Strategy Research Project

UNMANNED AIRCRAFT SYSTEMS' ROLE IN NETWORK CENTRIC WARFARE

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USAWC STRATEGY RESEARCH PROJECT

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ABSTRACT

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Recent proliferation of Unmanned Aircraft Systems (UAS) has significantly affected combat operations. Current operational theaters serve as proving grounds for both programmed and experimental UAS; many are successfully supporting the commanders' situational awareness requirements. Wartime commanders are increasing their requests for UAS. The Department of Defense's (DOD) subsequent actions to fulfill these requirements attest to their growing relevance. Like many of the technical capabilities fielded as part of DOD transformation, UAS requires communications networking resources to operate in order to realize their maximum potential. However, fully integrating UAS within these operational theaters continues to challenge military leaders. DOD cannot progress on the path to implement its vision of Network Centric Warfare (NCW) without fully integrating UAS into the theater communications network.

This paper examines UAS' role in NCW. It starts by providing brief background on NCW and UAS to establish their distinct relevance. Then it addresses three key considerations necessary to fully integrate these two elements: UAS' role in facilitating information dissemination, UAS' role as an aerial communications relay, and UAS'

ability to operate within a constrained frequency spectrum environment. It then concludes with recommendations for establishing UAS as a valuable theater asset within the network-centric warfare environment.

UNMANNED AIRCRAFT SYSTEMS' ROLE WITHIN NETWORK CENTRIC WARFARE

Military history reveals certain technological advancements that have forever altered the conduct of warfare. Some examples include: machine guns and enhanced field artillery in WWI; vast improvements in airplanes and tanks during WWII; and air mobility via the helicopter in the Vietnam War. Currently, the U.S. has been at war for six years: What is the icon of today's battlefield? Perhaps Unmanned Aircraft Systems (UAS) should join this list. While this paper does not seek to support or refute this proposition, it does argue that the proliferation of UAS has significantly affected combat operations. Current operational theaters serve as proving grounds for both programmed and experimental UAS; many have successfully supported commanders' situational awareness requirements. Wartime commanders are increasing their requests for UAS. The Department of Defense's (DOD) subsequent actions to fulfill these requirements attest to their growing relevance. Like many of the technical capabilities fielded as part of DOD transformation, UAS requires communications networking resources to operate and to realize their maximum potential. However, fully integrating UAS within these operational theaters continues to challenge military leaders. DOD cannot fully implement its vision of Network Centric Warfare (NCW) without fully integrating UAS within the theater communications network.

This paper examines UAS' role in NCW. First, it provides a brief background on NCW and UAS to establish their distinct relevance. Then it explores three key considerations necessary to fully integrate these two elements: UAS' role in facilitating information dissemination, UAS' role as an aerial communications relay, and UAS' ability to operate within a constrained frequency spectrum environment. It then concludes with recommendations for establishing UAS as a valuable theater asset within the network-centric warfare environment.

Network Centric Warfare: A Matter of DOD Transformation

To meet the nation's global wartime imperatives, the President's 2006 National Security Strategy highlights the need to "transform America's national security institutions."[1] Accordingly, the Department of Defense is transforming to provide joint-force capabilities designed to meet an increasing array of challenges. This transformation includes, in part, the integration of advanced information and communication technologies necessary for enabling rapid information-sharing across the battlefield. The operational benefits derived through this infusion of networked capabilities are commonly termed "network-centric capability or net-centricity." The DOD Forces Transformation and Resources office maintains that enabling Network-Centric Warfare (NCW) is at the heart of U.S. military transformational efforts.[2] But what precisely is Network Centric Warfare and why is this concept relevant to Unmanned Aircraft Systems (UAS)?

To answer that question the author first provides basic NCW tenets:

- A robustly networked force improves information sharing.
- Information sharing and collaboration enhance the quality of information and shared awareness.
- Shared situational awareness enables self-synchronization.
- These, in turn, dramatically increase mission effectiveness.[3]

Not focused exclusively on technology, NCW seeks to empower military commanders by providing them with enhanced situational awareness and information superiority. The

Services currently rely on their individual funding to field networked communications and electronic systems to achieve this operational advantage and to meet warfighters' increasing information demands. Collectively, these efforts consumed about $65 billion of DOD's 2007 budget.[4] Recent operations have exhibited a dramatic growth in intelligence, surveillance, and reconnaissance (ISR) information requirements from the tactical soldier on point all the way to the combatant commander's joint operation center. In response to these demands, the Services have rapidly fielded UAS, which now provide critical access to this information and are gaining significant popularity through their demonstrated successes. For example, the 2006 Quadrennial Defense Report cites a vignette which describes a deployed ground force in battle coordinating with UAS pilots in Nevada, who then direct UAS in support of combat operations — all facilitated by the power of network connectivity.[5] While this singular example is impressive, UAS of varying sizes, capabilities, and missions are arriving on the battlefield in increasing numbers.[6] Network Centric Warfare, a concept central to DOD transformation, is executed through the networking (or interconnectivity) of critical battlefield elements to enhance combat effectiveness. However, the question is whether this fully includes a large scale integration of UAS. To address this matter, one must first acknowledge that UAS are indeed a vital capability with increasing strategic and operational relevance. Moreover, what is the relationship between UAS and the "network" and why is this matter relevant? The author first provides a brief background on UAS and then cites proof of their growing significance. It then argues for the operational benefits of fully integrating UAS into the theater communications network.

Unmanned Aircraft Systems: Doing the Dull, Dirty, and Dangerous[7]

While examples of earlier deployment exist, successful UAS operations in Iraq and Afghanistan have brought this capability into global prominence. UAS provide a tactical and strategic ISR capability into the theater by providing real-time, full-motion video (FMV), imagery, and sensor information to the commanders, significantly increasing their overall situational awareness. Traditionally used as an ISR asset, UAS now provide additional battlefield functions such as strike capabilities, air interdiction, and aerial communications relay. There is almost no limit to UAS' capabilities, a fact recognized by both the Combatant Commands and the separate military service departments. In fact, UAS fulfill (or could fulfill) 17 of the DOD's 99 prioritized capability gaps, an inclusive list using input from all the services, the FY08-13 Combatant Commanders Integrated Priority List, global counter terrorism planning requirements, and lessons learned analysis. Two of these gaps are in the top 10.[8] This demand has not gone unnoticed. According to the Government Accountability Office (GAO), the DOD's FY08 budget request includes $2.23 billion for UAS which represents a 600% increase from 2001.[9] The significant increase in the number of UAS, from a current level of approximately 3900 in contrast to 50 in 2000, further suggests a growing operational relevance. Most of the available UAS in the DOD inventory now serve within Iraq or Afghanistan.[10]

This paper does not seek to examine in detail the technical composition, variants, and operational capabilities of all UAS. Rather, it provides fundamental understanding of UAS to ensure necessary background. DOD categorizes UAS into three classes. Man-portable UAS are hand-held devices designed to support small, ground elements. Tactical UAS have greater capability (greater loiter times, more coverage distance) and offer increased FMV and sensor services with a more robust product distribution ability.[11] Theater level UAS support theater-wide requirements by providing the most robust capabilities; they require significant theater network resources.[12]

UAS consists of four basic components. First is the aircraft (fixed or rotary wing) and its associated payload. The payload varies according to the UAS size and mission. Payloads include weapons, sensors, FMV apparatus, and communications equipment. Second is the Ground Control Station (GCS) which serves as the control hub directing the UAS operation. Larger, theater-level UAS (such as the U.S. Air Force Predator) require significant GCS equipment and facilities, portions of which are located outside of the operational theater. Third is the associated communications architecture connecting the UAS to the GCS; it ensures control of the aircraft and receives collected products. This architecture ranges from a simple line-of-sight structure supporting a small, man-portable or tactical UAS to a more complex, satellite-based architecture supporting a theater-level UAS. Fourth component is the associated viewing apparatus, such as the Remote Video Terminal (RVT) used to receive FMV directly from the aircraft.[13] To operate effectively, all UAS classes require theater communications resources such as available frequency spectrum (at times referred to as bandwidth) and networking architecture.

DOD is making considerable long-term strategic investments in UAS and is promoting NCW as part of military transformation. But are these two goals mutually supportable or divergent? The 2006 QDR clearly links the two objectives, stating that the DOD remains “invested in new equipment, technology, and platforms for the forces, including…unmanned vehicles…all linked by Net-Centric Warfare Systems.”[14]

However, the current operational demands to rapidly field UAS have created significant theater network issues. In fact, DOD is currently unable to realize the full operational effectiveness of UAS. GAO testimony cites continued challenges in network interoperability and spectrum availability as two main impediments to current employment of joint UAS.[15]

DOD cannot successfully implement NCW without fully integrating UAS within the theater communications network. But what does this task entail? This paper examines three UAS requirements in robust, fully functional NCW: UAS facilitates information dissemination, UAS serves as an aerial communications relay, and UAS operates within a constrained frequency spectrum environment.

Information Dissemination: Establishing Situational Awareness

Keeping in mind its aforementioned tenets, NCW provides an operational advantage by providing relevant information to the right place, at the right time, and in the right format. Increasing UAS numbers and their expanding ISR missions mark them as a prime candidate to function fully within this environment. To achieve this goal, UAS must provide widespread, networked access to the information they provide, which presents significant implications for the theater communications architecture. When discussing effective UAS integration, General William T. Hobbins, Commander, U.S. Air Force Europe, states that:

> It’s got to go to the core of operations. The information from (UASs) could, and I contend, should populate the global information grid[16], to the maximum extent possible. Systems of systems can provide the appropriate information at the right time to those who need it. This would correspond to improve situational awareness at all levels of warfare. … It's about decision superiority.[17]

Creating an “information stovepipe” where the UAS data is transmitted to a single location provides value only to a limited audience. The situational awareness information that UAS provides greatly add to the “common operational picture” of the battlefield. But should everyone have access to this information? Should all UAS information populate the theater information grid? Answering these questions serves two purposes central to a discussion on information dissemination. First, it forces a disciplined approach to addressing information exchange requirements (who needs the information and therefore, where does the information need to go). Second, it highlights interoperability requirements between the UAS components and the theater communications architecture (how effectively the information gets to their destinations).

Each Service seeks to codify information demand and exchange requirements, in part, to properly train and equip their organizations. While this is an imperfect science, requirements do vary at the tactical, operational, and strategic levels. This paper offers two brief data points to shape this discussion. First, DOD has stated that it is technologically impracticable to provide full access to the products derived from tactical, hand-held UAS.[18] Accordingly, this analysis will focus on operational and strategic level UAS unless otherwise noted. Secondly, leaders should beware of the “transfixing” effect that UAS video can have on personnel within the command and control facilities. Real-time ISR video feeds can unnecessarily become the center of attention of those not directly involved in that mission. In fact, a recently published multi-service UAS manual warns that “access to real-time UAS video requires discipline and dedication to viewing the imagery only when necessary and by those who have a need.”[19]

While the Services may not fully capture all information requirements, operational and strategic UAS must enable common access to the information they provide to function as a relevant asset within NCW. Such access requires interoperability with the network transport and data systems within the communications architecture of the theater. However, the GAO has continually cited a lack of interoperability among the various UAS components and current communications systems, designating this shortcoming as a major impediment to joint operations.[20] To meet military demands, DOD rapidly designed, enhanced, and fielded UAS. Traditional acquisition processes that govern DOD programs of record do not always allow the rapid infusion of the technological advancements sought by deployed military units.[21] Unfortunately, time saved in quickly fielding Service-specific UAS has also affected their ability to operate jointly. Each Service, as well as U.S. Special Operations Command, is developing UAS to support all military echelons from the small unit level to the Joint Force Commander. "In fact, by 2010, DOD plans on having at least 14 different UAS in the force structure to support a variety of missions."[22] Additional experimental UAS variants will add to this number and could easily contribute to the interoperability issue. Lack of interoperability creates significant engineering challenges for theater network planners — at times resulting in less than ideal architectural solutions. In worse cases, lack of interoperability breaks the information flow and prevents information-sharing altogether.

To establish uniform standards and provide executive-level oversight, DOD established the UAS Task Force with a mission to "lead a Department-wide effort to coordinate critical UAS issues, and to develop a way ahead for UAS that will enhance operations, enable interdependencies, and streamline acquisition."[23] One significant product developed by the UAS task Force is the recently published *Unmanned Systems Roadmap 2007-2032,* which serves as OSD-level guidance regarding future development, funding, and prioritization efforts across DOD.[24] In view of past difficulties involved with integrating UAS in a joint environment, improving standardization and interoperability is a main goal for this organization. Indeed, each Service understands the operational and logistical benefits derived from adhering to a coordinated DOD UAS acquisition strategy. For example, BG Stephen Mundt, Director of Army Aviation, reported in his congressional testimony that a principal goal of Army UAS strategy is commonality. Contributing to this commonality is the Army's "One System Ground Control Station (GCS)". This equipment (also pursued by the U.S. Marine Corps) promotes interoperability among Army UAS and will allow a greater degree of operational flexibility while simplifying training and logistics requirements. This GCS employs the Tactical Common Data Link (TCDL), which provides the data link from the aircraft and promises significant interoperability improvements.[25] Knowing that his Congressional audience remains deeply concerned over costly and divergent acquisitions, BG Mundt emphasized that:

> The One System will be …TCDL compliant, which will provide us a more reliable datalink and more efficient use of the frequency spectrum. The One System will also be NATO Standardization Agreement 4586 compliant which will provide us interoperability across joint and coalition unmanned systems. The One System concept has already peaked interest with our NATO partners. They understand the power of having a single set of ground equipment that can interoperate with an entire fleet of joint and coalition unmanned aircraft.[26]

DOD recognizes the value of employing TCDL across all Services and maintains that goal as one of its primary objectives required to achieve interoperability.[27] To further improve information dissemination, the U.S. Army is also fielding the One

System Remote Video (OSRVT) terminal to its deployed forces. OSRVT is a light-weight (portable or platform-mounted) system capable of receiving broadcast images from several UAS simultaneously.[28] While these are steps in the right direction, it addresses only a portion of the problem. Many UAS still pass their critical video, sensor, and control information to a single Ground Control Station in a closed circuit fashion, thereby isolating the UAS from the theater network and thus from other battlefield elements.[29] Users then must often rely on a completely separate networking solution to receive UAS products.

One example of a separate network is the Global Broadcast Service (GBS) program, which offers a high-speed, one-way flow of information (video and data) to deployed and garrisoned users. Additional theater communications resources must transmit the UAS video from the local source to a GBS theater or primary injection point, perhaps located outside of the country of origin, which in turn re-transmits the video via satellite to users' GBS receive suites located back in the theater.[30] Such videos have certainly traveled a long way to get disseminated throughout the theater battlefield. This example is not intended to denigrate the GBS program. In fact, this program currently provides an invaluable product to the warfighter. The existing theater network simply cannot disseminate the large amount of UAS video required throughout the region. However, NCW requires consolidation of networking solutions to enable rapid information exchange, to enable users to query relevant information sources, and to promote positional awareness of key battlefield elements.[31] For UAS to be a viable part of the NCW environment, they must be able to directly "plug" into the theater network. Common GCS using TCDL is a start, but DOD must provide a communications network interface to complete the architecture. One such DOD program may indeed fulfill this requirement: The Warfighter Information Network-Tactical (WIN-T) offers significant promise for enabling effective UAS information dissemination.

WIN-T is a multi-billion dollar Army program that has the documented requirement to provide a single integrated communications network that promotes joint interoperability and enables linkage of battlefield sensors to the GIG. WIN-T will eliminate the need for various non-interoperable networking solutions currently in use. It also provides a much needed communications-on-the-move capability for all echelons. Inherent within the WIN-T concept is the full network integration of UAS to maximize network capacity and efficiency and to improve information dissemination.[32]

Information requirements must link to the fielding of interoperable solutions. This interoperability enables military and commercial systems to communicate with one another efficiently and thus provide broad access to their products. UAS information dissemination provides an important contribution to achieving battlefield situational awareness. UAS (which includes its components) must take into account the current and future capabilities of the communications network and vice versa. Both UAS and the network are co-equals in NCW. UAS clearly needs the network to disseminate its products. So, how can UAS assist the network in its role in providing communications connectivity throughout the battlefield?

Building the Aerial Communications Layer

As previously stated, NCW requires the networking of personnel and battlefield command systems to enhance overall combat effectiveness. Building this omnipresent network connectivity continues to challenge the theater commander. Traditionally viewed as an ISR asset, one emerging role of UAS may offer a substantial contribution to this situation. To realize the benefits envisioned by advocates of NCW, DOD must explore the capability of UAS to broaden communications connectivity throughout the battlefield, in effect serving as a "network multiplier." Functioning as an aerial communications relay node, UAS provides the ability to extend the network to more units operating at greater distances or within urban or other adverse environments. Given the almost insatiable appetite for the network, theater planners continue to increase the use of UAS as aerial relay nodes. In fact, of the sixteen different mission areas associated with theater UAS, Combatant Commands ranked "communications/data relay" as fourth.[33] The following section argues that UAS serve a growing and significant role in enabling NCW through their ability to extend the network. This analysis focuses on DOD's programmed and experimental approach to building the aerial communications layer and addresses associated opportunities and challenges.

What is meant by an 'aerial communications layer' and why is it required? Answering these fundamental questions requires a look at the conduct of current military operations and requires a brief scan of future joint operational concepts. Today, U.S. forces are spread out over great distances, operating in urban or mountainous terrain, and often arrayed in a non-contiguous fashion. To support these units, the network requires an architecture consisting of three layers (or tiers). Traditional line-of-sight communications (the terrestrial communications layer) do not consistently operate within this environment due to visual obstructions. Satellite resources (the space communications layer) are not universally available or responsive enough to support both planned and ad hoc requirements. However, an interconnected third tier within the network, the aerial communications layer, ensures not only adequate coverage but also adds sufficient redundancy to mitigate risks due to overreliance on a single path or given group of transmission systems.[34]

What about future joint operations? Strategic military publications offer clear insights to future joint warfighting capability requirements. The 2005 National Defense Strategy cites the ability to conduct network-centric operations as one of DOD's "key operational capabilities" required to ensure effectiveness of a highly distributed force.[35] In describing required future capabilities, The Capstone Concept for Joint Operations declares that "the joint force will capitalize on being networked…and will exploit network connectivity among dispersed joint force elements to improve information sharing, collaboration, coordinated maneuver, and integrated situational awareness."[36] The supporting Joint Functional Concepts (Command and Control, Force Application, Protection, Focused Logistics, Battlespace Awareness, and Net-Centric Environment) all tout their respective domain requirement for a ubiquitous network. While DOD continues to program and field improvements in terrestrial and space communications capabilities, their limitations persist and requirements keep accumulating.[37]

The essential question is whither the network can meet these future expectations. The answer is quite significant. No network equates to no Network Centric Warfare. Given the looming impediments to DOD transformation and future joint operations, leveraging UAS to increase network robustness and to provide access to otherwise disadvantaged users is an option worthy of serious consideration. In fact, a DOD-sponsored study has concluded that total satellite demands will exceed requirements without the establishment of an aerial communications network.[38] The U.S. Army Signal

Center has confirmed this conclusion by asserting that future network capacity will meet only half of military requirements; the Signal Center therefore strongly advocates development of an aerial communications layer to redress this shortfall.[39] Fortunately, DOD has several programmed and experimental efforts underway to develop such capability.

The Services are on a path to build an aerial layer communications capability using either manned or unmanned platforms. The Air Force's Objective Gateway, an acquisition program-of-record, is designed to field an airborne network relay and communications gateway to link up various air and ground elements. As a key part of this program, the Battlefield Airborne Communications Node (BACN) provides an airborne communications relay package and data information server. Although the Air Force is currently testing BACN within a manned aircraft, program technicians anticipate integrating this system within a UAS.[40] The Marine Corps has provided their Marine Airborne Re-Transmission System (MARTS) in response to urgent requirements from their deployed units. This experimental program, developed by the Defense Advanced Research Project Agency, fields a tethered, unmanned airship that relays radio communications within an area in excess of 68 nautical miles.[41] The Navy is also pursuing similar aerial communications relay capabilities to support their fleet. To meet current demands and future requirements, the Army is making a considerable effort to provide a UAS tactical aerial communications relay.

Although ISR remains a primary mission, the Army's Shadow UAS also provides radio communications relay to brigade-sized elements.[42] Further, the Hunter (and starting in 2009, the Sky Warrior) provides a division-level UAS capable of supporting communications relay missions. To address the reality of competing UAS priorities, the Warrior is designed to execute multiple missions, such as simultaneous ISR support and communications relay.[43] While these examples suggest a growing Army interest in using UAS as an aerial communication relay, what is more indicative of Army commitment is the envisioned role of that capability within several high level acquisition programs: Future Combat Systems (FCS) , WIN-T, and the Joint Tactical Radio System (JTRS).

The 2007 Army Modernization Plan asserts that FCS is the "cornerstone of the materiel modernization of the Army" and is indeed central to the Army's relevance in the 21st century. This multi-billion dollar program fields an interoperable mixture of 14 manned and unmanned systems; through the power of network technology, it provides situational awareness to all platforms right down to the individual soldier. Originally designed to field four different UAS, FCS will now consist of a Class I and Class IV UAS.[44] Among its mission capabilities, the Class IV UAS, currently designated the Fire Scout, provides aerial communications relay coverage. According to the Army's concept, to achieve their maximum capability the FCS BCT

> ...leverages all available resources to provide a robust, survivable, scalable and reliable heterogeneous communications network that seamlessly integrates ground, near ground, airborne and space-borne assets for constant connectivity and layered redundancy.[45]

The Army's WIN-T program and the DOD's JTRS program will provide this network transport layer to connect both FCS Brigades and today's modular forces. To address future network demands, both programs also provide aerial communications relay packages for UAS. In several ways, DOD has just begun to develop aerial communications relay capabilities. The Services continue to pursue this capability for a simple but telling reason: They require more network access than they currently possess. Using UAS for this mission presents both opportunities and challenges for DOD and indeed for advocates of NCW.

The potential benefits include addition of another means to extend the network to those who would otherwise remain isolated. Aerial communications relays could serve as an alternative to terrestrial systems that functionally rely on both line-of-sight and protected territory to function – both being problematic in counterinsurgency operations in urban and complex terrain. It also provides an alternative to costly and limited satellite resources – which do not respond quickly to short-notice demands.

With these potential benefits, however, come significant challenges. Separate Service-led pursuits increase the risk of exacerbating the problems first realized in integrating UAS within the joint operational environment to execute ISR missions. Without established program standards and technical protocols for developing an aerial layer tier, DOD may not provide a capability that interoperates with existing and future data and transport architectures. To efficiently integrate an aerial tier within the theater network, units need appropriate concepts and doctrine that provide network management and planning guidance. UAS aerial communications relay missions must expand the network in a predictive and responsive manner which may conflict with other UAS mission requirements (i.e. ISR) deemed at a higher priority by unit commanders. Lastly, in order for UAS to further enable NCW as an aerial communications relay, DOD must address a problem that continues to plague the operational success of current UAS ISR missions and indeed many other systems – lack of available operating spectrum.

Spectrum Availability – Making the Magic Work

While not all military leaders understand, nor care to understand, the technology that enables the vast amount of electronic systems found in today's military environment, there is one cold hard fact that most experienced leaders now understand: They need bandwidth to make the "magic" work. Perhaps more precisely: The availability of adequate frequencies within the electromagnetic frequency spectrum enables many of these systems to operate. However, the lack of spectrum availability continues to impede current military operations. UAS are chief amongst these spectrum claimants; according to a 2007 GAO report, UAS suffer from operational problems due to increased competition for available spectrum and their inability to operate within this constrained environment.[46] UAS must acquire the ability to operate in a spectrum-constrained environment to perform their various missions and to function fully as a NCW asset. The following section first provides brief insights on how DOD arrived at this dilemma and examines its associated operational implications. The analysis then focuses on several initiatives aimed at addressing spectrum problems within DOD — specifically, those efforts concentrating on better integrating UAS into the NCW arena.

In keeping with transformation objectives, DOD has equipped its forces with significant technological capabilities. Units now possess dramatically improved command and intelligence systems, wireless and satellite communications, and other technical systems designed to protect their forces and enhance operational performance. These military units have brought these new capabilities, as well as commercially procured systems deemed critical, to Iraq and Afghanistan and turned them all on. This surge resulted in a massive grab for available frequencies – all competing not only with U.S. and Coalition military systems but also with civilian, host nation, and other governmental agencies.[47] In some cases, military systems did not operate or were degraded due to frequency interference. Despite extensive coordination by U.S. Central Command to ensure proper pre-deployment apportionment of frequencies, the scale and complexity of operations in Iraq has dashed any hope of resolving all spectrum conflicts. John Grimes, the DOD Chief Information Officer and Assistant Secretary of Defense for Networks and Information Integration, has admitted that DOD did not fully anticipate the demand for spectrum in the beginning of the Global War on Terrorism.[48] As significant as this demand was in the early stages of the war, the need continues to soar with the introduction of additional UAS, wireless radio systems, weapons, and sensors used by U.S. and coalition forces.

To compound the problem, the U.S. is now engaging in a form of electronic warfare in an effort to defend against insurgency tactics that employ radio controlled improvised explosive devices (IEDs). To counter the threat of IEDs, the U.S has quickly fielded an array of electronic jamming devices that, while successfully disrupting the signals enabling the IEDs, have also the unintended consequence of jamming U.S. and Coalition systems to include radio links controlling UAS.[49]

UAS continue to fill a significant need; they are in greater demand as they demonstrate battlefield successes. However, without the flexibility to operate in a dynamic, spectrum-constrained environment, they impose severe planning limitations on their users. Simply stated, UAS cannot operate nor “plug” into the network without spectrum resources – which makes their potential contributions to NCW questionable. How did DOD get into this predicament? To address this question, this section asserts two contributing factors. First, operational necessity to quickly field UAS led to design solutions that did not take into consideration spectrum limitations. Second, the DOD failed to enforce spectrum supportability as a criterion during the traditional acquisition processes.

UAS components require frequencies to send and receive signals that control aircraft and transmit collected video, data, or relayed communications. Each of these signals operates within a portion of the electromagnetic frequency spectrum. National and international regulations apportion those bands for military, civilian, and emergency (etc.) use; bands of the spectrum contain unique technical characteristics conducive for certain functions. For example, certain frequencies travel greater distances or can transmit larger amounts of information. Given this technical reality, many military (and civilian) systems gravitate to common frequency bands. Thus, activating all of these systems in the same geographical area creates conflicts. For example, many tactical and theater-level UAS can operate only in the 4-8 Gigahertz range, referred to as C-band. Unfortunately, this is also the same band used by numerous radar systems, satellite and troposcatter communications equipment, and aircraft altimeters. Additionally, certain tactical UAS are “hard-coded” to use limited frequency pairs that are also heavily used in civilian and other military systems — and are in fact not available for use in some countries outside the U.S.[50] Fielding UAS quickly provided a much needed war-fighting capability but its design limitations have created problems for the theater commanders. In fact, DOD has cited inadequate spectrum resources or interference issues as the direct cause for numerous UAS operational failures.[51] If UAS do not have access to adequate frequencies, commanders must also make difficult prioritization decisions or come up with alternative solutions. Fielding capabilities quickly sometimes require a departure from traditional DOD acquisition processes, which often leads to unforeseen operational problems. However, what about those systems, to include UAS, that follow established DOD acquisition guidelines?

This paper does not thoroughly review DOD acquisition policies and procedures. However, it has found that these regulations include “spectrum supportability” criteria to ensure that the designed equipment can function in the environment for which it was acquired. But, a report released by the Defense Spectrum Office asserts that “Current methods for assuring that systems have spectrum access are poorly defined, too slow, subjective and inconsistent.” This report goes on to claim that, in fact, the acquisition community frequently avoids spectrum supportability requirements.[52] In the final analysis, UAS and other critical military systems are encountering operational problems due to inadequate spectrum resources because of problems within military acquisition processes.

As spectrum availability problems still persist, both DOD and the UAS development community have recognized the scope and severity of the problem. Vice Admiral Nancy Brown, the Joint Staff J6, asserts that adjustments to DOD acquisition processes now require earlier spectrum supportability assessments. Adm. Brown goes on to claim that improved spectrum management tools and training within the Services will improve current integration problems and help prevent further spectrum-related conflicts.[53] The UAS development community is also taking steps to ensure their products can operate within spectrum constraints. UAS using Tactical Control Data Link (TCDL) enhances interoperability and therefore improves informational dissemination.

TCDL also promotes efficient use of the frequency spectrum by providing UAS the flexibility to operate in a wider range of frequencies.[54]

In keeping with DOD transformation objectives and indeed current wartime operational requirements, the Services developed and fielded UAS and other capabilities that use advanced communication, sensor, and networking technologies. In essence, the DOD has entered the early stages of executing NCW – and within this construct has revealed some significant challenges. Access to frequency spectrum is a fundamental requirement for many of these systems; a requirement taken for granted by some product developers. So this issue continues to cause operational problems for theater commanders. DOD's continued emphasis on network-centric operations makes reliable spectrum access even more critical.[55] UAS serve many significant roles within today's Joint, Interagency, Intergovernmental, and Multinational operational environment with more possibilities on the horizon. All of these missions require unimpeded spectrum resources. Without adequate spectrum, UAS cannot provide and disseminate invaluable ISR information and cannot provide an aerial communications layer to support the soaring demands on the common theater network. The issues addressed in this paper are all inter-related; therefore, DOD must address each with this fact in mind.

<u>Recommendations</u>

Integrating UAS within the theater communications network has challenged both deployed units and DOD leadership. Acknowledging the severity of this problem and the invaluable service that UAS provide, the military has emplaced several initiatives that address this challenge – several of which are mentioned above. DOD's transformation efforts and future operational concepts envision a network-enabled force empowered with systems that provide enhanced “situational awareness” of the operational environment. To ensure that UAS function fully as a NCW asset, DOD leaders should consider the following recommendations:

(1) DOD must ensure the design and fielding of UAS is done in close partnership with those agencies responsible for building and sustaining the common communications network. In pursuing the benefits of net-centric operations, many different military organizations develop systems that rely on the common “network” or networking resources to function. More specifically, the organizations that design, field, and sustain UAS are not the same organizations that are charged with similar responsibilities for the communications network. Observing established architecture standards and protocols will promote interoperability. But the scale of UAS operations requires increased collaboration among the joint and service-level communications communities. The goal of the communications network is to serve the needs of the warfighter which includes enabling those battlefield systems, such as UAS, that require network support. Likewise, UAS must interface with the common network to ensure efficient dissemination of their products. DOD must establish this partnership early in the product design phases and ensure it remains intact throughout the acquisition process.

(2) DOD must systematically support the development of an aerial communications layer to broaden network availability and increase network efficiencies. The demand for network capacity continues to soar. Each service is pursuing an aerial communications relay capability to partially address these demands. However, DOD

must ensure a coordinated approach to developing this capability by establishing and enforcing networking standards and protocols. DOD must provide concepts for network management and network planning. Lastly, DOD should formally pursue a High Altitude Long Loiter (HALL) capability as part of the aerial layer tier. While experimental HALL variants exist, DOD does not have a formal HALL program-of-record. These platforms can provide communications coverage for hundreds of kilometers; and, unlike other lower level UAS, they do not suffer from line-of-sight, airspace, spectrum, and weather limitations.[56]

(3) DOD must ensure that UAS can operate in an environment with limited availability of frequency spectrum. UAS roles and missions will only increase as necessity demands and more innovation takes place. They will operate not only in isolated battlefields, but also in highly populated urban areas and ad hoc military operating bases. As for many network-centric systems, DOD must strictly enforce spectrum supportability benchmarks early in the acquisition process. UAS testing should occur in a spectrum-constrained environment often in the design phases; UAS should have the ability to reprogram to a wide range of frequencies as required. To increase the ability to de-conflict UAS and resolve other spectrum interference issues, DOD must develop management tools that provide real-time awareness of spectrum use and that populate a database that graphically visualizes frequency use within a given environment.[57]

Conclusion

DOD, and indeed other U.S. and international government and civilian agencies, has only just begun to capitalize on unmanned aircraft systems. Successes in this domain also inspire the design of unmanned systems that operate on land and on or under water. The potential of these systems to serve is almost unlimited. However, putting these capabilities into operation requires a thorough understanding of the communications environment in which they must function. These systems, like so many other capabilities designed under the imperative of promoting network-centric warfare operations, generate requirements on the theater communications network. To make DOD's vision of NCW a reality, UAS and the "network" must co-operate. Achieving this goal requires fulfilling three mandates: UAS must perform interoperability with both the theater network and other adjoining systems to promote information dissemination efficiencies; DOD must support developing UAS's role as an aerial communications relay node to broaden network connectivity within the theater; and DOD must ensure that UAS can function within an environment that contains limited frequency spectrum availability. The Services can certainly field net-centric "pieces and parts" that alone offer tremendous potential. However, interconnecting these systems to build a unified, networked capability that satisfies warfighters' demands remains the ultimate challenge. Several solutions indicated within this paper such as WIN-T, TCDL, and OSRVT indicate that DOD acknowledges this assertion. The successful integration of UAS within the theater network is indicative of DOD's ability to field and sustain net-centric capabilities as per their transformation and visionary objectives.

Endnotes

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[3] Ibid., 7.

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[8] Ibid., 20.

[9] U.S. General Accountability Office, *Unmanned Aircraft Systems: Advanced Coordination and Increased Visibility Needed to Optimize Capabilities: Testimony to the Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives* (Washington, D.C.:U.S. General Accountability Office, July 2007), 2.

[10] Ibid.,2.

[11] See Unmanned Systems Roadmap, Appendix A, for a listing of numerous programmed and experimental UAS to include their background, characteristics, and performance data.

[12] Air, Land, and Sea Application Center, *UAS: Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems* (Langley Air Force Base: Air, Land, and Sea Application Center, 3 August 2006), I-2 to I-3.

[13] Ibid., I-5 to I-6.

[14] QDR, vii-viii.

[15] U.S. General Accountability Office, *Unmanned Aircraft Systems: Advanced Coordination and Increased Visibility Needed to Optimize Capabilities: Testimony to the Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives,* 10-11*.*

[16] U.S. Joint Chiefs of Staff, Joint Publication 3-0, *Joint Operations*, defines the Global Information Grid (GIG) as "the globally interconnected, end-to-end set of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating, and managing information on demand to warfighters, policy makers, and support personnel. The Global Information Grid includes owned and leased communications and computing systems and services, software (including applications), data, and security services, other associated services, and National Security Systems."

[17]Capt Elizabeth Culbertson, “Unmanned Aircraft Key to Future Operations, General Says,” Armed Forces Press Service, 20 October 2006 [News Article on-line]; available from http://www.defenselink.mil/news/newsarticle.aspx?id=1730; Internet; accessed 5 November 2007.

[18] U.S. General Accountability Office, *Unmanned Aircraft Systems: Advanced Coordination and Increased Visibility Needed to Optimize Capabilities: Testimony to the Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives,* 6.

[19] Air, Land, and Sea Application Center, III-6.

[20] U.S. Government Accountability Office, *Unmanned Aircraft Systems: DOD Needs to More Effectively Promote Interoperability and Improve Performance Assessments: Report to the Subcommittee on Tactical Air and Land Forces, Committee on Armed Services, House of Representatives* (Washington, D.C.:U.S. General Accountability Office December 2005), 2.

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[22] U.S. General Accountability Office, *Unmanned Aerial Vehicles: Major Management Issues Facing DOD’s Development and Fielding Efforts, Testimony to the Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives* (Washington, D.C.:U.S. Government Accountability Office, March 2004), 3.

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[27] Unmanned Systems Roadmap, 4.

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[31] Jeffrey L. Groh, "Network-Centric Warfare:Just About Technology?," in *The U.S. Army War College Guide to National Security Policy and Strategy*, ed. J. Boone Bartholomees, Jr. (Carlisle Barracks: U.S. Army War College, June 2007), 380.

[32]U.S. Department of the Army, *2007 Army Modernization Plan* (Washington D.C.: U.S. Department of the Army, 5 March 2007), 152.; see also U.S. Army Signal Center, Capability Development Document for Warfighter Information Network-Tactical (WIN-T) (Fort Gordon: U.S. Army Signal Center, 6 November 2006), i and 35.

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[34] U.S. Army Training and Doctrine Command, *Force Operating Capabilities, TRADOC Pamphlet 525-66* (Fort Monroe: U.S. Army Training and Doctrine Command, 1 July 2005), 21.

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[44] U.S. Department of the Army, *2007 Army Modernization Plan* (Washington D.C.: U.S. Department of the Army, 5 March 2007), 7-8. See also http://www.army.mil/fcs/ which provides information on the Army's Future Combat System program.

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[54] U.S. General Accountability Office, *Unmanned Aircraft Systems: Advanced Coordination and Increased Visibility Needed to Optimize Capabilities: Testimony to the Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives*,11.

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