

Unmanned Aerial Vehicles: Improving Warfighting Capabilities In The Urban Environment

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Abstract

As worldwide urbanization increases and our adversaries seek to use the urban terrain to asymmetrically engage US forces, the US military must be able to effectively conduct military operations in the urban environment that maximize maneuverability, flexibility, and lethality, while minimizing the risk to our forces. Not only must our warfighters have timely, reliable information about the urban terrain, they must also possess the capability to effectively address these threats to seize the initiative from our adversary, allowing us to dictate where and when to accept the fight.

This paper suggests that unmanned aerial vehicles (UAVs) is one system, although accepted for its value in providing our warfighters with enhanced information, surveillance, and reconnaissance (ISR) capabilities, has more to offer. In the fluid urban environment, ISR is only one critical aspect to successful mission accomplishment; UAVs can be used to conduct other key missions, as well. It is proposed they could be used to overcome communications shortfalls; look inside buildings to ascertain occupancy and purpose; detect, identify, track, and target enemy threats; and sense out mines and weapons of mass destruction employment.

The conclusion is UAVs have demonstrated their potential usefulness. However, the US military needs to continue to investigate other missions against which to employ UAVs to take advantage of their inherent flexibility and maneuverability to enhance our urban warfighting capabilities. Further, UAVs are not viewed as the panacea for the challenging problems encountered in urban operations, they should be employed to complement manned aircraft. However, we need to address the unmanned-manned force mix and doctrinal issues to maximize their utility.

Introduction

As many of the service conceptual templates and our national security strategy allude to, in the future, the United States will likely encounter threats across the full spectrum of conflict, and in a wide variety of environments, from desert, to jungle, to the urban environment.¹ Joint Vision 2010 states that, "Full Spectrum Dominance will be the key characteristic we seek for our Armed Forces in the 21st century."² As stated in the Marine Corps' *Operational Maneuver from the Sea*, "Many of these will be associated with the littorals, those areas characterized by great cities, well-populated coasts, and the intersection of the trade routes where land and sea meet."³ For the United States military to concentrate on only one of these potential conflict environment scenarios would be dangerous and very narrow-minded. However, as world demographics continue to shift towards urbanization⁴ and the political and socioeconomic environment of Third World countries increasingly affects the international security environment, the probability the US military will have to operate in an urbanized setting is high.⁵ I believe it is, therefore, incumbent upon the US military to possess the capability and proficiency to effectively operate in the urban environment, to understand the characteristics and the threats associated with the urban terrain, and to assess what capabilities and address what limitations we have currently. With this information, we can ensure development of the capabilities and tactics and procedures needed to provide our forces the best opportunities for success in military operations in urban terrain (MOUT) missions while also reducing the likelihood of collateral damage and US casualties.

At the heart of our ability to successfully operate in any environment are the critical requirements to provide our military forces with timely, accurate information; to protect vital infrastructure; to minimize casualties to civilians; to minimize the risk to our troops to the maximum extent possible; and to promote stability.⁶ Our ability to gather and disseminate vital information will provide our warfighters increased awareness of the environment, allowing them to proactively react to dangers and bring to bear the best mix of assets to maximize our response and minimize the risk to themselves.⁷ This requirement is no less important in the urban environment and is probably exacerbated because US military forces are least familiar with this environment. The US military continues to procure weapons systems and train for the big, knockout blow engagements--the large, conventional operations if you will--and to a large extent, only marginally addresses systems that will provide for effective, efficient, risk-reducing operations in asymmetrical types of scenarios. FM 90-10, last revised in 1979, states, "Tactical doctrine stresses that urban combat operations are conducted only when required and built-up areas are isolated and bypassed."⁸ Because many believe that for the foreseeable future the US will not engage in a major contingency against a peer competitor⁹ and that future adversaries will probably not want to engage the US military in a conventional scenario, our adversaries will then use the urban terrain to avoid confronting our strengths and seek to utilize their strengths. The urban adversary will use the canopy of buildings and underground passages to conceal their intentions, their forces, and their weapons systems. Therefore, we must possess the ability to provide the warfighter with the information and capabilities vital for accomplishing a quick,

successful mission, while at the same time minimizing the risk of loss of life to our troops. Getting caught in an attrition-type conflict in an urban setting will sap resources and manpower and degrade troop morale.

Current strategic, space-based and airborne systems provide high quality imagery and information, provided the adversary has not hidden or modified weapon storage facilities or used the concealment features inherent in buildings or high quality decoys to hide their capabilities. Aerial photography may provide information that shows abnormalities and alterations to the terrain, but can it effectively and reliably look inside buildings or sniff out chemicals in a suspect area? Using unmanned aerial vehicles (UAVs) in a tactical, urban setting can give our forces the "eyes and ears" to provide the "up close and personal" look critical in urban areas, and enhance our ability to more accurately determine the validity of an adversary's system, accurately identify a facility's real use, or assess the threat to our forces.

As a result, this research will address what UAVs can do to help provide the "up close and personal" view of the urban operating area to improve the situational awareness and operational flexibility of US military forces operating in an urban scenario. I will examine the urban environment, highlighting common characteristics found in the urban environment and then discuss attributes of current and developmental UAV forces and possible threats UAVs can expect to encounter and which assets we must consider employing. Next, I will discuss potential uses of UAVs and highlight those I believe to be most important, focusing on their impact on enhancing the urban warrior's

effectiveness in accomplishing the mission and conclude by briefly discussing implications for force structure and doctrine by using UAVs in the urban environment.

As Lieutenant General Paul Van Riper states in his *A Concept for Future Military Operations on Urbanized Terrain*, "The tide of expanding urbanization in the developing world has increased the likelihood that Marines will again be called upon to operate in urban areas."¹⁰ I believe not only the Marines, but all ground forces will potentially have the task of conducting military operations in urban terrain (MOUT) in the future. As the enemy's order of battle moves towards nonlinear, nonplatform-oriented applications, such as is likely to be found in an urban environment, our ability to provide our ground forces with the most accurate, timely situational battlespace picture and provide assets which offer the greatest flexibility and combat power is critical to our successful conduct of operations in the urban environment.

Characteristics of the Urban Terrain

American military doctrine has generally supported avoiding conflict in urban areas primarily because of the "perception that the city consumes attacker resources," such as material, humans, and time.¹¹ Although this is true in many cases, the fact remains it was necessary to conduct MOUT in the past, such as at Hue City, Vietnam¹² or Grozny, Chechnya in 1994¹³ and it will be necessary to conduct them in the future. Many of our services' conceptual publications and procurement efforts focus on fighting the large, conventional battle against peer adversaries and gives only cursory thought to the types of asymmetric military operations involved in urban terrain scenarios. The US military must train for operations in all potential operating environments and utilize all its

capabilities to minimize the inefficient expenditure of resources, especially manpower. However, to help accomplish this goal in the urban arena, we must be familiar with characteristics common to the urban terrain and the threats associated with this environment.

Urban Terrain Characteristics

As the trend toward urbanization continues and as cities become physically larger, the urban terrain will become a more complex and dangerous environment that varies widely from one urban area to another.¹⁴ It will present unique challenges to military forces not found in land, sea, and air scenarios. It will cause communications and data exchange problems because of line-of-sight limitations and impact the effectiveness of high-tech, conventional weapons systems.¹⁵ Further; military operations in urban areas will span the complete spectrum of war from relatively benign environments, such as humanitarian operations where mere information on crowd movement is important, to environments where door-to-door combat is required to clear the area of the enemy, mines, weapons of mass destruction (WMD), etc. As a result, to operate effectively in this complex environment, commanders and those developing responses to this environment must understand the characteristics associated with this environment. There are several common characteristics which most urban areas possess.

The first characteristic the urban warfighter must consider is the layout and structural composition of the urban area. Within each city is a variety of different building constructions that an adversary could use in a variety of ways. As McLauren, et al. discussed, combatants in urban terrain scenarios tend to avoid using structures for

cover that are easy to destroy.¹⁶ Therefore, recognizing the types of structures that an enemy may use to conceal intent is critical. Along these lines, combatants will maximize the construction to limit observation distances, to set up fields of fire, and to restrict movement.¹⁷ They will tend to use covered, hard to detect structures, such as tunnels and passageways. Having knowledge of the city's underground network, its utility and service lines, and pipelines large enough to permit passage of humans, could be invaluable information for military units. Further, having an intimate understanding of the physical layout of the built-up areas is significant. The layout of buildings and streets can vary from random and dense with narrow, winding streets to the more modern areas that have wider streets and more high rise buildings. Knowledge of the layout is critical for determining concealment capabilities, obstacles, mobility limitations, areas well suited for ambushes and snipers, and command and control considerations. A commander who fails to address these characteristics fails to heed one of the five constant factors espoused by Sun Tzu--(Earth) comprises distances, great and small; danger and security; open ground and narrow passes--and seriously jeopardizes mission.¹⁸

Another characteristic the urban warfighter must consider is the population. Are they friendly to us or sympathetic to the enemy cause, what are the security implications? How will population size, medical and survival needs, evacuation requirements, and other essential services impact military operations and manpower requirements? Where the people are located, their movements, and their safety concern can affect how military units conduct operations. The density of the population within an urban area is a cause of concern for commanders due to our desire to minimize casualties or control crowds.¹⁹

Further, humans could be used as hostages by our adversaries to limit our options. As a result, our ability to gather accurate, timely intelligence will greatly impact the choice of tactics and weapons employment.

The above characteristics are further impacted by constraints imposed on military forces by the leadership via rules of engagement or directives. Although limitations imposed on safeguarding historic and cultural artifacts and buildings, and life essential assets, such as water treatment plants, are relevant to all fighting scenarios involving US military forces, urban fighting presents different challenges. Because of the relative proximity of combatants to each other, to important artifacts and structures in the urban arena, and to the population, having accurate information on the location of these facilities and how the enemy may be utilizing them for their purpose is critical to minimizing collateral damage and civilian casualties and will, in the end, be a big factor in assessing whether an operation is a success or failure. As the Russians learned from the experiences in the Battle of Grozny, distinguishing combatants from non-combatants was not easy,²⁰ and their indiscriminate escalation of military operations in Grozny in 1994/95 to defeat the Chechen rebels drew international condemnation for the excessive damage to noncombatant facilities and civilians.²¹ During the Gulf War, our military actions drew international concern for the bombing of a supposed "baby milk" factory. True or not, the fact is the world has not and in the future, will continue not to accept collateral damage or excessive civilian casualties. Therefore, to the maximum extent possible, we must possess the ability to distinguish military from civilian targets--a

difficult task in the urban terrain--as well as have the capability to accurately target enemy strong points to successfully affect operations.

A final characteristic that can influence urban operations concerns the ability to effectively command and control forces. Built-up areas degrade communications reliability due to line-of-sight restrictions, a limitation which sensors mounted on UAVs could overcome, and therefore, impede the ability to provide the intelligence and coordination necessary to conduct effective operations. The ability to maintain reliable communication with units operating in an urban area is not only important for coordinated movement of forces, it is critical to ensure accurate direction and fire support and prevent unnecessary destruction. The urban terrain provides unique obstacles to the ability to maintain communications between units because buildings, power sources, and adversaries conducting information operations in cities will interfere with communication signals.²²

The above characteristics portend of an environment that is complex, varied, and very dangerous. To effectively operate in as well as possess the capability to gather intelligence and provide the firepower will require preparation, training, and assets. However, these characteristics are only one part of the equation associated with the urban terrain. The second part of the urban terrain characteristic equation is the threats associated with MOUT. The urban environment that will confront friendly forces is a constantly changing, three-dimensional battlefield--street level, roof level, and underground level fighting.²³ It has the potential of isolating and separating units forcing them "to fight in small, decentralized elements," which hinders command and control and

massing of forces.²⁴ The masking and concealment aspects inherent in built-up areas allows the enemy to hide weapons systems and storage facilities. It can also reduce the visibility to see an adversary's forces by limiting the effectiveness of our space and airborne surveillance assets to provide the necessary information for effective conduct of operations and limit our ability to seize the initiative that all our service's doctrines espouse. To further complicate an already complex environment, the proliferation of modern weapons systems to Third World countries will provide them with chemical or biological agents, precision-guided munitions, day/night capabilities, and improved communications capabilities. All of these will put our forces at extreme risk and potentially exact a large toll in casualties and resource usage unless we utilize the best assets we can to minimize this risk. As a result, it requires we have the ability to reliably see beyond line-of-sight, around corners, and into buildings through the use of "through-the-wall viewing systems" and sensors mounted on UAVs²⁵ and to possess the ability to project combat power, with reliable accuracy and lethality, to any point in the urban terrain.

If we agree that the urban environment is an environment we will find our forces having to conduct operations in in the future, and that the environment does restrict our high-priced, conventional-oriented assets from being able to comprehensively and accurately provide the information and firepower necessary for conducting effective, efficient MOUT, how do we overcome the deficiencies in our urban warfighting capability? One possible solution is the use of UAVs to snoop around the streets and in buildings; to provide the "up close and personal" situational awareness; to provide the

firepower, when required, to quickly clear the urban arena; to be able to determine, with a high degree of reliability, that what we think is a weapon is, in fact, a weapon and not a decoy; to be able to assess whether an area is contaminated with chemical or biological agents; and to be able to attack a target with munitions while minimizing the risk to our forces. All these are critical to ensuring the safety of our forces and the city population, to minimize collateral damage, and to allow our forces, engaged in MOUT, to apply maneuver warfare.²⁶

Various military forces have used UAV assets in a variety of scenarios, but only recently have we really started to seriously look to integrate them into our planning efforts. According to Major General Kenneth Israel, Director, Defense Airborne Reconnaissance Office, unmanned aerial vehicles have been doing a "magnificent job" in providing surveillance in Bosnia.²⁷ Despite limitations such as the impact of weather conditions on remote control ability,²⁸ or the fact that UAV design and mission purpose must be addressed together for maximum effectiveness, UAVs have demonstrated their capabilities and potential to greatly enhance warfighting in the future. As a result, what are the available current capabilities in our UAV assets to provide the warfighter with the intelligence and operational flexibility they need for successfully conducting MOUT?

UAV Assets and Threats

Extremely flexible and discreet, UAVs are becoming integral weapons in today's military forces.²⁹ These systems provide a wide range of capabilities and options for the warfighter. Some UAVs are more strategic in their application and intended mission focus, while other are more tactically oriented. This chapter will focus specifically on the

tactical UAVs, as they have the most immediate applicability to the urban environment. When discussing these systems and assessing their capabilities, we must consider several factors to determine their applicability to a given environment.

One of the first, and most important capabilities to consider in deciding whether to employ UAVs is the system's range capabilities. In other words, how far in front of the troops does the warfighter need intelligence or desire to employ firepower? This is an important consideration from the standpoint that the farther the UAV can range, the more comprehensive the intelligence picture and the better the situational awareness. As a result, the warfighter is better able to employ the best tactics for the situation and bring in the most appropriate fires. Although most urban areas are relatively small, if the intelligence picture is not far enough forward, line-of sight and communications reliability problems inherent in the urban arena will mask the threat. Forces may believe an environment is benign when in fact a more comprehensive intelligence picture might show enemy force buildup, extensive minefields, or a toxic environment. Additionally, with a less comprehensive intelligence picture, the commander may not employ the best tactics for the threat or be prepared to handle the threat situation. For this paper, I will investigate only those UAV assets and capabilities which have the most relevance for employment in the urban environment.

A second factor of importance concerns the suite of packages capable of employment on the UAV. Critical in discussing this factor is the intelligence gathering suites or sensors on the UAV. Most tactical UAVs carry some form of electro-optical/infra-red (EO/IR) sensor and line-of-sight (LOS) packages to facilitate

differentiating between friendly and enemy forces, assessing battle damage, acquiring of targets, and seeing around corners and into buildings.³⁰ These are the common missions associated with tactical UAVs. As the technology is refined; however, and to enhance their value in urban operations, these systems must have the capability to carry and deliver weapons and payloads, such as miniature sensors, reliably extend communications capabilities to the warfighter beyond LOS, and provide force protection to the urban forces. The integration of UAV assets into urban terrain operations must address these capabilities to provide commanders with a comprehensive "up close and personal" and lethal air capability, which minimizes the risk to personnel.

However, UAVs employed in high threat areas, such as the urban terrain, must be survivable. Equipping UAVs with weapons provides the warfighter with expanded flexibility and lethality to affect operations in the urban setting, while reducing the casualty factor, but also make systems vulnerable to enemy threats. Additionally, equipping UAVs with weapons will reduce the response time for targeting an enemy and allow us to attack them when they are "most valuable and most vulnerable."³¹

A third factor to consider in assessing a UAV's applicability to operate effectively in an urban environment is its loiter or hover time. Because of the fluid nature of the urban battlefield and an adversary's ability to hide in buildings, tunnels, and other inherent, visually restrictive places in urban areas, having the capability to find the enemy and minimize their maneuverability, while maximizing ours, for extended periods of time is a valuable capability. UAVs--"because they are not constrained by human endurance"³²--can loiter longer and provide surveillance of a suspected area longer and

thus, detect infrequent movements and cause the enemy some level of apprehension as to their next move. This persistent surveillance provides the warfighter several advantages. First, it takes the initiative away from the enemy and enhances our ability to respond in an appropriate and timely manner. Second, it allows us to dictate when and where we will accept battle, allowing us to bypass and isolate enemy resistance areas, and exploit gaps and avoid surfaces, and thus, shift the initiative in our direction.³³ Third, the longer sortie durations of UAVs means fewer aircraft can provide the same level of coverage and thereby, reduce operating costs.³⁴ In the volatile urban terrain, possessing these capabilities will significantly reduce the enemy's options and reduce the risk to our forces.

UAV Assets and Capabilities

Because of the inherent closeness associated with combat in the urban environment, it will be necessary for UAVs to possess the capabilities to conduct extended surveillance, be highly maneuverable and survivable, be able to assess suspect areas, and be able to provide robust, reliable communications and force security to enhance the warfighter's effectiveness in the urban terrain. One UAV system in development and test is the Multipurpose Security and Surveillance Mission Platform (MSSMP). This system, which looks similar to a spaceship, can conduct a wide variety of missions from fire control and force protection to signal relays and remote analysis of potentially polluted areas, such as chemical or biological contaminants.³⁵

The MSSMP has the ability to fly or hover, at very low altitudes, down city streets and conduct numerous operations. In fact, it can fly at or below roof-top level, peer or fly through windows, or land and continue to survey the environment. However, as is the

case with any system that operates this close to harm's way, this system is very susceptible to attack. As UAV and miniaturization technology improve, enhanced stealthiness, maneuverability, and survivability capabilities will make UAV military application more survivable deep in hostile terrain. Systems will be hardened, carry more countermeasure capabilities, and even be armed with weapons systems. The MSSMP, for example, could be smaller and equipped with a weapon system that allow it to be more covert and if attacked defend itself.

The MSSMP can carry an acoustic and visual motion sensor package, which will allow it to conduct force protection missions and detect, track, and locate targets.³⁶ Also, the MSSMP can carry and drop off payloads, such as radio relay equipment to enhance communications capabilities, or intrusion detection devices, providing the warfighter with enhanced situational awareness of the terrain and security protection well beyond the troop's forward advance. With the ability to maneuver up to 10 km from its base, the MSSMP has the ability to provide the warfighter with critical information about the physical layout of the city's streets and buildings, providing a forward looking view of the enemy's force location. All these capabilities go toward enhancing battlefield situation awareness, while also extending the eyes of the warfighter well in front of the forward advance.

Several similarly capable tactical, UAV systems currently in the inventory that possess attributes suited to employment in the tactical, urban environment are the Pioneer, Hunter, and Outrider UAVs. These systems are designed to conduct real-time reconnaissance and surveillance/target acquisition missions, on the battlefield via the

EO/IR sensor packages they carry.³⁷ They also possess the capability to provide radio relay missions that can extend the warfighter's communications range beyond normal radio ranges to enhance command and control and coordination.

The Marine Corps is currently evaluating a version of the Pioneer UAV called COBRA (Coastal Battlefield Reconnaissance and Analysis) for minefield detection and mapping and could provide a very valuable capability for the urban warfighter.³⁸ This system will eliminate the need to have humans perform this very dangerous operation and thus, greatly reduces the risk to our forces--a critical consideration in any military operation conducted today or in the future--not only from the mines but from the highly exposed position they are put into when conducting mine detection operations. Designed to operation at low altitudes, 1000 feet or less, the COBRA Pioneer's detection suite can discern between decoy and real mines, with very high accuracy. Although not possessing the ability to maneuver or hover for extended periods of time, like the MSSMP, these UAVs could operate effectively in an urban environment with wide streets and open spaces.

Another UAV system that shows promise not only regarding the ability to conduct the recon/surveillance and targeting missions normally associated with UAVs, but will enhance UAV survivability is unmanned micro aerial vehicles--miniature UAVs.³⁹ Although still in the conceptual phase, but possessing many advocates for this capability, these systems offer a number of benefits and possible applications, especially military applications in urban settings. The US Defense Advanced Research Projects Agency (DARPA) has begun investigating the feasibility of these systems looking at

aerodynamics, power sources, payload capacity, and potential missions.⁴⁰ Because of their small size, some with wing spans of no more than several inches, we could deploy these systems in a very discreet manner, inside buildings, as "flies on the wall," etc., and would be practically invisible to the person on the street, yet could possess the ability to perform a variety of missions, such as reconnaissance/surveillance, detection, targeting, and weapons delivery. With the tremendous strides being made today in miniaturization, these micro air vehicles are a real possibility in the future and should be seriously investigated for military applications in the urban terrain, where their stealthiness would enhance survivability and security of the system and our forces. Additionally, as our technology advances, the possibility of using these micro UAVs to carry micro weapons systems would provide a potentially destructive, psychological moral advantage.

Many military forces have used fixed-wing UAVs to conduct missions for a long time, for example, the Israelis used them against the Syrians in 1982.⁴¹ However, as robotics technology improves other shapes of UAVs, such as helicopters, are emerging. Recent tests of several unmanned robotic helicopters has demonstrated their value in a variety of missions, including urban scenarios.⁴² On one demonstration flight, the helicopter "followed traffic on a highway and hovered close to a hotel, filming rooms through its windows."⁴³

However, the employment of UAVs in urban scenarios is not without risk that we must consider. As already discussed, the urban environment is a highly complex, threat intensive arena. The low performance and maneuverability characteristics of most of today's UAV systems and their vulnerabilities to enemy threats is a shortfall that requires

further attention. UAVs operating in the urban environment will be vulnerable to small arms fire, surface-to-air missiles, and anti-aircraft artillery (AAA). Additionally, they will be susceptible to such tactics as electronic attack, primarily through the disruption of the electronic signals that control the UAV and their ability to send information back to their operators. Further, as technology improves, and UAVs become more robust and payload capable, and adversaries recognize the military importance of these systems, they will probably target UAVs with more exotic assets such as lasers, electromagnetic pulse devices, and airborne assets, such as fixed and rotary-wing aircraft.⁴⁴ However, these threats are not much different from the threats encountered by any low performance aircraft. Today, we have the capability to mitigate some of these vulnerabilities through the use of stealth technology and the use of more robust materials and as miniaturization and stealth technology refinements continue, and are combined with enhanced UAV technological improvements, UAV vulnerabilities will diminish.

All these threats will be a function of the enemy's perception that UAVs are a threat to their security and effective accomplishment of their mission. Today, UAVs are in many regards a curiosity that elicits surprise and a psychological impact when encountered on the battlefield. During the Marine Corps' Hunter Warrior experiment, the Red force reported feeling "harassed" by UAVs and deviated from their planned maneuver scheme because of the impact of being "watched."⁴⁵ However, these types of enemy reactions will diminish as UAVs are encountered more frequently in conflict scenarios and as their novelty wears off. As the adversary realizes these are military systems, which can seriously impact operations, they will respond more aggressively to a

UAV's presence. They will attack these systems with whatever weapons systems they possess, shooting them down, disrupting their communications links, or just attempting to avoid them, to the maximum extent possible. Additionally, just as the US military will continue to integrate UAV technology into our urban military plans and operations, our adversaries of the future will also likely employ this capability, as well. Most recently, during the Battle of Grozny, the Russians recognized the usefulness of UAVs in enhancing their operations.⁴⁶ Therefore, it is incumbent upon us to not only develop this technology and assess mission applicability for employing UAVs, but to better understand and be knowledgeable about our future adversaries and how they could use these systems against us.

Having looked at current UAV capabilities and recognizing that UAV technology has tremendous applicability and benefit to our urban warfighters, against what missions should we employ them in the urban environment?

UAV Missions in the Future

As the US military continues to look for methods to minimize the risk to our troops and maximize scarce resources, and as our budgets and troop strengths continue to shrink, the integration of technological advances, which enhance our ability to efficiently and successfully accomplish missions throughout the conflict spectrum, will become critical. In the future, the US military will perform more and more operations that deviate from the traditional, conventional missions, but which are potentially more dangerous. Missions, such as counter-drug operations or humanitarian operations in hostile settings, will become more prevalent. Possessing the capability to employ advanced weapons

systems that not only enhance our warfighting capability and accomplishment of the mission but also can help minimize collateral damage and the loss of human life, will be important. Unmanned aerial vehicles are one example of a technologically advanced system that offers these benefits not only today, but in the future.

In the very complex and potentially dangerous urban environment, unmanned aerial vehicles offer the military the best of many worlds. They are flexible, relatively inexpensive, possess a fairly small logistics footprint, are easy to operate, and have the potential to replace humans in conducting dangerous missions, such as surveillance and reconnaissance in the urban area. As miniaturization trends continue in the future, we will continue to further realize and expand these advantages of UAVs. As a result, the US military must begin to look beyond solely manned platforms as the answer to addressing urban terrain scenarios and look to integrate UAVs into the force mix and to maximize one of our biggest advantages--high technology.⁴⁷

Intelligence, surveillance, and reconnaissance (ISR) is one of the primary missions which we now, and in the future, should employ UAVs against, in the urban terrain. Ideally suited for this mission because of the ability to range well ahead of troop advance, and their ability to persist over an area for long periods of time, a capability difficult and costly to arrange from space-based systems, will provide warfighters the ability to "see" what is out there in the streets. They can be used to map sections of a city, showing possible lanes of fire, enemy strong points, areas with impassable features, or likely areas for ambushes, in near real-time. A commander who has the capability to see beyond the line-of-sight has the ability to spot for artillery ahead of his troops and therefore, has a

decided advantage over his adversary and could severely restrict their surface movement. This could drive the enemy underground, which by itself will reduce an enemy's options and movement rate.

UAVs could also serve to gather information about activities if the enemy is operating underground or inside buildings. We could equip UAVs with "through-the-wall" viewing systems or sensors to monitor power usage in a building⁴⁸ and penetrating radars to survey underground force movements. UAVs could also be configured to carry unattended sensors which we could deploy in underground tunnels to detect troop movement.

Additionally, if, as some believe, urban engagements will see an increase in mine use and sophistication, we could use UAVs to provide remote mine reconnaissance and carry mine detection sensors⁴⁹ and ground penetrating radar.⁵⁰ The result is a commander more aware of the urban battlefield situation who can develop plans and use tactics more specifically tailored to the current situation and who will be able to gain the initiative and negatively impact the enemy's decision process. Finally, the ability of UAVs to fly more closely into the operational environment will facilitate identifying critical civilian structures, their uses, either civilian or military, and overall, enhance the granularity of the situational picture. The granularity provided by our tactical UAV assets fused with our strategic overhead assets will allow our commanders to base tactics and decisions on a more clearly defined and comprehensive view of the battlespace. This leads to a second critical mission we should use UAVs against in the urban arena--to detect, identify, track, and target enemy threats.

Target location is always of prime importance and it is no less important in the urban arena, and in fact, may be more critical. Being able to detect, identify, track, and target enemy systems remotely not only increases the likelihood of mission success, but keeps our troops out of harm's way. UAVs could be configured to drop unattended ground sensors which could monitor force movement in an area and alert the commander of potential enemy force concentrations. Also, a consideration that we must account for in any military operation, but that is critical and made more difficult in urban operations, is the minimizing of noncombatant casualties and collateral damage to historic, religious, or civilian structures. It is more difficult in urban settings because of the close proximity of forces to each other and to those important structures. UAVs, because of their capability to get close to the operating environment and their ability to be equipped with sensors which could sniff out gunpowder, would enhance our ability to more accurately differentiate between combatants and noncombatants and allow for more accurate targeting and reduction of civilian losses. As the Russians discovered from their experiences during the Battle of Grozny, without this capability effective operations, in the urban environment, are very difficult and can compound operational efficiency by alienating civilians.⁵¹

Additionally, as UAV technology and capabilities increase, their ability to see inside buildings, to reliably detect mines, to map facilities to identify its purpose and layout, and track enemy troop and vehicle movement will greatly reduce the enemy's ability to seize the initiative and impact operations. We could also use UAVs to deploy surveillance devices, such as sensors designed as bricks or bottle caps,⁵² much like the

way we conduct leaflet drops. As a result of having the enhanced ability to detect, identify, and track enemy force movements and facility purposes, we can then more reliably and accurately target threats and thereby, successfully complete missions. Again, UAVs could perform this targeting mission and reduce the need to put our forces in harm's way.

In the future, UAVs must be capable of carrying and accurately employing weapon systems. Employed in conjunction with a UAV force capable of gathering enemy force movements, facilities purposes, and the ability to loiter in the terrain for extended periods of time, we could quickly and confidently employ weaponized UAVs against the threat. This combined force package of UAVs will provide warfighters with immediate supporting fires to eliminate a threat⁵³ while greatly increasing the likelihood of mission success, reduced civilian casualties, and reduced collateral damage. Further, as envisioned by the Defense Science Board, UAVs could be configured to carry dozens of munitions, an arsenal UAV, which would provide the warfighter with enhanced flexibility, fire power, and force protection capabilities.⁵⁴

A fourth mission for UAVs, and one that in the future will be much more likely and critical than today, is the ability to remotely sense weapons of mass destruction (WMD) usage. As the proliferation of WMD increases and their use becomes a greater possibility, possessing the ability to detect the use of these devices, especially chemical and biological, in the crowded arena of tomorrow's cities will be invaluable. The safety and security of our troops are always of paramount importance; however, having the ability to detect WMD usage will also enhance our ability to provide for the security of

the citizenry, an objective we have historically embraced as of vital importance in any operation we conduct.

A final mission of critical importance which future UAVs must perform is to provide a more robust, reliable communication link and data dissemination capability in the urban environment.⁵⁵ If we are to provide warfighters the kind of situational awareness needed to conduct effective, successful urban operations, we must be able to quickly and reliably get accurate information to those needing it. It does no good to be able to detect, identify, and track an enemy if we can't disseminate the information. Line-of-sight restrictions in the urban terrain make communications between individuals and units very difficult. However, UAVs can help overcome this problem by serving as a communications relay. Equipped with radars, we could deploy UAVs forward of our forces in an array that would allow reliable communications. Even if communications is limited because of building interference or some other factor inherent in the urban environment, UAVs could pop up above the city infrastructure to transmit its data.

UAVs are the not the sole answer to overcoming the challenging problems encountered in urban operations. They should be employed in a manner which complements manned aircraft. However, we need to develop the mentality to look outside the manned paradigm and to investigate the possible missions against which we could employ this systems so that we can enhance the warfighter's options and minimize the risk to our forces. UAVs could perform a variety of missions in the urban environment, including overcoming communication shortfalls; conducting persistent surveillance and reconnaissance well forward of our forces; looking inside buildings to

determine occupancy and purpose; and detecting, identifying, tracking, and targeting enemy threats. Without this capability we could find our force's maneuverability restricted and the enemy controlling the initiative and dictating when and where to accept the fight.

Conclusion

As we approach the next millennium and beyond, the US military will be tasked to perform a variety of missions. Many believe we will not engage in a major contingency for the next 15-20 years and more likely combat forces will be employed against nonconventional adversaries employing asymmetrical tactics. However, the idea that we could be fighting nonconventional adversaries should not imply that they will sit by idly and do nothing. Many of our potential adversaries are actively acquiring and upgrading their capabilities to better fight their type of asymmetrical conflict. They are acquiring widely available 21st century technologies for use against us in order to delay and disrupt our abilities to respond rapidly and effectively.⁵⁶ They will attempt to use these systems in as rapid a manner as possible to achieve their objectives while at the same time making it harder for us to achieve ours. They will seek to exploit our vulnerabilities and maximize their strengths, maneuverability and concealment. Additionally, we will not have the luxury of six months to prepare for our next conflict, as we did in the Gulf War.

As a result, we must start now investigating technologies that will provide the best options to employ in the urban environment and develop the tactics and doctrine to fight effectively. We need to maximize the one decided advantage we have--technology--to

decrease our vulnerabilities to asymmetric contingencies. By maximizing our technological advantage, we will enhance our warfighter's operational flexibility and minimize the risk to our most valuable resource--our personnel. Our leaders must start to get over the mindset that manned is good, unmanned is not good. This paper attempted to highlight one such system, unmanned aerial vehicles, that is starting to receive serious attention as a means to help reduce the risk of casualties, expand our warfighter's operational options, and use the technological advantages the US possesses to combat adversaries in an unconventional environment, the urban terrain.

UAVs, although still in their infancy stage regarding capabilities and mission employment, have demonstrated their potential usefulness in several operational scenarios. In the last few years we have demonstrated the use of UAVs, in the urban arena, to have applicability to greatly increase our reconnaissance and surveillance capabilities and overcome communications problems in the urban environment. They offer a number of advantages compared to manned systems, such as cost savings, smaller logistics footprint, and ability to stay aloft longer, which extends their applicability beyond the ISR and communication missions. As the technology improves, these systems will become smaller, more survivable, and more capable of performing many missions. Missions such as peering inside buildings, physically entering a facility to determine who is in the building and its purpose and layout, or air dropping sensors to facilitate enemy detection and tracking, will not be beyond operational possibilities. All this with the added benefits of being able to fly up close in the urban terrain to ensure more reliable target recognition and delivery; thereby, reducing collateral damage.

This is not to say that UAVs are the solution to all urban operations and that UAVs should replace, in total, manned aircraft. We need to determine the manned-unmanned force mix and analyze how best to integrate UAVs into the force structure to complement manned systems, and define what mission types should employ UAVs with the ultimate goal of maximizing mission accomplishment and reducing the risk to our troops. However, this will not occur without a commitment to develop these capabilities and the doctrine to ensure we maximize the benefits of their employment.

To ensure we maximize UAV capabilities, in the urban environment, several areas need addressed. First, we need to continue to push the envelope of UAV technology and seriously look at their ability to perform more than just the stereotypical reconnaissance and surveillance missions. Although important, especially for providing commanders the most timely and accurate situational awareness, we need to investigate using these systems more creatively and in missions that are typically manned aircraft roles. This will provide the urban warfighter the ability to rapidly respond to an enemy's attack, without the delay of calling for aircraft strikes, and thus be able to quickly mass fire rather than forces. Employing UAVs in roles, such as payload delivery, mine detection, or weapons delivery, and reduce the reliance on humans to perform these dangerous missions will enhance a commander's options. Employing these systems against more dangerous missions will move our forces further from harm's way and help reduce casualty numbers while reducing the physical and mental strain of fighting in this environment.

Secondly, we need to more thoroughly develop doctrine that will maximize how we use UAV capabilities, in cooperation with manned systems, in operational situations to maximize our combined arms capabilities. To a large extent, employing UAVs is not much different from employing manned aircraft except that we must come to grips with and accept the fact unmanned aircraft can perform many of the missions previously reserved for manned aircraft. However, doctrine will need to address that the use and massing of unmanned assets should take precedence over manned assets whenever possible. If UAVs can perform a mission typically accomplished by manned systems, then UAVs should be our first preference. Also, because of the expanded capabilities technologically advanced systems, such as UAVs, bring to warfighting, we will need to develop doctrine that addresses these capabilities to maximize their impact on warfighting. Finally, the influence of UAV operations on the ATO process, its impact on airspace management,⁵⁷ and its impact on command and control issues need analyzed and doctrine developed.

Regarding the use of UAVs in their reconnaissance/surveillance roles, our doctrine needs to specifically address how we can fuse the information from our strategic and tactical systems and get it to the urban warfighter quickly. It should look at how to incorporate tactical UAV, satellite, and manned and unmanned strategic aircraft imagery and information into a layered, "all seeing" situational umbrella to maximize its value to the warfighter.⁵⁸ The doctrine must also layout how we can best conduct missions to take advantage of the above enhanced capabilities.

All this should focus our efforts to integrate UAVs into our operational plans and against as many possible missions as we can. By focusing on mission employment, we can then ensure we align UAV development, capabilities, and missions in the same direction and ensure, to the maximum extent possible, the survivability and capability of UAVs. Without this focus, UAVs will languish on the periphery of military employment and we will fail to fully integrate this technological advantage to our benefit.

A third area that requires attention concerning the employment of UAVs in the urban environment is to look at the impact on force structure. Because force drawdowns will continue or at least level off in the future, and we will continue to have less presence overseas, we will require the ability to rapidly deploy, with light, agile, lethal forces.⁵⁹ As a result, any system which has a small logistic signature and is not manpower intensive will be a big asset to increasing our worldwide deployability and options flexibility. In the future, UAVs will be ideal systems for meeting these requirements. However, they will require forces trained to operate and employ them effectively. But as technology improves the operation of these systems will become even more friendly and less tethered to human control than they are currently. Also, because the simplicity of these systems will continue to improve and perform missions that are currently performed by humans, these systems can help reduce the manpower requirements for missions, which presently require manned systems. As a result, the human factor would only occur when necessary and more in a coordination role rather than being at the pointy edge of the sword.

In summary, the US military will have to operate in the urban environment in the future. It is critical we possess the ability to conduct operations in this environment that

maximizes our maneuverability, flexibility, and lethality while minimizing these capabilities to our adversaries and the risk to our forces. In the fast changing urban environment, we must employ systems that provide highly reliable, real-time tactical reconnaissance as well as the ability to accurately and quickly identify and target threats.

The concept of employing UAVs, in a reconnaissance role, on the modern battlefield is proven.⁶⁰ However, UAVs possess characteristics and capabilities that can go far beyond the purely intelligence gathering mission, given the proper budgetary focus and overcoming the manned versus unmanned mindset. Employing UAVs in the urban environment against more dangerous missions, such as facilities analysis or mine detection, not only reduces the physical and mental strain on our forces, but significantly enhances our ability to more precisely and successfully conduct operations in this very congested arena. The inherent flexibility and maneuverability of UAVs make these systems valuable assets for employment in the urban terrain and will enhance our warfighting capabilities in the future. However, to fully realize their potential, we must integrate UAV operational mission employment and doctrine along with pushing the envelope of UAV technological development to fuse and focus mission, doctrine, and capability in the same direction. UAVs are not the panacea for every mission in the urban environment, but their capabilities do provide a very flexible option, that used in cooperation with manned aircraft and our strategic overhead assets, will improve the urban warfighters capabilities.

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