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Taking it to the Streets:
Exploding Urban Myths About Australian Air Power

by Gareth B.S. Neilsen

FOREWORD

All indications are that there is an increased likelihood of military forces having to operate in urban areas against unconventional adversaries in the future. However, at the same time, military forces must also be able to counter the more conventional state-on-state security threats which may well arise if unconventional adversaries are allowed to extend their agenda. This paper examines the capabilities of air power to achieve joint synergies at each of the tactical, operational and strategic levels of conflict to contribute to military victories that support national security objectives across the unconventional and conventional dimensions of operations.

The paper assesses current and future air power capabilities that can be brought to bear in urban conflict as well as its interdependent relationship with ground forces. The articulation of specific doctrine, procedures, and training capabilities are considered as necessary foundational elements for ensuring success in joint operations in this challenging arena of conflict.

Air power alone cannot win urban battles. However, a joint approach reliant on Special Forces can create efficient precision strike capabilities even in the most complex urban areas. A combined arms approach to urban operations will be able to control the tempo of battle becoming a war-winning factor. The effects of such an approach will exceed the individual contributions of the three services and effectively 'tip the balance' in favor of conventional forces and their governments.

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ABSTRACT

The urbanization and cultural friction arising from globalization have increased the likelihood that the Australian Defence Force (ADF) will participate in urban combat operations in future conflicts. As a conventional military power, the ADF must now adapt for the unconventional adversary, but without ignoring more traditional security threats. This paper asserts that ADF aerospace power, by virtue of its freedom to exploit the third dimension, and through the use of high-technology, networked systems, can achieve joint synergies at each of the tactical, operational and strategic levels of conflict, and thereby contribute to military victories that afford an acceptable political outcome.

The nature of urban conflict is examined from both a military and a political point of view, and the merits and limitations of aerospace power are examined in enacting a counter-force strategy. This paper will focus on offensive air operations in urban areas as part of an integrated scheme of maneuver. It will examine real-time targeting and the delivery of precision-guided munitions to produce controlled (and limited) firepower effects in order to both win battles and display national intent. Current and future ADF aerospace capabilities are assessed against the requirements of urban battle, revealing an interdependent relationship with ground forces. While the study contends that the ADF is well on track in developing a balanced, flexible and networked force, it also recommends the acquisition of several new aerospace systems that have particular merit in the urban environment. Additionally, the evolution of specific doctrine, procedures, and training capabilities are portrayed as necessary foundational elements for ensuring success in joint operations in this challenging arena of conflict.

INTRODUCTION

> *The twentieth century was the last in history when humankind was mostly rural. The battlefields of the future will be highly complex urban terrains. If our soldiers cannot fight and kill at close range, our status as a superpower is in question.*[1]
>
> – Robert D. Kaplan, 2002

Recent studies have predicted that by 2030 sixty percent of the world's population will reside in urban areas.[2] This represents an almost fifty percent increase in current urbanization levels over a 25 year period. Many of the world's future centers of population will occur in third world countries where control of the city may mean control of the entire country as well.[3] This is relevant to Australia's strategic security outlook given the projected demographic changes in Southeast Asia.[4] The increasing importance of cities and urban areas as political, cultural and economic "centers of gravity" will only increase the likelihood of conflict occurring in built-up areas. Therefore as global urbanization continues, the likelihood of the Australian Defence Force (ADF) participating in urban combat operations increases commensurately.

Future ADF involvement in urban areas could cover the entire spectrum of activities, ranging from humanitarian relief and peace-keeping operations, through counter-terrorist responses involving precision strikes on a handful of specific targets, to a large scale unconventional war. It should be borne in mind that military activities represent but one possible option available to policy makers. The ADF may only be required to achieve limited objectives as part of a coordinated government response involving other diplomatic, cultural, informational and economic instruments. The use of force, particularly in unconventional conflict, may constitute a small part of a much bigger picture, just as an urban battle constitutes part of a much broader operational plan. The political relevance of military action cannot be overstated in this context.

Historically, conventional war doctrine has recommended against committing forces to urban areas unless operationally necessary. Potential adversaries to Australia may well have studied the history of urban conflict and determined that its propensity for casualties, collateral damage and resource intensity can prove a significant political weakness to a militarily superior nation. This is particularly relevant to a conservative, democratic nation such as Australia. A key strategic ADF weakness is land force manpower. Consequently urban operations represent one of the highest risk activities Australia can commit to (and arguably the arena of choice for an unconventional adversary).

The ADF is consequently faced with two main challenges in dealing with the complexities of the urban environment. How can a conventional fighting force prevail over an unconventional foe to secure a military victory that leads to an acceptable political settlement? And how should the ADF leverage its current and future capabilities to achieve this aim without turning its back on conventional regional threats? The answer, in part, lies in breaking an old perception that the urban battle is predominantly a land battle. Modern aerospace power can also contribute significantly to the fight. By exploiting the third dimension, and by virtue of modern high-technology systems, aerospace power can help create total battle space awareness, influence the tempo of combat, and achieve synergies in combined operations. This paper will focus on offensive air operations in urban areas as part of an integrated scheme of maneuver involving real-time targeting, and the delivery of precision-guided munitions to produce controlled (and limited) firepower effects to win battles and display national intent. By developing a balanced, flexible and networked force, the ADF can most reliably achieve tactical victories, as well secure desired strategic outcomes against conventional and unconventional adversaries in future urban operations.

FUTURE CONFLICT IN THE URBAN ENVIRONMENT

> *We are entering an age of warfare, in which precision strike weapons and low-technology fertilizer bombs compete uneasily for dominance.*[5]
>
> – Australian Strategic Policy Institute, 2004

The Effects of Globalization

According to a recent report by the US National Intelligence Council, the likelihood of great power conflict escalating into total war in the next 15 years is lower than at any time in the past century. The proliferation of international terrorism, however, shows no signs of abating.[6] Whilst globalization is encouraging the urbanization of the planet, unprecedented economic growth will not be evenly distributed. Instead globalization will favor the technically proficient and progressive in their search for personal freedoms and liberal trade. Resultant challenges to traditional ideals give radical Islam an appeal to many Muslims. These young men and women are attracted to western concepts of prosperity, but are frustrated by declining literacy and rising unemployment, and may feel estranged by an alien culture. Consequently broad Islamist movements akin to, or inspired by, al-Qaeda are merging with local separatist movements to develop an increasing hold over a bulging, disaffected and alienated population who are unresponsive to what they perceive as unrepresentative government.[7]

A New Generation of Warfare

These politically savvy movements are engaging in a new form of warfare against states that combines all available instruments – political, cultural, economic, social and military – to indirectly target political decision makers, largely by influencing the population through the mass media and internet. Characterized as fourth generation warfare (4GW) by USMC Colonel Thomas X. Hammes, it aims to convince political leadership that their strategic goals are either unachievable or else too costly for the limited gains they may provide. Fourth generation warfare is based on the premise that political will can defeat superior military power, and is the only form of war that has permitted inferior forces to claim victory against world "super" powers.[8] After decades of armed resistance, Ho Chi Minh's communist forces eventually prevailed over the United States, compelling their withdrawal from Vietnam in 1973. After a similarly long struggle, the Soviets ceded Afghanistan to the Mujahidin in 1988-89. In both cases massive amounts of "blood and treasure" were expended by the militarily superior nation against a determined and resourceful adversary. But faced with poor prospects of securing an acceptable political end-state, despite military victories, political leadership became convinced of the futility of continued hostilities.

The intensity of warfare is often dictated by the weaker side's ability to absorb attrition, and so is often of low but protracted intensity. Guerilla tactics are commonly favored, pitting strengths against the government force's weaknesses, and then disengaging to subsequently claim a moral or political victory through closely coordinated diplomatic activities. Protracted warfare also accords with the 4GW strategy to wear down a nation's resolve to continue, by highlighting the costs accrued versus limited gains. The impatience of western governments, the media, and the constituents plays into the 4GW strategy.

Terrorist activity and insurgency are also manifestations of 4GW, given their political focus, their reliance on public support, and their asymmetric approach to operations. 4GW practitioners are characterized by their fierce determination to prevail, and their willingness to die for their cause if necessary. The western world is currently facing its greatest 4GW challenge – the Global War on Terrorism (GWOT), otherwise referred to as the Global Struggle Against Violent Extremism (GSAVE). Despite a quick military victory to Coalition forces in Operation *Iraqi Freedom* in 2003, the insurgency that has infiltrated the cities and towns of Iraq is proving much more costly and time-consuming to deal with, and offers no assured outcomes as of the present.[9]

Networked Adversaries

Globalization's instant connectivity has enabled the 4GW threat to become increasingly de-centralized, evolving into a disconnected array of groups, cells, and individuals that do not need a stationary headquarters to train, plan or carry out operations. Training materials, targeting guidance, weapons know-how, and fund-raising are increasingly being conducted online.[10] What emerges is a picture of a far more diffuse threat, involving autonomous groups with different aspirations, yet linked through shared ideologies. With no clear command structure, this presents a much harder enemy to defeat.[11] The problem has proved vexing to conventional military forces, given the absence of a clearly defined center of gravity.

The Likely Urban Setting

Urban areas present the most likely settings for 4GW activities such as terrorism, insurgency, and civil war. The disempowered and disaffected, currently organized under the auspices of religious fundamentalism, choose to fight centers of concentrated national power.[12] Areas where population and/or infrastructure are either concentrated or vulnerable present as lucrative targets. Using easily procured or manufactured means such as small arms, fertilizer bombs, or even computer viruses, adversaries can effectively engage in asymmetric warfare that maximizes fear and disruption amongst the population. Sustained subversive operations can challenge law-enforcement and military forces, and thereby embarrass political leadership.

The ADF Mission

Protection of urban centers of gravity from physical attack will remain a prime ADF mission. A weaker adversary may show a logical preference for such "soft" targets. Contrary to hardened military sites, soft targets include facilities that employ fewer (or no) defenses, but which may provoke maximum public and political response if attacked. Defending Australia and its interests from 4GW attack requires sound intelligence, effective border control, a good deal of public support, and timely intervention. Unfortunately, this requires government agencies to be lucky every day, whereas the adversary need only get lucky once in order to score a political victory. Moreover, a purely defensive posture does not provide a positive object; that is an end state that promises the eventual elimination of the 4GW threat. Australian forces must therefore be prepared to seize the initiative and go "on the offensive" when directed by political leadership.

The 4GW battle space is both non-linear and non-contiguous. Political boundaries are an advantage for the non-state adversary, but a source of tactical vulnerability for democracies. The ideological nature of 4GW compels us to focus less on the adversary's physical centers of gravity, and instead concentrate on their mechanisms of operation and adaptation; in particular the reactions of leadership, population, and logistics assets.[13] Three likely centers of gravity thus emerge: the ability of the adversary to plan, prepare for, and conduct hostile acts; the ability to influence the populace; and the ability to move resources unhindered.[14] But because fourth generation warfare also involves a contest for the sympathy of a population (upon whom the adversary relies for intelligence, shelter, finances and resources) winning the "hearts and minds" of the people is crucial to winning the war.

Modern Constraints on Conventional Urban Warfare

Case studies of many urban battles[15] commonly reveal three recurring characteristics. Firstly, many involved limited conflict for limited objectives. Second, the defender often violated the law of armed conflict (LOAC) in an attempt to deny the attacker the use of air power. Third, instantaneous feedback was provided to the public through the mass-media.[16]

With nothing to lose, the weaker adversary cares little for public opinion, international law, political agreements or prospects of free trade – mechanisms typically used to check state behavior. The adversary may choose to fight as a non-uniformed militia, hide amongst non-combatants, or fight from prohibited structures.[17] World opinion, enabled by an ever-present media, offers modern military forces no such latitude.

During the Israeli invasion of Lebanon in 1982, the Palestine Liberation Organization (PLO) placed artillery and anti-aircraft weaponry on or around civilian structures such as hospitals, schools, churches and mosques. Tenants of multi-storey buildings were forced to remain on upper floors, and as such act as human shields in

an attempt to deny Israel the firepower advantage offered by their air force. The PLO's abuse of LOAC was overlooked by the international media, who condemned the Israeli Air Force urban air attacks for the casualties they produced.[18]

The heightened risks of collateral damage in urban environments can partially offset a conventional military's technological superiority[19] as well as threaten to rob even a technically well-fought campaign of a political victory. Military forces must therefore conduct counter-force operations with close regard to two important principles - military proportionality and discrimination – in order to maintain public support.

The concept of military proportionality requires that the application of combat power, and resultant destruction of life and property, should not be disproportionate to the military or political advantage gained.[20] For instance, the cost of Russian combat operations during the invasion of Grozny in 1995 was estimated at 400 billion rubles, whereas the reconstruction costs were around 3.5 trillion.[21] In many past asymmetric conflicts, the weaker side has still gained a political victory in the face of military defeat by portraying that defeat as a rout. During Operation *Allied Force*, Serbian propaganda claimed thousands of civilian casualties, thus attempting to exploit NATO's moral status. The media arguably created strategic effects that rivaled NATO's kinetic operations.[22]

To satisfy requirements of discrimination, forces must make every effort to distinguish between military and civilian objects, and to afford protection to non-combatants.[23] During the 1991 Gulf War, Iraqi officials quickly capitalized on the mistaken bombing by Coalition air forces of the al Firdos bunker in Baghdad. The Iraqi leadership broadcast graphic pictures of maimed or killed women and children. In so doing they attempted to challenge the morality of western military tactics, and to constrain the campaign through political pressure. To that end they were successful. Future air strikes on Baghdad required Commander-in-Chief (CINC) approval, a measure that increased Coalition workload and slowed the targeting process.[24] According to the law of war, the Iraqi government was culpable for the deaths of these non-combatants. Nonetheless, the attack still generated negative public opinion toward the Coalition.

Because of legal concerns, military lawyers frequently play as large a role in targeting decisions as do the "weaponeers," resulting in strict Rules of Engagement (ROE) for military operations in sensitive political, religious or cultural areas. Restrictive ROE may consequently deny friendly forces certain advantages, expose them to additional risks, or encourage protracted hostilities (which may actually accord with the adversary's intended strategy). Consequently, great pressure exists for a quick victory in order to consolidate gains prior to outside interference (either physical or political), minimize aggregate damage, and maintain the support of a public who has come to expect surgical precision and minimal casualties.

EMERGENT COUNTERFORCE STRATEGY

> *The political object is the goal, war is the means of reaching it, and the means can never be considered in isolation from their purposes.*
>
> – Karl von Clauswitz, On War

Functional Versus Physical Space

The military's immediate role in kinetic 4GW operations involves targeting the adversary's functional (rather than physical) space.[25] This includes his ability to recruit, train, communicate, and move resources. Possible tactical targets include training camps, supply depots, transport vehicles, leadership, and the war-fighters themselves. But it should also be noted that our own physical centers of gravity and the enemy's functional centers of gravity may occupy coincident spaces (the adversary uses the same communications nodes, avenues of approach and shelters as the "host" population). Because countering a fourth generation adversary involves a contest for the sympathy of the population, and may be conducted in their midst, our military response must remain mindful of that population's culture, religion, sense of morality, and need for security.

Non-Kinetic Imperatives

Success in fourth generation war requires not just winning battles, but selecting a successful overarching strategy that coordinates diplomatic actions with military operations. Consider the Vietnam paradox of clear-and-sweep operations. Tactically decisive in removing insurgents, the clear-and-sweep approach was politically self-defeating in the resultant destruction and consequent alienation of the population. Similarly in September 1993, the assessment by Major General Garrison, Commander of the US Army's Task Force Ranger (TFR) of the plan to capture Somali warlord, Mohammed Farah Aideed, was ominously precise: "If we go in the vicinity of the Bakara Market [in Mogadishu], there's no question we will win the gunfight. But we might lose the war."[26] The hostility of the population toward US forces resulting from the level of destruction to the city, the disproportionate attrition suffered by TFR in securing a limited objective, and the lack of a coordinated diplomatic response, combined to compel the US to withdraw forces from Somalia altogether. This equated to a US political defeat by the much weaker Somalia National Alliance (SNA).

Determinants of Political Success in Modern Warfare

In Clauswitzian terms, war is a contest to either annihilate the opponent or else break his will to resist. For a democracy to prevail over an adversary, public support for government policy (which underpins a government's political legitimacy) must outlast the enemy's will to continue. Public support is subject to many influences and is often based on perceptions. The factors which can influence public attitudes and determine the political success of a campaign are depicted at Figure 1.

The merits that the public accords the tactics involved can be just as decisive as the physical outcomes of battle, and serve to tip the scale. The orientation of the balance illustrates the level of public support for the contestants. Political failure by the 4GW antagonist is denoted by rejection of his underlying ideology by the population, or the physical annihilation or dissolution of the group. Political failure of government is denoted by withdrawal of stated policies, ceding contested territory, or granting political legitimacy to the opponent.

Tactical considerations are considered above the "see-saw." Tactical outcomes are determined by factors such as comparative strengths, fighting style, logistics, attrition, and the morale of combatants. Each opponent will attempt to apply positive pressure on his side by virtue of his tactics to tip the scale to produce a favorable outcome of battle.

But it should be noted that the value of the object at stake (the stated war aims) can also influence the relative merits of these tactical outcomes. For instance, a nation is likely to be more accepting of disruption and collateral damage in a war for survival than it would be in a struggle for a limited object. In this case, the fulcrum would be translated to the right, causing the balance to slant up to the right, suggesting public support for government would be retained even in the advent of extreme military action. This may not apply in a conflict to secure a non-vital national interest.

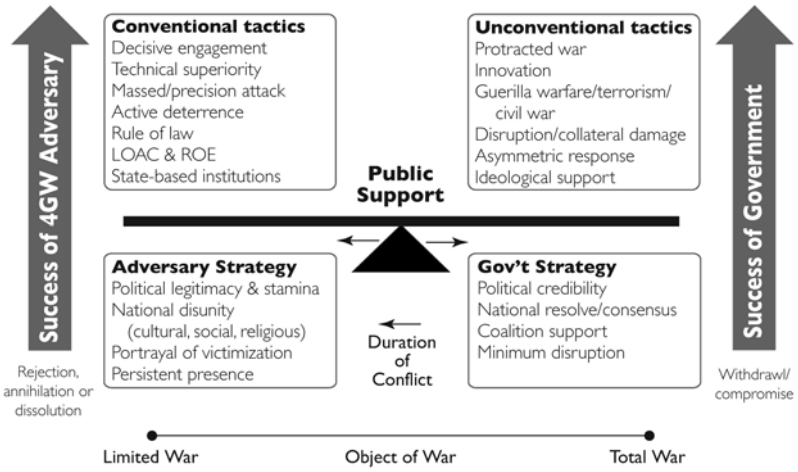

Figure 1. Determinants of Political Success in Modern Warfare

The position of the fulcrum is also subject to purposeful manipulation. The 4GW adversary may attempt to draw the fulcrum to the left by de-emphasizing the object at stake or by undermining the government. This can be achieved through diplomatic, military or symbolic gestures which emphasize the futility of extant policy, by exaggerating claims of disruption, attrition or collateral damage for limited gains, or by provoking a hostile government over-reaction and then assuming the role of the victim. By moving the fulcrum to the left, an asymmetric condition exists where the 4GW opponent can achieve political success disproportionate to his physical efforts. The dynamics which occur beneath the see-saw are strategic in nature, and potentially far more influential on the overall outcome than the tactical factors alone.

One further powerful determinant influences the fulcrum – the duration of the conflict. The longer a campaign continues, the further the fulcrum will move to the left, making it increasingly difficult for a government to sustain public support for a military campaign for limited objectives in the absence of tangible signs of progress. Therefore by simply "not losing" the 4GW adversary enjoys a strategic advantage.

By a combination of tactical measures (applying weight to the balance) and strategic measures (to create asymmetry and thereby influence the leverage these tactics have) each side attempts to tip the balance in their favor and secure outright political victory. Figure 1 illustrates the need to view military operations in the context of a continuum of operations (involving all instruments of national power), and consider the second and third order strategic outcomes arising from tactical events. It shows how it is possible to win the battle, yet lose the war through a narrow focus at the tactical level. It therefore emphasizes the importance of coordinated political/diplomatic responses that complement military activities.

Aerospace power can deliver leverage to conventional forces that face a fourth generation adversary. Control of the air, active intelligence and surveillance, battlefield air interdiction and offensive air support all play key tactical roles in defeating 4GW combatants. But the key to success lies in being able to penetrate the enemy's decision cycle (the observe-orient-decide-act loop)[27] in order to anticipate, understand and preempt his intentions. To the extent that victory can be influenced by the outcome of battle, aerospace power can assist in the defeat of the enemy by rendering physical effects that accord with diplomatic or cultural imperatives and satisfy political intent.

Aerospace power's contributions to the creation of battle space knowledge, and the delivery of precision-guided munitions (PGMs) lie at the heart of this capability. Just as importantly, by demonstrating resolve whilst minimizing disruption and the need for extensive re-construction, aerospace power can help to preserve civil-military ties and to create a secure environment that hinders both the resurgence of subversive activity and the spread of hostile ideologies. The complex characteristics of the urban environment in which this mission is conducted will require that force be applied with great tact, skill and diplomacy – qualities not traditionally associated with brute-force firepower, nor easily tolerated by a potentially disaffected or alienated population.

THE CHARACTER OF URBAN BATTLE

> *It seemed to me that it was precisely here, in the fighting for the city, that it was possible to force the enemy into close fighting and deprive him of his trump card – his air force.*
>
> – General Chuikov, Soviet Commander in Stalingrad, on the Battle of Stalingrad 1942-1943.[28]

Urban warfare can render immediate and non-contiguous strategic effects,[29] yet military practitioners commonly focus at the tactical level. To understand why, we must first examine the physical characteristics of the urban environment and analyze contemporary approaches to military problems.

The Urban Environment

"An urban area consists of a topographical complex where man-made construction or high population density are dominant features."[30] Complexes of buildings can easily become defensive positions. Battles can rapidly disintegrate into a series of separate and isolated conflicts resulting in a loss of command and control by military commanders. Consequently there is a high reliance on autonomous action at the tactical level.[31] Urban terrain tends to diminish the military's advantages of speed, maneuver and firepower, and allows opportunities to the adversary for ambush and disengagement. This provides the defender with a "force multiplier" by which he may adapt his style of fighting. Given contemporary doctrine's aversion to urban combat, as well as the ADF's relative inexperience in this theater of warfare, a competent adversary will predictably attempt to draw the fight into the city.

Close, Fleeting Engagements

The density of the urban environment often results in engagements at close range. The advantage of superior firepower is lost as friendly forces are drawn into the adversary's weapons envelope.[32] During the Battle for Stalingrad in September 1942, commanding Russian General Chuikov noted the Luftwaffe had firm mastery of the air, but with limited accuracy could only bomb positions where there was a broad expanse of no-man's-land. Consequently he opted for a close-in fighting strategy – to the distance of the throw of a grenade.[33]

Modern urban combat studies conclude that only 5% of targets appear at a range of more than 100 meters, and 90% are confronted at ranges of 50 meters or less. Human targets are generally acquired at 35 meters or less.[34] Soldiers may have very little time to engage targets before being engaged themselves. Targets rarely present themselves for more than a few seconds, and frequently only a part of an individual or vehicle is exposed.[35] Efforts to mark targets for air-delivered weapons with colored smoke or white phosphorus may alert the adversary to a pending attack and allow combatants to disperse. The physical qualities of the urban environment cede many advantages to the unconventional opponent.

Challenges to Command, Control and Communication

The challenges of visibility, feature recognition and navigation in a fragmented or unfamiliar environment greatly contribute to small units becoming isolated from supporting elements and losing situational awareness. This problem is exacerbated by inaccurate maps, or collateral damage that can block roads, or alter or destroy familiar landmarks. Ground units are dependent upon their own resources, and fight individual battles without reference to, or support from, other friendly forces. The navigation difficulties encountered by the 10th Mountain Division's Quick Reaction Force (QRF) in their initial rescue bid to recover a downed Blackhawk aircrew in Mogadishu were largely attributed to poor communications connectivity. The complexities of the urban environment were exacerbated by the placement of SNA road blocks and well-prepared ambush zones. In this instance, time-delayed directions from an overhead P-3 Orion (which had to be manually relayed through TFR Headquarters) caused the QRF to miss several turns, requiring segments of the route to be retraced. This reinforced the SNA's ambush plan.[36]

ADF command and control systems are largely reliant on voice communications to maintain situational awareness, negotiate urban obstacles, and prevent isolation of ground combat elements. But resultant radio traffic may overload traditional line-of-sight (LOS) voice communications networks, which themselves are often degraded in built-up areas.[37] Commanders could therefore experience great difficulty keeping the battle oriented at the operational or strategic level, owing to the practical difficulties of following tactical evolutions.

Limited Battle Space Awareness

The scheme of maneuver historically employed by ground commanders attempted to mitigate lack of battle space awareness by using artillery, armor or close air support to clear the area well ahead of advancing troops.[38] Modern constraints on collateral damage no longer allow this approach. This both slows the tempo of battle, and exposes friendly forces to greater risk of fratricide, which has emerged as one of the most highly publicized failings of modern conventional warfare. Of the 615 American service men and women killed in the 1991 Gulf War, friendly fire accounted for 18% of all battle injuries and 24% of all deaths ('blue-on-blue' incidents

between land forces were over twice as numerous as those involving air power elements).[39] Notwithstanding the operational effects of unnecessary battle casualties, fratricide creates great strain between joint and coalition forces, and produces significant political pressure that can work in the adversary's favor.

Consequently, conventional forces have taken two approaches to the problem. Firstly, tighter procedural controls have been enforced through more stringent ROE regarding target identification and prosecution. And secondly, better active de-confliction has been achieved through the development of Anti-Fratricide Identification Devices (AFIDs)[40] and networked situational awareness tools, such as the US Army's Blue Force Tracking system, or BFT.[41]

Control of Tempo

Cities allow an adversary with inferior equipment, training or manpower to engage on more even terms. The adversary can control the tempo of the battle through concealment, ambush and rapid maneuver, choosing to fight only when at an advantage, or else disengaging. Control of tempo presents a moral and operational dilemma for the conventional military force in terms of attrition, delay, discrimination between combatants and non-combatants, proportionality of weapons effects, and negative media coverage.[42] As General Chuikov remarked concerning the Battle for Stalingrad in 1942-43, "time is blood."[43]

Narrow streets and restricted avenues of access inhibit traditional concepts of maneuver making it difficult for military forces to maintain the initiative.[44] During Operation *Iraqi Freedom* in March 2003, 3rd Infantry Division (3ID) armored forces entering Najaf were challenged to protect themselves as narrow streets forced them into a single-file unsupported column that exposed their flanks at every intersection.[45] In Mogadishu the 10th Mountain Quick Reaction Force convoy that was dispatched to rescue downed TFR aircrew was forced to skirt SNA controlled areas and took nearly an hour to reach their objective – a trip that would normally have taken approximately five minutes.[46]

Urban terrain often involves complex operations that significantly slow entire campaigns. In January 1995 the primary focus of Russian forces in Chechnya was the capture of Grozny. Although Russians forces gained control of the city (at a cost of nearly 800 Russian troops, 20 of 26 tanks, and 102 of 120 armored vehicles), Chechen Rebel forces maintained the initiative throughout the 18 month Russian occupation. They then subsequently recaptured the city in less than two weeks.[47]

Limited Firepower Support

Restricted observation and limited fields of fire often deny military forces the advantages of massed firepower.[48] Use of traditional firepower support systems such as artillery and armor involve significant risk of collateral damage. Resultant rubble further inhibits maneuver (especially for tanks and wheeled vehicles), and provides hostile forces with additional cover.[49]

Anti-Air Threats

Urban terrain also allows ease of concealment of anti-air weapons. Even simple weapons such as small arms or rocket-propelled grenades (RPGs) can pose a credible threat to slower moving airborne platforms such as rotary-wing aircraft, which are traditionally assigned troop-support roles.[50] In Mogadishu, SNA warlord Mahommed Farah Aideed considered US TFR attack helicopters an American "center of gravity."[51] Arguably this contention was valid at each of the tactical, operational and strategic levels of analysis. Vulnerability of helicopters represented a critical failure on behalf of TFR planners that resulted in the loss of five helicopters to RPG attacks.[52]

Extensive Resource Requirements

Urban terrain presents a physically structured but fragmented series of compartmentalized battlefields that can absorb large quantities of personnel. Once committed, they are hard to extricate, regroup, reinforce or re-supply. Without the advantage of superior firepower the brunt of the assault is borne by ground combatants who must carefully and methodically concentrate on small areas in "clear and hold" operations. Surrounding and isolating these areas is necessary to clear non-combatants, deny the adversary the opportunity to escape or

introduce hostages, and to cut off enemy lines of communication and re-supply. Offensive urban operations are estimated to require "eight or nine times more manpower for operational equality."[53] In Mogadishu, 90 soldiers were dedicated to securing a single helicopter crash site, multiple rescue/recovery attempts were launched, and the final rescue convoy comprised 70 vehicles. The total costs of the operation to TFR and the 10th Mountain Quick Reaction Force in capturing a handful of key SNA operatives was 18 dead, 78 wounded, numerous damaged vehicles, 1 prisoner of war, and five downed MH-60 helicopters.[54] Such losses would clearly be both operationally and politically unacceptable to the ADF. Our limited land force manpower reveals urban combat as one of the highest risk operations.

Increased Battle Fatigue

The continuous level of alertness demanded by close-quarters combat, and the stresses associated with isolated small unit operations conducted with insecure flanks or an unprotected rear contribute to the rapid onset of battle fatigue within hours rather than days.[55] Several days of sustained pressure can challenge soldiers' endurance, with levels of fatigue prejudicing safety and operational effectiveness.[56] Military forces must therefore hold larger reserves and/or be prepared to rotate forces more frequently.

Civilian Relationships

The presence of civilians on the battlefield imposes significant constraints on how conventional forces conduct battle, and can contribute to a tendency for military forces to regard all civilians with suspicion.[57] In 2003, Fedayeen forces in Najaf sheltered with families and forced civilians to walk into firefights (upon threat of certain execution). They also used ambulances to ferry troops and conduct RPG attacks, and used mosques and schools for cover, concealment and weapons storage.[58] Differentiating combatants from civilians became difficult under such subterfuge, and contributed to hesitancy by 3ID forces to engage the enemy.[59]

The care of civilians also produced a diversion of manpower and resources. 3ID troops risked their safety to protect or tend to civilians during battles, and were later required to remove the bodies of dead civilians that were caught in the crossfire or purposely drawn in by the Fedayeen.[60]

Lessons Learned for Aerospace Power

Observation of urban battle characteristics yields some important considerations for airmen. Firstly, control of the air remains an essential precursor to military power achieving full effect. Secondly, airborne platforms will most probably be restricted to one pass to locate, identify, fix and engage the target. Third, to defeat even basic enemy air defenses, aircraft must achieve a stealthy ingress and/or employ a stand-off weapon. Fourth, air delivery platforms may require significant target resolution in order to discriminate friend from foe. Finally, weapons employed need to be capable of achieving a reliably low Circular Error Probable (CEP)[61], and may need to produce limited explosive effect. This will both limit collateral damage, and allow ground forces to receive the benefit of close air support without having to retreat to avoid blast effects. Collectively these lessons explain the increased reliance on precision guided munitions in modern combat. Whereas 7% of strike sorties during Operation *Desert Storm* employed PGMs, they accounted for nearly 65% of air-delivered munitions during Operation *Iraqi Freedom*.[62]

Furthermore, in order to better control war, commanders in general require a robust and comprehensive communications suite that can link fighting forces with supporting elements, aid in identification, share targeting information, and convey mission and firing orders. Creating battle space awareness for all friendly forces requires the compilation of a common relevant operating picture (CROP). For operations over long distances or in urban areas, this often necessitates establishing airborne communications links.

THE MERITS OF AEROSPACE POWER IN URBAN BATTLE

> *I see battlefields that are under 24-hour real or near-real time surveillance of all types. I see battlefields on which we can destroy anything we can locate through instant communications and almost instantaneous application of highly lethal firepower.*
>
> – General William Westmoreland

Aerospace power's ability to exploit the third dimension allows it to overcome the very characteristics of the urban environment that drive surface combatants to piece-meal operations – limited visibility and maneuverability. Importantly, such freedom allows aerospace forces to dominate the fourth (and arguably most crucial) dimension – time.[63] The tempo with which force is applied is more important than the level of destruction wrought on the enemy.[64] Murray and Scales eloquently captured this concept in Newtonian terms: "one can achieve overwhelming force by substituting velocity for mass."[65] Using a combined-arms approach, aerospace power allows friendly forces to better work inside the enemy's decision cycle, and to shape the battle space by limiting his possible responses and denying him the capacity to organize effective resistance. Aerospace power then presents a favorable form of asymmetry which can help achieve optimum synergies at each level of conflict – tactical, operational and strategic.

Strategic Synergy

The inherent speed, reach and responsiveness of aerospace power platforms make them well suited to non-contiguous battle. Elements can deploy and conduct offensive operations faster than any other form of combat power. Intelligence, surveillance and reconnaissance (ISR) platforms which exploit the third dimension can provide accurate intelligence in sufficient time to allow commanders to anticipate or counter enemy intentions. The stealth and stand-off capability of modern aerospace power can be used to create surprise, thereby generating an asymmetric response that can compromise the adversary's situational awareness, dislocate his will to fight, or otherwise shape his future behavior.[66]

These qualities were amply demonstrated in the battle for Fallujah during Operation *Iraqi Freedom* in November 2004. Space platforms, Joint Surveillance, Targeting and Attack Radar Systems (JSTARS), and unmanned aerial vehicles (UAVs) provided Coalition forces with superior intelligence on enemy strong points that were either being fortified or occupied prior to attack. Intelligence-driven targeting was then disseminated to Coalition ground and air elements which simultaneously attacked from many directions. They employed a broad spectrum of capabilities (including infantry maneuver teams supported by mortar fires and air-delivered PGMs) to induce shock, and overload enemy command and control. Penetrating precision-guided munitions were employed against a bunker complex with excellent results. The bunker and more than 20 enemy solders were destroyed. A supporting AC-130 also drew heavy praise from Coalition troops, operating at night and shaping the deep battle space with outstanding accuracy.[67]

As a result of many such closely coordinated actions during OIF, the Iraqi leadership's decisions were quickly overtaken by the tempo of operations. Having lost the initiative, enemy forces were presented with a dilemma – whether to disperse and remain hidden from the Coalition air forces (but still vulnerable to Coalition ground forces and strike missions) or else concentrate and close with Coalition ground forces (facing their superior firepower, and even swifter destruction in the allied air interdiction campaign).[68] Whilst urban terrain increased mission complexity for Coalition forces, it failed to provide the enemy refuge from attack.

Aerospace power's focus on sensors, information systems, and precision weapons requires fewer resources to achieve decisive results. This yields several strategic and political advantages. Smaller, more agile forces can better operate inside the adversary's OODA loop to produce precise effects. This gives the impression of omnipotence. During Operation *Iraqi Freedom* this contributed to the psychological dislocation of the enemy.[69] The ability to produce massed effects without the need to mass forces minimizes the 'military footprint' in country,[70] which itself may serve to preserve the legitimacy of the host government. And the accuracy of modern precision

air-delivered munitions can increase the probability and predictability of political success by decreasing the prospects of civilian casualties, collateral damage and attrition.[71]

Video accounts of "surgical" strikes on targets in Baghdad during *Desert Storm* contributed to a dramatic transformation of popular attitudes toward the efficacy of a military solution.[72] Moreover, these air strikes did little to adversely affect the "hearts and minds" of Iraq's civilian population.[73] Twelve years later, OIF air strikes achieved similar results.[74] Attrition of friendly aerospace power forces has reached a historical low. During OIF the Coalition lost only two fixed-wing aircraft to enemy action.[75] In several ways therefore aerospace power has helped resolve the conflicting requirements of applying tactical force whilst containing strategic effects – that is to produce politically feasible outcomes from military operations.

Operational Synergy

Unconstrained by many physical urban barriers that reduce ground combat to a series of sequential objectives, aerospace power allows the conduct of concurrent operations and campaigns, thus maximizing the effectiveness of finite military forces.[76] This is a crucial consideration for the ADF. Aerospace power's emphasis on agility (the ability of multi-role platforms to change from one type of activity to another, often within the same sortie), and networked information systems, provides a force-multiplier. Finite forces are better able to capitalize on emergent, time-sensitive or time-critical targets that are typical of the urban battle space.[77] The success of the *Desert Storm* air campaign generated greater appreciation for simultaneity, and blurred the distinction between strategic and tactical air warfare.[78] Concurrent operations can create multiple dilemmas that prevent the adversary from reacting in time to be effective.[79] In urban warfare, simultaneity can help break stalemates, regain the initiative, and dictate the tempo of battle.

Tactical Synergy

Aerospace power is an inherently offensive military instrument - a potent psychological advantage over the adversary, as well as a practical means of breaking the defensive mindset that has traditionally accompanied urban combat. By networking UAVs and other sensors with the command and control system, the versatility and flexibility of modern aerospace weapons systems can be harnessed to cater to the dynamic targeting environment. Carrying an array of weapons with specific fusing options, combat aircraft can quickly respond to late-notice targeting requests or else be re-directed to where they are most needed in support of ground forces (the push-CAS concept).[80] Over the course of OIF the number of pre-planned targets dropped by nearly 50%, with the remainder devoted to "on-call" requests to support troops in contact with the enemy or to prevent Iraqi units positioning for attack.[81] Such real-time targeting accords with the doctrinal aim of centralized control and decentralized execution, which attempts to maximize tactical synergy.

LIMITATIONS OF AEROSPACE POWER IN THE URBAN ENVIRONMENT

The clever combatant looks to the effect of combined energy, and does not require too much from individuals.

– Sun Tzu, The Art of War

Impermanence

Aerospace power by itself is unable to hold ground. While the use of UAVs and air-to-air refueling may greatly extend an airborne presence, airpower platforms are generally limited by either platform or crew endurance, or exhaustible stocks of on-board weaponry. This implies an ongoing need for joint operations in battles for urban terrain.

Interdependence with Ground Forces

The rapid battle field victories and minimal losses ascribed to Coalition forces during OIF illustrate the benefits of a combined arms approach in accelerating the tempo of battle and confounding the enemy leadership with multiple dilemmas. Such tactics served to challenge the traditional concept of airpower as a solely supporting element in joint operations. Space-based ISR, UAVs, JSTARS, and offensive air assets certainly helped to amplify and extend the impact of ground maneuver in a campaign that integrated air, conventional ground and special forces (SF) to prosecute counter-force targets. The resultant speed of ground movement served to force enemy units into the open. Offensive air assets then destroyed them while they were massed and exposed.[82] The air and the ground campaign were essentially the same. NATO air forces were much less successful against Serbian armored forces sheltering in Kosovo's urban districts in 1999 in the absence of cooperating ground troops. [83]

Considering the ideological basis of many "small wars," government forces must also address counter-value targets, such as centers of population, nodes of communication, infrastructure, manufacturing sites, or even important buildings. Not all of these targets need be the subject of kinetic operations. In fact, as a conflict draws to a conclusion, aerospace power is more likely to be relegated to a supporting role. During stability and security operations (SASO) the presence of offensive airpower platforms may help to create a secure environment by emphasizing the presence of a stable ruling party which possesses the means to exert its influence. Whilst aerospace power may serve to express national resolve, ultimately the peace will be won through more personal interactions. "Boots on the ground" will determine the final outcome. As per Figure 1, military forces will be more concerned with supporting government strategy than with waging hostile actions.

Lack of Persistence

Optimizing weapons effects requires an intimate knowledge of the target, including its physical nature, its function, and its habits.[84] This process of target "assimilation" may require persistent and prolonged surveillance, and draw upon several intelligence sources. Whilst UAVs would no doubt assist commanders achieve real-time battle space awareness, aerospace power alone will not necessarily provide sufficient detail or certainty. During Operation *Enduring Freedom* (OEF) target acquisition of most unidentified enemy positions was often only achieved by special forces in direct contact with elements of the Taliban. Even with a significant US capability of stand-off sensors focused on a comparatively small area, SF's persistent presence was crucial in determining the precise locations of almost half of the potential strike targets.[85] This graphically illustrates the value a "human in the loop" offers the targeting process.

Incomplete Intelligence

Aerospace platforms provide an unrivalled vantage point for military observation, but a subtle distinction should be made between electronic reconnaissance products (which are subject to analysis) and knowledge. Discrepancies between CIA and CENTCOM bomb damage assessments during *Desert Storm* stemmed as

much from incomplete information (despite holding a preponderance of intelligence gathering platforms) as they did from variations in analytical technique. Hardened Iraqi aircraft shelters that had been successfully struck with penetrating laser-guided bombs (LGBs) often showed little external damage on subsequent reconnaissance over-flights, save a small hole in the roof. Consequently many targets, listed as "possibly damaged" were needlessly struck several times in the basis of space/aerial imagery alone.[86]

Photographs and footage that portray current enemy disposition cannot necessarily predict future enemy intentions nor assess how much fighting spirit the enemy has left (this is particularly relevant when fighting insurgents). Human intelligence (HUMINT), derived from sources such as local inhabitants, enemy defectors, prisoners of war, and combatant eyewitness accounts, can offer the advantages of local knowledge (technical, doctrinal and/or cultural), prolonged observation (enemy habits), and adjustable aspect (such as the ability to see under bridges or into underground access ways that are common in urban areas). Given that most HUMINT is collected by ground forces, aerospace ISR cannot necessarily be treated as a "stand-alone" intelligence capability.

Target Designation and Terminal Guidance Considerations

Despite the advantages of precision-guided munitions, aerospace platforms are not totally immune to the physical limitations of the urban battle space. In areas of significant vertical development, ordnance may have to be delivered along an oblique axis of an "urban canyon" in order to hit a specific face, window or balcony. Laser-guided munitions require a constant line-of-sight (LOS) be maintained between the laser designator and target for the duration of the weapon's time of flight. But this may be prevented by shielding structures or reflective surfaces. Evasive aircraft maneuvers may similarly result in breaking lock during the weapon's terminal phase. Buddy lasing provided by either a manned or unmanned aerial platform may therefore be necessary. Alternatively, a suitably trained, equipped and positioned ground-party may be called upon to provide terminal weapon guidance. Notwithstanding, laser-guided munitions still suffer from uncontrollable interferons such as smoke, dust, fog and rain.

A relatively new development – the Joint Direct Attack Munition (JDAM) – employs a global positioning system (GPS) guidance unit on a "dumb" bomb to achieve prescribed impact angle, azimuth and elevation.[87] JDAMs thus provide a truly all-weather weapons guidance capability. During OIF Coalition aircraft were able to destroy approximately 30 vehicles and halt an Iraqi formation near An Najaf during an intense sand-storm, or shamal, using only four JDAMs.[88] During *Desert Storm*, such weather would have granted Iraqi forces immunity from LGB attack and effectively stopped the air war. JDAMs therefore offer the ultimate weapon guidance capability in terms of reliability, flexibility and independent action.

Symbiosis with Special Forces

The ADF's current reliance on ground forces to provide targeting intelligence and weapons terminal guidance functions suggests an ongoing reliance on special forces. Effective targeting (including infiltration, observation and analysis) of potential strike targets requires specialist knowledge, and often involves a great deal of target assimilation not consistent with regular forces. Similarly, ground-based lasing requires specific skill sets and equipment that currently only SF possess. This constitutes the basis of a symbiotic relationship between aerospace power and special forces. What aerospace power lacks in persistence and permanence, it makes up for in versatility and payload. Conversely, special forces' requirement to transport significant varieties and quantities of heavy weapons is greatly reduced with consequent improvements in agility and flexibility.[89] Despite anticipated advances in technology, this symbiotic relationship is expected to endure.

FUTURE ADF DIRECTIONS

> *Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.*
>
> – Giulio Douhet, 1922[90]

The Case for High End Technology

Network-centric warfare (NCW) is high-technology warfare based on a common relevant operating picture (CROP) created through shared situational awareness. In essence it involves the integration of commercial off-the-shelf (COTS) information technology into widespread networked military applications. Operation *Enduring Freedom* demonstrated the merits of NCW in providing enhanced knowledge, speed, precision and lethality. The rapid movement of coalition forces into and within theater, and the responsiveness, accuracy and reliability of networked systems gave the opponent little time to react or prepare defenses. The "knowledge edge" produced through a CROP improves shared situational awareness and facilitates more rapid decision making to enable greater synergy between supporting units. Additionally, advances in aerospace systems technology have contributed to better weapon-to-target matching, greater accuracy and more controlled effects to allow tactical objectives to be achieved with fewer sorties, and with minimum collateral damage.[91]

Constrained by a limited budget,[92] and with several "legacy systems" in the acquisition pipeline, transforming for NCW will require the ADF to remain adaptive and flexible. It will continue to rely on multi-role and multi-mission platforms and well-trained crews. Achieving a successful NCW capability will require the ADF to carefully foster resources to develop a system that links sensors, decision-makers and shooters to detect and prosecute even mobile threats in near real-time, as part of a joint or coalition force. Given the complexities of creating a cohesive network, the ADF's comparatively small size emerges as a potential advantage. Notwithstanding the positive effect of scale, the ADF must be careful to develop systems and doctrine that are compatible and interoperable with likely coalition partners.

Intelligence, Surveillance and Reconnaissance (ISR)

Winning battles depends on our ability to know the enemy.[93] This dictum is a strong argument for robust intelligence, which is necessary to satisfy the "observe" and "orient" elements of the OODA loop. The RAAF currently possesses a real-time ISR capability, in the form of the AP-3C "Orion" surveillance aircraft. Since January 2003, this platform, which has a historical role in maritime surveillance, has demonstrated its versatility in providing situational awareness to Coalition ground, air and naval forces in the Middle East Area of Operations (MEAO). The AP-3C's comprehensive communications and sensor suites (including digital multi-mode radar and electro-optical systems) have proven their utility in the urban environment. Crews have been able to communicate directly with land forces and pass real-time imagery.[94] This has led to the capture of a number of enemy operatives through the aircraft guiding troops to enemy hiding locations. Future systems enhancement programs will also permit RAAF F/A-18s to provide similar support to combined arms forces. While the requirements of target assimilation may never displace HUMINT in the early targeting process, the ADF is increasingly turning to real-time imagery to support target detection, classification, tracking, and prosecution.

The decentralized nature of urban warfare requires that commanders have ready access to imagery and information to make rapid tactical decisions. But during high-intensity operations, such demands may overwhelm the ADF's limited number of manned, multi-mission assets, or else detract from their intended offensive roles. Consequently, the RAAF may not be able to simultaneously provide both a comprehensive strike and ISR capability in support of ground force maneuver. The solution lies in supplementing current capabilities with unmanned platforms (including space-based and air-breathing assets) to provide a layered system of ISR.

Space-based ISR

Space-based ISR platforms offer the ultimate in permanence, although they do suffer from their own limitations such as reliance on weather, lower resolution, and dynamic lag in tasking. The ADF is constrained from acquiring and developing its own satellite capability largely by budget limitations, and is therefore forced to rely on commercial satellite sources, and intelligence products supplied by allies. Without assured access to satellite imagery and communications networks, this represents a major weakness in Australian intelligence gathering capability and connectivity. During times of conflict, satellite services struggle to cater to demand. Extensive use by other commercial competitors and allies may result in Australian forces' requests for satellite services and products being affording lower priority. Consequently, access to imagery used for operational planning or bomb damage assessment (BDA) may be slow, limited or denied.[95] Furthermore, an adversary in possession of a computer, modem and credit card could have access to the same commercial satellite products, thus denying Australia any real intelligence advantage. The availability and reliability of satellite communications is similarly subject to influences beyond the ADF's control.

A cost-effective ISR option worthy of investigation involves the use of near-space platforms (sensors held aloft by inflatable balloons). Near-space platforms occur in two basic types – free floating systems (essentially a weather balloon with an attached sensor package) and maneuvering vehicles (a high-performance, autonomously recoverable glider is suspended from the balloon). The latter option offers great flexibility. The glider is able to detach from the balloon, soar for hours above the battle space, and recover an expensive payload from hundreds of kilometers away to a relatively small, unprepared landing surface. The United States Air Force has produced a working example of this concept, named Talon Topper, under the Tactical Exploitation of National Capabilities (TENCAP) program.[96]

By floating payloads into a region of the stratosphere where winds are light and the weather virtually non-existent, fielded forces can enjoy a persistent, over-the-horizon capability to augment space and air-breathing communications and ISR platforms. Near-space occurs well below orbital altitudes, and is roughly defined as the region between 65,000 and 325,000 feet. This offers benefits to image resolution and low-power receptivity which are relevant to the challenges of urban operations. Such performance may not be possible from low-earth orbit or geo-stationary satellites, which typically operate at altitudes of 300 and 37,000 kilometers respectively.[97]

Balloon-based systems are comparatively cheap, easy to launch, and offer increased payload flexibility compared to satellites. Only the relatively cheap balloon canopy is lost on each mission, and the payload can be quickly redeployed. Payloads may range from only tens of pounds up to thousands of pounds, depending on the size of the balloon. Light-weight sensor packages can therefore be deployed responsively in the field.[98] Apart from the initial charge of helium, they require no further replenishment, and so are free of the usual crew or platform endurance limitations associated with air-breathing assets. Near-space platforms thus offer a cost-effective and practical alternative to satellites to provide persistent, broad-footprint tactical and operational communications and ISR.

Unmanned Aerial Vehicles (UAVs)

The ADF cannot afford stealth technology for a majority of its assets. Therefore it will rely on UAVs to provide a standoff capability that will permit forces to operate even when an adversary's air defenses are effective. Australia plans to acquire up to a dozen UAVs, including Global Hawk[99] at a cost of more than 750 million [Australian] dollars under Project AIR 7000.[100] Global Hawk's flexible and persistent multi-sensor surveillance configuration, including electro-optical (EO), infra-red (IR), synthetic aperture radar (SAR) and ground moving target indicator (GMTI), proved its worth during Operation *Iraqi Freedom*. Even when severe shamals blinded its optical and infra-red sensors, Global Hawk could still target Iraqi ground forces by radar to coordinate JDAM attacks. Captured Iraqi soldiers spoke of collapsing morale when "in the midst of a raging sand-storm, armored vehicles began exploding all around them."[101]

Global Hawk holds great potential in the urban environment in applications such as ISR, targeting, precision strike support, and BDA. SAR and GMTI sensors in particular are well suited owing to their ability to resolve small targets amongst cultural clutter.[102] Buildings, roads and even individuals are discernable from dozens of

miles away.[103] Global Hawk may also play an important role in providing communications links and distributing a common battle field picture to leadership and fielded forces.

The Australian Regular Army (ARA) is also investing in UAVs that will enhance layered airborne sensor coverage. The short-range miniature Skylark is a light-weight, man-packed UAV that can provide color crystal display (CCD) video or infra-red telemetry. A field-portable receiver can then overlay images on a map situational display. The Skylark is launched by hand and recovered by performing a deep-stall onto a pre-positioned inflatable cushion designed to protect the payload.[104] Skylark's minimal need for launch and recovery space makes it ideal for urban operations.

The ARA will also acquire the larger I-View UAV.[105] With greater endurance and payload, it can deliver synthetic aperture radar images and target tracking functions for up to eight hours at altitudes up to 15 000 feet. It is capable of operating at distances of up to 150 kilometers from the ground station, and can also relay information for fellow I-View units (as well as other compatible UAVs) operating at lower altitudes. Its catapult launcher and parafoil recovery system allow it to be deployed and recovered from an area smaller than a football field.[106]

Unmanned Combat Air Vehicles (UCAVs)

Intelligence on fleeting targets is of little value, however, if not followed by similarly time-sensitive engagement. This fact has prompted the development of the unmanned combat air vehicle (UCAV).[107] With only a limited number of future offensive ADF air platforms potentially available (all limited by impermanence), UCAVs could play an import role in future ADF operations. A multi-sensor UCAV platform such as Predator would ideally suit urban battlefield requirements, with a proven capability to locate, identify and prosecute mobile threats in near real-time. Ideally, a balanced force would employ a mixture of manned and unmanned combat vehicles and observation platforms to provide persistent ISR, and a flexible and responsive offensive aerospace capability. As networked battle space awareness develops throughout the ADF, unmanned vehicles will find themselves in increasing demand.

Risks of UAV/UCAV Attrition

The freedom to prosecute targets without putting aircrew or the ADF's more expensive platforms in danger translates to UAVs and UCAVs consistently performing higher risk operations. This could easily correspond to a higher UAV attrition rate. During Operation *Allied Force*, NATO forces lost a total of 21 UAVs and UCAVs (mainly to Serbian small arms fire).[108] Attrition needs to be realistically factored into ADF acquisition, and managed through combat risk assessment and flight safety management programs.

Airspace management

The adoption of tactical UAVs presents new challenges to safe and efficient airspace management. Short-range UAV systems (which have very limited payloads) do not utilize transponders (which communicate their presence to other airspace users) nor do they possess significant visual or radar signatures to allow other aircraft to "see and avoid." Tactical UAVs therefore present an unregulated risk to other high-value aerial platforms (both manned and unmanned) conducting coincident operations. During the Operation *Allied Force* air campaign, NATO forces required manned aircraft to stay above 15 000 feet in order to maintain separation with UAV traffic.[109]

Separating UAVs through procedural controls such as de-confliction or airspace apportionment will restrict, rather than integrate, land and air forces, yet positive control of all UAV activity in the joint area of operations may prove complex and cumbersome. This significant challenge to C4ISR has prompted the United States armed forces to consider integrating its separate service networks via a Family of Interoperable Operational Pictures (FIOP).[110] This represents an attempt to draw sufficient relevant material from independently developed CROPs that have proliferated within the US services to produce a more universal battle picture. The ADF must consider interoperability issues carefully throughout the development of its ISR network to ensure the safety, efficiency and combat effectiveness of future airspace activities.

Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR)

To ensure that urban battle follows a cohesive operational plan, surface and aerospace command and war fighting elements must be integrated in a seamless C4ISR network. Aerospace power's ability to view and direct the battle space as a continuum, free of many typical line of sight limitations, helps condense the decision cycle and produce a "knowledge edge" over the adversary. Knowledge of roadblocks, enemy movements and concentrations, and proximity of non-combatants, can assist in controlling surface forces, while real-time targeting from air- and space-borne ISR assets will allow timely and accurate employment of tactical-level firepower. During OIF, US forces removed Saddam Hussein's regime from power in half the time it took during the 1991 Persian Gulf War. Ground forces "were able to advance quickly, bypassing whole divisions, because they had a good picture of the Iraqi forces' disposition throughout the country while the Iraqis did not have a clue beyond visual range."[111]

Under Project AIR 5333 the ADF is interfacing command centers with civil and military surveillance and control facilities (including the 'Jindalee' Over the Horizon Radar[112]), air and ground weapons systems, and both fixed and deployed radio sites, to form a networked system called "Vigilare." The volume and accuracy of targeting and mission information will favor data-links (such as Link-11 and/or Link-16) as the primary form of communication. This will facilitate fuller and more instant connectivity between sensors and shooters, with reduced risks of targeting error – important features when engaging fleeting or time-sensitive targets and when operating in the politically sensitive urban battle space.[113]

Networking even a relatively small defence force is a potentially complex task. Introducing new data feeds and supporting future advanced reporting systems emerges as a technical issue, rather than a matter of acquiring new platforms. Clearly, Vigilare represents a long-term project for the ADF. Careful forethought will be necessary to ensure its basic architecture grants each service the functionality and compatibility it requires, and considers band-width limitations to supporting fast operations.

Airborne Early Warning and Control (AEW&C)

The Royal Australian Air Force (RAAF) is currently acquiring an airborne early warning and control (AEW&C) capability under Project AIR 5077, known as "Wedgetail" (named after an indigenous eagle).[114] This will not only integrate offensive air assets with other aerospace users, but will also contribute to the compilation and dissemination of a CROP. AEW&C will play an important role in urban warfare, considering the many airborne assets that could require close integration within a relatively concentrated airspace and within limited time periods. Active control will not only assist in maximizing the operational effectiveness of finite air forces, but also help avoid incidents of fratricide.

Armed Reconnaissance Helicopters

The Australian Regular Army's recent acquisition of the "Tiger" Armed Reconnaissance Helicopter (ARH) represents a dramatic improvement for ADF urban combat capability. Precision-directed 30 mm cannon and 7.62 mm ball machine gun fire are ideal against "soft" targets. Effective out to 1500 meters, but with a dispersion rarely greater than 5 milliradians,[115] such fires are well suited to aerial support missions which require exacting discrimination.[116] With a roof-mounted sight incorporating TV and thermal imaging sensors, and laser designation, the Tiger ARH need only expose its main rotor and canopy roof in order to fix a target, before employing an AGM-114 (M) laser-guided Hellfire missile. This weapon follows an up-and-over trajectory that is well suited to urban profiles. The Hellfire was designed as an anti-armor weapon. The M model employs a shaped charge warhead, making it an excellent weapon against light vehicles, but less effective against troops in the open or sheltering in hardened structures).[117]

One weapon not currently in the ADF inventory but worthy of consideration is the RBS-17 Hellfire, developed for the Swedish Navy as an anti-ship missile. Its blast fragmentation warhead makes it suitable for anti-personnel uses, but its 20 lb explosive yield will limit collateral damage. The two Hellfires could therefore complement each other, covering most probable urban targets.[118] Although the Tiger possesses sophisticated self-defense systems, it nonetheless remains vulnerable to simple air-defense weapons (ranging from improvised

explosive devices, or IEDs, placed on roof-tops, to RPGs), meaning fixed-wing platforms with a greater stand-off capability will still have utility in urban battles.

Fixed-Wing Gunships

The demands of urban warfare on aerospace power for persistence, flexibility, responsiveness and precision explain the emergence of the AC-130 Gunship as a favored offensive air support weapon. Along with Predator UAVs armed with Hellfire missiles, AC-130s have been the most requested form of aerial fire support to ground forces during Operation *Iraqi Freedom*.[119]

The AC-130's suitability for urban employment stems from its ability to prosecute small targets whilst containing collateral damage. The accuracy of the gunship's fire control systems, use of low-yield munitions, and its ability to detect and identify targets in complex urban terrain helps in this regard. US Air Force AC-130s employ all-weather sensors, such as the APQ-180 synthetic aperture strike radar, all-light television (ALLTV), thermal imaging, and laser target illumination, to fix stationary or mobile targets. Radar beacons can also be used by friendly ground forces for identification or to provide radar target offsets in complex terrain.

Armaments include two 20mm Vulcan cannons, a 40mm Bofors cannon, and a 105mm Howitzer, which fires either a 34.2 pound white phosphorus projectile (used as a smoke round with limited incendiary effect) or a 32.5 pound high explosive round. The latter's fusing options allow point detonation, delayed detonation (for penetrating vehicles or light structures) or proximity detonation (rounds can be set to explode seven meters above the ground for anti-personnel applications).[120] With a weapons load of 100 rounds of 105mm ammunition, 256 rounds of 40mm ammunition, and 3,000 rounds of 20mm ammunition, the AC-130 offers both excellent versatility and persistence.[121]

The AC-130's roles include armed reconnaissance, convoy escort, air interdiction, and close air support. It is capable of providing suppressive fires to within 200 meters of friendly troops (in the case of the 105mm gun) or within 125 meters for all other guns.[122] It can create precision firepower effects at a fraction of the cost of PGMs or air-to-surface guided missiles, but offers superior on-station endurance (in terms of both fuel and munitions) compared to other offensive airpower assets. The AC-130 employs sufficient stand-off for low or medium threat scenarios, and can readily switch roles by virtue of the flexibility of its targeting systems and the variety of weapons it carries.

The omission of AC-130s from the US force package in Mogadishu in 1993 has been cited as a significant factor in Task Force Ranger's losses to the SNA.[123] In short, planners were over-reliant on MH-60 helicopters for fire support, and failed to adequately assess the small arms/RPG threat to their rotary-wing aircraft. With a greater stand-off capability, the AC-130 could have assumed the fire support role for convoy escort, and thereby limited the helicopters' exposure to hostile fire. It also could have more effectively secured the helicopter crash site(s) to protect downed aircrew and facilitate access to the Quick Reaction Force, as well as provide a seamless communications link to vector the QRF to the site. The Mogadishu experience provides a salient warning to the ADF, which will rely heavily on the Tiger ARH to provide troop support functions.

Whilst the cost of acquiring AC-130s may be beyond the immediate resources of the ADF,[124] their inclusion in campaign planning (albeit in a coalition context) should nevertheless still be considered. However, given that the RAAF already operates the airframe and will continue to retain requisite maintenance and training infrastructure, the long-term acquisition of four to six AC-130s may constitute a suitable offset against a drawdown of overall strike assets when the F-111 and F/A-18 fleets are retired from ADF service. The AC-130's combat profile, which suits it to both conventional and unconventional roles, is well matched to the types of conflicts the ADF is likely to encounter in its areas of responsibility. Moreover, the relative paucity of fixed-wing gunship platforms amongst Australia's allies (the USAF operates but 21 of them) would make an Australian AC-130 fleet a much-valued coalition asset.[125]

Strike/Fighter Aircraft

Delivery platforms will ideally be networked, possess a range of sensors, and be able to either self-designate targets or else link with another party to perform target lasing for the delivery of precision-guided munitions.

The installation of Block II AN/AAQ-28(V) "Litening-AT/ISR" targeting systems to RAAF F/A-18s under Project AIR 5376 will integrate these functions into a single pod (whereas previously three were required), freeing weapons stations for other mission requirements.[126] Additionally, Litening pods will also produce precision geo-coordinates for J-series weapons. [127]

Project AIR 6000 seeks to replace the RAAF's current F/A-18 fleet with a fifth-generation multi-role fighter, nominally the F-35 Joint Strike Fighter (JSF). JSF will be optimized for the air-to-ground role, and will offer improved survivability through stealth and stand-off. As either a stand-alone weapons system, or in concert with ground forces, JSF will be well suited to urban operations. Ground forces will be able to up-link digitized target coordinates, and then view corresponding down-linked electro-optical or infra-red imagery provided by JSF to confirm targeting data. JSF can then employ an array of "smart" stand-off weapons, including JDAMs or small diameter bombs (SDBs), and self-designate targets for LGB delivery. Importantly, JSF's ability to store multiple target data, and helmet-mounted cueing system, will allow the pilot to visually acquire targets in complex urban terrain at an increased distance, and well before rolling in on attack heading.

Precision-Guided Munitions (PGMs)

OIF clearly demonstrated the cost-effectiveness of smart weapons. Combat aircraft were consistently capable of achieving "one missile, one kill" exchanges.[128] Since Operation *Desert Storm*, PGMs have emerged as the political weapon of choice for military operations on urban terrain owing to their precision, reliability and dramatic effect. In fact such weapons made their debut during the Vietnam conflict, in answer to the challenge of attacking heavily defended North Vietnamese bridges.[129] This may explain the emphasis given to high explosive content during the subsequent development of smart weapons. The comparatively high cost of PGMs compared to "dumb" bombs may also account for the pursuit of greater "bang for the buck."

The political constraints applied to military operations on urban terrain often allow for only minimal collateral damage, suggesting a need for comparatively limited-yield weaponry. Likewise the close range of ground engagements also calls for a smaller blast pattern for close air support (CAS) applications. The USMC commonly applies ROE that limit CAS weapons to 500 lb explosive yield or less.[130] Even then, the employment of a GBU-12 (laser-guided 500 lb bomb) may be undesirable in proximity to friendly troops except in dire circumstances. A laser-guided Mk 81 bomb (250 lb) may be more suitable for such applications. In some cases, the use of an inert (concrete) bomb may also produce the required effect. Precision-guided concrete bombs were used during Operation *Iraqi Freedom* to prosecute enemy military targets that were situated in proximity to prohibited civilian structures such as mosques, hospitals and schools. The bomb's kinetic energy was sufficient to destroy the intended target, but the absence of shrapnel resulted in only localized damage.

The AGM-65 (Maverick) series of weapons (available with TV, IR or laser guidance) offers precision targeting with flexible warhead and fusing options. The laser-guided AGM-65E is well-suited to the urban environment, capable of a 4 foot CEP, and an explosive yield of only 300 lb. Additionally, it is the only weapon incorporating a fail-safe measure - if laser line-of-sight is broken, the weapon will de-arm and send a fly-up signal.[131] This improves the chances of re-acquiring laser designation in built up areas whilst preserving available energy.

The new Small Diameter Bomb (SDB) similarly holds promise as a 'light' urban stand-off weapon, with a range of up to 40 miles. The SDB is designed to destroy a variety of targets, and can penetrate over 1.2 meters of steel-reinforced concrete, yet inflict minimum collateral damage due to its limited (250 pound) explosive yield. This compact weapon allows increased weapons loads on current strike aircraft, and will be compatible with UCAVs and the F-35 JSF.[132] Fitted to internal weapons bays, JSF will carry up to eight SDBs.[133]

As with all ordnance, dud bombs (those that fail to guide or detonate for whatever reason) present several unwanted challenges. Politically, the attacking force may emerge with an image of ineptitude or obtuseness. Secondly, the opportunity for decisive engagement may have been lost. Lastly, unexploded bombs present hazards to urban dwellers and friendly forces, and can provide insurgents with potential material for IEDs, which are the highest killer of Coalition ground forces in Iraq today.[134] Reliability of PGMs is therefore just as important as precision.

The recent development of the 500 pound JDAM holds promise in this respect. Capable of achieving consistent CEPs of 9.6 meters,[135] its seeker-less GPS guidance unit provides a truly all-weather precision strike capability that allows the platform to launch at an 'unseen' target. But the hazards of misidentifying an urban target on the basis of electronic sensors alone may lead to restrictive ROE that prevents release under such circumstances. The ADF should therefore aim to develop a flexible inventory of both laser- and GPS-guided munitions.

Whilst the cost per PGM may appear extreme in comparison to 'dumb bombs,' several considerations argue the merits of the high-tech option. Firstly, the cost of PGMs continues to decline. In 1992 the JDAM project aimed to produce precision guidance kits at a unit price of US$40 000. In 2002 the cost had approximately halved[136] and equated to about two percent of the cost of a Tomahawk Land Attack Missile (TLAM).[137] Secondly, PGMs deliver more reliable effects, reduce the number of sorties required, and can greatly accelerate the tempo of battle (which itself creates cost off-sets). Most importantly, the cost benefits of PGMs can best be considered in the savings associated with human life, valuable national infrastructure, and political legitimacy.

Non-Lethal Weapons

The emergence of new technology weaponry that can incapacitate personnel without causing physical destruction is now finding application in US military operations.[138] Non-lethal weapons can aid in discrimination, minimize casualties, make post-conflict reconstruction easier, and possibly result in less restrictive ROE. Additionally, they could prove a boon to intelligence collection efforts by minimizing enemy casualties.

High-powered microwave (HPM) devices are currently used on US Army Stryker fighting vehicles in Iraq to remotely explode improvised explosive devices (IEDs). HPMs and other directed energy weapons may have future personnel control applications. Training a concentrated microwave beam on the target causes an irresistible burning sensation, causing the victim to flee, yet produces no permanent injury.[139] Other non-lethal weapons under current investigation include sonic devices, laser weapons, and substances that can be dispensed from napalm canisters, such as sticky or slick foams, marker dyes, irritants and sedative drugs. Such developments are still subject to considerable legislative and technical development, and by-and-large remain the subject of secretive research.

Psychological Operations

Because of the ideological context of expected future wars, psychological operations (psyops) justify serious consideration. Even the mere presence of an offensive aerospace capability can be sufficient to deter militant or subversive behavior. For this reason 3ID psyops teams broadcast recordings of helicopters in the streets of Najaf during OIF.[140] In combination with leaflet drops, firepower demonstrations produced excellent coercive effects during *Desert Storm*. The defection of virtually an entire Iraqi battalion was attributed to an MC-130 dropping a massive 15 000 pound BLU-82 bomb on adjacent desert.[141] During Operation Restore Hope in Somalia, airborne psychological operations included: high-speed, low-level runs over Mogadishu to intimidate rival factions; leaflet drops to dissolve General Aideed's support base; and the dropping of a non-fused LGB into SNA Headquarters to demonstrate targeting efficiency and capacity for destruction.[142] As a prelude to kinetic operations, leaflet drops or airborne loud-speaker broadcasts could be used to warn an easily intimidated populace of pending hostilities, or to direct an evacuation. Psyops operations are relatively simple, effective and easily adapted to ADF aerospace platforms. They therefore represent a cost-effective extension of capabilities.

URBAN WARFARE TRAINING REQUIREMENTS

> *Wars may be fought with weapons, but they are won by men. It is the spirit of the men who follow and of the man who leads that gains the victory.*
>
> – General George S. Patton

Whilst the focus of this paper has concentrated on the technological aspects of military "transformation," the ADF must also focus on how to make effective leaders and decision makers in the chaotic urban warfare environment. The urban battle space places particularly stringent requirements on war fighters, in terms of rapid analysis, free-thinking, and risk taking, in addition to the usual demands of the mastery of arms. Developing these abilities requires realistic training and testing under simulated conditions as close to actual combat conditions as possible.

Currently, only limited training facilities exist for ADF land and air components to individually acquire and refine urban war fighting competencies. Australia does not currently possess a facility for integrated training in urban operations. Given the political sensitivities of the urban battle space, there is little latitude for error or experimentation in actual combat. This suggests serious consideration should be given to the development of single service and combined arms urban warfare training and associated facilities. The use of simulation, part-task training, air weapons range details, and even free-play exercises will provide the ADF with a basis for the development and evaluation of urban warfare doctrine, tactics and procedures.

Simulation and Part-Task Training

Aircraft simulators and part-task trainers offer the cheapest and safest form of air-delivered weapons training. Cockpit systems drills, range procedures, and attack profiles appropriate to the urban environment can all be introduced to the trainee in graduated exercises that offer the benefits of interactive learning, instant de-briefing, and selective replay. The complexity of target environments can also be adjusted through selection of simulated urban terrain options, and other complicating factors such as wind, haze and cloud can be added at will. Mission profile fidelity becomes a challenge when one considers the urban mission in its entirety. For instance, simulating a typical urban CAS mission could require inputs from a ground party, a simulated forward air controller, an AWACS/JSTARS platform, and other aerial platforms that require active separation. Simulation complexity would be further increased by the presence of active threats or interference from non-combatants. It would prove difficult for a console operator to effectively control all of these inputs and thereby provide realism whilst retaining mission flexibility. The demands of "real-time" imagery, such as that provided by a UAV, or used during weapon guidance, further adds to simulation complexity. The technical challenges and costs involved in providing such fidelity may prove prohibitive for the time being, meaning simulation will provide a limited (albeit important) part of urban air warfare training.

Urban Targeting Drills

The ADF's limited experience in urban warfare forces it to draw heavily on historical analysis or the methods of other military forces when developing doctrine. Urban targeting drills constitute the primary means of developing crew competencies, and refining tactics and procedures.[143] Ground forces similarly need practical experience in urban targeting drills, particularly for CAS. Skills involved include prioritizing requests for fire support, describing required effects, passing target details and defining attack cones, clearing non-combatants from the area, authorizing the delivery or ordnance, and bomb damage assessment.

However, sole reliance on urban targeting drills may lead to commanders or crews developing unrealistic expectations or acquiring bad habits that could contribute to tactical or strategic defeat.[144] Training that overlooks the pressures associated with actual weapons releases in urban areas may contribute to a reluctance or refusal to drop ordnance in actual combat conditions. This could stem from lack of confidence, inexperience in applying rules of engagement, or fear of repercussions arising from an inappropriate weapons release. Conversely, a complacent attitude that arises due to a lack of realistic feedback in training could contribute to

excessive collateral damage or fratricide. No form of training prepares crews for urban combat like dropping real weapons in proximity to real people. Live-firing details therefore play a necessary part in preparatory training of any combat force.

Air Weapons Range Training

The complexities of the urban arena pose some particular challenges for air weapons range (AWR) training. First, an effective urban training complex should offer a structured physical environment that features vertical development and repetitive patterns to simulate an urban environment. Second, it must also incorporate multiple observation posts to provide accurate bomb plots along urban canyons, and to facilitate joint training.

The United States Marine Corps (USMC) first addressed this challenge in 1999 by establishing an urban training complex at Yuma, Arizona. Known colloquially as "Yodaville," this urban complex covers an area of approximately 1000' x 800' and is composed of thousands of stacked, surplus cluster bomb crates and discarded shipping containers. The result is a mock city comprising 167 buildings up to four storeys high, replete with streets, street lights, vehicles and "stick-figures" (man-sized figures made from metal reinforcing bars which can be dressed in military uniforms or civilian garb).[145]

Yodaville is cleared for employment of both light and heavy inert ordnance. Joint training exercises conducted include low- and medium-threat urban CAS drills, air interdiction, time-critical targeting, and convoy escort drills.[146] Terminal control may be provided by either ground or airborne forward air control (FAC). Troops may also provide laser target designation from as close as 1200 yards from the target. Safety measures preclude personnel from entering the urban complex during live firing, owing to the inability to reliably ensure all canyons are clear. Whilst this obviously produces some limits to realism in joint training, ground and air crews alike can still gain valuable experience in tactics, control and communications, targeting, and weapon guidance procedures. For the benefit of its aircrew undergoing the Weapons and Tactics Instructor Course at Yuma, the USMC also conducts a simulated urban CAS scenario over the nearby township of Ajo, using the same terminal-control support.[147]

Yodaville is now one of many such urban training centers across the USA used to ensure war fighters train like they fight. The use of discarded or surplus materials for construction and enlisted manpower have allowed for a cost-effective approach to providing such training facilities. The site, situated near a mining facility, was acquired for just $500, 000. The urban complex was largely built by Marine Corps engineers, with some civil contractor input for monitoring systems and road constructions (at an approximate cost of US$2 million).[148] Considering the potential benefits to joint training and preparedness, construction of a similar facility in Australia (or the adaptation of an existing AWR) holds merit for the ADF, and may provide an attractive venue for joint training with coalition partners.

Free-Play Exercising

Studies of successful military leaders show that the most effective tactical decision makers rely on recognitional decision making. That is, they have the experience to accurately interpret uncertain or volatile situations and make rapid, correct decisions. Just as importantly, they can also recognize when not to take rapid, decisive action.[149] Urban AWR sorties can provide valuable training for recognitional decision making. Unfortunately the value of training will be somewhat limited, owing to both the constrained size of the complex, and the degree of "scripting" required in the absence of a fully integrated land campaign.

As a complimentary activity, the ADF could also consider running limited free-play exercises in, and over, an actual urban area. Venue selection would require detailed analysis including the suitability of available urban terrain, noise abatement requirements, prevailing weather, airspace availability and control, participation of local government agencies, and the cooperation and support of the general public. Such an exercise would require the services of a dedicated legal team, and would need to be accompanied by a comprehensive information campaign. The aforementioned selection criteria would most probably rule out such an exercise being convened at a capital city. Rather, a smaller regional center may be more suitable.

Whilst difficult to initiate and coordinate, such exercises would prove invaluable in creating sound joint and inter-agency relationships (which would inevitably be required in a real conflict). Similarly, the Australian population would also stand to gain a better appreciation for the capabilities of its armed services. Exercising could become interactive with community groups and other government agencies participating. To keep the exercise truly free-play, participating forces would have to deal with inevitable surprises presented by aggressive, innovative, thinking enemies (provided by "red forces") rather than merely deal with "scripted" operations.

CONCLUSION

The 21st Century has heralded a new age in conflict – that of the "small war" - often ideological in nature, and fuelled by religious fundamentalism. Globalization has set the scene for a convergence of interests and a clash of cultures in the increasingly populated urban areas of secular power. Adversaries will often be small, non-state actors, fighting with limited means, but vying for ultimate stakes. Innovative and resourceful, they will likely attempt to coerce government through acts of terrorism and insurgency in the cities, targeting leadership, infrastructure and the population itself, all the while seeking sanctuary amongst these same targets.

This paper has asserted that aerospace power represents a politically attuned instrument capable of displaying national intent. As such it should play a pre-eminent role in the ADF's contribution to the GWOT, as well as in other more conventional urban conflicts. Whereas urban combat inhibits surface movement and invites a "defensive-bias" mindset, aerospace power's ability to exploit the third dimension can transform urban warfare from tactical-level, infantry-oriented, attrition-based warfare favoring the defender into strategically focused, offensive combat. Its ability to bypass physical barriers and anticipate the enemy's decision and action cycles assists friendly forces to regain the initiative and dictate the tempo of operations. The requirements of controlled effect and minimal collateral damage, and the need to preserve political legitimacy in waging urban warfare, advocate the merits of these high-technology options.

The ADF must be careful to invest in flexible and adaptive systems and structures in order to achieve these goals. The combination of a robust C4ISR system, which produces the knowledge edge, and the ability to strike with precise and measured effects, will allow conventional military forces to wage their own brand of asymmetric warfare that targets the adversary's functional and adaptive centers of gravity. Australia's "NCW Roadmap" thus spells out a highly enabled system comprising capable offensive platforms (such as the FA-18, Tiger armed reconnaissance helicopter, and later, JSF), integrated with a comprehensive ISR system (comprising UAVs in the near future, the Wedgetail AEW&C aircraft, and various ground radar feeds) which are networked through the Vigilare command and control system. This will link sensors, commanders, and shooters in an efficient and effective manner to provide dominant battle space knowledge and real-time targeting. Australia's limited access to satellite-based systems may be addressed through the use of near-space platforms. The use of field-deployable balloons and sensor payloads offers a responsive and cost-effective way of completing a layered system of C4ISR for theater operations.

In order to best satisfy requirements of discrimination and proportionality, ADF aerospace platforms will need to employ modern weaponry that offers precise delivery, selectable fusing options and, importantly, limited yield. Some expansion of the ADF weapons inventory will therefore be required. In the interests of optimal flexibility, air-delivered PGMs should be capable of laser and/or GPS terminal guidance, so that challenges from environmental interferons or changing ROE can be reliably dealt with.

Two weapons systems not included in the ADF inventory, but whose capabilities would greatly enhance ADF effectiveness in urban warfare, are the UCAV and the fixed-wing gunship. The former offers a responsive and precise attack capability that few manned platforms can match in terms of persistence. The latter's similar performance, but vastly superior versatility and payload, arguably justify its higher price tag, given its application in the types of conflict the ADF is likely to encounter in future.

Given that people, not machines, win wars, the value of training in preparing for urban conflict cannot be overemphasized. Technical proficiency must be underpinned by confident recognitional decision making that only comes with practical experience. This will require the development of comprehensive joint doctrine, tactics

and procedures, and the conduct of combined-arms training that progresses from simulated exercises, through urban air weapons range training to free-play exercises.

Aerospace power alone cannot win urban battles. Hampered by lack of permanence, it cannot effectively hold ground, nor can it necessarily achieve requisite target assimilation. This suggests an ongoing reliance on support from ground elements, especially SF, who share a symbiotic relationship in the conduct of urban precision strikes. Combined arms approaches to urban operations have produced impressive results in terms of controlled tempo of battle and reduced attrition. Networking has allowed ground and air elements to develop a supported/supporting role in a truly joint campaign to achieve synergy at each of the tactical, operational and strategic levels of warfare. The effects rendered in such campaigns can therefore exceed the separate contributions of each armed service to effectively "tip the balance" in favor of conventional forces and their governments.

The growing threat from non-state actors by virtue of globalization has seen the emergence of the GWOT as a prime security concern, giving greater emphasis to counter-force and counter-value operations. But while aerospace power can be used to resolve battles, it cannot be used in isolation to effectively resolve conflict. Stability and security operations will no doubt continue to draw heavily on aerospace power to help shape the battle space for peace enforcement operations, by providing ISR, and by contributing both lethal and non-lethal effects. However "boots on the ground" will remain the basis of the counterinsurgency force.

As a branch of psychological warfare, "terrorism succeeds wherever it can generate a sense of vulnerability, helplessness and powerlessness, sufficient to coerce a population or its government."[150] Modern ADF aerospace power can contribute to the GWOT by responding with its own brand of psychological warfare. By possessing the means to detect and forcibly remove the protagonists and their infrastructure, aerospace power can reassure the public of a government's commitment to national security, and the efficacy of a military solution in securing a conclusive outcome in what has often involved protracted and destructive hostilities. Through the precise and controlled application of aerospace firepower, military forces can support the government's imperative to maintain political legitimacy through preserving valuable infrastructure and avoiding indiscriminate casualties. Finally, by taking the initiative in physically defeating those who resort to terrorism or acts of coercion, aerospace power can demonstrate the futility of pursuing such tactics against a determined democratic people, and thereby strike at the adversary's most vulnerable spot – the motivation of its members and the readiness of others to join its ranks.

LIST OF ACRONYMS

ADF	Australian Defence Force
AFID	Anti-Fratricide Identification Device
ALLTV	All-Light Television
ARA	Australian Regular Army
ARH	Armed Reconnaissance Helicopter
AWR	Air Weapons Range
BDA	Bomb Damage Assessment
BFT	Blue Force Tracker
CAS	Close Air Support
CCD	Color Crystal Display
CENTCOM	Central Command
CEP	Circular Error Probable

C4ISR	Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance
CIA	Central Intelligence Agency
CINC	Commander-In-Chief
COTS	Commercial Off-The-Shelf
CROP	Common relevant Operating Picture
EO	Electro-Optical
FAC	Forward Air Control
FIOP	Family of Interoperable Operating Pictures
FM	Field Manual
GBU	Guided Bomb Unit
GMTI	Ground Moving Target Indicator
GPS	Global Positioning System
GSAVE	Global Struggle Against Violent Extremism
GWOT	Global War On Terror
HPM	High-Powered Microwave
HUMINT	Human Intelligence
IED	Improvised Explosive Device
IR	Infra-Red
ISR	Intelligence, Surveillance and Reconnaissance
JDAM	Joint Direct Attack Munition
JSF	Joint Strike Fighter
JSTARS	Joint Surveillance Targeting Attack Radar System
LGB	Laser-Guided Bomb
LOAC	Law Of Armed Conflict
LOS	Line-Of-Sight
MEAO	Middle East Area of Operations
NCW	Network-Centric Warfare
OEF	Operation *Enduring Freedom*
OIF	Operation *Iraqi Freedom*
OODA	Observe-Orient-Decide-Act

PGM	Precision-Guided Munition
PLO	Palestine Liberation Organization
PSYOPS	Psychological Operations
QRF	Quick Reaction Force
RAAF	Royal Australian Air Force
ROE	Rules of Engagement
RPG	Rocket-Propelled Grenade
SAR	Synthetic Aperture Radar
SASO	Stability and Security Operations
SDB	Small Diameter Bomb
SF	Special Forces
SNA	Somalia National Alliance
TENCAP	Tactical Exploitation of National Capabilities
TFR	Task Force Ranger
TLAM	Tomahawk Land Attack Missile
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Air Vehicle
USAF	United States Air Force
USMC	United States Marine Corps
3ID	3rd Infantry Division (United States Army)
4GW	Fourth Generation Warfare

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7 *Mapping the Global Future,* 81.

8 Colonel Thomas X. Hammes, USMC, *The Sling and the Stone. On War in the 21st Century* (St. Paul, Minnesota: Zenith Press, 2004), 207-208.

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13 Everman, op. cit., 28-30.

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20 James H. Toner, *Just War Criteria: A Brief Overview*, (Air War College Faculty Paper, Maxwell AFB, Al.: Air University Press, April 2004), 5pp, in *Department of Leadership and Ethics 2006 Reader* (Maxwell AFB, Al.: Air University, Air War College, 2006), 181.

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22 Kemper, op. cit., 18.

23 Toner, op. cit., 181.

24 Rick Atkinson, *Crusade. The Untold Story of the Gulf War* (London: Harper Collins Publishers, 1994), 285-9.

[25] Major Lee K. Grubbs, US Army, and Major Michael J. Forsyth, US Army, "Is There a Deep Fight in a Counterinsurgency?," *Military Review*, July-August 2005, 28.

[26] Rick Atkinson, "The Raid That Went Wrong: How an Elite US Failed in Somalia," *Washington Post*, January 30, 1994, A27, in Major Roger N. Sangvic, *Battle of Mogadishu: Anatomy of a Failure*, (student monograph, Fort Leavenworth, Ka.: US Army Command and General Staff College, School of Advanced Military Studies, 1998), 13.

[27] OODA describes the elements of a decision making loop that can help compress the time required for a commander to observe a situation and take action. By understanding the OODA loop the commander can operate inside the "decision cycle" of the adversary, forcing him to deal with irrelevant or outdated information. The aim is to create disorder and panic, shatter the cohesion of enemy forces, and thereby bring about the enemy's collapse. This requires not only faster decision making, but a comprehensive knowledge of the adversary and the operating environment. The theory was first espoused by Col. John Boyd, USAF (Ret'd). Robert Cobram, *Boyd. The Fighter Pilot Who Changed the Art of War*, (New York, N.Y.: Back Bay Books/Little, Brown and Company, 2002), 333-338.

[28] General Vasili I. Chuikov, Marshal of the Soviet Union, *The Battle for Stalingrad*, trans. Harold Silver, (New York, N.Y.: Holt, Rinehart and Winston, 1964), 72.

[29] Urban battle's propensity for damage and human suffering makes for compelling reporting. By virtue of the internet and the ever present media, sensational coverage of events can be directly conveyed to the general public, and as such is influential in guiding public opinion.

[30] US Army Field Manual (FM) 3-06.11, *Combined Arms Operations in Urban Terrain*, 28 February 2002, 1-1.

[31] Major Timothy L. Saffold, USAF, *The Role of Airpower in Urban warfare. An Airman's Perspective,* Air Command and Staff College Wright Flyer Paper No. 6 (Maxwell AFB, Al.: Air University Press, December 1998), 7.

[32] During the Tet offensive of 1968, the North Vietnamese Army (NVA) forced meeting engagements to a range inside the circular error probable (CEP) of the fixed wing aviation attack assets (250 feet). Major W.H. Moos, USMC, The Employment of Marine Aviation in Offensive Urban Combat Operations, (student paper, Quantico, Va.: USMC Command and Staff College, May 1979), 20, in Davis, op. cit., 42.

[33] Chuikov, op. cit., 84.

[34] Saffold, op. cit., 10.

[35] loc. cit.

[36] Sangvic, op. cit., 17.

[37] US Army Field Manual (FM) 3-06.11, *Combined Arms Operations in Urban Terrain,* 28 February 2002, III-3.

[38] In the Battle for Aachen in the fall of 1944, the US First Army's focus of fire support was to reduce the city to rubble and allow infantry to clear the enemy from the city core. Burleson, op. cit., 29-30.

[39] Richard P. Hallion, *Storm Over Iraq. Air Power and the Gulf War*, (Washington D.C.: Smithsonian Institution Press, 1992), 247.

[40] In Operation *Desert Storm* US ground forces employed infra-red identification beacons to complement visual identification symbols painted on vehicles. Hallion, op. cit., 222-3.

[41] BFT is a GPS-based system that presents icons of other participating BFT platforms (both ground and air) on a moving map display. First deployed during Operation *Enduring Freedom*, and later during Operation *Iraqi Freedom*, the system has enhanced over-the-horizon communications and helped improve situational awareness of airborne, armored and mechanized units. BFT provides near real-time position reporting, two-way text messaging, and air traffic avoidance warnings, and facilitates more effective command and control over a widened battle space. Major Nathan K. Watanabe, US Army, *Blue Force Tracker and Army Aviation Operations in Afghanistan*, n.p., on-line, Internet, 16 January 2006, available from: <http://www.quad-a.org/chapters/Drum/blue_force_tracker_and_army_avia.htm>

[42] Saffold, op. cit., 12.

[43] Chuikov, op. cit., 80.

[44] Saffold, op. cit.,13.

[45] Jason Conroy and Ron Martz, *Heavy Metal. A Tank Company's Battle to Baghdad*, (Dulles, Va.: Potomac Books, 2005), 150.

[46] Sangvic, op. cit., 15-16.

[47] Burleson, op. cit., 47-49.

[48] Burleson, op. cit., 60.

[49] Moos, op. cit., 14, in Davis, op. cit., 39.

[50] Davis, op. cit., 13-17.

[51] Mark Bowden, *Blackhawk Down*, (London: Transworld Publishers, 1999), 134-5, 167-8.

[52] Burleson, op. cit., 46-47.

[53] Sangvic, op. cit., 15-18, 30.

[54] 1983 US Army Research Institute Survey statistic quoted in Burleson, op. cit., 67.

[55] Sangvic, op. cit., 16, 19-20.

[56] G.J. Ashworth, *War and the City* (New York, N.Y.: Routledge, Chapman and Hall, 1991), 121, in Saffold, op. cit., 13.

[57] After three days of conducting probes into Najaf during OIF, exhausted elements of 3ID required a 24 hour break to recover. Conroy and Martz, op. cit., 186.

[58] Saffold, op. cit., 11.

[59] Conroy and Martz, op. cit., 137-8, 154.

[60] Conroy and Martz, op. cit., 127, 134.

[61] Conroy and Martz, op. cit., 130-1, 137.

[62] CEP is a measure of the accuracy of a ballistic weapon. This defines the radius of a circle within which 50% of weapons should impact.

[63] Williamson Murray and Major General Robert H. Scales Jr., *The Iraq War. A Military History*, (Cambridge, Ma.: Harvard University Press, 2003), 177.

[64] Colonel Philip S. Meilinger, USAF, *10 Propositions Regarding Air Power* (Washington D.C.: Air Force Museums History Program, 1995), 28.

[65] Saffold, op. cit., 20.

[66] Murray and Scales, op. cit., 245.

[67] Royal Australian Air Force AAP 1000 *Fundamentals of Australian Aerospace Power, Fourth Ed.,* Chapter 5, 140.

[68] Captain James T. Cobb, 1st Lieutenant Christopher A LaCour and Sergeant 1st Class William H. Hight, "The Fight for Fallujah. TF 2-2 in FSE AAR: Indirect Fires in the Battle of Fallujah," *Field Artillery*, March-April 2005, 26-27, on-line, Internet, 13 February 2005, available from: <http://www.tradoc.army.mil/pao/ProfWriting/2-2AARlow.pdf>

[69] Murray and Scales, op. cit., 181.

[70] Murray and Scales, op. cit., 93.

[71] Lt Col William B. Danskine, USAF, "Aggressive ISR in the War on Terrorism. Breaking the Cold War Paradigm," *Air and Space Power Journal*, Summer 2005, 75.

[72] Post-OIF studies estimated one civilian died for every thirty-five munitions dropped. During Operation *Enduring Freedom* it was closer to one in twelve. Quoted in Murray and Scales, op. cit., 179.

[73] Hallion, op. cit., 196-7.

[74] War correspondent Milton Viorst reported from Baghdad that Iraqi civilians were tolerant of stray bombs in Coalition air strikes, referring to them as "mistakes.' Quoted in Hallion, op. cit., 199.

[75] Murray and Scales, op. cit., 179.

[76] Murray and Scales, op. cit., 178.

[77] *AAP 1000*, Ch 5, 131.

[78] For example, on 17 January 1991 two US Navy F/A-18s on a strike mission against H-3 airfield in western Iraq were alerted to two approaching Mig-21s. The Hornets locked the MiGs on air-air radar and shot both down with a combination of AIM-7 and AIM-9 missiles. They then successfully attacked H-3 using 2000 lb PGMs. Hallion, op. cit., 194.

[79] As a result the USAF merged its offensive air capabilities into a single Air Combat Command. Hallion, op. cit., 264-265. The RAAF has similarly has merged its strike and fighter wings into a single Air Combat Group.

[80] Department of Defence. ADDP-D3. *Future Warfighting Concept*, (Canberra, ACT.: National Capital Printing, December 2002), 25.

[81] USAF 442d Fighter Wing Instruction 11-201, order 1.4.30 defines Push-CAS (push-close air support) as "a tasking process where aircraft are turned and re-launched as quickly as possible to an orbit point close to the battle to assume continuous airborne alert." The process has been used in OEF and OIF to provide ground forces with responsive close air support. 442d Fighter Wing Instruction 11-201, n.p., 31 December 1998, on-line, Internet, on-line, Internet, 18 January 2006, available from: <http://www.e-publishing.af.mil/pubfiles/442fw/11/442fwi11-201/442fwi11-201.pdf>

[82] During each 24 hour period Coalition forces launched 1500-2000 sorties. Approximately 500 targets were pre-planned. Many targets were assigned to crews once airborne, or else strike sorties were diverted to provide close air support. Murray and Scales, op. cit., 170.

[83] At the Karbala Gap, 3/7Cavalry Squadron deliberately drew out Iraqi armor to present targets for precision air attack. Murray and Scales, op. cit., 245.

[84] Murray and Scales, op. cit., 242.

[85] Regarding Operation *Desert Storm*, Coalition Force Air Component Commander General Charles Horner stated "in the past you wanted to know where the tanks were stored. Now you want to know where the load-bearing wall is located on the building

where the tanks are stored. You want to know – is the overburden on the bunker 26 feet of concrete or 26 feet of earth? The data demands on modern warfare are just going out of sight, but its important," in David Jeffcoat, *Air Power and Special Forces: A Symbiotic Relationship*, Air Power Development Centre Paper No. 14, (Fairbairn, ACT.: Royal Australian Air Force Air Power Development Center, 2004), 21.

[86] Jeffcoat, op. cit., 29.

[87] Rick Atkinson, *Crusade. The Untold Story of the Gulf War*, (Hammersmith, London: Harper Collins, 1994), 234.

[88] Lt Col Eric E. Theisen, USAF, *Ground Aided Precision Strike. Heavy Bomber Activity in Operation Enduring Freedom*, Maxwell Paper No. 31, (Maxwell AFB, Al.: Air University, Air War College, July 2003), 5.

[89] Murray and Scales, op. cit., 171-2.

[90] Jeffcoat, op. cit., 22 - 23.

[91] Giulio Douhet, *The Command of the Air* (Washington D.C.: Office of Air Force History, 1983), 30.

[92] AAP 1000, Chapter 5, 138.

[93] The 2004/2005 Australian Defence Budget was $17 billion (Australian). Patrick Walters, "Defence accounts too rubbery for A-G," *Australian,* 12 November 2005. Australia currently spends approximately 1.9% of gross national product on defense. Greg Sheridan, "Alliance Strong, But Our Defence Outlay Weak," *Australian*, 18 November 2005. Further breakdowns in Australian defense spending are promulgated in the Department of Finance and Administration Agency Budget Statements, Part C, Section 1, available from: <http://www.finance.gov.au/publications/PortfolioBudgetStatements/PBS-04-05/part_c_section_1_04_05.html>

[94] Barry R. Posen, "The Struggle Against Terrorism: Grand Strategy, Strategy and Tactics," *International Security*, Vol. 26, No. 3, (Winter 2001/2002), 46.

[95] Australian Government, Department of Defence, *Disarmament of Iraq. Operation Falconer*, on-line, Internet, 13 February 2006, available from: <http://www.defence.gov.au/opfalconer/default.htm>

[96] During OIF in 2003 the Defence Intelligence and Geospacial Organisation encountered difficulty acquiring hi-resolution and normally commercially available satellite images of Iraq. Whilst access to archived images was satisfactory, commercial providers were slow to deliver specific requests for new material, and instead referred Defence planners to US intelligence services. Subsequent availability of satellite imagery could not be assured unless US sensors were trained on common US/Australian areas of interest. Andrew Fowler, "Satellite hitch restricts RAAF reconnaissance," *7.30 Report*, 17 April 2003. Transcript, n.p. on-line, Internet, 21 January 2006, available from: <http://www.abc.net.au/7.30/content/2003/s835050.htm>

[97] LtCol Ed Tomme and Col Sigfried Dahl, "Balloons in Today's Military? An Introduction to the Near-Space Concept," *Air and Space Power Journal*, Winter 2005, 46.

[98] Distance is critical to image resolution and receiving low-power signals. Resolution varies with the inverse square of the distance – double the distance, halve the resolution. Near-space platforms therefore offer 10-20 times the resolution of orbital satellites. Tomme and Dahl, op. cit., 43.

[99] Balloons can be launched in minutes to hours, and require approximately one minute per 1,000 feet of ascent. Tomme and Dahl, op. cit., 48.

[100] Global Hawk operation is essentially autonomous, using fail-safe programs. It can be reprogrammed in flight should mission changes dictate. System redundancy will greatly reduce the probability of loss and allow extended time on station while a replacement vehicle is enroute. Global Positioning System (GPS) aided inertial navigation systems provide the accuracy required for both runway environment and flight operations, and will assist with timely and accurate targeting. AAP 1000, Chapter 7, 199.

[101] Edward Trower, "RAAF Braces For Major Challenges of Next 20 Years," *Australian Defence Journal*, July/August 2004, 12.

[102] John A. Tirpack, "The Blended Wing Goes to War," *Air Force*, October 2003, 27, in Wesley P. Hallman, "Airpower and Psychological Denial," *Joint Forces Quarterly*, No.37, Spring 2005, 33-39.

[103] Synthetic Aperture Radar (SAR) is a computer-supported radar system that takes advantage of an aircraft's forward movement during the travel of the radar pulse to simulate a much longer antenna length (in the order of 2 000 feet). This allows the use of lower electromagnetic frequencies which provide much finer resolution. A Ground Moving Target Indicator (GMTI) radar compares two snapshots to determine the position and track of multiple targets. The tracks are then spatially and temporally correlated with SAR or other sensory imagery to present a moving target display that can be fused with road or map data.

[104] Hallion, op. cit., 292.

[105] "Skylark IV Miniature Aerial Vehicle," *Defense Update. International Online Defense Magazine*, Issue 2, 2005, n.p., on-line, Internet, 16 January 2006, available from <http://www.defense-update.com/products/s/skylark1-uav.htm>

[106] The Honourable Senator Robert Hill, Australian Minister for Defence, *New Tactical Unmanned Aerial Vehicle Capability*, Department of Defence Press Release 199/2005, 12 December 2005.

[107] The aircraft can be landed within 50 meters of a designated point, according to manufacturer's claims. "I-View Tactical UAV System," *Defense Update. International Online Defense Magazine*, Issue 2, 2005, n.p., on-line, Internet, 16 January 2006, available from: <http://www.defense-update.com/products/i/view.htm>

[108] During OEF laser-guided Hellfire-C missiles were fired from a Predator UAV launched from the Indian Springs Air Force Auxiliary Airfield, near Nellis Air Force Base in Nevada, to destroy enemy vehicles and personnel in Afghanistan. The emergence of the UCAV arose as a consequence of the lag time observed between UAV surveillance activities and the deployment of strike aircraft from Italy during the NATO air campaign against the former Yugoslavia in 1999. By the time attack aircraft arrived on station many military targets were no longer available to be engaged. However, targets located by armed UAVs could be attacked immediately with on-board weapons. AAP 1000, Chapter 10, 288.

[109] Platforms lost in combat included the CL-289 (7), Predator (5), Crecerelle (3), Hunter (2), Pioneer(2) and Phoenix (2). "UAVs over Kosovo – did the Earth Move?," *Defence Systems Daily*, n.p., on-line, Internet, 17 January 2006, available from: <http://defence-data.com/features/fpage34.htm>

[110] Ibid.

[111] A full explanation of the FIOP system-of-systems initiative is given in Robin Quinlan, *Family of Interoperable Operational Pictures (FIOP)* (Washington D.C.: Office of the Secretary of Defense), on-line, Internet, 15 September 2005, available from <http://www.dtic.mil/ndia/systems/Quinlan.pdf.

[112] Major Ow Kim Meng, RSAF, Major Song Chun Keet, RSAF, and Captain Goh Meng Kiat, RSAF, "Airpower in OPS IRAQI FREEDOM," *Pointer Journal. Journal of the Singapore Armed Forces*, Vol. 30, No. 3, 2004, 3.

[113] The Jindalee Over the Horizon Radar (JORN) bounces high frequency signals off the earth's ionosphere to provide a wide area surveillance capability. Three sites have been established across Australia to monitor air and sea approaches to the continent. AAP 1000, Chapter 7, 194.

[114] AAP 1000, Ch 7, 214.

[115] Wedgetail will provide the ADF with an enhanced surveillance capability, particularly in the broad expanse of the Australian north, and complement the Jindalee Over-the-Horizon Network (JORN) of ground-based radars. It will also be able to support other ADF and coalition efforts throughout the world. The aircraft will be a derivative of the Boeing 737-700, fitted with a dorsal phased array RADAR, Electronic Warfare self-protection system, and air-to-air refueling capability. AAP 1000, Chapter 7.

[116] A radian is equal to the angle at the center of a circle subtended by an arc of length equal to the radius. A milliradian is equal to one thousandth of a radian.

[117] Davis, op. cit., 80-92.

[118] Everman, op. cit., 17.

[119] Everman, op. cit., 18.

[120] United States Air Force Scientific Advisory Board, *Report on Air Force Operations in Urban Environments. Volume 1: Executive Summary and Annotated Brief*, (Washington D.C.: United States Air Force Scientific Advisory Board, 1 August 2005), vi.

[121] Air Force Special Operations Command, AFSOC Instruction 11-202, vol. 14, AC-130U Operations, 1 May 1997, 7, on-line, Internet, 20 January 2006, available from: <http://www.fas.org/man/dod-101/sys/ac/docs11020214.pdf>

[122] "AC-130 Specifications," *GlobalSecurity.org*, 27 April 2005, n.p., on-line, Internet, 20 January 2006, available from: <http://www.globalsecurity.org/military/systems/aircraft/ac-130-specs.htm>

[123] AFSOC Instruction 11-202, vol. 14, 12.

[124] Sangvic, op. cit., 29-34.

[125] The unit cost of the AC-130H is $132 million. The unit cost of the more modern AC-130U (based on the C-130H airframe) is $190 million (figures in US fiscal 2001 constant dollars). "AC-130H/U Gunship," *Air Force Link*, October 2005, n.p., on-line, Internet, 20 January 2006, available from: <http://www.af.mil/factsheets/factsheet.asp?fsID=71>

[126] The USAF currently operates eight AC-130H and 13 AC-130U aircraft. loc. cit.

[127] Daniel Cotterill, "Decision on new targeting pod later this year," *Australian Defence Magazine*, March 2005, Vol. 13, No. 3, 48.

[128] "Battlespace…" *Australian Defence Business Review*, Vol 24 No 9: August/September 2005, 31.

[129] On several occasions two-ships of Lantirn-equipped F-15Es managed to destroy sixteen tanks with sixteen GBU-12s. Hallion, op. cit., 203

[130] Hallion, op. cit., 303.

[131] Davis, op. cit., 23,24.

[132] Davis, op. cit., 91.

[133] "Small Diameter Bomb," *Defense Update. International Online Defense Magazine*, Issue 5, 2004, n.p., on-line, Internet, 20 October 2005, available from: <http://www.defense-update.com/products/s/sdb.htm>

[134] "F-35 Joint Strike Fighter," *Wikipedia*, 8 February 2006, n.p., on-line, Internet, 8 February 2006, available from: <http://en.wikipedia.org/wiki/F-35_Joint_Strike_Fighter>

[135] Jill Carol, "A Makeshift Hunt for IEDs in Iraq," *USAF Counterproliferation Warfare Center Asymmetric Warfare Outreach*, No. 15, 14 December 2005.

[136] Theisen, op. cit., 5.

[137] Meng, Keet and Kiat, op. cit., 3.

[138] Murray and Scales, op. cit., 276.

[139] *Military Operations in Built-Up Areas (MOBA)*, Report of the Defense Science Board (DSB) Task Force (Washington, D.C.: Office of the Under Secretary of Defense for Acquisition and Technology, 1994), 32.

[140] Known as the Active Denial System (ADS), this weapon generates short, intense energy pulses that produce transient surges of thousands of volts. Because the microwave energy penetrates less than a millimeter into the skin, injury is very minor. Squadron Leader C.R. Coles, RAAF, Air-delivered non-lethal weapons and the RAAF weapons inventory, Australian Defence College Geddes Paper, (Canberra, ACT: Australian Defence College, 2003), 76, on-line, Internet, 17 January 2006, available from: <http://www.defence.gov.au/adc/docs/Publications/Geddes%20Papers%202003/09%20Air-delivered_Squ%20Leader%20Coles.pdf>. Plans are currently underway to install ADS on AC-130 gunships. Further technical information on non-lethal weapons is available at "Non-lethal Directed Energy Weapons," Defense Update. International Online Defense Magazine, Issue 1, 2005, n.p., on-line, Internet, 20 October 2005, available from: <http://www.defense-update.com/features/du-1-05/NLW-DEW.ht>

[141] Conroy and Martz, op. cit., 136.

[142] Hallion, op. cit., 219.

[143] Davis, op. cit., 51-58.

[144] Pre-sortie planning may draw on archived photographs and radar predictions or commercially available satellite images to decide ingress and egress routes, tactics, and weapon trajectory profiles. Exercises involve acquiring the prescribed target either visually or using on-board sensors, a simulated weapon release, and escape tactic. Lessons learned are largely drawn from self-assessed post-flight analyses, including extensive review of cockpit systems recordings such as Pavetack or heap-up display (HUD) tapes, to determine the likelihood of target impact and success of tactics. Mission success (and survival) is based on theoretical assessment.

[145] Kemper, op. cit., 25.

[146] James W. Crawley, "Bombs Away at Yodaville," San Diego Union-Tribune, 18 June 1999, n.p., on-line, Internet, 01 February 2006, available from: <http://www.geocities.com/Pentagon/6453/yodaville.html>

[147] Corporal Michael Nease, "Agile Lion demonstrates future of net-centric warfare," *Marines.com*, January 2006, n.p., on-line, Internet, 01 February 2006, available from: <http://www.marines.mil/marinelink/mcn2000.nsf/lookupstoryref/200512212614>

[148] Kemper, op. cit., 28.

[149] Mark Shaffer, "Yodaville Exists for Bombing Runs – Arizona's Newest Town Inviting Target," *Arizona Republic*, 23 August 1999, n.p., on-line, Internet, 01 February 2006, available from: <http://www.geocities.com/Pentagon/6453/yodavillea.html>

[150] Hammes, op. cit., 239.

[151] Stephen Sloan, *Beating International Terrorism. An Action Strategy For Preemption and Punishment*, Maxwell AFB, Al.: Air University Press, 2000, 3.