JANE'S STRATEGIC
ADVISORY SERVICES

UAS: Unmanned, Unbound

Exploring Future Operational Concepts for Unmanned Aerial Systems

Author: **Tate Nurkin**
Contributor: **Seth Drewry**

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With the release of "UAS: Unbound, Unmanned", Jane's Strategic Advisory Services (JSAS) offers its third White Paper addressing relevant defense and aerospace markets and technologies. This report will be released as part of our participation in Defense Asia 2006 where we will present on the topics of Unmanned Aerial Systems and Unmanned Underwater Systems. As with our previous topics, US military vehicles and the future of long range strike, we have chosen to address a topic that is at the crossroads of developing next generation technologies and strategies. What makes this paper unique is that it combines our historic expertise in market and technological analysis with our emerging capabilities in Alternative Futures Analysis. While most applications of Alternative Futures Analysis focus on geopolitical security trends, JSAS is at the cutting-edge of merging the traditional futures analysis methodologies with a more industry focused analysis of alternative events. This new capability will allow our clients to identify the emergence of potential trends and milestones to develop contingency plans for market shifts or disruptions.

Using the basic tenets of futures analysis, this paper analyzes the alternative future concepts of operations (CONOPS) for Unmanned Aerial Systems (UASs). While UASs have been a part of military operations for a number of years, the future development of effective and relevant systems will require further evaluation of CONOPS as new missions emerge. It is not enough to develop cutting-edge technology in hopes of meeting future requirements, it will be necessary to first define future missions and build and develop the technology for those missions. In this paper JSAS explores potential future missions for UASs as an early guide post for UAS requirement planning.

Again JSAS has utilized its vast network of resources to identify a large number of relevant issues to this market. The analytical insight that Jane's brings to bear, matched with access to knowledge is unrivalled. This paper represents that balance between analytical rigor, editorial perspective, relevant content and insight, and global reach. This balance provides our clients with a truly rounded and comprehensive perspective to meet their financial and strategic goals. Jane's is the first stop for consulting firms, publications, governments and industry when analyzing defense and aerospace markets. The ability to merge a variety of sources, our analytical integrity and over 100 years experience make Jane's the authoritative source in our core markets. This paper is testament to that ability and we hope that you find it a useful tool in analyzing the future of the UAS market.

Respectfully,

John Kenkel
Senior Director,
Jane's Strategic Advisory Services

EXECUTIVE SUMMARY

Unmanned Aerial Systems (UASs) are becoming an increasingly important element of many modern militaries. Their success on battlefields in Afghanistan, Iraq, the Levant, and in other surveillance functions in other parts of the world has driven interest in and demand for a variety of types of unmanned systems and has demonstrated in stark relief the following values and capabilities:

- ***Low Risk and Low Cost:*** UASs are relatively inexpensive systems to build and procure and are far more expendable than manned systems.

- ***Persistent Surveillance:*** The most obvious and frequently referenced unique operational capability of UASs is their ability to linger over and around targets for several times longer than manned aircrafts.

- ***Precision Strike:*** Unmanned Combat Aerial Systems (UCASs) will be a critical weapon in the precision strike arsenals of a growing number of states, particularly as these states deal with contingencies in urban, maritime or difficult to access areas.

- ***Tactical and Combat Reconnaissance:*** Lightweight, easy to assemble and launch UASs can allow operators to see around corners and over obstacles in urban environments or fly into caves, ravines and thick canopied jungles to provide highly specific intelligence and a clear situational awareness of the imminent threat environment.

- ***Resilience and Access:*** UASs can access areas that are inaccessible to manned platforms, including harsh physical environments-extreme radiation, heat, cold, storms, chemical or biological weapons-exposed environments-that could not be safely inhabited by manned vehicles.

- ***Dynamic Re-tasking and the Blending of Stove-piped Missions:*** Unlike most manned aircraft, which are developed as fighters or bombers or surveillance aircraft, UASs can be developed and equipped to be all of the above, depending on the payloads with which they are equipped. This blending of what were previously stove-piped missions will allow for far greater flexibility and efficiency of tasking.

- ***Versatility:*** Unmanned aerial systems come in nearly all shapes and sizes, from large long-range bombers with the same wingspan as that of current manned platforms such as the B-2, to small and micro-UASs that can be launched by hand or carried into battle in the backpack of a soldier, sailor or Marine.

- ***Network Centric Warfare Enablers:*** UASs can also be used as sensors and communications relay nodes connecting platforms and units and enabling a more complete version of network centric warfare.

- ***Chemical, Biological and Radiological Detection:*** One of the many payloads with which UASs can be equipped are advanced MASINT sensors with the ability to detect signatures of Weapons of Mass Destuction (WMDs).

- ***Stealth:*** Stealth technologies can be-and are-easily adapted to unmanned aerial systems.

Future increased demand for UASs will be due only in part to the robustness and variety of the systems and their capabilities. It will also be driven by the distinctive utility and applicability of these capabilities in meeting the range of threats and contingencies that are likely to emanate from plausible future security and operating environments.

Over the next 15 to 20 years the international security environment is likely to produce novel military contingencies that will threaten the stability and security of the international system and the security and stability of states. Predicting the full spectrum of specific future contingencies that will emerge over the next 15 to 20 years is, of course, an impossible task. However, one can plausibly list several broad, occasionally intersecting, types of future contingencies with which national militaries will have to cope. UASs will be well-suited to play important roles in the following types of contingencies and environments:

Urban Warfare: One near certain assumption that can be made about the battlefield of the future is that it will have a heavily urban component. But the urban operating environment is a foreboding one that throughout history has posed problems to military operators for two main reasons:

- ***Terrain:*** Cities are confusing places with mazes of streets and tall buildings that restrict freedom of motion, line-of-site, and direct fire opportunities for attacking forces. The urban terrain also exponentially amplifies the number of opportunities for harassing attacking or foreign forces.

- ***Precision:*** Civilians will be mixing with combatants in urban environments and operators will be required to make almost instinctual distinctions between legitimate targets and by-standards.

UASs will be instrumental in surmounting these challenges. One of the most important missions will be to look down on entrenched adversaries from above buildings to mitigate the line-of-site dilemma and provide operators on the ground with a wider perspective of their environment.

Micro-UASs will also be useful in meeting more tactical exigencies facing war-fighters on the urban battlefield. Small squads of soldiers, Marines and SOF, possibly even individuals, will be equipped with micro-UASs and will use these systems to gather and disseminate invaluable and urgent tactical intelligence. Larger systems will be used to supply forces, perform combat search and rescue and serve as communications relays when forces are isolated on urban battlefields.

Finally, the ability of UASs to operate in close environments in which larger manned aircraft would be incapable, including the ability of vertical take-off and landing (VTOL) UASs to attach to buildings or suspected targets and perform surveillance will be important. UASs will also have a strike role in future warfare, and their abilities to operate in closer and tighter quarters than manned aircraft will present operators more and more lucrative opportunities to strike adversaries taking refuge in the unruly topography of the future urban battlefield.

Of course, UAS use in urban environments does not come without some risks and vulnerabilities. UASs, particularly those flying at low altitudes, will be vulnerable to urban air defenses, such as Man-Portable Air- Defense Systems (MANPADs). Moreover, the increased number of UASs operating above the urban battlefield will present challenging airspace de-confliction issues which will be difficult to adequately resolve.

Maritime Security: The future operating environment will also have a significant maritime component, and the value that UASs can and will provide in meeting maritime contingencies should not be discounted. UASs can arrive at a contingency in advance of maritime assets and provide persistent situational awareness and targeting to these assets as they approach. Moreover, UASs can be used in conjunction with manned aircraft as strike assets, if required.

The main challenge for UASs in the future maritime battle-space will be reaching and remaining on station. Pre-positioning of UASs in key strategic areas will help provide the coverage that commanders and operators will require. Operating UASs off of maritime platforms, such as aircraft carriers and the decks of smaller ships, will also allow UASs to reach maritime contingencies quickly.

UASs will also assist in the surveillance of maritime borders and contested maritime areas. As non-state and transnational threats-smuggling, crime, terrorism-become more pronounced and coherent, the need for the persistence that UASs can provide by monitoring huge areas of open sea will be more valuable.

Locating, Tracking and Interdiction of Clandestine Transfers of Weapons of Mass Destruction (WMD): UASs will also be extremely relevant in a range of tasks associated with locating, tracking and interdicting the clandestine transfer of WMDs. UASs can penetrate difficult topography or closed societies to gather intelligence on weapon location and can be used to covertly track weapons once they are located. UASs of all shapes and sizes could provide continual surveillance of vehicles or vessels on which weapons are actually located. Such intelligence could be invaluable to operators and decision-makers as they devise the most effective means of interdicting or eliminating the weapons themselves.

UASs could be relevant in strike missions to eliminate WMD once they are found, but it is more likely that manned platforms or ground-launched cruise missiles or a combination of the two would be used in order to deliver sufficient destructive power. Still, UASs would be uniquely equipped to verify the elimination of any loose nuclear weapons and determine if and when radiation levels in a post-strike environment are "safe" for troops or manned platforms to enter.

Anti-Access Contingencies: Stealthy UASs or UASs operating at high altitudes will be able to penetrate most future air-defenses to perform two key tasks. First, these aircraft will be able to hover above air-defenses and key strategic targets to provide intelligence, including battle damage assessment and targeting information, to stand-off weapons systems located outside of the access exclusion zone. Stealthy UASs will also be able to penetrate anti-access capabilities to perform strike missions themselves.

However, the effectiveness of even today's most persistent UASs will be diminished against highly robust systems by the amount of time it will take to arrive on station thousands of miles away. Aerial refueling of UASs (potentially conducted by other UASs) will mitigate this dilemma to a degree, but presents its own logistical problems that may only enhance the difficulties of "time-on-target" for UASs in anti-access contingencies.

One final way in which UASs can be used to degrade this capability is through the use of UAS swarms to "light up" adversary air defenses for subsequent platforms to strike.

Operating in Post-WMD and Natural Disaster Environments: UASs would provide a safe, survivable, low risk capability to carry and drop supplies into radiated areas and to provide valuable intelligence on the evolving humanitarian and security situation within contaminated areas. These systems would likely be contaminated themselves while in the "hot zones", but because the UAS operator would be well outside of the zone, the system could operate for extended periods of time with no risk to human operators. UASs could play a similar role in providing situational awareness and, potentially, limited humanitarian relief after natural or other human disasters where environments will be too dangerous or uncertain for humans to operate.

The greatest challenge to UAS use in a post-nuclear environment and, to a lesser extent, post natural disaster environments, will be a lack of experience in developing and actually implementing a concept of operations for operating in these harsh environments.

"Long War" Related Contingencies: It is in "Long War" related contingencies that UASs have already most obviously demonstrated their value on the battlefield. UASs have been immensely effective in providing tactical intelligence of terrorist and insurgent locations and movements and, as described at the outset of this paper, have also performed strike missions against individuals and small groups.

UASs will also play an important force protection role against terrorist and insurgent attacks. As military targets' defenses harden, insurgents and terrorists will increasingly seek to strike foreign forces remotely, through mortar and missile attacks. UASs can provide surveillance and strike against mortar attacks; sensors, radar and, possibly, intercept capabilities for theater missile defense; and advance surveillance to mobile forces that will help protect against improvised explosive devices. UASs will also continue to be used in psychological operations (PSYOPS) designed to change the sympathies of the populations of states in which forces are operating.

Border Patrol: The lack of rigid borders in the future security environment will allow the covert or nearly covert movement of people, assets, platforms, information, money and trade across borders, much to the benefit of insurgencies, non-state actors and criminal networks. Securing future borders, therefore, will be a primary goal of state militaries and security forces.

The use of unmanned aerial systems in monitoring borders can help make it more difficult for forces of instability and insecurity to covertly or illicitly cross borders. But even the persistent surveillance capabilities of UASs cannot provide complete visibility of activities along a border. However, working in conjunction with border patrol forces on the ground, these systems can make borders more robust and can ensure those detected crossing borders are tracked and apprehended. Several key themes, common insights and challenges regarding UAS use on the future battlefield emerged across the range of contingencies.

Time on Target: The requirement for rapid responses to complicated contingencies and the enduring need for ever more persistent surveillance to meet each of the contingencies described above will require development of extended persistence, pre-positioning, maritime air take-off and landing and aerial refueling:

Enhanced Strike Capability and Payloads: UASs will be required to carry out an increasing number of strike missions on the future battlefield. These missions will mandate UASs be able to be equipped with heavier payloads and advanced autonomous target recognition capabilities. In addition, more UASs with strike capabilities will be required. Development of lighter yet more powerful power sources for UASs will be an important step in facilitating the use of heavier strike payloads on UASs.

Enhanced Resilience: As UASs operate in more and more dangerous environments they will need to become more resilient. Counter-UAS technologies and tactics will develop in response to their increased capabilities, and UASs will need to improve their resilience in the face of future air defense threats. Stealth technologies and operating UASs in swarms will be key in providing this enhanced resilience.

Small and Micro-UASs: Small and micro-UASs will play a more prominent role on the future battlefield. In the world's most advanced militaries, smaller UASs will accompany small squads and platoons into battle. Being able to produce and operate these numbers of UASs will be a challenge for UAS developers.

Organization, Culture and Concepts of Operations: Integrating UASs and developing concepts of operations (CONOPS) for UASs on the future battlefield will present significant challenges to future militaries. Managing the change from primarily manned to increasingly unmanned aviation in modern militaries will be difficult to manage and may create tensions and frictions that will slow down UAS development and implementation.

INTRODUCTION

In the fall of 2002 al-Qaeda's top operative in Yemen, Abu Ali, likely believed he was well outside the long, but limited, reach of the United States and its allies. Mr. Ali was suspected of aiding the 2000 attack against the USS Cole in Yemen that nearly sank the American destroyer and had been a focus of US counter-terrorism operations in the region since. Yemen, a fragmented and impoverished state in which the central government exercises little control over its rural tribal areas, offered a near perfect place for Ali to avoid US and Yemeni efforts and to continue planning and operating against the US and its interests in the region.

However, on 3 November 2002, Mr. Ali's assumption of immunity was shattered. He and five of his al-Qaeda associates were killed when a "Hellfire" missile fired from a CIA Predator-A drone struck the car in which they were traveling. It was a major victory for the United States and its allies in the war against al-Qaeda and its affiliates throughout the world, but the attack also was a significant event in the maturity and the exposure of an increasingly potent weapon. It was an emphatic indicator of the increasing level of sophistication of unmanned aerial systems (UASs) and, significantly, of the increasingly varied and important roles these systems could play on the battlefields of the present and future.

Since that November day UASs have repeatedly demonstrated their value on battlefields in Afghanistan, Iraq and in the broader "Long War" against violent extremism and terrorism. As such, these systems have become an ever more important element of many modern militaries throughout the world. Ministries and Departments of Defense are growing more acutely aware of the following advantages that unmanned systems can provide on and off the battlefield:

Low Risk and Low Cost: UASs are relatively inexpensive systems to build, maintain (including training) and procure, in part because they do not need to be modified to accommodate human pilots or tailored to human needs. The absence of humans in the cockpit of UASs also makes them considerably lower risk and, though military planners and budget offices do not like to think of it this way, more expendable than manned systems. The loss of an inexpensive and reasonably easily replaced system is far easier to accept than the loss of a human operator, especially given domestic political environments throughout the world that are understandably sensitive to the loss of life of soldiers, sailors, airmen and marines.

Persistent Surveillance: Perhaps the most obvious and frequently referenced unique operational capability of UASs is their ability to loiter over and around targets for several times longer than manned aircrafts. UASs are not inhibited by the limits of human endurance and are currently capable of staying airborne for a day or more. This endurance makes unmanned systems perfectly suited to perform persistent surveillance on the future battlefield and will assist military planners throughout the world in meeting a range of plausible future threats and contingencies.

Precision Strike: On the future battlefield, it will be necessary to strike a single building rather than a city block, one car rather than an entire convoy. Unmanned Combat Aerial Systems (UCASs) will be a critical weapon in the precision strike arsenals of a growing number of states, particularly as these states deal with contingencies in urban, maritime or difficult to access areas.

Tactical and Combat Reconnaissance: Lightweight, easy to assemble and launch, UASs can allow operators to see around corners and over obstacles in urban environments or fly into caves, ravines and thick canopied jungles to provide highly specific intelligence and a clear situational awareness of the imminent threat environment.

Resilience and Access: UASs can access areas that are inaccessible to manned platforms, including harsh physical environments that could not be safely inhabited by manned vehicles. This resilience will allow operations and intelligence collection to continue even among the most adverse of environments.

Dynamic Re-tasking and the Blending of Stove-piped Missions: UASs are being developed to carry out a range of tactical missions. Unlike most manned aircraft, which are developed with fighter, bomber or surveillance roles, UASs can be developed and equipped to be all of the above, depending on the payloads with which they are equipped. This blending of what were previously stove-piped missions will allow for far greater flexibility and efficiency of tasking. In addition, future systems will likely enhance the capability of unmanned systems to play all of these roles simultaneously in a given mission and therefore to be re-tasked dynamically mid-mission based on how future contingencies develop.

Versatility: To speak of the vast assortment of types and sizes of UASs that are in production or development throughout the world as a single capability or platform is misleading. Unmanned aerial systems come in nearly all shapes and sizes, from large long-range bombers with the same wingspan as that of current manned platforms such as the B-2, to small micro-UASs that can be launched by hand or carried into battle in the backpack of a soldier, sailor or Marine. Moreover, these systems can carry a number of different types of payloads as well. Thus, UASs have an impressive variety of tactical and strategic applications on the current and future battlefield, such as surveillance, strike, lift and supply of materials, refueling, WMD detection and communications relays.

Network Centric Warfare Enablers: In addition to performing operational tasks such as surveillance and strike, UASs can also be used as sensors and communications relay nodes connecting platforms and units, enabling a more complete version of network centric warfare. UASs are prominently featured in this role in the US Army's $1.8 billion Future Combat System (FCS) and other militaries, notably the Israeli Defence Forces, are clearly thinking about UASs in this role as well.

Chemical, Biological and Radiological Detection: One of the many payloads with which UASs can be equipped are advanced Measurement And Signature Intelligence (MASINT) sensors with the ability to detect WMD signatures. This detection role will be key in an environment in which chemical, biological, radiological and nuclear weapons proliferation will be more plausible.

Stealth: Stealth technologies can be-and are-easily adapted to unmanned aerial systems to be create low observability. The combination of low-observability and the ability to linger and hover make UASs a powerful platform for surveillance and strike in the highly-contested future battlefield

This trend toward the increased relevance, acceptance and integration of unmanned systems by modern militaries is certain to persist. The shifting nature of the international security

environment and the novel and diffuse threats and contingencies that are likely to emerge will require a more robust UAS presence and will demand the capabilities and advantages these systems can provide.

In this white paper, Jane's Strategic Advisory Services (JSAS) analysts seek to develop a more precise understanding of both the environments and contingencies that will mark future warfare and the roles and missions that UASs are likely to play on the future battlefield.

The analysis that follows is divided into five discrete sections. Section One provides an overview of the history of UAS development and of the roles and missions that UASs have previously performed on the battlefield. Sections Two and Three establish and explain the parameters of alternative future security and operating environments. Section Two identifies and describes the actors, forces and interactions that are driving or shaping these environments while Section Three explains the key characteristics and qualities of these environments. Section Four describes seven future types of contingencies emanating from these security and operating environments and analyzes how UASs will be deployed in these situations. The final section synthesizes key issues and technological and organizational advancements that would be required for UASs to effectively carry out the missions described in Section Four.

SECTION ONE:

A brief history of unmanned aerial systems

Unmanned Aerial Systems have gained considerable exposure in the recent past. Different UASs have proven themselves in the on-going, post September 11, 2001 conflicts and missions throughout the world.. UASs are now a cornerstone of military plans for future force composition, a development unimaginable just one decade ago. While only new to the public consciousness, UASs have been under development for nearly half a century and have been deployed on the battlefield since the Vietnam War.

First UAS developments

While some histories of the UAS begin with the development of the V-1 rocket by Nazi Germany in the Second World War, these weapons were more precursors to the systems that would become known as modern UASs. The V-1 demonstrated the formidable threat a UAS could pose in combat, and Allied, particularly American, attempts to combat this sophisticated weapon laid the groundwork for the post-war development of UAS programs in the United States.

The US military began its UAS development in earnest in the 1950s, though it was not until the Vietnam War that the US was able to deploy an effective unmanned aerial system. The first demonstration of these new systems was the Lightning Bug tactical reconnaissance drone used for missions such as bomb damage assessment, target evaluation, searching for POWs and dropping propaganda leaflets. These missions were considered too dangerous for manned aircraft due to extensive Vietnamese air defenses. Despite the success of the Lightening Bug, investment in the US UAS program stalled after the conclusion of the Vietnam War.

Soviet UAS efforts during this period demonstrated an existent, though not extensive, unmanned capability largely designed to operate over long ranges and after a nuclear war. Designs grew out of targeting drones and ICBMs. The first Soviet unmanned aerial system was the DBR-1, a long-range, system developed in the early 1960s that entered service in 1963 in a reconnaissance role.[1] The first Soviet tactical UAS was the TBR-1,

1 "Russian Unmanned Aerial Vehicles," Jane's Intelligence Review, July 1994, p 291.

based on a subsonic target drone, which was introduced into service around 1965. The DR-3 eventually replaced the TBR-1 in operational service. Throughout the 1970s, Soviet designers developed new unmanned systems, such as the Tu-141, for reconnaissance at the tactical and operational level.[2]

New beginnings

The 1980s represented a time of renewed attention on UASs and the unique capabilities they provide. In particular, Israel's use of unmanned systems in campaigns in southern Lebanon instigated discussion about the potential of UASs in the modern battlefield and spurred new developments. The Israelis used their Scout and Mastiff systems in a reconnaissance role and in swarms to confuse and expose enemy air defenses to allow for additional waves of manned aircraft to destroy those defenses. This established Israel as the world leader in unmanned capabilities following over a decade of investment in its program. No longer were UASs used in a primary reconnaissance role; now, they were also used as part of battlefield tactics to achieve a military goal.

The US military also invested in new UASs to fulfill reconnaissance functions. Starting in the late 1970s, the US Army attempted to develop the Aquila to perform tactical reconnaissance missions. Plagued by a lack of set requirements and poor program management, the DoD cancelled the program in 1988 after an investment of around $1billion. The Aquila failure instilled wariness about UASs in the US and led to a rethinking of the US military about these systems.[3]

After US operations in Lebanon, Libya and Grenada demonstrated the need for inexpensive tactical reconnaissance and targeting capability, the Navy held a competition in 1985-6 for a Tactical Unmanned Aerial Vehicle (TUAV) system. The Pioneer was chosen. Its success during Operation Desert Storm engendered an appreciation of the potential benefits of unmanned systems directly supporting combat operations. Only one out of 36 Pioneer UASs was lost to enemy fire during Desert Storm, demonstrating clear survivability benefits for UASs in a battlefield environment. Iraqi soldiers even attempted to surrender to Pioneer systems. Operation of the Pioneer was not without difficulties, however. Eleven vehicles were lost and another 10 damaged due to hardware failure or other operator error.[4]

At the end of the 1980s, the US developed a strategic approach to the development of unmanned aerial capabilities. In response to concerns by US policymakers about a lack of coordination and insufficient UAS procurement efforts since the end of the Vietnam War, Congress demanded a more concentrated approach from the DoD. In response, the DoD founded the Unmanned Aerial Vehicle (UAV) Joint Program Office (JPO) in 1989 and established the UAS Special Studies Group to set UAS requirements and procure systems. The DoD and Congress refocused UAS acquisition in 1991 by having the Defense Acquisition Board (DAB) assume a greater role. The DAB almost immediately redefined UAS acquisitions as high priority programs, ensuring significant funding and attention from procurement officials.

The Soviet Union (and subsequently the Russian Federation) was also involved in developing new systems during this time. The USSR developed the Pchela-1 (Honeybee) remotely piloted vehicle to support company-level troops for tactical purposes, departure from previous Soviet systems.[5] An upgraded version became known as the Schmel-1. This marked the departure from traditional heavy systems and the start of UASs to support troops in the field directly.

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2 Piotr Butowski, "Russian Reconnaissance UAVs - Part 1," Jane's Intelligence Review, December 1995, p 4.

3 Ian Curtis, "Flying in the Sun: RPVs Are In Vogue Again," Defense & Foreign Affairs, August 1989, p. 12.

4 Clifford Beal, John Boatman, Mark Hewish, "UAV Development the Art of Compromise," Jane's International Defence Review, May 1, 1993, p377.

5 "Russian Unmanned Aerial Vehicles," 1994.

UASs: Systems of the future

After the Gulf War, the US placed increasing importance on UASs to perform a number of roles from strategic reconnaissance to direct support of tactical elements.[6] UASs were used to expose Iraqi air defenses, map attack routes and identify Iraqi troop locations. Despite the renewed attention on UASs and appreciation of the potential unique capabilities, progress on procurement was inhibited by funding, technological and political difficulties.[7]

During this period, the US military also experienced several organizational realignments of UAS programs. Responsibility for UAS development shifted between joint and individual service procurement, reflecting the difficulties of merging requirements for different services.[8] The DoD initiated acquisition reform in 1994 to lower system costs and to reduce acquisition time. At this time, the DoD modified its procurement strategy to incorporate the Advanced Concept Technology Development (ACTD) approach.

Despite these issues, the Air Force demonstrated its new operational focus on UASs by activating its first UAS squadron in 1995. UASs flown in the Balkans provided extensive real-time, tactical reconnaissance support, proving to the US and its NATO allies the usefulness of intelligence gained through these systems.[9] Additionally, military planners recognized that using UASs would reduce the number of lives and platforms endangered through performing the roles unavailable to UASs at that time.[10]

US procurement during this time was split between short-range, tactical systems and long-range, strategic systems.[11] Capabilities centered on various reconnaissance and intelligence capabilities; only more recently has discussion and development of systems focused on combat capabilities.

Short-Range, Tactical Systems

In 1992, the US chose the Hunter offered by Israeli Aircraft Industries (IAI) in partnership with TRW to fulfill the US short-range UAS (SR-UAS) requirement for the US Army and Marines. This system offered short-range tactical reconnaissance in support of operational military units. This system was moved into Low Rate Initial Production (LRIP) in 1993 with first delivery of a completed system in 1994. This platform was the mainstay of the US short-range systems during the 1990s and into the 2000s, after the cancellation of other programs during this period such as the CR-UAV, the BQM-145A and the Outrider.

The US Army chose AAI's Shadow 200 in December 1999 for its tactical UAV requirement. The Shadow was intended to conduct reconnaissance, surveillance, target acquisition and battlefield damage assessment on behalf of brigade commanders. The US Marines began the Dragon Warrior program in 1998 and the Dragon Eye program in 2000 to provide a close-range, tactical reconnaissance capabilities.

Long-Range, High Endurance Systems

With the retirement of the SR-71 and the aging U-2, the US recognized it needed persistent, long-range reconnaissance capabilities. Several programs went into development during this time. The Gnat 750 used by the CIA was the precursor to the two main programs that survived into full procurement: Predator and Global Hawk.

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6 Charles Bickers, "Unmanned Air Vehicles, UAVs Take Off Into A Multifunction Future," Jane's Defence Weekly, August 12, 1995, p33.

7 "UAV Development the Art of Compromise," 1993.

8 "Congress urged to keep UAV programs centralized," Aerospace Daily, July 10, 1996, pg. 44.

9 Kenneth Munson, "UAVS, The Unmanned Air Vehicle Comes of Age," Jane's Defence Weekly, July 22, 1995, p 21.

10 James W. Canan, "Seeing more, and risking less, with UAVs," Aerospace America, October, 1999, pg. 26.

11 Roger Lesser, "Unmanned aerial vehicles - still a top DOD priority; Department of Defense," Defense Electronics, March, 1993, pg. 36.

In 1996, Defense Advanced Research Projects Agency (DARPA) chose a team led by Teledyne-Ryan (now Northrop Grumman) to supply the Tier II-plus High Altitude Endurance (HAE) UAS, now known as the Global Hawk. This system was designed to replace the capability largely provided in the past by the SR-71 and U-2 systems. The Global Hawk now forms the backbone of a long-loiter, global strategic reconnaissance capability for the US military. It is designed for endurance of up to 41 hours, with a range of 13,500nm, at an altitude of 65,000ft.

The Predator, originally named the Tier II Medium Altitude Endurance (MAE) UAV, was developed by General Atomics. ACTD was completed in 1996 and the program entered LRIP.[12] The Predator was first used extensively in the Balkans and became a significant and highly valued system in service today in Afghanistan and Iraq. Its evolution demonstrates the evolution of UAS capabilities. The Predator-A model was designed originally as a surveillance and reconnaissance aircraft, though throughout the late 1990s there were efforts to provide the aircraft with a ground-attack capability. This capability was demonstrated with the Predator-A attack on Abu Ali in Yemen.

The Air Force began operating armed Predator-As within a few years and began conducting limited close-air support operations in Afghanistan and Iraq. The new Predator-B model features an improved design to support more robust air-to-ground capabilities.

The US Army has agreed to procure the Warrior Extended Range/Multi-Purpose (ER/MP) UAS and is currently set to procure 11 systems composed of 12 aircraft and five control stations each. One system will outfit each of the 10 active army divisions and one system for training. The US wants to extend the number of systems that it will procure in the future.

New Systems and Roles

Military forces have been integrating UASs into doctrine, albeit intermittently, for the past four decades. Many of these systems have played niche tactical and strategic reconnaissance capabilities and have excelled under the duress of combat. Due to these successes, militaries throughout the world are developing expanded missions for their future UAS forces. One of the main roles envisioned is combat, though other missions have been conceived of as well. Organic capabilities have been derived in some cases, such as the Predator A; however, several new systems in development are expected to expand the role that UASs will be filling in the future.

In the late 1990s, DARPA began to evaluate the use of UASs designed to fill a combat role. The program later became the Joint-Unmanned Combat Air System. Both Boeing and Northrop Grumman built demonstrators: the X-45C and the X-47B, respectively. Despite successful design and development, in November 2005, the DoD transferred J-UCAS to a joint Air Force and Navy office and scheduled a fly-off between the demonstrators. In February 2006, the Quadrennial Defense Review (QDR) directed the Navy to take over J-UCAS management. In the 2007 defense budget, the Air Force redirected its J-UCAS funding to a new "next-generation long-range strike" development program that, according to observers, is likely to include a mix of unmanned and manned bomber aircraft, reducing the probability of procurement for the X-45. J-UCAS had been downgraded to Navy UCAS, or N-UCAS, leaving the X-47 as a stable program with likely Navy procurement.

The US Special Forces have also procured a number of UASs to assist in their specialized missions. Most of these procurements have provided tactical, short-range reconnaissance, though US Special Operations Command (SOCOM) has been a leader in expanding the mission profiles of UASs. For example, the SOCOM selected the CQ-10A SnowGoose to perform surveillance operations as well as to dispense leaflets for Psychological Operations (PSYOPs), deliver supplies in small quantities to SOF, and to provide communications relay

12 "Predator Becomes First ACTD Approved for Production," C4I NEWS, August 28, 1997.

capabilities. SOCOM is expected to continue to be a leader in defining roles for unmanned systems.

Israel still retains its status as the world leader in UAV technology. In addition to reconnaissance UAS developments, such as the fourth-generation medium-altitude long-endurance (MALE) Mahatz 1[13] and its upcoming mini-UAV competition expected to be awarded in late 2006, Israel is undertaking the development of Unmanned Combat Air Vehicles (UCAVs). Israel has recently chosen the Heron II, known to the Israeli Air Force (IAF) as the Eitan, to fulfill its high-altitude long endurance (HALE) requirement. The system will provide the IAF with long-range capabilities to deal with distant threats, such as Iran, and the Navy will use the system for maritime patrol.

While lagging behind US and Israeli programs, European UASs programs have proliferated since the 1990s. A previous example of a successful European UAS is Sagem's Sperwer, with several international sales. European governments have decided to engage in joint procurement for the Neuron, a stealthy UCAV, with development led by Dassault in a pan-European partnership involving Saab, Ruag, Hellenic Aerospace Industries, and Alenia Aeronautica. EADS is also developing the Barrakuda, a stealth UCAV, and BAE is known to be developing the Raven.

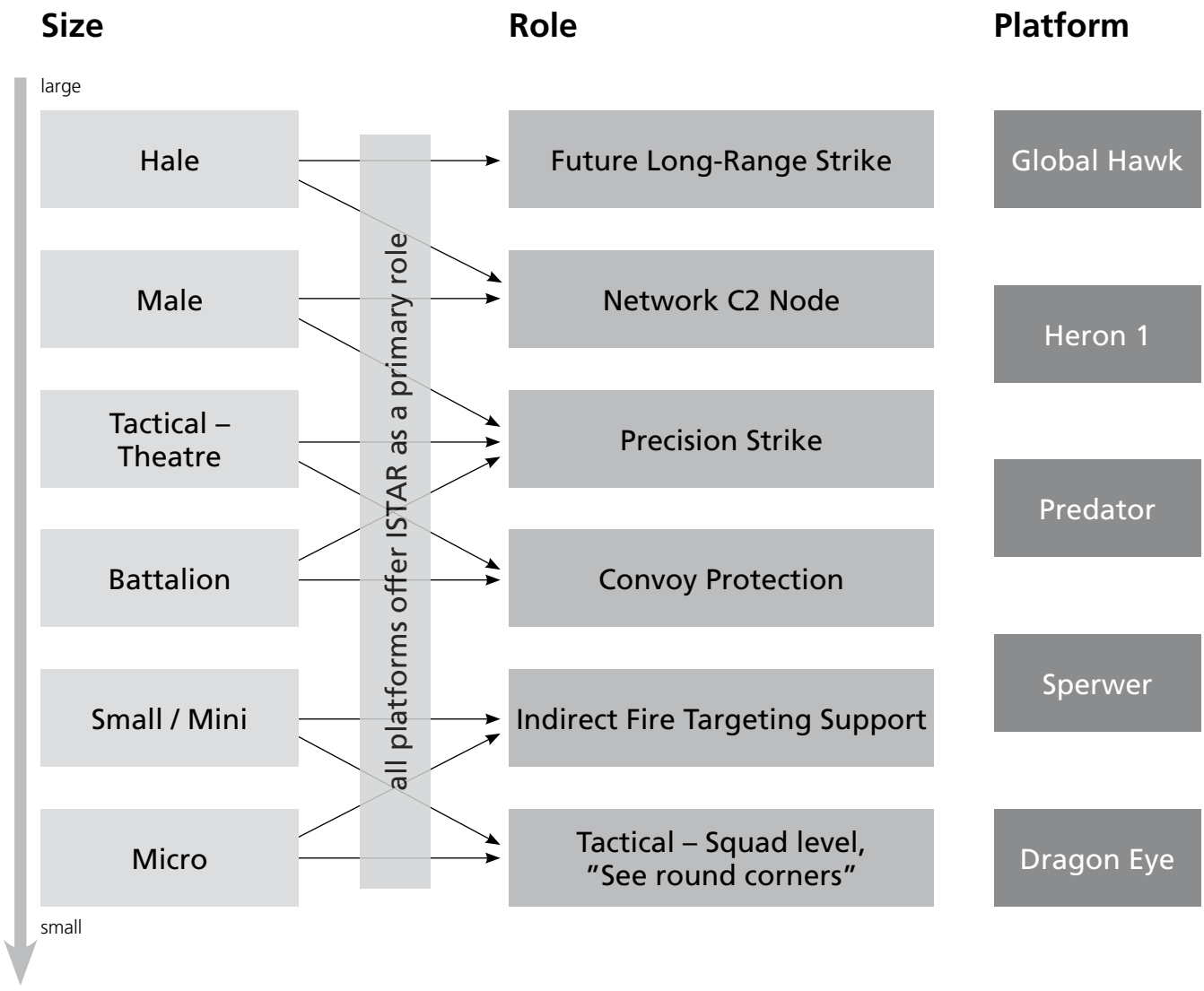
US strategy for the future is to use UASs for missions defined as "the Dull, the Dirty, and the Dangerous." The US has developed a long-term vision outlining a diverse number of future missions for UASs.[14] The US is planning to fulfill the following roles and capabilities, currently provided by manned platforms, with UASs by 2030 during the timeframe indicated:

- Communication Relay - 2005-2010
- SIGINT Collection - 2010-2015
- Maritime Patrol - 2010-2015
- Aerial Refueling - 2015-2020
- Surveillance/Battle Management - 2002-2025
- Airlift - 2025-2030
- Suppression of Enemy Air Defenses (SEAD) - 2005-2010
- Penetrating Strike - 2010-2015
- Integrating Strike/SEAD - 2015-2020
- Counter Air - 2020-2025
- Integrated Strike/SEAD/Counter-Air - 2025-2030

13 Similar to export version Heron.

14 Office of the Secretary of Defense, US Department of Defense, Unmanned Aircraft Systems Roadmap 2005-2030, 2005.

The term UAV or UAS covers an enormous spectrum of systems operating in a multitude of roles, from those able to fit in the palm of the hand, to full-sized aircraft.



SECTION TWO:

Establishing alternative future environments

Understanding future environments

These new roles and capabilities must be applied against new and emerging threats. Assessing which of these new roles and missions will be most relevant and urgent in the future will depend greatly on the dynamics and dimensions of the future international security environment and the nature of the future battlefield that emerges from this new security environment.

The international security environment is undergoing a profound and prolonged shift. Old dynamics are giving way to an environment marked by a range of diffuse, but also increasingly coherent threats. These threats are likely to metastasize over the next 10 to 20 years to produce novel military contingencies against which military planners and political decision-makers will need to prepare and in which UASs will be highly relevant.

Predicting the exact nature of these contingencies is impossible, absent the mystical and somewhat apocryphal powers of a crystal ball. However, understanding and preparing for uncertain alternative futures is possible, though it does require a certain measure of creativity and imagination. The remainder of this paper will focus on using the following four-step methodology to develop plausible alternative future security and operating environments and to understand what roles UASs can play on the future battlefield that these environments produce. The four discrete steps for establishing these environments and assessing UASs roles are:

- ***Identifying the forces, actors and interactions that are shaping the nature of the future security environment:*** What are the foundations and the drivers of changes in the future security environment and on the future battlefield? What are the critical uncertainties whose resolution will drive the future in one direction or the other?

- ***Describing characteristics of the future security and operating environment:*** What are the key qualities of future environments? What sort of strategic and operational challenges do these environments present?

- ***Identifying the types of contingencies that future decision-makers and operators are likely to face:*** What sort of conflicts are these environments most likely to produce? What sort of missions are implied by these environments.

- ***Assessing the relevance of UASs in these environments:*** Are UASs relevant to completing these missions, meeting these challenges, and fighting these conflicts? What specific roles can UASs play on the future battlefield? What are the restrictions and potential inhibitors of UAS effectiveness in these new environments?

The future operating and security environments laid out below may not be the most likely to emerge in the next two decades. Certainly, other visions of the future could be reasonably posited. However, these futures are plausible ones and will reveal the challenges and conflicts with which future strategists and operators will have to deal and provide a foundation for assessing roles for UASs on the future battlefield.

Drivers of the future security and operating environments

The first step in understanding the nature of future security and operating environments is to identify and understand the forces and actors that will drive or shape their characteristics. Below and in Figure 1 is an identification and explanation of ten “drivers” that will help sculpt these environments.

1) Demographics, Disease and Population Movements: States and societies throughout the world are facing a range of internal challenges and pressures that will strain government and social institutions and almost certainly increase tensions between neighbors as these pressures spill across national borders.

Demographics: Demographic trends and disease in several key states and regions threaten to fundamentally alter the composition of societies and challenge the capacity and capabilities of workforces and militaries. In Japan and Europe aging populations and low birth rates will reduce populations, with implications for the future labor force, economic well-being and ethnic make-up of societies. The opposite trends are driving demographic instability in the Middle East. Societies from North Africa to Pakistan are disproportionately young. Russia's human capital is being eroded by a declining population that is less healthy, older, and with a short life expectancy. China's demographic profile is a mix of possible afflictions, including low birth rates, ageing and striking gender imbalances.

Such shifts will place tremendous strains on governments, particularly those that lack resources and institutional agility. Internal pressures could also trigger large movements of populations both within states and across national borders as individuals move to meet labor demand or avoid disease.

Urbanization: The next decade and a half will see an increasing number of humans living in urban environments, which will have to change in order to accommodate their new size. As a result, societies and social priorities will change and state governments will be stretched to adjust. More densely packed and tense urban areas will pose myriad challenges to local and central governments.

2) The Environment and Resource Competition:
Environmental and Natural Disasters: Environmental and natural disasters will have important security effects and create new security challenges. Earthquakes, tsunamis, and hurricanes cause large population movements, which bring about their own security concerns beyond the pressures they place on the states that are receiving displaced persons. Population movements provide ample cover for insurgents, criminals and terrorists to move freely across borders and approach soft targets and can lead to local and regional instability. In addition, natural and environmental disasters are likely to lead to soft power competitions between regional powers vying to increase influence in states and regions through economic and humanitarian assistance.

Resource Competitions:
Demand and competition for specific key resources such as energy resources, water, and other natural resources (timber, for example) will drive security strategies in key regions, particularly Asia and the Middle East. States will target adversary resource vulnerabilities and seek ways to best exploit their own resource independence. Energy competitions will be a particularly strong driver.

The demand for energy resources-oil, natural gas-is growing throughout the world, particularly in the modernizing societies of East Asia. In this competition for energy, states will put a premium on securing the transit of energy as well as the source of supply. Sea-Lines of Communication (SLOC) security will become a key concern of all actors, and states will seek capabilities that either allow them to project naval power to deter, dissuade and defeat interdiction threats or to find alternative means of the delivery of oil and gas, such as overland pipelines.

3) Erosion of the State
It is not difficult to conceive of a future in which states are undermined by an array of societal and regional ills, even if the concept of the state as the primary entity of the

international system is not in immediate jeopardy. The state is likely to endure for the foreseeable future, but the potential for the collapse or failure of individual states will create threats to international security and stability that are difficult to deter and contain. These threats will be greatly intensified when political instability and failing states combine with other drivers of the future security environment, such as WMD proliferation and extremist ideologies.

4) Shifting Alliance Structures

The system of alliances, both formal and informal, that has helped maintain stability between great powers and regional balances of power and deterred potential adversaries will erode and give way to either new types of arrangements between old allies or entirely new strategies for ensuring national security. NATO will likely endure as a useful institution and as a forum for Western states to engage one another on security issues. However, its influence and coherence could be minimized through either over-extension or internal friction. Similarly, the US alliance structure in Asia could also undergo a restructuring as states may be forced to make subtle but important choices about the nature of their security and their regional alignments. Whatever the exact string of events or the nature of the future East Asian security environment, it is likely to have a different, and probably far less established, look than that of today.

The erosion and restructuring of old alliance structures will lead to the creation and maturity of new security arrangements, such as the Shanghai Cooperation Organization (SCO). The rise of organizations such as the SCO could have as much of transformative effect on the landscape of the future security environment and on future security strategies of states as will the testing of established alliances.

5) Non-State and Emerging Actors

In addition to new security organizations and arrangements, the future international security environment will be marked by the emergence of new and different state and non-state actors, such as terrorist and extremist organizations; drug, crime and trafficking networks; new and emerging regional powers; and populist leaders and other individuals with growing power bases. In many ways, the emergence of these types of actors has already taken place. Future access to information and to modern media, such as the internet and countless 24-hour news networks, facilitate the exposure of individuals and organizations and will lead to the continued rapid ascension of some actors from the fringes of society or the international system to a far more prominent place. Moreover, the future is likely to see the deepening and broadening of the relationships between terrorist, extremist and criminal networks.

6) Globalization and Technology

The inter-connectedness of economies stemming from globalization will ensure that political and economic dynamics in one state or region are felt intensely in several others. But these effects, both positive and negative, will not necessarily be felt uniformly or evenly. While many, mostly industrialized, technologically advanced and politically stable, states will accrue significant economic benefits from globalization, many other states have been unable to modernize quickly enough or respond nimbly enough to reap globalization's rewards. The escalating movement against globalization, while exceptionally varied and inconsistent in its message, is more likely to grow more forceful over time than it is to dissipate and could easily merge with other anti-Western and anti-capitalist ideologies and pose a serious, albeit highly negative, ideological challenge to the pervading economic order. Moreover, many states that are globalization net "losers" are also states that are beset with demographic conditions that will intensify the effects of economic hardship and accelerate the rate at which disaffection from the state turns into open hostility.

Of course, is also about the widespread access to technologies and information that cannot be effectively regulated by governments. But the advancement of technology is not now, nor has it ever been, an absolute good for societies, states or the international system. Technological advancement is nearly always neutral in nature, equally capable of empowering the forces of iniquity as those of modernity. While the internet and the "shrinking" of the world may provide information that can illuminate, educate and even liberate individuals throughout the world, it can also serve as an efficient way to rapidly or covertly disseminate information to audiences, both large and very specific, that mean to create instability and insecurity.

7) Proliferation of Conventional Military Technologies
One way increased access to technological know-how will have a profound effect on future security and operating environments is through the proliferation of advanced conventional military technologies. The future security environment will consist of a wider spectrum of militarily capable actors that will have the capability to pose significant, if asymmetric, threats to or achieve strategic leverage over states that have a more robust overall military capability.

8) Proliferation of WMD
The future proliferation of nuclear, biological and chemical weapons is a near certainty. It is only the scope of this proliferation that is in doubt. The trend toward de-nuclearization was a short-lived one, and the more states that cross the threshold into a fully weaponized nuclear capability, the greater the possibility of voluntary proliferation of nuclear weapons know-how and materials. The erosion of the barriers for nuclear weapons proliferation is being accompanied by an escalating demand for the weapons. States that have the nuclear arrow in their quiver or even might have them possess a certain measure of insurance and deterrence in a dangerous and uncertain world. One can plausibly imagine the spread of nuclear weapons to a dozen new actors, instigated by a single event that triggers a domino effect of proliferation, in a very short period of time: From Iran to Saudi Arabia to Egypt to Turkey, even to Japan and Australia under certain distant conditions.

9) Ideologies and Movements
The development and spread of ideologies and ideologically-based movements will also play an important role in shaping the future security and operating environments. Radical Islamist fundamentalism is likely to find more resonance within the Islamic World, even as military operations against militant Islamist extremists are more successful. Most will not subscribe to every element of the radical or extremist agenda or of the ideology itself, but rather will be drawn to the movement because it is the loudest and most effective voice of Islamic indignation in a world that is viewed as being particularly uncaring of Muslim interests.

Evangelical Christianity could also play a role in shaping the new security environment. The fastest growing religious movement in the world is not Islam, but rather evangelical Christianity, which is gaining followers across Africa, Asia and Latin America. As conservative forms of the Christian faith grow in the Third World and in states proximate to Muslim states, the potential for both conflict and for fundamental reorientation of states and societies becomes more likely. Hindu extremism in India and other religious movements will also play a more prominent and, perhaps, destabilizing role.

10) Quality of Governance
The domestic, technological and security challenges of globalization will test even the most institutionally agile and robust governments. Areas of weak governance that cannot effectively deal with these challenges will be persistent sources of instability and insecurity.

SECTION THREE

Characteristics of the future security and operating environments

The above section focused on understanding the forces, interactions and actors that will shape the future of the security and operating environments. The next step in developing an understanding the types of contingencies for which strategists and operators should prepare is identifying the eleven main characteristics of the future security and operating environments.

Complex Contingencies: Globalization of economies, the interlinking of states and societies and the global threat presented by terrorism and extremism will ensure that future contingencies will involve a number of actors, some of which may not be located within the region in which a contingency begins, and will be linked to important security issues in several states. Future contingencies are also likely to span great distances, evolve rapidly and cross discreet national and regional boundaries and, significantly, US combatant commands and international organization areas of influence.

Ambiguous Beginnings: Some future contingencies are likely to begin in ways that do not immediately threaten the interests of key actors. Rather, they will make incremental, sometimes imperceptible, advances that when viewed narrowly do not represent a fundamental shift to the security environment. When viewed with hindsight, though, these events will signal the emergence of severe threats. It is only over time that the genocide in Darfur became of acute concern to the international community. Similarly, states seeking to gain an increased measure of influence in key strategic regions may pursue strategies that combine engagement, obstinacy and coercion in order to blur their true intentions. Understanding when a contingency begins or when the balance of power between states has shifted could become increasingly difficult. A lack of this understanding could cause actors to intervene in a contingency long after the optimal moment.

Chaos and Conflict: Failing States, Ethnic Conflict and Weak Governance: Poorly governed states affected with deep societal and ethnic tensions will be lingering sources of tension and instability. From the Ferghana Valley to Kurdistan to Aceh to Sierra Leone to the Horn of Africa to Central America, the potential of state failure-meaning the loss of central government control of key societal, governmental, economic and military institutions-and collapse or persistent armed conflict exists. Similarly, more stable states that lack full control of the territory within their borders will also be sources of periodic and enduring instability. Specifically, Pakistan, Yemen, Iran, the Republic of Georgia, Azerbaijan, Ferghana Valley, Russia, Iraq, Afghanistan and the Philippines, all states that lack full control of the area within their borders, could be persistent sources of instability in and threats to the international system.

New Dimensions Demand New Maps: The Blurring of Borders and National Identity: The mostly arbitrary borders drawn by colonial powers in Africa and Asia are becoming considerably more fluid and ineffectual. In addition, concepts of national identity and sovereignty-even in North America, Europe and Russia-are becoming blurred and conflicted.

A Persistent Foe in the "Long War": Allied tactical military efforts to locate, apprehend or eliminate operatives and leaders from al-Qaeda and affiliated extremist organizations will be reasonably successful. However, the successful degradation of militant Islamic extremist organizations will take time and will only signal success in one aspect of the Long War. Al-Qaeda will continue its transition from a specific Islamic extremist organization to a broader Islamic extremist movement. "Bin Ladenism" and its successors and variants will have fully intersected and integrated with other anti-Western and anti-globalization ideologies and will find an increased resonance across a disaffected Muslim world. Political and societal

instability and lack of full government control of territory within national borders in the Caucasus, Central Asia, Southeast Asia, the Middle East, South Asia and elsewhere present ample opportunity for terrorists to recruit, train, plan and operate. Periodic terrorist attacks against targets of opportunity in Europe, Southeast and South Asia, the Middle East and even the United States will continue.

Urbanization and Crisis: The migration of larger percentages of the global population to urban areas will place tremendous pressures on national and local governments to meet the demands and challenges of these increasingly densely-packed cities. Urban environments will be overcrowded and tense places where conflicting ideologies, values and ways of life will collide in uncomfortable ways. Moreover, criminal networks, extremists, separatists and ideologues will thrive in the anonymity, angst and intricacy of large cities. Maintaining basic services will be a difficult challenge for federal and local governments, as will controlling or mitigating the effects of the forces of unrest and instability that will be operating on the dark and often overlooked periphery of the urban environment.

The Importance of Maritime Security: The future will also have a strong maritime component. Resource demand and competitions, the increasing globalization of trade and the rising threat of maritime terrorism will make SLOC security a driving interest of states in or with key interests in vital strategic regions, such as the Middle East, the Black Sea and the Straits of Malacca and Lombok. Strategic competitions and confrontations, primarily in Asia-Japan / North Korea, China / Taiwan, India / China in the Bay of Bengal, disputes of contested island chains-will also drive states to pursue maritime security capabilities, including maritime air power.

A Hyper-proliferated World: Perhaps the most disturbing and difficult to accommodate characteristic of the future security and operating environment is the likely proliferation of an actual, virtual or imminent nuclear weapons capability to up to a dozen new actors in the next fifteen years. The rapid hyper-proliferation of nuclear weapons (and, for that matter, chemical and biological weapons) could lead to a dangerous instability in the short term and a dramatic recalculation of security strategies in the long term. Uneven development of nuclear capabilities, both in terms of sophistication and rate of weapons development, by adversaries or potential adversaries, will create the opening for cataclysmic miscalculation as states seek to either exploit their temporary advantages in nuclear competitions or attempt to preempt adversaries that may be moving up the nuclear weapons development curve more rapidly.

In the longer-term, the presence of nuclear weapons in more states will also alter the way that conventional wars are fought. Direct strategies of targeting homelands may elicit a nuclear response. Thus, even advanced militaries may be required to develop indirect or "horizontal" strategies-interdicting energy shipments to vulnerable states or starting or supporting proxy wars, for example-to defeat, demoralize, dissuade or deter an adversary.

A Growing Spectrum of Militarily Capable Actors: Slightly less affecting than the proliferation of nuclear weapons is the proliferation of advanced military technologies, including advanced missile technologies, undersea warfare technologies and platforms and anti-satellite technologies to a broad range of actors. The often subtle, nearly undetectable, proliferation of advanced, commercial-off-the-shelf or dual-use technologies to a wider array of states creates three dilemmas for other actors.

- States may possess more sophisticated capabilities than anticipated, making future contingencies more complex and militarily challenging;
- Adversaries or potential adversaries could use existing advanced technologies in unique or novel ways that are difficult to anticipate;
- In this environment, it will be difficult to accurately determine when the balance of power between two or more states has undergone a pronounced shift.

Undeterrable Contingencies: The future security environment will also be marked by contingencies that develop an "irrational" momentum of their own and thus cannot be easily deterred or dissuaded. Ethnic, religious and sectarian conflict; conflict emanating from failed and failing states; conflicts with non-state actors; conflicts with states or actors holding absolutist or fundamentalist religious beliefs; and post-nuclear use environments in which actors will feel unconstrained by the usual moral and ethical restraints on using weapons of mass destruction all could arise in the future security environment and present exceptional challenges to existing ideas about deterrence and, when wars begin, peace-making and conflict resolution.

The Need for Precision and Speed: Future strategies, tactics and operations will need to be tailored to strike highly specific targets and have highly specific strategic and operational effects. On the future battlefield even the once vaunted meticulousness of campaigns in Bosnia and Kosovo will be insufficient and may, in fact, create effects that hinder rather than help a given state's cause. Punishing societies for the transgressions of their leaders or the accidental killing of even small numbers of innocents will trigger powerful and toxic reactions that extend well outside of the state and region in which conflict is taking place. Rapid responses will also be essential to mitigate the deleterious effects of crises or to keep contingencies from escalating. The process of alerting, mobilizing, and marshalling forces to meet rapidly developing contingencies may take too long, particularly if coordination between multiple militaries is required or if sufficient military forces are based well outside the region.

SECTION FOUR

Future military contingencies and unmanned aerial systems on the future battlefield

Over the next 10 to 20 years, the intersections of drivers and the security and operating environments described above are likely to produce a range of novel military contingencies that will threaten regional and international security and stability. While UASs will not be a "one-stop shop" that will answer all challenges of the future operating environment, they will feature prominently in meeting this range of contingencies and in operating on the future battlefield, particularly in the seven key environments and types of contingencies discussed below:

Urban Contingencies: One near certain assumption about the battlefield of the future is that it will have a heavily urban component. Urban operations, such as conducting building by building counter-insurgency operations or performing counter-terrorist intelligence missions in cities whose populations lie somewhere in the gray twilight between adversary and ally, will require military forces to master the urban battlefield.

But the urban operating environment is a forbidding one that throughout history has given an undeniable advantage to defenders entrenched in and with knowledge of the knotty and intricate dynamics of cities. From Stalingrad to Baghdad, Fallujah to Grozny, the past and present paint an ominous picture of the dangers of the future battlefield. As Sun Tsu famously cautioned: "The worst strategy is to attack cities. Attack cities only when there is no other alternative."

The commander of the future battlefield will have no other alternatives. The future enemy will be smart and diffuse and will thrive and take refuge in the ponderousness of cities. He will not engage his foe outside the comforts of an urban environment. He will need to be rooted out. If there is any silver lining to this dark gray cloud, it is that future commanders will have tools at their disposal that Sun Tsu and Von Paulus did not. Most notably, the

future commander will have a range of types of unmanned systems that will play a central role in making urban warfare a more tolerable, if not fully palatable, endeavor.

Urban environments are challenging to military operators for a number of reasons. Urban terrains are confusing, dense and filled with mazes of streets and alleys that defenders are likely to know better than attackers. Modern cities also are dominated by buildings of varying heights and shapes and tight corners that restrict line-of-site and limit the number of direct fire opportunities for operators that are less familiar with the terrain. The urban terrain also amplifies the number of opportunities for harassing of attacking forces. Finally, urban environments present operators with a challenge of precision. Civilians will be mixing with combatants and operators will be required to make almost instinctual distinctions between individuals or cars or trucks that present a real threat and those that are innocuous. Operators will also be required to be precise in their targeting in order to delimit the collateral damage they inflict and kill or wound only those that they mean to kill or wound.

UASs will be instrumental in surmounting these considerable challenges. Unmanned systems operating at a range of altitudes above the urban battlefield will be able to provide capabilities that are either too costly or too dangerous for manned systems. One of the most important missions will be to surveil and gather intelligence that provides operators on the ground with a wider perspective of their environment. They will be able to look down on adversaries from above buildings and mitigate the line of sight dilemma that makes urban operations so inherently risky. UAS applications in these environments will be refined and tailored to situations where operational commanders can best utilize a given system's capabilities.

Unmanned systems will also be eminently useful in meeting more tactical exigencies facing war-fighters on the urban battlefield. Special operations forces (SOF) are already using small, hand-held or backpack carry-able systems to see what awaits them around a building corner, through an open door or just beyond the irregular landscapes and rubble of blown-out buildings. UASs will certainly feature much more prominently in this role in the future. Small squads of soldiers, Marines and SOF, possibly even individuals, will be equipped with micro-UASs and will use these systems to gather and disseminate invaluable and urgent tactical intelligence. Communications relay capabilities will also provide urban forces greater operational capability, especially when line-of-sight communications are impossible or degraded due to the urban terrain.

Special and regular forces can also be made more independent through the uses of UASs. Unmanned Aerial Systems can provide transport and logistics support to cut-off troops. Troops can also be re-outfitted with different equipment if their needs differ from previous plans.

In addition, UASs may be able to provide effective combat search and rescue (CSAR) capabilities. This may increase the ability of forces to conduct their missions when planners can increase the probability of CSAR success while reducing the costs of sending assets into an active combat zone.

Finally, the ability of UASs to persistently surveil, hover, and, in the case of vertical take-off and landing (VTOL) UASs, attach themselves to roofs of buildings as well as their ability to operate in close environments that larger manned aircraft would be unable to, will be important. These capabilities will provide operators with the precision of targeting information that the future battlefield, particularly the urban battlefield, will demand. Small UASs can track cars and trucks, perhaps even attaching themselves to these vehicles, and even individuals, allowing operators to determine whether the car is a legitimate target or not. UASs will also have a strike role in future warfare, and their abilities to operate in closer and tighter quarters-and their less significant vulnerability-than manned aircraft will present

operators with more lucrative opportunities to strike adversaries taking refuge in the unruly topography of the future urban battlefield.

Of course, UAS use in urban environments does not come without some risks and vulnerabilities. To be most effective in giving operators the precision of information they most urgently require, UASs will be tasked to fly at low levels-from several dozens of feet to a few thousand. Operating at such low altitudes will make future UASs highly vulnerable to air defense systems, particularly MANPADs, which will be both more capable and more accessible to state and not-state actors alike. Even rudimentary future systems will be able to threaten systems operating within 10,000 - 15,000 feet of the surface.

The simplest solution to this problem is to make UASs increasingly stealthy. But stealth is expensive and is also an incomplete measure on a battlefield on which many UAVs of all sizes will be easily seen and heard by humans. Technologies that allow UASs to approach a target using their main engines and then hover and operate using a quieter engine will also be of use, but it is still unrealistic to expect that stealthy technologies alone will overcome the urban air defense challenge. In addition, making UASs less costly will reduce the downsides of losing assets. This will also have the effect of increasing the number of systems at the disposal of commanders, further increasing capabilities.

New tactics must also be devised and employed to circumvent or overwhelm urban air defenses. For example, the use of UAS swarms could be an effective means of subverting or overwhelming air defenses. Similar to the carrier battle group concept, swarms of UASs would approach a particularly well-defended or sensitive target together. Most of the UASs in the swarm would be decoys, either placebo flying devices with no payload or systems that are larger or emit a more significant electronic signature and thus become more obvious targets for air defense systems. Mixed in among the decoys would be multiple-redundancy will be key-"live" UASs that would be charged with collecting intelligence or striking a given target. While it is plausible that adversaries could randomly strike only live systems it is considerably more likely that live systems would be successful in carrying out their mission.

Even these new tactics will come with complications for future operators on the urban battlefield. First, increasing the number of UASs in the sky will increase the burden on human operators stationed hundreds of miles away. UAS operators will be asked to control multiple UASs simultaneously, which, while certainly possible, will introduce the limits of human capability more prominently into UAS operations. Furthermore, as UASs carry out more urban missions at different altitudes and as decoy UASs multiply the number of unmanned systems in the air, the skies above the urban battlefield will become increasingly cluttered. The problem of de-confliction of battlefield airspace is already hampering Coalition operations in Iraq where soldiers and Marines are required to file flight plans for unmanned systems several hours in advance. It is simply not realistic to expect operators in a highly dynamic and fluid environment to know more than minutes ahead of time when and where to use their powerful new resource.

No easy solution to the problem of de-confliction of the future battlefield airspace exists: The immovable object of the need for an uncluttered future air space is directly in the path of the unstoppable force of an increased demand for low-flying manned and unmanned systems. However, some insight into the future dynamics of urban battlefield air-traffic control can possibly be gathered from a somewhat unlikely source: Driving on the streets of the Taipei, Taiwan.

Taipei's streets are dangerous places for the uninitiated driver. Thousands of scooters speed and dart between various makes and sizes of cars, trucks and cabs. Lane dividers are painted on the streets, though it is unclear why the government wasted the time and money to do

so. Only the slimmest of margins is necessary for cars to slide in between one another. Stop lights, too, are more suggestions than dictates, and traffic is routinely stopped for cars or scooters to turn left, even if their light is red. Somehow, though, the air around Taipei is not dominated by the incessant honking of malicious horns nor has "road rage" entered the Taiwanese lexicon to any great extent. Accidents do happen, apparently, but mostly the drivers of Taipei have adapted to the anarchic driving and traffic patterns. The system, incomprehensibly complex and random, is managed by its own arbitrariness. It is a self-governing and self-regulated system in which the drivers of Taipei take the irregularities and clutter of their streets into account.

So, too, could the airspace above the future urban battlefield become a self-regulating system into which complexity and arbitrariness are taken into account by traffic controllers, UAS operators and pilots. This is far from a perfect solution. It will require great skill from pilots and operators and may require the pace of operations to slow down. Accidents will happen, just as they do in Taipei, but it is likely that the operational cost of these accidents will be greatly outweighed by the value that UASs will bring to operators on the future urban battlefield.

Maritime Security: Future battles will not play out exclusively in urban environments nor will they take place exclusively on or over land. Land warfare will still include rural, wilderness, desert and mountain contingencies and these less frequent conflicts will present their own unique, though more manageable, challenges. But the future operating environment will also have a significant maritime component.

Energy security vulnerabilities in modernizing states and the increasing interdependence of the global economy will make sea-line of communication (SLOC) security a main concern of most states as well as a main target of opportunity for terrorist, pirates and criminal organizations. The interdiction of maritime commerce may also be used as a means of horizontal escalation in conflicts between nuclear states that cannot target one another's homelands directly, but still seek to undermine their adversary's national will and ability to conduct military operations. Energy competition will also drive maritime border disputes as states make conflicting claims on maritime areas and islands that are suspected of being able to produce oil or natural gas. In addition, maritime borders, coastlines and ports will need guarding in a future environment that will be marked by persistent terrorism, smuggling and destabilizing flows of large numbers of immigrants and displaced individuals. Finally, maritime contingencies will emanate from disputes over issues such as fishing rights and the demarcation of maritime exclusion zones, which have been a historically persistent source of conflict between states.

While common sense perhaps dictates that unmanned underwater vehicles will be most relevant in meeting the demands and challenges of the future maritime battlespace, the value that UASs can and will provide in meeting maritime contingencies should not be discounted. Navies of the future are likely to be stretched thin by the range of maritime security threats and concerns and by the proliferation of anti-access technologies such as diesel subs and advanced mines and missiles. The United States Navy, the world's largest, will be comprised of more capable vessels, but will also be smaller, far less than the nearly 300 ships it currently possesses. Navies throughout the world will be similarly comprised of fewer, but more capable and more expensive vessels. The loss of one of these vessels will mark a more significant loss in capability than it would in larger navies and will constitute a greater loss.

To mitigate both the cautiousness that such circumstances could induce in naval commanders and the effects of the loss of ships when conflict breaks out, air assets will be required to operate as naval assets. UASs will be particularly relevant and effective in this role. The enhanced endurance of most future UASs will be critical in confronting the

tyrannies of time and distance that will mark the future maritime battlespace, particularly the massive maritime spaces of Southwest, South and East Asia where many maritime contingencies are likely to take place. UASs can arrive at a contingency in advance of maritime assets and provide persistent situational awareness and targeting to these assets as they approach. Moreover, UASs can be used in conjunction with manned aircraft as strike assets, if required.

The main challenge for UASs in the future maritime battlespace will be reaching and remaining on station. Launching UASs from land bases well outside a region or even from bases proximate to contingencies may not be sufficient to meet the contingency before it escalates or spins out of control. Pre-positioning of UASs in key strategic areas-the Strait of Malacca and Sea of Japan, for example-will help provide the coverage that commanders and operators will require, and increased persistence will be needed to ensure that these pre-positioned assets are able to stay in a key area for more than a day or two at a time. Future UASs will be most valuable in meeting maritime contingencies if they are capable of persisting for a week or weeks at a time; can be easily re-tasked; and still carry advanced reconnaissance, communications and / or strike payloads. Other advanced payloads, such as MASINT sensors with the ability to detect WMD signatures, may be crucial to detect clandestine and illicit transport.

UASs will also be important in playing a more tactical and short-range role in the future maritime environment and this role will require future systems to operate off of maritime platforms, such as aircraft carriers and the decks of smaller ships. Several members of the international defense industry are currently developing naval unmanned aerial systems capable of operating off of the decks of ships, but this is a relatively unexplored area and the increasingly intense demands of the future maritime battlespace will require more robust maritime UAS solutions.

Another important maritime security role that UASs are likely to play in the future is the surveillance of maritime borders and contested maritime areas. Australia is already using UASs to monitor contested fishing zones and to defend against smuggling of drugs and people. As these types of threats grow more pronounced and coherent the persistence that UASs can provide in monitoring huge areas of open sea will be more valuable.

Locating, Tracking and Interdiction of Clandestine Transfers of Weapons of Mass Destruction: UASs will also be extremely relevant in a far more specific and far more urgent contingency: Locating, tracking and interdicting the clandestine transfer of weapons of mass destruction, particularly nuclear weapons. This clandestine transfer could include the controlled transfer of nuclear weapons from one state to another-North Korea to Iran, for example-or the clandestine or illicit acquisition of nuclear weapons by a non-state actor. In a world marked by several more nuclear actors, unstable states and societies and poor governance in key regions, the potential for nuclear weapons proliferation to unpalatable regimes or to extremist non-state organizations or of a “loose nuke” scenario in which nuclear weapons are lost or stolen becomes more plausible. Whether it be a cargo ship carrying a nuclear weapon in its hull across the large and lonely Pacific Ocean, or radiological or nuclear material on the loose in the high passes and valleys and closed and tribal societies of Central and South Asia, the range of threats posed by clandestine proliferation poses a near unfathomable surveillance challenge for decision-makers and operators alike.

The first challenge posed by WMD proliferation is finding them. Operators and decision-makers will be required to act quickly to make sure that the stolen, lost or illicitly acquired weapons do not go untracked for too long a period of time. Prepositioned UASs may be able to provide a useful reconnaissance tool in circumstances where the general location of missing weapons is known or the weapons are discovered missing or acquired very soon

after acquisition. In these cases, UASs can be re-tasked dynamically and arrive in a given theater in a short period of time and provide persistent surveillance of the area that the weapons could have reasonably traveled in the amount of time since they became "lost."

However, it is unlikely that all future loose nuclear weapons scenarios will involve such good initial intelligence or good fortune. Thus, in most cases, the effort of finding loose nuclear weapons will be reliant first on human and signals intelligence to delimit the search area of weapons to a specific area before UASs can be effectively employed. Without this intelligence, UASs will be able to do little more than persistently search for a needle in a very large haystack.

Fortunately, illicitly acquired nuclear weapons are unlikely to be used immediately after being acquired. They are most likely to be acquired in regions or states that would not represent high value targets or may, indeed, share ideological or political views with those that acquire these weapons. The weapons, then, must be hidden and transported from the point of acquisition to the intended target. The act of hiding and transporting these weapons will present opportunities to recover them. Again, UASs have an important, if secondary, role to play.

If a general location of the weapons can be determined, UASs can be utilized to penetrate otherwise difficult topography or closed societies to gather intelligence on weapon location. For example, the densely canopied jungles of Southeast Asian archipelago nations offer an ideal location to hide weapons. Tactical UASs can be used to penetrate these jungles or, similarly, caves or cities, to gather information and intelligence that would otherwise be inaccessible to operators and decision-makers.

UASs can be used to assist in covertly tracking weapons once they are located. UAS payloads with sophisticated MASINT sensors, currently found on manned aircraft, would be useful for identifying where nuclear weapons may be stored. Tracking radiological, chemical or biological signatures, while difficult, may help to monitor and identify locations of WMDs. While there will be tremendous pressure to eliminate any loose nuclear weapons or other WMD as rapidly as possible after they are located, there may also be value in tracking the weapons as they are transported in order to determine the location of other individuals that are involved in the acquisition and use of these weapons. UASs of all shapes and sizes could be useful in this endeavor, including micro-UASs that could discretely attach themselves to ships or trucks and provide continual surveillance of the vehicle or vessel on which the weapon is actually located. Such intelligence could be invaluable to operators and decision-makers as they devise the most effective means of interdicting or eliminating the weapons themselves.

Of course, a number of compelling options exist to eliminate these weapons before they are used, including UASs. Manned aircraft or stand-off weapons may be equally, if not more, appropriate to perform strike missions against a loose nuclear weapon in transit-for example, on the high seas-or hidden perhaps deep beneath the earth's surface. While future UASs will be able to carry a more significant weapons payload than they do today, access areas that manned platforms cannot and autonomously make decisions of when to strike, the need for absolutely decisive military force will perhaps mandate the overwhelming firepower that can be gained only through a combination of strike assets.

However, UASs will be uniquely equipped to perform the final mission relevant to best meeting the threat of loose nuclear weapons: battle damage assessment. Verifying the elimination of any loose nuclear weapons will be vital to securing targeted states and societies. The resilience of UASs in what could be a radiated or contaminated post-strike environment and their ability to access and gather intelligence in difficult geographies, topographies and terrains in which non-state actors are likely to operate and reside will be

invaluable in determining the success or failure of a particular strike, and in determining if and when radiation levels in a post-strike environment are "safe" for troops or manned platforms to enter.

Anti-Access Contingencies: Anti-access conflicts are those in which a state with a technologically advanced and asymmetrical capability attempts to deny entry of a competitor or adversary to a given region or theater through the use of advanced aircraft and stand-off missile technologies, computer network and anti-satellite warfare and undersea capabilities, such as submarines and mines. As advanced conventional weapons and commercial off the shelf technologies proliferate, more actors will be able to develop the requisite capabilities to keep actors out of key strategic regions. Devising and implementing low-risk means of identifying adversary air defenses and of operating inside a denied area will be the fundamental issue facing strategists and operators fighting anti-access contingencies.

Stealthy UASs or UASs operating at high altitudes (from 30,000 feet to, potentially, the 70,000 foot elevations previously occupied only by U-2 aircraft) will be able to penetrate most future air-defenses to perform two key tasks. First, these aircrafts will be able to hover above air-defenses and key strategic targets to provide intelligence and targeting information to stand-off weapons systems located outside of the access exclusion zone. The persistent surveillance capabilities will also allow these unmanned systems to provide battle damage assessment information back to the stand-off operators after strikes. Stealthy UASs will also be able to penetrate anti-access capabilities to perform strike missions themselves. Long-range unmanned systems taking off from well-outside the access exclusion zone could enter the zone, loiter and search for targets and then strike before returning to their bases.

As with every application of unmanned systems to the future battlefield, potential complications do exist. Most notably, future anti-access capabilities will vary in their degree of robustness. Exceptionally robust systems could keep manned and unmanned assets several thousand miles out of a given theater and will not be degraded or defeated in a short period of time. The effectiveness of even today's most persistent UASs will be diminished against highly robust systems by the amount of time it will take to arrive on station thousands of miles away. If a system can stay airborne for 30 hours and it takes eight hours to get to a potential target, the system can only provide surveillance over that target for 14 hours before it has to begin its return journey. While 14 hours is a significant amount of time and constitutes an improvement over the amount of surveillance a manned platform could provide, it does limit the amount of insight operators have into the nature of the anti-access threat they face.

Aerial refueling of UASs (potentially conducted by other UASs) will mitigate this dilemma to a degree, but unless aerial refuelers are also stealthy and capable of operating at reasonably high altitudes against robust anti-access systems, the operating UAS will still have to leave the zone of access exclusion to rendezvous with the refueler. Clearly, the ability to linger for considerably longer periods of time-days rather than hours, or perhaps weeks-will be key to providing both continual surveillance and persistent strike designed to diminish anti-access capabilities. Further development of stealthy UAVs and UCAVs, automatic target recognition capabilities and increasing strike payloads of UCAVs will be important in increasing the role of UAVs in meeting the anti-access threat.

One final way in which UASs can be used to degrade this capability is through the use of UAS swarms to "light up" adversary air defenses for subsequent platforms-manned, unmanned or ground launched cruise missiles-to strike. This tactic was used successfully by the Israelis as early as the 1982 Bekaa Valley campaign and will remain an effective tactic well into the future.

Operating in Post-WMD and Natural Disaster Environments: If states and international organizations and alliances are unable to stop the use of nuclear weapons-either inter-state use or a scenario like the one above involving use by a non-state organization-militarily advanced states, and international organizations and alliances will be compelled to perform a range of missions, both military and humanitarian.

Bringing humanitarian relief to highly-radiated, post-nuclear environments will be risky to relief providers and may not, in fact, be particularly useful. Most casualties from the blast would succumb immediately after or well before humanitarian relief could arrive. Immediate post-blast relief would be more useful in the wake of chemical, biological or radiological attacks. Still, the political and human costs of inaction in response to any WMD attack on the part would be exceptionally high. In addition, post-WMD use environments would present their own fairly daunting security challenges that would need to be mitigated. Monitoring of the situation within the radiated area would be essential, though it is highly unlikely that manned platforms or humans would be able to survive in these environments.

UASs would provide a safe, survivable, low risk capability to carry and drop supplies into radiated areas and to provide valuable intelligence on the evolving humanitarian and security situation within contaminated areas. These systems would likely be contaminated themselves while in the "hot zones", but because the UAS operator would be well outside of the zone, the system could operate for extended periods of time with no risk to human operators. Decontamination of the systems after they left the hot zone would be required, and it might be necessary to abandon some systems in hot zones after performing their missions. UASs could play a similar role in providing situational awareness and, potentially, limited humanitarian relief after natural or other human disasters where environments will be too dangerous or uncertain for humans to operate.

The greatest challenge to UAS use in a post-nuclear environment and, to a lesser extent, post natural disaster environments, will be developing and actually implementing a concept of operations for operating in these harsh environments. Little actual experience with cleaning up post-nuclear or highly-radiated environments exists, and given that it is only in the last several years that the profile of UASs has been raised, expertise in how best to use unmanned systems in these intense and sensitive environments is even less abundant.

"Long War" Related Contingencies: The Long War is unlikely to come to a sudden conclusion in the next decade or even two. In fact, the very nature of the war will make "battles of annihilation" in which one side is the definitive winner and the other the shamed and defeated loser not just unlikely, but nearly impossible. There will be no Yorktown or Waterloo to signal the end of this war. Rather, the Long War will involve prolonged episodic operations against individuals and small groups located primarily in states-Yemen, Afghanistan, Iraq, Indonesia, Philippines-against which the US and its allies are not at war. Identifying suspected terrorists and interdicting known terrorists before either one strikes will be the main challenge for strategists and operators. Covert operations, persistent surveillance and intelligence gathering and precision strike, often in difficult topographies and urban areas, will be essential capabilities for meeting the threats of the Long War.

It is in "Long War" related contingencies that UASs have already most obviously demonstrated their value on the battlefield. UASs have been immensely effective in providing tactical intelligence of terrorist and insurgent locations and movements and, as described at the outset of this paper, have also performed strike missions against individuals and small groups. As the al-Qaeda network becomes more geographically diffuse and as al-Qaeda and its affiliates limit their movements among or between non-friendly populations, the need for rapid and precisely targeted strike will become more intense.

UASs will also play an important force protection role against terrorist and insurgent attacks. Military installations have become far more difficult for terrorists to penetrate with car or truck bombs since the start of the Iraq War. Devastating attacks like those against the US Air Force barracks at Khobar Towers in Saudi Arabia and the USS Cole in Yemen remain well within possibility, of course, but as these targets' defenses harden, insurgents and terrorists will increasingly seek to strike foreign forces remotely, through mortar and missile attacks.

UASs can provide persistent surveillance of an installation's perimeter out to the suspected maximum range of a mortar strike. If adversaries are detected, the UAS can provide intelligence and targeting information to forces in the installation who can then calibrate a preemptive strike; signal another UAS to provide strike or, possibly, perform the strike mission independently.

In addition, as Hezbollah has recently demonstrated, militias and insurgencies are likely to be armed with increasingly technologically advanced weapons and materials, including ballistic missiles. Future UASs may be able to play several significant roles as component parts in theater missile defense (TMD) systems. UASs could operate as communications relay nodes or as sensors to detect the launch and trajectory of ballistic missiles. Future UASs may also be the main platform for interdiction of ballistic missiles, though this will require a leap forward in UAS design capabilities that have been most prominently demonstrated in previous UAS development programs. An unmanned airborne laser may not be currently under development, but there is little reason to believe that this capability will not be within reach in the next two to three decades.

UASs will also be highly relevant in performing force protection functions against improvised explosive devices (IEDs). Unmanned ground systems will be effective in this role as well, but are more vulnerable to being victims of IEDs than UASs and will not provide the broader perspective that airborne systems will. Mobile units can send UASs in advance of patrols to provide surveillance along the prospective route and send intelligence back to operators to warn of impending danger. Such tactics could be cumbersome and could easily slow down units and patrols as they rush to meet threats. However, it will also help protect troops and help ensure that they arrive to contingencies.

While this paper has focused primarily on the military missions of the Long War, the war itself is primarily a conflict of ideas and ideologies. Affecting the attitudes and beliefs of populations in which Allied troops will be required to operate in future Long War-related contingencies will be a critical task that could greatly facilitate counter-insurgency and counter-terrorism operations. UASs could be used as part of any Psychological Operations (PSYOPS) strategy-leaflet dropping, etc-designed to alter or influence the allegiances and actions of indigenous populations.

Border Patrol: Borders between states and regions will lose their salience in the future security environment. This erosion and fluidity of national borders and the shifting of priorities of individual and group identity in many states and regions in Eurasia and the Middle East will have a profound effect on the nature of the future operating environment and the future battlefield. The lack of rigid borders will allow the covert or nearly covert movement of people, assets, platforms, information, money and trade across borders, much to the benefit of insurgencies, non-state actors and criminal networks. Securing future borders, therefore, will be a primary goal of state militaries and security forces.

It will not be an easy goal to achieve, however. Many of the borders that are of most concern today (the border between Pakistan and Afghanistan, Iran and Iraq, Syria and Iraq) are occupied by individuals who are often working at cross-purposes with the state. The Durand Line border between Pakistan and Afghanistan is an area where the Pakistani government

has little operational control and the tribal leaders that do control the autonomous areas of Pakistan's northern frontier have not proven particularly compelled to assist in the arrest of the cross-border movement of al-Qaeda and Taliban fighters. Moreover, even short borders between states that are in control of all of the territory along the borders are nearly impossible to "seal." There is simply too much area with too many geographic and topographic irregularities to be covered by too few sets of eyes, creating an abundance of opportunities for individuals and small groups to sneak from one state to the other. Long borders-like those between the United States and Mexico and the US and Canada- are impossible to close completely. Hundreds of miles of fences can provide a measure of dissuasion, but this takes time, money and manpower and the history of border fences and walls suggests that ways around, over, under or through barriers will also exist.

However, the use of unmanned aerial systems in monitoring borders can help make it more difficult for forces of instability and insecurity to covertly or illicitly cross borders. Even the persistent surveillance capabilities of UASs cannot provide complete visibility of activities along a border. These systems working in conjunction with border patrol forces on the ground, though, can make borders more robust and can ensure that those that are detected crossing borders are tracked and apprehended. In fact, UASs have been already used in this border patrol mission in Israel and more recently by the United States along its long southern border with Mexico. , UASs become considerably more relevant as military manpower becomes stretched by other, perhaps more pressing, tasks and by the sheer magnitude of the task of guarding even short borders.

CONCLUSION:

Key issues and challenges

UASs are already fulfilling several of the general roles identified in Section Four. Certainly, UCASs are already providing precision strike and other UASs are providing persistent and tactical surveillance. Future UASs would require "only" some degree of enhancement to these existing capabilities to fulfill the missions that JSAS analysts have envisioned. Other roles identified above are new and may require more fundamental technological, organization or tactical advancements. The section below is a synthesis and summary of key, recurring themes and possible advancements that will be necessary for UASs to play the crucial role on the future battlefield that JSAS has envisioned:

Time on Target: The requirement for rapid responses to complicated contingencies and the enduring need for ever more persistent surveillance to meet nearly each of the contingencies described above will require UASs to stay aloft longer and get to key areas quicker that they do today. Four enhanced capabilities will be critical to achieving this extended persistence:

- ***Extended Persistence:*** Staying aloft for a day or more is a fairly revolutionary capability in 2006. However, this degree of persistence will not be sufficient to meet, contain or, significantly, pre-empt, many future contingencies. The ability to get on station rapidly and stay on station undetected for an extended period of time will be critical. Thus, future UASs will require the capability to persist and operate for days, weeks, or potentially, months.

- ***Pre-Positioning:*** The ability to stay aloft for several days or weeks at a time will allow operators to pre-position UASs in key strategic locations with greater frequency and greater effect. Pre-positioned assets will provide operators the ability to react quickly to contingencies that are well outside of their immediate area of operation. Pre-positioning of unmanned assets will also have political repercussions as many states will be highly unlikely to allow foreign assets to provide persistent surveillance of their territory while

these UASs wait for contingencies to break out. Thus, states seeking to pre-position UASs in key strategic regions may be forced to keep their assets in international waters, which could reduce their ability to immediately affect or prevent a given contingency.

- ***Maritime Air Take-Off and Landing:*** Another means of mitigating the pre-positioning dilemma is to be able to carry assets close to key strategic areas or areas marked by instability and insecurity on maritime assets such as aircraft carriers or the decks of capital ships. Launching Unmanned Aerial Systems from submarines is also a future capability that is in the early stages of development today that would be useful in the operating environment of the future. Designing more types of aircraft that are capable of operating off of maritime assets will be an important future development that will greatly enhance the effectiveness and applicability of UASs on the future battlefield.

- ***Aerial Refueling:*** The ability to refuel UASs in flight will allay to a degree the need for the development of technologies that will allow UASs to persist independently for weeks or months. However, aerial re-fuelers are likely to be very vulnerable aircraft that would have a difficult time operating in contested environments. Stealthy refuelers would be of particular utility as would aerial re-fuelers that are themselves unmanned.

Enhanced Strike Capability and Payloads: UASs will be required to carry out an increasing number of strike missions on the future battlefield. Three issues will need to be overcome for UASs to perform this more prominent strike function:

- ***Heavier Payloads:*** UASs will be required to strike targets that are deeply buried or hardened or are simply more resilient than a car or truck, such as the one in which Mr. Ali was traveling in 2002. Also, UASs may be used in contingencies in which they carry non-lethal weapons, which can be heavier and more unwieldy than missiles. Thus, UASs will need to be capable of carrying and delivering heavier payloads into battle. Part of the payload problem can be resolved by developing lighter and more powerful power sources for UASs, which will create more available weight on existing platforms for heavier payloads without necessarily having to build bigger platforms.

- ***More Platforms:*** Militaries will need to develop more platforms capable of performing strike missions. The focus of much of the early and current UAS development has been on systems whose primary role is related to C4ISR functions, such as reconnaissance, sensors and communications nodes. As UASs become a more significant portion of military air forces, more systems will be dedicated to performing strike missions.

- ***Advanced Autonomous Target Recognition (ATR):*** The need for advanced ATR will increase as the role for machine automation, including UASs, on the battlefield increases. ATR will also be exceptionally relevant in providing increased speed in targeting in a battlefield environment that will require both speed and precision.

Enhanced Resilience: As UASs operate in more and more dangerous environments they will need to become more resilient. The relationship between UASs and the capabilities being developed to counter them is dynamic. Counter-UAS technologies and tactics will develop in response to the increased capabilities of unmanned aerial systems and UASs will need to improve their resilience in the face of future air defense threats. Furthermore, stealth is also relevant in environments in which air defenses are weak or non-existent. The capability to observe without being noticed will mean that UASs will be able to "see" more interesting and more revealing activities.

The increased use of stealth to make UASs low-observable will be key, but it will not be a panacea to the emerging detection and air defense threat. Technologies that allow strategic UASs to fly at exceptionally high altitudes and allow tactical UASs to fly silent while over or

around a target will also be of particular use. The use of decoy UASs as part of UAS swarms, which will confuse or overwhelm many future air defenses, will also provide an increased measure of protection against future air defenses.

Small and Micro-UASs: Autonomous small and micro-UASs will be crucial in meeting many, if not all, of the missions outlined above. The ability of UASs to fly into areas that manned areas cannot and to attach to adversary assets or to structures in urban environments will be essential to the tactical success of future operations. As such, small and micro-UASs will play a more prominent role on the future battlefield. In the world's most advanced militaries, UASs of varying sizes-from micro-UAS, to mid-sized VTOL UASs-will accompany small squads and platoons into battle. However, development and production of small and micro-UASs pose technological and aerodynamic challenges that must be overcome. In addition, the production and use of a large number of small and micro-UASs does present a formidable airspace de-confliction challenge.

Organization, Culture and CONOPS: The integration of large numbers of UASs into future militaries is not assured to go smoothly, especially since the enhanced profile of UASs is likely to bring about a reduced profile for pilots of manned aircraft. Changing aviation culture within national militaries will present a substantial challenge. Significant resistance to this cultural change has been encountered even in militaries that have been thought leaders on the subject and are leading the transformation to a larger role for UASs. Managing this change will be a significant challenge for militaries throughout the world.

So, too, will be the process of re-organizing militaries to best exploit UAS technology. New structures, relationships and interactions will be required. Changing military culture and organization simultaneously will not be easy for more flexible and adaptable military bureaucracies, much less for militaries that lack these qualities.

Finally, developing enhanced UASs with capabilities to operate in the future battlefield will mean nothing if these technological and organizational changes are not accompanied by new concepts of operations and tactics. Theories and notions about how UASs, troops and manned platforms will interact in the range of contingencies outlined above are being worked and re-worked fairly frequently within many militaries throughout the world, but it is unlikely that effective CONOPS and tactics will be refined until forces and platforms are actually tested in battle.

ABOUT THE AUTHORS

Mr. Tate Nurkin
Engagement Manager, Jane's Strategic Advisory Services

Tate Nurkin, Engagement Manager: Tate Nurkin is an Engagement Manager with Jane's Strategic Advisory Services. Prior to joining Jane's, Mr. Nurkin worked for Joint Management Services, a small defense consulting firm in Atlanta, GA, The Strategic Assessment Center of Science Applications International Corporation, and, most recently, the Defense Natural Team of Booz Allen Hamilton. In his role as Engagement Manager, Mr. Nurkin oversees Jane's research and analysis support to both corporate and government clients, particularly focusing on enhancing Jane's open source intelligence (OSINT) and scenario building and alternative futures analysis capabilities as well as defense industry and security-related assessments.

Mr. Nurkin specializes in scenario building and alternative futures analysis of the emerging security environment; the strategic and operational threats, challenges, and opportunities presented by these alternative futures; and the capabilities that may be required to meet these threats and challenges or fully exploit future strategic opportunities. He has provided alternative futures and other analytical support to over a dozen agencies and offices within the US and international defense and intelligence communities. Substantively, Mr. Nurkin's research has focused on strategic dynamics of the international system, military transformations and military adaptation of emerging technologies, strategic competitions in Asia, nuclear weapons deterrence, Islamic extremism and Eurasian security and societal stability. Mr. Nurkin received his bachelor of arts in history and political science from Duke University and earned his Masters of Science in International Affairs from the Sam Nunn of International Affairs at the Georgia Institute of Technology.

Mr. Seth Drewry
Associate, Jane's Strategic Advisory Services

Seth Drewry is the lead manager on multiple US and Asia/Pacific projects for Jane's Strategic Advisory Services (JSAS). As an Associate with JSAS, his primary clients are defense and aerospace firms in the US and Asia/Pacific markets. Mr. Drewry has significant experience in understanding and analyzing the complex Asian defense industrial base. He has managed numerous projects looking at the global defense electronics, advanced materials, C4ISR, tactical vehicles, network-centric architectures, small arms, and dual-use technologies and their complex interaction with technology control regimes at the national and international level. Mr. Drewry has also assisted governmental organizations in the development of counter-proliferation policies. He has extensive experience in developing forecast tools for Jane's on defense systems for individual clients as well as off the shelf products, helping clients to manage revenue pipelines and develop risk mitigation strategies. Mr. Drewry has also analyzed the homeland security/domestic preparedness market, helping organizations develop "All Hazards" risk mitigation strategies and implementing global emergency preparedness best practices.

Mr. Drewry has been an invited speaker to the US Embassy hosted Private / Public Sector Summit on National Security in Ottawa, Canada and the Southeast Regional Association of Japanese Studies, and Defense Asia 2006 in South Korea. He has contributed to Jane's Defense Industry and Jane's Chem-Bio Web, has edited Jane's School Safety Suite of products as well as the Asia Policy Weekly, and has been quoted in publications such as the Mainichi Shimbun (the largest daily circulation paper in Japan) and the Sunday Express in the UK. Mr. Drewry holds a Masters Degree in International Security Studies from Georgetown University and a Batchelor of Arts in History with an emphasis on East Asia and security policy from the University of Virginia.

Asia
Jane's Information Group
78 Shenton Way
#10-02
Singapore 079120
Tel: +65 6325 0866
Fax: +65 6226 1185
e-mail: asiapacific@janes.com

Europe and Africa
Jane's Information Group
Sentinel House
163 Brighton Road
Coulsdon, Surrey CR5 2YH
United Kingdom
Tel: +44 (0) 20 8700 3700
Fax: +44 (0) 20 8700 3751
e-mail: customerservices.uk@janes.com

Japan
Jane's Information Group
Palaceside Building 5F
1-1-1, Hitotsubashi
Chiyoda-ku, Tokyo 100-0003
Japan
Tel: +81 (0)3 5218 7682
Fax: +81 (0)3 5222 1280
e-mail: japan@janes.com

Middle East
Jane's Information Group
PO Box 502138
Dubai
United Arab Emirates
Tel: (+971 4) 390 2336
Fax: (+971 4) 390 8848
e-mail: mideast@janes.com

North/Central/South America
Jane's Information Group
110 N. Royal Street
Suite 200
Alexandria, Virginia 22314
United States
Tel: +1 (703) 683 3700
+1 (800) 824 0768
Fax: +1 (703) 836 0297
+1 (800) 836 0297
e-mail: customerservices.us@janes.com

Oceania
Jane's Information Group
PO Box 3502
Rozelle Delivery Centre
NSW 2039
Australia
Tel: +61 (0) 2 8587 7900
Fax: +61 (0) 2 8587 7901
e-mail: oceania@janes.com

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