a 48.7-foot wingspan, is 27 feet long, and typically cruises at about 80 miles per hour. Its inverted-V tail protects the pusher propeller during takeoffs and landings.[9] Typical operating altitudes for the Predator are between 10,000 and 15,000 feet, but it has the capability to fly at altitudes up to 25,000 feet. The MQ-1 has two hard points, which are typically used to carry a pair of AGM-114 Hellfire missiles. The larger version of the Predator—the MQ-9 Predator B, now called the Reaper—can operate at altitudes above 45,000 feet and has six hard points, allowing it to carry up to ten AGM-114 Hellfire missiles or four 500-pound–class precision weapons.[10] Depending on the mission profile, the MQ-1 can stay on station as long as 24 hours, but typical sorties in Southwest Asia provide 14 hours of station time. The older Predator versions carried two electro-optical (EO) and infrared (IR) sensors, while the most recent variants include a laser designator capable of designating targets for attack or guiding laser-guided munitions. A synthetic aperture radar (SAR) payload is also available for the MQ-1 which allows the system to see through weather and clouds, but the installation prevents the carriage of missiles.[11] A SAR payload will be standard on the MQ-9 Reaper.[12]

Predator Organizations. The Air Force designed the Predator system to be operated beyond the line of sight from its ground control station (GCS), which requires the use of satellite communications for aircraft control. A local line-of-sight GCS is responsible for takeoffs and landings; once the UA is successfully airborne, another GCS located outside of theater assumes control of the mission.[13] At Nellis AFB, Nevada, rated pilots fly the Predator, and sensor operators control what the sensors are looking at, all through a Ku-band satellite link.[14] Currently, there are three Air Combat Command Predator squadrons: the 11th, 15th, and 17th Reconnaissance Squadrons, all based at Creech AFB in Indian Springs, Nevada. The Air Force Special Operations Command also has the 3rd Special Operations Squadron flying the MQ-1,[15] and the Air National Guard is transitioning some of its units to UAs, having already started converting the 163rd Air Refueling Wing at March AFB, California, to the MQ-1.[16] In November 2006, the USAF stood up the first MQ-9 squadron at Creech and designated it the 42nd Attack Squadron. The USAF plans to buy some 170 MQ-1s by 2010 as well as 50 to 70 MQ-9s by 2012 to outfit approximately 15 squadrons for a total of over 220 additional UAs.[17]

Operational Use. Although first deployed to gather intelligence for the North Atlantic Treaty Organization (NATO) in Bosnia, the Predator demonstrated its potential in Kosovo supporting OAF. Video feeds from the Predator were data-linked to the combined air operations center (CAOC) and to other command headquarters, providing the first-ever real-time video feeds of major air combat operations.[18] Serbian forces claimed to have shot down several Predators, while others were lost to icing and technical malfunctions such as loss of the C2 data-link signal. Despite these early issues, Predators were deployed to central Asia shortly after 11 September 2001 (9/11) and have been in continuous operation ever since to support combat operations across the entire theater. They have been singled out by operational commanders as vital to their mission.[19]

Recent developments allow video sharing between aircraft and ground personnel. The remote operations video enhanced receiver (ROVER) can receive video feeds from several types of UAs through a multiband antenna, allowing an operator such as a joint terminal attack controller (JTAC) to view the video in real time on the ground while supporting ground operations and directing air strikes. The ROVER is being fielded as standard equipment for USAF JTACs serving in Iraq and Afghanistan. There are 245 ROVER kits in-theater for USAF JTACs alone, with the US Special Operations Command (USSOCOM) and other organizations fielding kits to outfit their forces as well.[20]

US Army Warrior

The mainstay of the division- and corps-level reconnaissance systems has been the RQ-5 Hunter built by Northrop-Grumman. Although full-scale procurement was halted in 1996 with only seven systems of eight aircraft each, 18 more aircraft were purchased in 2004. The Hunter has been employed in the Balkans as well as in Operation Iraqi Freedom (OIF).[21] The Hunter has an EO/IR sensor payload for day and night operations and can fly at altitudes up to 25,000 feet for up to 12 hours.[22] In 2004 the Army deployed a weaponized version of the Hunter, the MQ-5, to Iraq along with the Viper Strike munition; soon all versions will carry the weapon. The Viper Strike is a laser-guided, glide munition capable of using global positioning system–aided navigation with a semiactive laser seeker for terminal guidance. The weapon uses a four-pound high explosive antitank (HEAT) warhead for top-down attack, which helps to minimize collateral damage.[23] Tests of the Viper Strike went very well, with seven out of nine direct hits during one testing phase.[24] Combat results have yet to be released in a public forum.

The discontinuation of the Hunter program and the cancellation of the RAH-66 Comanche helicopter spurred the Army's interest in the ER/MP UA. In response to the 1990 Joint Requirements Oversight Council (JROC) endorsement of the mission needs statement (MNS) for a long-endurance reconnaissance, surveillance, and target acquisition (RSTA) capability, the Army produced an operational requirements document (ORD) to reemphasize the MNS and to outline how the ER/MP program would satisfy Army requirements still unmet for RSTA.[25] With the ORD in hand, the Army moved forward with a competitive process and in August 2005 awarded General Atomics the ER/MP contract to build the Warrior system.

The Warrior UA is very similar to the Predator yet slightly larger: 28 feet long with a 56-foot wingspan. (See table 1 for comparisons with the MQ-5 Hunter.) The Warrior UA carries a payload similar to the Predator and can carry four AGM-114s externally. The major difference from the Predator is the heavy-fuel engine that allows the Warrior to burn JP-8, making fuel resupply common with almost all Army vehicles. Whereas the Air Force uses rated pilots to fly the Predator, Army aviation uses enlisted operators to operate the 11 systems with 12 UAs per system. Included with the UAS is the one-system ground control station (OSGCS), which will allow a single common "cockpit" design to control the entire span of UAs operated by the Army. Units in the field will be able to link to Warrior (and other UA) video using the one-system remote video terminal (OSRVT), which

Table 1. Comparison of UAVs

	RQ-5A	*MQ-5B*	*Warrior A*	*Warrior Block 0*
Length (ft)	23	23	27	28
Wing span (ft)	29	34.25	48.7	56
Max. gross takeoff weight (lbs)	1,600	1,950	2,350	3,000/3,600
Cruise speed (kts)	60	62	70	60–75
Max. speed (kts)	110	110	125	150
Range mission mode (km)	125	125	125	350
Range w/relay (km)	200	200	No relay	No relay
Satellite communications (SATCOM)	No SATCOM	No SATCOM	SATCOM	SATCOM
*Takeoff distance (ft)/ landing**	1,600	2,084	2,000	3,200
Service ceiling (ft)	15,000	18,000	25,000	29,000
Max. endurance (hrs) with 80 lb payload	9.2	20	31.3	40+
Hardpoints rating (lbs)	-	2 @ 100	4 @ 150	2 @ 250, 2 @ 500

* Take off and land fully loaded at 9,000 ft density altitude on flat runway

Adapted from Col Don Hazelwood, UAS project manager, Redstone Arsenal, AL, briefing to the author, 21 November 2006.

is a ROVER terminal on steroids that gives the operator more situational awareness on the UA position and attitude by using a Falcon View map software overlay.[26]

USAF Doctrine for ISR Tasking

Most theater ISR requests are coordinated through the ISR division (ISRD) of the air operations center (AOC). Typically the ISRD consists of several teams that correlate and fuse intelligence, manage ISR operations, and prioritize requests for information/intelligence (RFI).[27] Planning for ISR operations starts when requirements are established, validated, and prioritized. The collection manager aligns these requirements with platforms and sensor capabilities, first coordinating with planners to determine if organic platforms can handle the mission.[28] These ISR requirements are prioritized into the ISR sensor collection "deck" and tasked by the ISRD for airborne platform collection through the air tasking order (ATO).[29] Technological innovations have led to tasking manned multirole platforms like fighters with targeting pods as nontraditional ISR (NTISR) collectors, while traditional ISR-only unmanned platforms like the Predator have now been tasked to perform strike operations. In these cases, mission priorities for the aircraft, sensor employment, and authority-to-task must be clear and precoordinated.[30] This doctrine can cause tasking conflicts as addressed below.

Joint Doctrine for TACS/AAGS

The tasking process for C2 of close air support (CAS) for ground forces has evolved over many years since first practiced in Europe in 1944. The theater air control system (TACS) is the combined force air component commander's (CFACC) mechanism for tasking and controlling air and space power to support the needs of the ground forces. The TACS allows the CFACC and his or her CAOC to centrally plan and control airpower, while the subordinate levels of the TACS network are responsible for decentralized execution.[31] These are the basic tenants of airpower employment and the fundamental organizing principles for air and space power.[32]

The basic element of the TACS consists of the tactical air control party (TACP), which is made up of air liaison officers (ALO) and enlisted terminal attack controllers (ETAC). The TACP is aligned with Army maneuver units from battalion through corps with the principle purpose of advising on the capabilities and limitations of airpower and assisting in the planning, integration, request, and control of airpower.[33] At the corps, the air support operations center (ASOC) processes immediate requests for CAS and is responsible for coordinating and controlling missions in its assigned sector, as well as assisting with time-sensitive targeting (TST).[34] All elements of the TACS can communicate via multiple nets and means including the joint air request net (JARN) and the tactical air direction net (TADN).[35]

The Army air-ground system (AAGS) is closely related to and interconnected with the TACS. At all levels, the Army airspace command and control (A2C2) element coordinates Army aviation integration and deconflicts fire support requests with the fires cell and the TACP. Requests for preplanned air support are sent through Army operations channels to the battlefield coordination detachment which is collocated with the CAOC.[36] Together the network, called the TACS/AAGS, is the system for requesting and controlling airpower in direct support of ground forces. The solid lines in figure 1 depict the traditional C2 communication relationships between elements of the TACS/AAGS, while the dashed lines depict alternate communication links between the ground and airborne elements of the system.

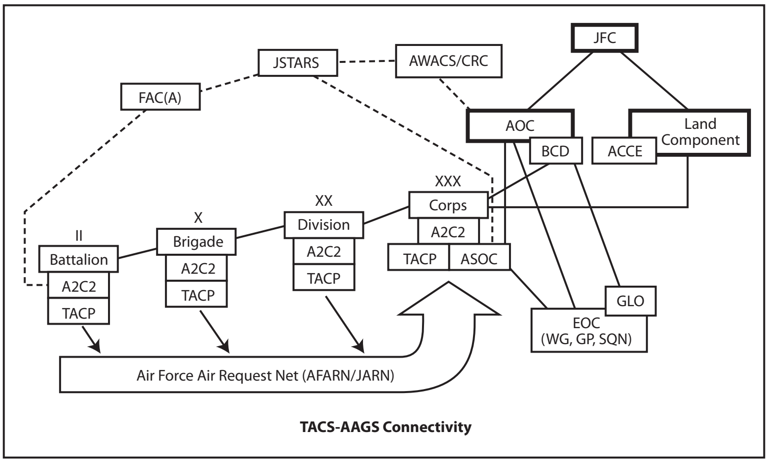

Figure 1. Key Air Force and Army Components of the TACS/AAGS. (Reprinted from Air Force Doctrine Document [AFDD] 2-1.3, *Counterland Operations*, 11 September 2006, 52.)

A key term needed to discuss airspace deconfliction between fixed wing and rotary wing is the *coordinating altitude*. The coordinating altitude is a procedural measure (altitude restriction) that separates the blocks of airspace in which fixed-wing and rotary-wing aircraft operate.[37] Many organic Army UAVs operate below the coordinating altitude as a method of deconfliction from fixed-wing aviation.

Doctrinal and Mission Issues

This section discusses the C2, service program, doctrinal, and employment issues associated with Air Force and Army weaponized UAs. It explores the disconnects in the process used by the USAF to task and employ the MQ-1 Predator, addresses the Army's effort to procure the Warrior in spite of a debate over its role and missions, and discusses some doctrinal differences between the Air Force and Army on terminal control, tasking, and overall C2. There are fundamental differences between the Air Force and the Army on direct support and ownership of UAs. Without serious dialogue and compromise, the end state could be a crowded airspace with redundant capability.

Tasking and Employment of the USAF Predator

The use of the RQ-1 for ISR only was challenged when Gen John Jumper, former chief of staff of the Air Force, directed the integration of a laser designator in time for operations in Kosovo that allowed the Predator to designate targets for attack by other aircraft. The USAF started to realize the full potential of UAs for strike and not just ISR after the first Hellfire missile was test fired in 2001.[38] The debate still rages. Air National Guard Brig Gen Stanley E. Clarke, deputy director for strategic planning for the Air Staff, recently commented on the subject: "It's not clean-cut anymore. Predators fitted with Hellfires raise a very interesting question—are they strike or ISR [systems]?"[39]

Whether the weaponized UAs are perceived as strike or ISR systems affects the operational concept of how they are tasked and employed. Previously, RFIs were sent to the ISRD for processing and prioritization. These requests were prioritized in the ISR deck and sourced with a platform. The system worked well for traditional imagery requests when multiple RFIs were serviced by one pass of the platform. In that case, it made perfect sense to organize and prioritize the requests and then coordinate which asset would image the target. RFIs need to be into the network three days prior to the date flown; depending on the type of imagery requested, it could be up to three days before the end user gets the final product.[40] Maj Clayton "Bags" Marshall provided insight on the insufficiency of ISR doctrine for weaponized UA employment:

> The current ATO cycle works great for a campaign against static targets. But in the current war, the 72 hour ATO cycle plus 20 hour sortie length means that the Predator target deck is obsolete by takeoff. Instead, Preds are given takeoff times and then parceled out to users in blocks of time for ad hoc target prosecution. [The] problem is that users have to compete for Pred time, so they put forward their most "pressing" requests in order to get slated for Pred time in the first place. When they actually succeed in getting support, they usually throw out their outdated request[s] and start from scratch with new, up-to-the-minute targets.[41]

The advantages of the Predator are its long dwell time and full-motion video (FMV) capability. Ground commanders immediately saw the value of the Predator for gaining battlespace awareness and for battle tracking. The big question now for ground forces is "How do I request an armed Predator?" Army units in Iraq or Afghanistan often turn intelligence tips into operations in a matter of hours; for special action units, this may take a matter of minutes.

Requesting an MQ-1 three days out for an event that has yet to materialize is not feasible. Pulling the MQ-1 away from its deck tasking is not easy either. It is often easier to task a CAS asset through the ASOC to support a short-notice operation than it is to prove to the ISRD that the raid in progress is a higher priority than servicing the ISR deck. What is required for the mission is an asset with long dwell time and video downlink for the ground commander's situational awareness. The ability to quickly target the same objective from the same platform makes the weaponized UAV very effective. If more firepower is required, the JTAC can closely coordinate with the sensor operator to mark targets for other airborne strike assets. The fighters themselves are often equipped with ROVER downlink capability, but they frequently have to leave station to go to the tanker and then play catch up upon returning to get reacquainted with the tactical situation.

FMV is most useful for the ground commander and operators involved in the current, ongoing mission or operation. FMV is of less value as a data source because it is not mensurated or cannot be ortho-rectified. Coordinate mensuration, also called ortho-rectification, is the process whereby aerial photographs are registered to a map coordinate system and potential measurement errors are removed to obtain precise coordinates.[42] RFIs requiring this type of imagery are best left to the traditional ISR platforms, but because of the lack of total ISR assets on the battlefield in Iraq and Afghanistan, the MQ-1 often gets tagged with missions better suited for other platforms.

The dwell/stare time of UAs like the Predator is particularly useful for special operations forces (SOF) that are looking for patterns or chasing individuals. The quietness of some UAVs from a standoff perch will not "spook" or tip off the suspect like the sound from a fast-moving fighter, an EP-3, or AC-130. Because of these characteristics, the MQ-1 is often the platform of choice for SOFs, who often have priority for the asset over conventional ground forces. With not enough MQ-1s, data-link frequencies, and GCS-controlled orbits to go around, the conventional ground units are often left with their organic UAs or fixed-wing NTISR, which may or may not have ROVER downlink and is often not the ideal platform for the tactical situation.

Unmanned Aircraft Roles and Missions

To close its requirements gap for ISR in Southwest Asia, the Army issued the UAS ORD. The utility of UAs has driven an increase in Army procurement of UASs to fill this gap. The Warrior UAS program will add 121 vehicles to Army aviation. The entire program is expected to cost approximately $1 billion.[43] Originally, the Army intended to grow by FY 2011 to 230 UAV units comprised of approximately 2,331 systems and 7,085 air platforms of all types.[44] Recent adjustments, however, based on budgetary constraints and joint force requirements mean that the number of UAs fielded will not be as robust as planned; two classes of midsized UAs for the future combat system will not be developed.[45]

Weaponized, fixed-wing Army UAs, operating at altitudes up to 25,000 feet, got the attention of many in the Air Force. Discussions between the services about roles and missions have been ongoing periodically since the inception of the Air Force as a separate service. The debate over the role of Army aviation in the 1960s led to the agreement that Army aviation would be strictly limited to support of ground troops and would not encroach on traditional USAF roles such as interdiction or CAS. This 1966 agreement between the Army and Air Force chiefs of staff authorizing the development of attack aviation was amended in 1975 to clarify that the attack helicopter did not provide CAS.[46] The most recent guidance on roles and missions of the services is found in the 2002 DOD Directive (DODD) 5100.1, *Functions of the Department of Defense and Its Major Components*, which states it is the responsibility of the US Air Force to "organize, train and equip and provide forces for close air support and air logistic support to the Army and other forces, as directed, including airlift, air and space support, resupply of airborne operations, aerial photography, tactical air reconnaissance and air interdiction."[47] It further states that the Air Force is responsible for providing aerial imagery.[48]

Some argue based on the DODD that fixed-wing weapons delivery is strictly an Air Force mission. Others similarly argue that air-breathing ISR platforms operating at altitudes above the coordinating altitude in support of ground operations are also an Air Force mission. However, from the perspective of Army aviation, a UA delivering an AGM-114 is really no different from an AH-64 Apache shooting the same missile at a ground target. Likewise, the Army has been operating the Hunter for years at altitudes above the coordinating altitude with few issues.

Terminal Control

Another mission under debate is the terminal control of weapons released from platforms providing CAS. Terminal control is the authority to direct aircraft to maneuver into a position to deliver ordnance.[49] Because of the close proximity of friendly forces to the target, CAS requires detailed integration of each air mission supporting ground forces to avoid fratricide and to achieve the desired effects on the target.[50] The Air Force supports Army maneuver units with JTACs and forward air controllers (airborne) (FAC[A]) to provide this detailed integration for CAS as part of TACS. The JTAC on the ground directs CAS in support of the ground commander's intent and links the CAS pilot (who may otherwise be unfamiliar with the ground situation) to the battle by providing the situational awareness of target and friendly locations. JTACs and FACs(A) are the only personnel trained and authorized to provide terminal control of CAS on the battlefield. From a doctrinal perspective, the Air Force likes to see Airmen control airpower. The Army recently established the requirement for JTACs down to the company level due to the changing nature of the nonlinear battlefield and endorsed the JTAC memorandum of agreement (MOA) that set JTAC standards across the services.[51] Understanding the unique JTAC training requirements that limit production numbers, the Army and Air Force along with USSOCOM established the joint fires observer (JFO) program that will produce advanced forward observers (FO) capable of conducting surface-to-surface fires and providing targeting support to JTACs.[52] The JFO will use technology such as the ROVER to act as a sensor for the JTAC, who will have overall positive control over weapons release from CAS platforms.

The issue of terminal control for a weaponized UA blurs when it comes to cross-service ideas on the employment of joint fires and CAS. The Air Force considers a Predator-delivered Hellfire in support of ground forces to be CAS, and CAS requires a JTAC or FAC(A) somewhere in the loop to clear fires and ensure deconfliction. (The *Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, published by the Air Land Sea Application Center, provides a helpful discussion on how the JTAC and UAS can fit together in a CAS employment scenario.[53]) On the other hand, according to current Army doctrine, an FO who is not even JFO- or JTAC-qualified can conduct an attack aviation call for fire with an AH-64 armed with AGM-114s.

Table 2, based on Joint Publication (JP) 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support*, provides a brief synopsis of the circumstances under which the JTAC uses each type of CAS terminal attack control.

The JTAC will usually control a UA using Type 2 CAS procedures. The difficulty in controlling a UA-delivered AGM-114 is magnified because the FO/JFO or JTAC will probably not see the platform, as in a Type 2 or 3 final control. Without ROVER or OSRVT, the JTAC will have to resort to basic CAS talk-on and deconfliction procedures; training and certification in this case are essential. The Air Force mitigates this sort of risk by having rated pilots fly the MQ-1 and a JTAC/FAC(A) perform the final control.

Table 2. Types of CAS Terminal Attack Control

Type of Control	*JTAC Actions*	*Remarks*
Type 1	Used when JTAC must visually acquire the attacking aircraft and the target for each attack.	Attacking aircraft geometry is required to reduce the risk of the attack affecting friendly forces.
Type 2	Used when JTAC requires control of individual attacks and any of the following conditions are true: • JTAC is unable to visually acquire the attacking aircraft at weapons release. • JTAC is unable to visually acquire the target. • The attacking aircraft is unable to acquire the mark/target prior to weapons release.	Applicable scenarios are night, adverse weather, and high altitude or standoff weapons employment. Successful attacks depend on timely and accurate targeting data that may be provided by another source [e.g., scout, combat observation and lasing team (COLT), fire support team (FIST), UAV, SOF, or other assets with accurate real-time targeting information].
Type 3	Used when JTAC requires the ability to provide clearance for multiple attacks within a single engagement subject to specific attack restrictions.	Type 3 control does not require the JTAC to visually acquire the aircraft or the target; however, all targeting data must be coordinated through the supported commander's battle staff.

Adapted from JP 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support,* 3 September 2003, V-14–V-19.

With the Army, the Warrior could potentially be employed by a distant crew supporting an FO on the ground without a ROVER/OSRVT feed or JTAC in the loop. This situation will present significant operational challenges without proper consideration of CAS doctrine and procedures for UA employment. The complexity concerning the delivery and deconfliction of freefall weapons exacerbates the issue of terminal control by non-JTACs. Should the Warrior Block 0 be outfitted for GBU-12 laser-guided bombs or the small-diameter bomb, additional debates will emerge about overlapping roles and missions. Is the Army developing a fixed-wing CAS and interdiction capability that is redundant to the missions and systems that the USAF provides?

Army Direct Support Doctrine

Each Army division will eventually get its own organic Warrior system. While this will help meet UA requirements for the divisions, it could lead to the ineffective use of a very capable asset. The ER/MP mission profiles will include RSTA; communications relay; chemical, biological, and nuclear detection; critical logistics delivery; air-to-ground targeting; and potentially air-to-air targeting.[54] The number of diverse missions and varied requests for support across the battlefield could quickly lead to confusion and ineffective UA employment as ground units and even divisions fight for control of the asset for their mission requirements. The Army Air Corps in North Africa in 1943 quickly learned that attaching fighter units to specific ground units was an ineffective way to employ airpower across the entire spectrum of the battlefield. Out of this confusion was born the airpower tenant of "centralized control/decentralized execution" as a way to focus the specific effects of airpower at the right place and time on the battlefield. Gen Dwight D. Eisenhower stated in dispatches following the North African Campaign that "direct support of ground troops is naturally the method preferred by the immediate military commander concerned," but his vision did not extend beyond the local battle.[55] It did not consider "the competing demands of individual commanders on a far-flung battlefront, each of whom would naturally like to have at his disposal some segment of the Air Force for his own exclusive use."[56]

The Army's answer to limited support from low-density, high-demand theater assets as well as gaps in corps-level Hunter coverage was to procure the Warrior. The ER/MP ORD cited an Air Combat Command white paper, dated 13 April 2004, which stated "the Air Force has been unable to service every request in the past due to limited assets."[57] Is organic ownership of a weaponized UA the right response to past lack of assets? Will organic ownership lead to ineffective or inefficient UA employment across the battlespace? These are the questions that future doctrine will have to address to ensure the right mix and proper employment of weaponized UAs.

Grant precisely captures the issue: "For the future, it all comes down to where to place the limits on organic UAVs and how to ensure that all UAV systems are netted into a central battlespace information architecture."[58] The system will be in place for potential centralized control/decentralized execution of Army-operated UASs. The OSGCS is designed with a common cockpit so control of platforms can be switched from unit to unit across the battlefield, allowing individual users to take control for their specific mission and then pass it back to the division.[59] The TACS/AAGS network exists to allow UA requests to be prioritized and platforms to be distributed. The Army is already discussing manned-unmanned teaming to decrease sensor-to-shooter delays.[60]

The way the Army approaches attack aviation support to ground units is changing. In Iraq AH-64s are providing convoy escort and quick reaction for troops-in-contact situations. They are teaming with JTACs, fixed-wing CAS, MQ-1s, and other UAs to find, fix, and finish insurgents who can be found in a range of situations such as planting improvised explosive devices, conducting ambush operations, and setting indirect attacks with mortars and rockets. This new approach to ground operations is not called CAS but direct support. Whatever it is called, it is an example of what can be accomplished with joint integration. Organic ownership may not be the right answer for UA employment unless a better way to control assets in near real time can be accomplished. As an example of why legacy A2C2 procedures are not adequate for tomorrow's battlespace, the 4th Infantry Division (4 ID) saw the need to change from older ways of C2 to a near-real-time coordination during their recent deployment to Baghdad for OIF. This need was driven by the aircraft density and airspace complexity over Baghdad.[61]

TACS/AAGS Shortcomings

The TACS/AAGS system has served the Army and Air Force well over the years but is not optimized for the future battlefield. The coordinating altitude was 200 feet in Europe during the Cold War; now, due to increased low altitude activity in Iraq, it is 3,000 feet.[62] "The ground is rising," said Brig Gen Michael Longoria, formerly of the joint air-ground operations (JAGO) office at Langley AFB, Virginia. He further related that the JAGO office has heard of requests for block airspace up to 10,000 feet.[63] The C2 of airspace to support Army aviation is typically executed by procedural control, which means that established procedures, routes, and fire support coordination measures (FSCM) are in effect and followed by aircrews and UA operators alike.[64] Blocks of airspace and routes are set aside to ensure deconfliction from other assets in the airspace. This will be a particular problem for the battlefield of the future because it is difficult to clear entire volumes of airspace to deliver fires, particularly for assets like the guided multiple launch rocket system (GMLRS). This is an additional problem for large numbers of UAs operating in support of multiple units spread across the battlespace. Under the current construct, airspace coordinating measures (ACM) such as restricted operations zones (ROZ) are established to support UA operations. The number of ROZs required to support all of the UAs expected on the future battlefield will clog the airspace and constrain fires deconfliction. Currently, there is no DOD guidance on how many aircraft can be effectively managed in a particular section of airspace. The Center for Army Lessons Learned (CALL) captured the issue well in a recent report from a trip to Southwest Asia: "ACMs such as ROZs do not integrate airspace users. . . . Because airspace is a finite resource, as the number of airspace users increases, [airspace C2] elements run out of airspace."[65]

At Army units from battalion through corps, soldiers and Airmen are wrestling with how best to address these issues and integrate operations more effectively and efficiently. The fire support cell (FSC) is a step in the right direction to integrate fire support activities and fires deconfliction. The ASOC until recently existed only at corps level but may now be included at division level. The A2C2 cell at all levels of the TACS/AAGS system is not truly integrated. It coordinates procedures for input into the airspace control plan and airspace control order and ensures proper inputs to the air tasking order but typically does not positively control day-to-day Army aviation operations. Under positive control, aircraft are positively tracked by electronic means and communication and are provided direction and deconfliction.[66] The 4 ID A2C2 cell saw the need to control airspace below the coordinating altitude over Baghdad. Procedural control in this situation was inadequate, so the cell created its own form of near-real-time control by mixing positive control with procedural control and cobbling together a low-altitude air picture with feeds from air defense radars. The situation was not perfect but was a vast improvement and allowed a more effective and efficient use of the airspace by multiple users. The 4 ID is one of the first units to deploy to Iraq with the personnel and resources to accomplish this task—there is no Army doctrine for the Army to control airspace.[67] Through the Control and Reporting Center, the ASOC provides positive control for aircraft operating in CFACC airspace above the coordinating altitude.[68] The airspace of the future will have to be integrated for effective employment of all assets in the battlespace to reduce sensor-to-shooter delays and integrate joint fires from multiple assets, be they fixed-wing fighters, rotary-wing attack aviation, GMLRS, or UAs.

Recommendations

To optimize the employment of weaponized UAs in support of ground forces and gain the maximum capability from systems like the Warrior and Predator, the Army and Air Force will have to address the interservice issues concerning the doctrine, roles and missions, and operation of UAs. The following recommendations are intended to help resolve these issues.

Treat the MQ-1 like CAS

The MQ-1 or Warrior UA is best suited to be managed like CAS. In a speech in early 2007, US Air Forces in Europe commander Gen William T. Hobbins said, "We need for unmanned aircraft to act like manned aircraft. We need unmanned aircraft to be tasked like manned aircraft. We need unmanned aircraft to fly in strike packages with manned aircraft."[69] Full-motion video is most useful to the ground commander in real time. There are theater-level requirements for long dwell/stare FMV, but those can be prioritized just like CAS requests are. When fighters are directed to a troops-in-contact situation, they can be pulled at any time to support a higher tasking. Likewise, they are available to support NTISR taskings when not requested to support ground operations. The MQ-1 and future weaponized UAs can be tasked in the same manner. Since FMV cannot be mensurated, its value to future targeting is limited. UAs are best employed in finding the target. The UA can either self-designate the target, or another cell such as the ISRD or a JTAC, using a program called the Precision Strike Suite for Special Operations Forces, can pull mensurated or "sweetened" coordinates for precision-guided munition (PGM) engagement.[70] The ISR deck should be serviced by traditional assets such as F-16s with the tactical airborne reconnaissance system, which can be mensurated or downlinked to a ground station, or the Global Hawk, which is more suited for theater-level ISR.

The method for requesting the MQ-1 is optimized for intelligence gathering but not for ground forces. The ISR request system is great for national- or theater-level assets but is not effective to support a dynamic tactical battlefield. Request for UA support is treated like ISR and is handled via a DD Form 1975, which is similar to the form used for CAS requests. The TACS/AAGS system is designed to handle CAS requests and can handle tactical ISR requests in the same manner, but the breakdown occurs at the CAOC. The ISRD and the senior intelligence duty officer decide MQ-1 courses of action based on intelligence gain/loss, which tends to make the employment doctrine look more like centralized control/centralized execution. To further complicate matters, the explanation of dynamic retasking is confusing in the UAS *Multi-Service Tactics, Techniques, and Procedures*.[71] All the requestor wants from the tasking process is the ability to watch the ground action in real time and prosecute targets as they emerge. In these situations there is less intelligence gathering than battle tracking. The dwell time of UAs makes them attractive to the ground commander to cover drawn-out ground missions over NTISR-providing fighters that may depart mid-mission for fuel. The Army understands the utility of FMV and dwell time to the ground commander, hence its push to accelerate and increase the number of UAs supporting ground units currently in Iraq.[72]

Give the Weaponized Unmanned Aerial Mission to the USAF

Weaponized, fixed-wing ISR support to ground forces, able to operate at altitudes up to 25,000 feet, is clearly an Air Force mission as outlined in DODD 5100.1, *Functions of the Department of Defense and Its Major Components*. Paragraph 6.6.3.2.5 states that it is the USAF's function "to organize, train, equip, and provide forces for *close air support* and air logistic support to the Army and other forces, as directed, including airlift, air and space support, resupply of airborne operations, *aerial photography*, *tactical air reconnaissance*, and *air interdiction of enemy land forces and communications*" (emphasis added).[73] The Army's answer to the ISR gap and the lack of FMV capability to support ballooning theater requirements is to buy its own platform. With cash in hand left over from the canceled Comanche program, the Army has executed the $1 billion Warrior UAS program. The Air Force is rapidly building MQ-1s and MQ-9 Reapers. Is this overkill, given the requirements? Is this redundancy cost effective in a time of budget constraints? Obviously, the discussion on roles and missions for UA support to ground troops must take place to answer these questions.

Based on the issues outlined in this study, the Air Force should take over the mission of operating weaponized UAs. This could lead to a variety of options, some of which have already been proposed by the Air Force. One option would be to habitually align Predator squadrons with Army units, similar to the way the Air Force supports ground units with TACPs, which could mean either USAF ownership outright or "Army buys, Air Force flies."[74] In conjunction to this proposal, the Air Force could station intelligence personnel with TACPs as ISR liaison officers (LNO) to Army units to assist in the employment of the Predator and Reaper following the principle of centralized control/decentralized execution. The LNO could also help facilitate ISR requests as well as assist in tactical target coordinate mensuration for PGM engagement.

An agreement on roles and missions is not likely soon. Congressional legislation sponsored by Senator Richard Shelby of Alabama and signed into law prohibits tactical UAV program funds from being transferred from the Army and mandates that the Army retain responsibility for and operational control of the ER/MP UAS.[75] Even if the services cannot agree on UA roles and missions, there are many advantages to be gained by collaboration. Merging of the joint war-fighter acquisition programs, as suggested by the *Quadrennial Defense Review (QDR)*, could eliminate duplication of effort, cut redundant systems, and ensure interoperability.[76] The *QDR* specifically addresses capability reviews to cut redundancies by assessing joint force capability portfolios.[77] The Warrior airframe, although sharing only 15 percent commonality with the Predator, has many positive attributes, such as the heavy fuel engine and automated takeoff and landing, and is designed to operate in austere conditions.[78] Sharing the same manufacturer could lead to massive cost savings by merging the acquisition programs, and, frankly, the Warrior is a better platform.[79] There are many features of the one-system ground control station and the one-system remote video terminal that promise great utility and could make the system interoperable across the services if jointly procured.

If the services decide that their weaponized UA programs should not be combined, both services will still gain by participating in a joint center of excellence (JCOE) as outlined by the JROC in June 2005 and directed by the chairman of the Joint Chiefs of Staff in November 2005.[80] The Air Force has years of experience in UA operations and has led the way with the MQ-1. Some USAF Predator pilots come from fighter cockpits and bring a wealth of weapons-delivery knowledge to the community. Cross talk could mitigate some of the inexperience of Army UAS operators in the area of UA-delivered weapons. The Air Force could share the training pipeline for Warrior with the Army. A joint training program could ease the burden on USAF rated officers required to fill positions as UA pilots by leveraging Army-trained UAS operators for many portions of the training curriculum.

The Army should consider allowing its operators to get a private-pilot, single-engine land rating and accrue flying hours towards an instrument rating (for which they get most of the academics in school). An instrument rating would help convince the Federal Aviation Administration (FAA) to allow UA operations in the national airspace, among other see-and-avoid concerns; provide a tremendous increase in access to training areas; and pave the way for routine border operations.[81] Currently, Predator operations in the nonrestricted national airspace are limited to case-by-case situations for transit only above flight level 180 where positive control is required.[82]

Establish Joint Standards for UA Weapons Employment

The earlier discussion of terminal control highlighted the need for joint UA employment standards to govern UA-delivered weapons. Just as the JTAC and JFO MOAs establish training standards across the services, so too an interservice training standard for weapons employment is required. The services need to endorse a detailed agreement about who can employ armed UAs, who can conduct terminal control, and what training requirements must be met by UA personnel.

Emerging tactics and procedures have not yet been incorporated into the joint publications such as JP 3-09.3, *Joint Tactics, Techniques, and Procedures for CAS*, although the UAS JCOE has recently made a submission regarding the employment of UAs in CAS.[83] The Air Force has addressed terminal control of CAS by armed UAs in AFDD 2-1.3, *Counterland Operations*, and this doctrine should be incorporated into joint doctrine immediately.[84]

Improve Joint Air-Ground Command and Control

Efforts also need to be made for real-time or near-real-time C2 of all fires and tactical assets to fight effectively in tomorrow's battlespace. The TACS/AAGS is a stovepipe system that was fine for rapid management, planning, and deconfliction on the Cold War–style battlefield but is not optimized to support real-time C2. It is not truly integrated even at corps level, yet it will need to be in order to coordinate rapidly changing airspace to support the needs of the commander, especially with the planned multitudes of UAs and other assets. Emerging technology is leading to the real-time C2 of combat power with the advent of data link; blue force tracker; and identification, friend or foe for UAs, in addition to systems like the Army's tactical air integration system (TAIS) and the Air Force Link-16.[85] These types of systems and technologies will enable the A2C2 cell to move from procedural control to positive control. With all elements in the battlespace under some type of near-real-time control, the need for many static FSCMs goes away. In his article on the joint air-ground control cell (JAGC2), Curtis Neal proposes a JAGC2 cell that fuses all elements of various staff functions such as the ASOC, FSC, A2C2, and ISR into an organization focused on maximizing the effects of a single war-fighting function (see fig. 2).

Having an element at division and corps like the JAGC2 is absolutely essential to maximize the effectiveness of armed UAs integrated with all other joint fires. Without the ability to deconflict fires in real time, UA operations will require blocks of airspace and ROZs that will hamper fixed and rotary wing integration and delay asset transfers between units. The JAGC2 will operate similarly to the aforementioned 4 ID air-

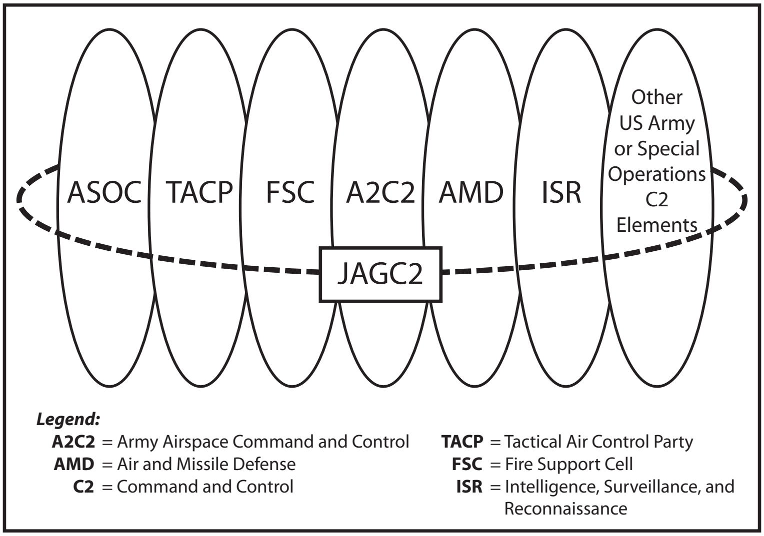

Figure 2. JAGC2 in the Division or Corps Main Command Post. (Reprinted from Col Curtis V. Neal, USAF, retired, "JAGC2: A Concept for Future Battlefield Air-Ground Integration," *Field Artillery Magazine*, November–December 2006, 15.)

space C2 cell during its Baghdad deployment. A JAGC2, digitally connected to all players who also have access to the standard integrated air picture, will be able to maximize the effects of armed UAs teamed with other assets in real time. This is a perfect network for centralized control/decentralized execution of all air-delivered effects on the battlefield.

Conclusion

This study examined the issues of weaponized UAV integration into the future battlespace from the standpoint of doctrine, operational concepts, and roles and missions and recommended ways to best employ this capability in the future. What started as an ACTD has come a long way to today's MQ-1 Predator, Warrior, and Reaper—all armed and lethal. The demand for FMV and ISR in Afghanistan and Iraq has increased tenfold, yet the inability to match platforms with requests has led to gaps in coverage, as requests have been left unfilled or filled with fixed-wing NTISR. In an effort to cover the ISR and FMV gap, the Army bought its own organic UAS to be operated at the division level. The weaponized Warrior UAS crosses service lines into what is traditionally an Air Force mission. Because of funding limitations, the Air Force had not planned to field the MQ-1 in the numbers the Army required but made several proposals to take over the entire program as an Air Force mission (Army buys, USAF flies). Currently, a *QDR* recommendation to merge the programs is delayed in staffing, and legislation precludes the transfer of the program without an amendment to the law.

Unless a decision is made soon on roles, missions, and numbers of UAs needed to support mission requirements, the Army and Air Force will have bought and fielded redundant systems with numbers in excess of battlefield requirements. To review, the following recommendations would prevent redundancy:

1. Treat weaponized UAs like CAS. Following the airpower tenant of centralized control/decentralized execution for UAs, as opposed to organic ownership, can decrease the numbers required to support the mission

effectively by the sharing of assets across the battlespace in a manner like CAS.

2. Give the weaponized UA mission to the USAF. The mission area is clearly outlined in DODD 5100.1 as an Air Force mission.
3. Merge the Predator and Warrior program requirements, which will reduce costs. The merger will require both services to thoroughly examine their ISR requirements as a collective joint portfolio, as suggested in the *QDR*, and establish firm acquisition numbers based on joint requirements.
4. Create a joint acquisition strategy for interoperability, airframe and spare part commonality, and cost savings. The USAF needs to terminate MQ-1 orders and buy the Army version of the ER/MP airframe immediately.
5. Establish joint standards for UA employment. Terminal UA control must be standardized across services for both UA operators and ground controllers.
6. Improve C2. Both services must look at how they command and control weaponized UAs. The Air Force must follow the lead of the Army and get the MQ-1 and MQ-9 out of the old-style ISR tasking channels and task them like fighter planes for CAS. Standing up the 42nd Attack Squadron with the MQ-9 Reaper is a step in the right direction, and all Predator units should follow suit. The TACS/AAGS system must be modernized along the lines of the JAGC2 to allow for near-real-time C2 and dynamic retasking of UAs to maximize employment and integration with other joint assets in the battlespace.
7. Reexamine how we train UA operators. The Air Force should consider the Army model of enlisted or warrant officer UA operators to ease the stress on the rated force, while the Army should consider the vast midsize UA and weapons-delivery experience resident in Air Force fighter and UA squadrons. Army UA operators need to have a private pilot's license and instrument rating that will not only provide an incentive to the enlisted force but also ease the transition for FAA approval to operate in the national airspace.

A major shift in thinking is required to find ways to best integrate weaponized UAs into the fight. Technology and innovation rapidly turn ideas into reality. Who would have thought six years ago that a test shot with an AGM-114 by an RQ-1 Predator would lead to major procurement programs of approximately $1 billion and Reapers armed with not only eight Hellfires but also two GBU-12s? Hate it or love it, *joint* is the way ahead for UA procurement and employment.

Notes

1. Elizabeth Bone and Christopher Bolkcom, *Unmanned Aerial Vehicles: Background and Issues for Congress*, Congressional Research Service Report for Congress (Washington, DC: Library of Congress, 25 April 2003), 20.

2. Sue Baker, "Predator Missile Launch Totally Successful," Aeronautical Systems Center Public Affairs news release, Wright-Patterson AFB, OH, 27 February 2001.

3. Rebecca Grant, "Clash of the UAV Tribes," *Air Force Magazine*, September 2005.

4. DOD, *Unmanned Aircraft Systems Roadmap, 2005–2030* (Washington, DC: Office of the Secretary of Defense, 4 August 2005), i.

5. Ibid., 1.

6. Bone and Bolkcom, *Unmanned Aerial Vehicles*, 2.

7. Ibid., 22.

8. Jim Krane, "Pilotless Warriors Soar to Success," *CBS News.com*, 25 April 2003, http://www.cbsnews.com/stories/2003/04/25/tech/main551126.shtml.

9. Brent Sadler, "In the Sights of a Joystick Killing Machine," *CNN.com*, 9 June 2006, http://www.cnn.com/2006/WORLD/asiapcf/06/09/sadler.predator.btsc/index.html.

10. Bone and Bolkcom, *Unmanned Aerial Vehicles*, 21.

11. Ibid., 22.

12. Maj Clayton R. Marshall, Joint UAS Center of Excellence project officer, Nellis AFB, NV, correspondence with the author, 18 January 2007.

13. Ibid.

14. Sadler, "In the Sights," 3.

15. Marshall, correspondence.

16. John A. Tirpak, "UAVs with Bite," *Air Force Magazine*, January 2007, 46.

17. Ibid.

18. Bone and Bolkcom, *Unmanned Aerial Vehicles*, 23.

19. Ibid., 24.

20. Grady R. Barnett, ACC/A8CT (TACP), Langley AFB, VA, briefing provided to the author, 18 February 2007.

21. DOD, *Unmanned Aircraft Systems Roadmap*, 7.

22. Bone and Bolkcom, *Unmanned Aerial Vehicles*, 28.

23. "Viper Strike Laser Guided Weapon for UAVs," *Defense-Update.com*, 25 September 2005, http://www.defense-update.com/directory/viper-strike.htm.

24. Harold Kennedy, "Services Focus on Fielding Munitions for Close Combat," *National Defense Magazine*, December 2005, http://www.nationaldefensemagazine.org/issues/2005/Dec1/Services_Focus.htm.

25. US Army, *Extended Range/Multi-Purpose Unmanned Aerial Vehicle Operational Requirements Document ACAT Level II for a Milestone B Decision* (Washington, DC: Headquarters, Department of the Army, 14 June 2004), 4.

26. Col Don Hazelwood, UAS project manager, Redstone Arsenal, AL, briefing to the author, 21 November 2006.

27. AFDD 2-1.7, *Airspace Control in the Combat Zone,* 13 July 2005, 30.

28. AFDD 2-9, "Intelligence, Surveillance, and Reconnaissance Operations" (Draft), 21 November 2005, 12–13.

29. Ibid., 15.

30. Ibid., 47.

31. AFDD 2-1.3, *Counterland Operations*, 11 September 2006, 51.

32. AFDD 1-1, *Air Force Basic Doctrine*, 17 November 2003, 28.

33. AFDD 2-1.3, 63.

34. Ibid., 55.

35. Ibid., 52.

36. Ibid.

37. JP 3-52, *Joint Doctrine for Airspace Control in the Combat Zone*, 30 August 2004, GL-6.

38. Marshall, correspondence.

39. Adam J. Herbert, "Eighty-Six Combat Wings," *Air Force Magazine*, December 2006, 29.

40. Personal experience of the author as commander, 18th Expeditionary Air Support Operations Group, Camp Victory, Iraq, May–September 2005.

41. Marshall, correspondence.

42. Center for Geographic and Statistical Analysis, http://www.co.yakima.wa.us/gis/Center/OrthoPhotos.html.

43. "$214.4M for R&D on Warrior UAV (updated)," *Defense Industry Daily*, 12 August 2005, http://www.defenseindustrydaily.com/2144m-for-rd-on-warrior-uav-updated-0995/.

44. Hazelwood, briefing.

45. "Army Makes Adjustments to Future Force Unmanned Aerial Systems," US Army news release, 9 January 2007, http://www.army.mil/-newsreleases/2007/01/09/1293-army-makes-adjustments-to-future-force-unmanned-aerial-systems/.

46. Grant, "Clash of the UAV Tribes," 2.

47. DODD 5100.1, *Functions of the Department of Defense and Its Major Components*, 1 August 2002, 24.

48. Ibid.

49. AFDD 2-1.3, 102.

50. Ibid., 6.

51. Col David R. Brown, "JTAC MOA vs JTTP," *Field Artillery Magazine*, January–February 2005, 18.

52. CW3 Christopher A. Saindon, USA, retired, "The FA: Leading Joint Interdependency with JACI," *Field Artillery Magazine*, September–October 2006, 16.

53. US Army Field Manual (FM) 3-04.15, *Multi-Service Tactics, Techniques, and Procedures (MTTP) for the Tactical Employment of Unmanned Aircraft Systems*, August 2006, chapter 4.

54. ER/MP ORD, 12, 18.

55. Quoted in Daniel R. Mortensen, *A Pattern for Joint Operations: World War II Close Air Support, North Africa* (Washington, DC: Office of Air Force History and US Army Center of Military History, 1987), 84.

56. Mortensen, *A Pattern for Joint Operations*, 84.

57. Quoted in Mortensen, *A Pattern for Joint Operations*, 17.

58. Grant, "Clash of the UAV Tribes," 9.

59. Hazelwood, briefing.

60. ER/MP ORD, 17.

61. CALL and Air Force Office of Lessons Learned (AF/A9L), *OIF-OEF Airspace Command and Control Collection and Analysis Team Initial Impressions Report*, Joint Report, 7 November 2006, 9.

62. Grant, "Clash of the UAV Tribes," 8.

63. Quoted in Grant, "Clash of the UAV Tribes," 8.

64. AFDD 2-1.7, 4.

65. CALL and AF/A9L, *OIF-OEF Airspace Command and Control*, 8.

66. AFDD 2-1.7, 4.

67. CALL and AF/A9L, *OIF-OEF Airspace Command and Control*, 25, 32.

68. AFDD 2-1.3, 58.

69. Quoted in John T. Correll, "Verbatim," *Air Force Magazine*, January 2007, 51.

70. Saindon, "The FA," 17.

71. FM 3-04.15, UAS MTTP, II-7.

72. Hazelwood, briefing.

73. DODD 5100.1, 24.

74. Col Keith Gentile, HQ USAF/A2ZC, Pentagon, briefing provided to the author, 4 May 2006.

75. *DOD, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act of 2006*, Public Law 109-48, HR 2863, 109th Cong., 1st sess., sec. 8119, 30 December 2005.

76. Gentile, briefing.

77. DOD, *Quadrennial Defense Review Report* (Washington, DC: Office of the Secretary of Defense, 6 February 2006), 68.

78. BG Stephen Mundt, deputy chief of staff, Army G-3/5/7, "US Army Unmanned Aerial Vehicle Programs," Statement to the House Armed Services Committee, 6 April 2006.

79. "Army and USAF Share Son of Predator," *Strategy Page*, 24 March 2006, http://strategypage.com/htmw/htairfo/articles/20060324.aspx.

80. Gen Peter Pace, chairman, Joint Chiefs of Staff, memorandum for the Joint Requirements Oversight Council, 23 November 2005, 1.

81. Hazelwood, briefing.

82. Marshall, correspondence.

83. JP 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support*, 3 September 2003, Incorporating Change 1, 2 September 2005.

84. AFDD 2-1.3, 38.

85. Col Curtis V. Neal, USAF, retired, "JAGC2: A Concept for Future Battlefield Air-Ground Integration," *Field Artillery Magazine*, November–December 2006, 14–15.

Abbreviations

AAGS	Army air-ground system
ACM	airspace coordinating measure
ACTD	advanced concept technology demonstration
AF/A9L	Air Force Office of Lessons Learned
AFDD	Air Force Doctrine Document
ALO	air liaison officer
AOC	air operations center
ASOC	air support operations center
ATO	air tasking order
A2C2	Army airspace command and control
CALL	Center for Army Lessons Learned
CAOC	combined air operations center
CAS	close air support
CFACC	combined force air component commander
COLT	combat observation and lasing team
C2	command and control
DOD	Department of Defense
DODD	Department of Defense Directive
EO	electro-optical
ER/MP	extended range/multipurpose
ETAC	enlisted terminal attack controller
FAA	Federal Aviation Administration
FAC(A)	forward air controller (airborne)
FIST	fire support team
FM	field manual
FMV	full-motion video
FO	forward observer
4 ID	4th Infantry Division
FSC	fire support cell
FSCM	fire support coordination measure
GCS	ground control station
GMLRS	guided multiple launch rocket system
HEAT	high explosive antitank
IR	infrared
ISR	intelligence, surveillance, and reconnaissance
ISRD	intelligence, surveillance, and reconnaissance division
JAGC2	joint air-ground control cell
JAGO	joint air-ground operations
JARN	joint air request net
JCOE	joint center of excellence
JFO	joint fires observer
JP	joint publication

JROC	Joint Requirements Oversight Council
JTAC	joint terminal attack controller
LNO	liaison officer
MNS	mission needs statement
MOA	memorandum of agreement
MTTP	multi-service tactics, techniques, and procedures
NTISR	nontraditional intelligence, surveillance, and reconnaissance
OAF	Operation Allied Force
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ORD	operational requirements document
OSGCS	one-system ground control station
OSRVT	one-system remote video terminal
PGM	precision-guided munition
QDR	*Quadrennial Defense Review*
RFI	request for information/intelligence
ROVER	remote operations video enhanced receiver
ROZ	restricted operations zone
RSTA	reconnaissance, surveillance, and target acquisition
SAR	synthetic aperture radar
SATCOM	satellite communications
SOF	special operations forces
TACP	tactical air control party
TACS	theater air control system
TADN	tactical air direction net
TAIS	tactical air integration system
TST	time-sensitive targeting
UA	unmanned aircraft
UAS	unmanned aircraft system
UAV	unmanned aerial vehicle
USSOCOM	US Special Operations Command

Bibliography

"$214.4M for R&D on Warrior UAV (updated)." *Defense Industry Daily*, 12 August 2005. http://www.defenseindustrydaily.com/2005/08/2144m-for-rd-on-warrior-uav-updated/index.php#more.

Air Force Doctrine Document (AFDD) 1-1. *Air Force Basic Doctrine*, 17 November 2003.

AFDD 2-1.3. *Counterland Operations*, 11 September 2006.

AFDD 2-1.7. *Airspace Control in the Combat Zone*, 13 July 2005.

AFDD 2-9. "Intelligence, Surveillance, and Reconnaissance Operations" (Draft), 21 November 2005.

"Army and USAF Share Son of Predator." *Strategy Page*, 24 March 2006. http://strategypage.com/htmw/htairfo/articles/20060324.aspx.

"Army Makes Adjustments to Future Force Unmanned Aerial Systems." US Army News Release, 9 January 2007. http://www.army.mil/-newsreleases/2007/01/09/1293-army-makes-adjustments-to-future-force-unmanned-aerial-systems/.

Baker, Sue. "Predator Missile Launch Totally Successful." Aeronautical Systems Center Public Affairs news release. Wright-Patterson AFB, OH, 27 February 2001.

Bone, Elizabeth, and Christopher Bolkcom. *Unmanned Aerial Vehicles: Background and Issues for Congress*. Congressional Research Report for Congress. Washington, DC: Library of Congress, 25 April 2003.

Brown, Col David R. "JTAC MOA vs JTTP." *Field Artillery Magazine*, January–February 2005, 18–21.

Center for Army Lessons Learned and Air Force Office of Lessons Learned. *OIF-OEF Airspace Command and Control Collection and Analysis Team Initial Impressions Report*. Joint Report. 7 November 2006.

Center for Geographic and Statistical Analysis. http://www.co.yakima.wa.us/gis/Center/OrthoPhotos.html.

Correll, John T. "Verbatim." *Air Force Magazine*, January 2007, 51.

Department of Defense (DOD). *Quadrennial Defense Review Report*. Washington, DC: Office of the Secretary of Defense, 6 February 2006.

DOD. *Unmanned Aircraft Systems Roadmap, 2005–2030*. Washington, DC: Office of the Secretary of Defense, 4 August 2005.

DOD Directive 5100.1. *Functions of the Department of Defense and Its Major Components*, 1 August 2002.

DOD, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act of 2006. Public Law 109-48. HR 2863. 109th Cong., 1st sess., sec. 8119, 30 December 2005.

Grant, Rebecca. "Clash of the UAV Tribes." *Air Force Magazine*, September 2005, 46–50.

Herbert, Adam J. "Eighty-Six Combat Wings." *Air Force Magazine*, December 2006, 24–29.

Joint Publication (JP) 3-09.3. *Joint Tactics, Techniques, and Procedures for Close Air Support*, 3 September 2003, Incorporating Change 1, 2 September 2005.

JP 3-52. *Joint Doctrine for Airspace Control in the Combat Zone*, 30 August 2004.

Kennedy, Harold. "Services Focus on Fielding Munitions for Close Combat." *National Defense Magazine*, December 2005. http://www.nationaldefensemagazine.org/issues/2005/Dec1/Services_Focus.htm.

Krane, Jim. "Pilotless Warriors Soar to Success." *CBS News.com*, 25 April 2003. http://www.cbsnews.com/stories/2003/04/25/tech/main551126.shtml.

Mortensen, Daniel R. *A Pattern for Joint Operations: World War II Close Air Support, North Africa*. Washington, DC: Office of Air Force History and US Army Center for Military History, 1987.

Mundt, BG Stephen, deputy chief of staff, Army G-3/5/7. "US Army Unmanned Aerial Vehicle Programs." Statement to the House Armed Services Committee, 6 April 2006.

Neal, Col Curtis V., USAF, retired. "JAGC2: A Concept for Future Battlefield Air-Ground Integration." *Field Artillery Magazine*, November–December 2006, 13–17.

Pace, Gen Peter, chairman, Joint Chiefs of Staff. Memorandum for the Joint Requirements Oversight Council, 23 November 2005.

Sadler, Brent. "In the Sights of a Joystick Killing Machine." *CNN.com*, 9 June 2006. http://www.cnn.com/2006/WORLD/asiapcf/06/09/sadler.predator.btsc/index.html.

Saindon, CW3 Christopher A., USA, retired. "The FA: Leading Joint Interdependency with JACI." *Field Artillery Magazine*, September–October 2006, 14–17.

Tirpak, John A. "UAVs with Bite." *Air Force Magazine*, January 2007, 46–50.

US Army. *Extended Range/Multi-Purpose Unmanned Aerial Vehicle Operational Requirements Document ACAT Level II for a Milestone B Decision*. Washington, DC: Headquarters, Department of the Army, 14 June 2004.

US Army Field Manual 3-04.15. *Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006.

"Viper Strike Laser Guided Weapon for UAVs." *Defense-Update.com*, 25 September 2005. http://www.defense-update.com/directory/viper-strike.htm.