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United States Marine Corps  
Command and Staff College  
Marine Corps University  
2076 South Street  
Marine Corps Combat Development Command  
Quantico, Virginia 22134-5068

MASTER OF MILITARY STUDIES

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**TITLE:**  
**Urban Close Air Support: The Landscape is Changing**

SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF MILITARY STUDIES

**AUTHOR:**  
**Russell V Johnson IV**

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Mentor and Oral Defense Committee Member: Paul D. Group

Approved: [Signature]

Date: 30 April 2015

Oral Defense Committee Member: Eric Y. Shibuya

Approved: [Signature]

Date: 30 April 2015

## Executive Summary

**Title:** Urban Close Air Support: The Landscape is Changing

**Author:** Major Russell Johnson, United States Marine Corps

**Thesis:** Megacities of ten million or more inhabitants are increasing as global population migrates to the urban environment. These cities are a likely source of future conflict and present unforeseen challenges to military operations. These challenges include the use of Close Air Support, including airspace management and control, survivability, collateral damage, and weaponeering.

**Discussion:** Global population migration to urban areas is increasing the number and size of the world's largest cities. Characteristics of these cities affected by large populations and geographic size are numerous and demand further study. This rise in population and geographic size will provide increased sources of conflict. Strain on infrastructure, technology, and mass communication allow exploitation of a densely populated and built up environment by threats to security. Unless these threats are existential to the U.S., the megacity will present a multitude of strategic, operational, and tactical challenges. Urban doctrine and tactical publications account for the complexity of operating in a large urban area, but do not completely appreciate the challenges associated with aviation operations in a megacity, including Close Air Support (CAS). Among the most important of these challenges are airspace management and control, survivability, collateral damage, and weaponeering.

**Conclusion:** These unique challenges to CAS in a megacity will require attention from planning through execution in order for future air operations to be successful in supporting overall military objectives. Recommendations for addressing these challenges include establishing acceptable levels of collateral damage, increasing intelligence and cyber integration with CAS, use of simulated urban environments for aircrew, and better training for ground commanders. Lastly, commanders must be willing to accept elevated risk during the conduct of these operations.

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## **GLOSSARY**

AGL	Above Ground Level
C2	Command and Control
CAS	Close Air Support
CDE	Collateral Damage Estimation
CDM	Collateral Damage Methodology
FAC	Forward Air Controller
FW	Fixed-wing
IAF	Israeli Air Force
IDF	Israeli Defense Force
JTAC	Joint Terminal Attack Controller
LOW	Law of War
MANPADS	Man Portable Air Defense System
NVD	Night Vision Device
PGM	Precision Guided Munition
RW	Rotary-wing
SDB II	GBU 53/B Small Diameter Bomb Increment II
UAV	Unmanned Aerial Vehicle
USAF	United States Air Force

## **Introduction**

“The worst policy is to attack cities. Attack cities only when there is no alternative.” -Sun Tzu<sup>1</sup>

The words of Sun Tzu regarding fighting in cities are timeless, the urban environment is the most challenging and complex of military operations and will continue to be in the future. Additionally, global urbanization trends coupled with the steady growth of unconventional threats suggest that urban combat will continue to not only increase in complexity, but be more likely. Population migration to urban areas has contributed to a sharp increase in in the last century of cities with more than ten million inhabitants, the term coined for them is “Megacity.” Global urban population has increased from 746 million in 1950 (30 percent of the population) to 3.9 billion in 2014 (54 percent).<sup>2</sup> Following the trend of urbanization, the potential threats to U.S. national and world security are also migrating to the urban landscape, where they have considerable freedom of movement, access to technology, and interaction with the population, a dangerous combination. Unless these threats are deemed existential to the U.S. or any allies, allowing the full application of military force, joint operations will require attention to a multitude of challenges presented by a megacity.

Current military doctrine and tactics have evolved through dozens of bloody battles to address the challenges of urban conflict and provide a sound foundation for the preparation and execution of such complex operations. This doctrine should be well understood prior to conducting any operation within the urban environment. There is also considerable literature on the rise of urbanization and the difficulties associated with this growth. But, there are many challenges that increasing megacities, urbanization beyond what has been previously studied or encountered militarily, pose to all elements of a military operation and are not addressed in doctrine. Over the larger geography and population of a megacity, forces may mount multiple

complex operations simultaneously, making coordination and deconfliction more challenging. Study of overall air operations in this environment must assess strategic impacts to a multitude of tactical operations including support of ground maneuver elements by armed aircraft, or Close Air Support (CAS). Challenges to the application of CAS in this environment are numerous, including airspace management and control, survivability, collateral damage, and weaponeering. These unique challenges to CAS in a megacity will require attention from planning through execution in order for future air operations to be successful in supporting overall military objectives.

In order to appreciate the issues concerning CAS in a megacity it is necessary to consider: 1) the impacts of population density and infrastructure complexity; 2) current doctrine and tactical publications; and 3) and finally the interaction between the population density and infrastructure complexity, as well as the relationship to current doctrine and tactics. An appreciation of these challenges is important for the future development of doctrine and tactics associated with operations in a megacity.

### **The Megacity**

A megacity is simply defined as one that has passed a threshold of ten million inhabitants.<sup>3</sup> Yet this definition does not completely describe the complexity that comes with increased migration to urban areas. Cities do not expand outwards to accommodate more people, nor does physical infrastructure to support increased inhabitants magically appear once they arrive in a city. How they expand due to many factors is important to understanding challenges that a military will face. In addition, advances in technology and mass communication are giving higher rates of people in these cities access to not only more information, but each other. Social connectivity has made even the least advanced megacity of today more interactive than

that of even ten years ago.<sup>4</sup> Lastly, and unfortunately for military tacticians and planners, there is no single template for megacities. All of these factors contribute to the argument that in many cases the scale of a megacity will challenge historical urban warfare methods that do not address the size and complexity of a megacity.<sup>5</sup> This is true with application of air power as well. While current doctrine and tactics for urban air operations are suited to the majority of cities across the planet, the sheer size of megacities gives rise to complexities in planning and execution that will have to be addressed for any operation.

While the overall population of an urban area is important to consider and what defines a megacity, urban density will impact operations as well. As a general rule, population density will increase complexity in regards to rules of engagement and law of war, among other functions. Due to modern warfighting ethics, U.S. military planners are committed to avoiding wanton destruction of entire urban areas and the mass killing of civilians. Displacement of the majority of over ten million citizens in a potential battle zone would also have major strategic and operational impacts. In Fallujah, Iraq, in 2004 the city was left with between 2,000 and 4,000 fighters that remained after an extensive information operation to encourage civilians to flee the upcoming operation, but collateral damage was still a consideration due to the need for a functioning city in order to achieve overall success in the war.<sup>6</sup> Attempting this method in a city of over ten million would likely require substantial attention, diverting focus from the operation itself. Conventional forces are also no longer able to commit “urbicide,” the destruction of a city.<sup>7</sup> Therefore, the application of firepower in these areas has to be carefully considered to include air power in support of ground operations.

Several factors converge to suggest that future military conflict is more likely to occur in cities. These include inadequate infrastructure, weak governance and security, and degree of

integration. The rate of urbanization in developing countries is higher than that of developed.<sup>8</sup> In his book, *Out of the Mountains: The Coming Age of the Urban Guerilla*, David Kilcullen discusses how urbanization in developing countries without the infrastructure to support such population growth will be one major source of conflict in the future:

Rapid urban growth in coastal, underdeveloped areas is overloading economic, social, and governance systems, straining city infrastructure, and overburdening the carrying capacity of cities designed for much smaller populations... The implications for future conflict are profound, with more people competing for scarcer resources in crowded, underserved, and ungoverned urban areas.<sup>9</sup>

Kilcullen describes Lagos, Nigeria as “the population of a megacity but the infrastructure of a mid-sized town.”<sup>10</sup> A 2014 U.S. Army study also points out that illicit networks can replace governance in areas that governmental control is over-extended.<sup>11</sup> The study outlines three different typologies used to classify megacities based on level of integration, broken down into governance and security systems, and gives examples of each. At the extremes of these typologies are highly integrated (New York) and loosely integrated (Lagos) cities, with moderately integrated in between (Rio De Janeiro, Brazil).<sup>12</sup> As has been seen by the U.S. and allied forces in Iraq and Afghanistan, a lack of governmental services and security are major factors in the influence threat organizations can have on an area of operation. Lack of infrastructure is not the only consideration. The 2008 terrorist attacks on Mumbai, India show that threat organizations in very small numbers are capable of using developed urban centers to not only stage but execute attacks with success. Additionally, the potential origin of a threat or location of a target can lie in the slums and busy city centers of a megacity. For example, if a conflict arises in the slums of Lagos, operations can occur in the densely populated center of the city near the coastline as the majority of the slums are located there. One slum in Lagos actually grew into the water until the government destroyed it in 2012, with floating living structures

erected with virtually no urban planning.<sup>13</sup> Conversely, the *favelas* of Rio de Janeiro are spread throughout the city, except for the small central business district on the waterfront. This would create an entirely different problem for air planners than Lagos.\* Level of integration and infrastructure will be major factors in the planning and execution of future operations in megacities. Air operations planning, especially for operations that utilize air-delivered ordnance, will have to consider the effects on slums and built up areas alike.

The emergence of mass communication through multiple means, especially the internet, and the ability of anyone with an internet connection to utilize these means, is relatively new to the considerations of military operational planners. Joint Publication 3-06, Joint Urban Operations,<sup>†</sup> discusses the strategic significance of this emerging technology, “Any individual observing military operations... can post information and images that have the potential to reach millions of people influencing their perceptions...”<sup>14</sup> Countless videos and messages passed on social media sites in current war-torn countries such as Syria and Iraq show the resilience of these types of communication where other basic services are unavailable. The Mumbai attackers used these technologies adeptly not only to command and control from Karachi, Pakistan, but to track the operation and capitalize on a flat command structure.<sup>15</sup> There has been a steep learning curve for understanding how to limit the impacts of this technology and, conversely, how to use it advantageously. It now has the ability to affect warfare at every level, from strategic to tactical.

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\* The government of Brazil engaged in pacification in the *favelas* beginning in 2008 in preparation for the 2014 FIFA World Cup and the 2016 Summer Olympics. Police security forces in Rio conducted a four-phase counterinsurgency-style operation to clear criminal elements, provide security for the population within the *favelas*, and ultimately pacify the population by occupying with paramilitary police. These operations required large units on the ground to combat criminal organizations with extensive control over the population, commerce, and even basic services in the *favelas*. One criminal gang was even able to bring down a police helicopter in 2009, killing two officers on board. See Molly Martin, “Mega-Cities and Mega-Events: Lessons from Favelas for the Future,” U.S. Army Foreign Military Studies Office, Fort Leavenworth, Kansas. Spring, 2012, 12-15.

<sup>†</sup> Hereafter referred to JP 3-06 JUO.

Tactical significance of communication technology in relation to modern military operations is important as well. Use of mobile phones as cueing devices and extensive use of off-the-shelf handheld radios by insurgent forces in Iraq and Afghanistan give insight to the ease of enemy forces to maintain situational awareness of friendly forces, especially aircraft location.<sup>16</sup> Adding internet connectivity allows instant communications between members of a force of any size in a large city. For an insurgent or conventional force with the ability to blend in with an urban population, the megacity provides two distinct advantages. First, an increase in physical size of a city gives more freedom of movement and the ability to locate and track adversary forces entering a city prior to their operation. Second, dense populations provide opportunity to extract intelligence from civilians, especially if they are sympathetic, and free instant communications exacerbates this advantage. These advantages can negate much of the speed, surprise, and standoff provided by attacking aircraft, considerations which will be discussed later.

Passing the ten million mark in population does not automatically create the complexity in a city described. Nevertheless, it is important for military planners to understand that operating in a city of this size will be vastly different from urban warfare in a city of tens or even hundreds of thousands. Urban migration and density, infrastructure, advances in technology and mass communication, and uniqueness are all factors that will impact the conduct of an operation and make the megacity an important distinction for future military thinking and planning. The conduct of air operations must be an integral part of this thinking, as it is an integral function of the success of a joint effort.

### **Current Doctrine and Tactical Publications**

Current doctrinal publications span the range of military operations. Many address urban operations and a select few discuss urban CAS. The evolution of these documents, based on best-practices gleaned from operations of the past, has made them viable for urban operations in the near future. (See Appendix A) They contain a wealth of information useful in planning and execution helpful in understanding and approaching operations in a complex urban environment. In order to be prepared for future threats originating from and utilizing the urban environment to their advantage, military thinking and doctrine will need to evolve to include the considerations for operations in environments with the size and scale of megacities. What follows is a short examination of one primary doctrinal source and two tactical publications for CAS and urban aviation operations; the aforementioned JP 3-06 JUO, Joint Publication 3-09.3 Close Air Support,<sup>‡</sup> and the newest version of MCRP 3-35.3A Aviation Urban Operations: Multi-Service Tactics, Techniques, and Procedures for Aviation Urban Operations.<sup>§</sup>

According to JP 3-09.3 CAS, the joint authority on armed air support for ground operations, the most recent definition for CAS is “air action by fixed wing (FW) and rotary-wing (RW) aircraft against hostile targets that are in close proximity to friendly forces and requires detailed integration of each air mission with the fire and movement of these forces.” The doctrine further points out that there are two important elements of this definition worthy of examination and full understanding, and this is especially true when discussing CAS in an urban environment.<sup>17</sup> The first of these, “close proximity,” does not have a distance associated with it. Proximity in the case of air delivered fires can mean any range of distances from friendly forces depending on a multitude of factors, including the specific ordnance to be used and the protection of friendlies from fratricide based on their location on the battlefield. In an urban

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<sup>‡</sup> Hereafter referred to as JP 3-09.3 CAS.

<sup>§</sup> Hereafter referred to as MCRP 3-35.3A AUO.

environment these distances can be and frequently are considerably closer than that of operations in an open battlefield. Conversely, the munition to be delivered may have the capability of affecting infrastructure in an urban environment that will impact friendly maneuver at a target distance further away from friendlies than the same ordnance in an environment with little or no manmade features. The second important element is the requirement for “detailed integration.” This implies that the fires provided by CAS aircraft in this role have to be integrated with the fire and maneuver of friendly forces.<sup>18</sup> Combined with an understanding of the concept of proximity, this distinction is important to urban operations as well. Air-delivered fires that do not fit the descriptions above of proximity and integration are not, by definition, CAS. Understanding the history and current doctrine of air support requires this basic understanding of the definition of CAS. JP 3-09.3 CAS also identifies the conditions for effective CAS to include effective training and proficiency, planning and integration, C2, air superiority, target marking, streamlined and flexible procedures, and appropriate ordnance. A further condition, favorable environment, is listed but not a requirement.<sup>19</sup> The document primarily provides procedures for applying air-delivered firepower in support of ground maneuver from planning through execution. It also describes the command and control systems employed by each service and the expected operational support for CAS including communications, intelligence, communications and integration. There is a discussion of special considerations for urban CAS which gives a good foundation for using CAS but is not intended, and not able, to address every scenario, including CAS in a megacity.

JP 3-06 JUO is also a relevant document for any urban operation. It discusses much of the elements of urban warfare that contribute to complexity in this environment. Air operations are briefly discussed in two paragraphs in the first chapter, but considerations for air operations

are touched on throughout.<sup>20</sup> This publication is the base source for urban operations planning and provides essential context and considerations for understanding the urban operational environment.

The 2013 edition of MCRP 3-35.3A AUO expands on the considerations described in many publications, including JP 3-09.3 CAS, to give a further understanding of the challenges of urban air operations and provide tactics and techniques. It outlines the importance of urban understanding and consideration based on trends in urbanization, giving planning and mission considerations for urban air operations. MCRP 3-35.3A AUO also provides a valuable overview of urban CAS and weapons systems, detailing many considerations and techniques for employment of ordnance in an urban environment. Overall this document is a complement to JP 3-09.3 CAS and focuses specifically on tactics, techniques, and procedures for successful air operations in an urban environment.<sup>21</sup>

The foundation provided in these documents, among other joint products, cannot be overlooked when planning or executing an urban operation. They provide a wealth of information to consider based on emerging technology, tactics, and historical lessons learned. The scope, complexity, and likelihood of conflict in a megacity requires further understanding for aviation operations to be successful in the future. Challenges for these operations must be examined before any operation is attempted in this environment.

### **Challenges to CAS in a Megacity**

The complex environment of a megacity and review of current doctrine and tactics highlight the challenges posed to a military force conducting aviation operations in support of ground maneuver in a megacity. The challenges of airspace management and control,

survivability, collateral damage, and weaponeering, are among the most important issues that must be addressed for the future.

### *Airspace Management and Control*

As current urban operations and doctrine suggest, the airspace above an urban environment will become a limiting factor in the flexibility provided by air delivered munitions. Dispersion enjoyed by ground units in an open battlefield is no longer possible with the smaller real estate occupied by like units in urban combat and command and control tends to become more decentralized.<sup>22</sup> Air operations are no different, if the amount of support provided to ground units in open terrain is attempted during urban combat the resultant midair collision danger to aircraft could create an unnecessary level of risk. Risk to aircraft and aircrew must be weighed with the level of support needed and every type of air support will be included as part of an urban operation, complicating airspace control. Close Air Support aircraft have to be safely integrated with manned intelligence gathering platforms, assault support aircraft providing logistics and casualty evacuation, command and control, and the increasing amount of unmanned systems that support tactical to strategic collection efforts and real-time battle tracking. This complicates two of the conditions for effective CAS, C2 and planning and integration. Management of this airspace will be challenging as the amount of required support increases due to size, complexity, and an increased need for ground maneuver units to occupy urban terrain.<sup>23</sup>

Historical examples of airspace management provide insight into the creativity that will be necessary to mitigate the midair risk in urban environments. The battle for Fallujah in 2004 combined the use of known airspace control measures with creative solutions to provide the maximum amount of support possible. Israeli Air Force (IAF) operations in Lebanon in 2006 were another example of the use of detailed deconfliction measures for safety of flight with a

large amount of aircraft over congested airspace. These procedures were further refined for operations in the Gaza Strip, but the underlying benefit of airspace control in both operations was the ability to maintain aircraft holding areas above unpopulated terrain until the need for air-delivered ordnance materialized. This provided necessary deconfliction and safety from threats in both cities. In Fallujah, the keyhole method was used for FW aircraft and RW attack aircraft were placed in battle positions outside the city until they were needed.<sup>24</sup> (See Appendix A for a description of keyhole CAS) The hunter-killer concept utilized by the Israeli Defense Force (IDF) in Gaza, where target cueing was provided by airspace saturated by unmanned and high-flying sensor platforms or ground units, allowed attack aircraft to rapidly engage targets minimizing exposure over the airspace. Israeli aircrews also enjoyed considerably less surface to air threat and the small size of Gaza simplifies the return to sanctuary.<sup>25</sup> (See Appendix B) The small size of these cities provided this capability, Fallujah is approximately ten square miles and all of the Gaza Strip is seventeen.<sup>26</sup> Compare these cities with Dhaka or Rio De Janeiro, 139 and 780 square miles respectively, this ability would be negated by the sheer size of the megacity if operations are conducted anywhere but the periphery.<sup>\*\*</sup> The majority of megacities based on geographic size are located in east or central Asia, areas of strategic importance and worthy of consideration as future sources of conflict. Inability to use a sanctuary on the outside of a city will force either ground units to clear large portions of cities before aircraft can safely operate or commanders will have to accept elevated risk in either response time or vulnerability.

Civilian airspace structure and air traffic will also pose a challenge to forces conducting operations in a megacity. JP 3-06 JUO discusses planning considerations for a population in an

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<sup>\*\*</sup> Of the current megacities Dhaka is the smallest in geography. Fortunately for joint planning, two of the largest three urban areas are New York and Los Angeles, where major combat operations are unlikely. See Wendell Cox, "Demographia World Urban Areas: 11th Annual Edition: 2015.01 (Built-Up Urban Areas or World Agglomerations)." (Wendell Cox Consultancy, Illinois, 2015). <http://www.demographia.com/>.

urban environment during a conflict, primarily whether to encourage departure from the city or not. Migration of more than ten million people from an urban area would be considerably difficult to manage, therefore a complete departure is unlikely and joint usage of airspace and air ports will be necessary.<sup>27</sup> In a megacity operation with either multiple areas of hostility or combat operations near a major airport, tactical airspace control measures will have to be integrated with existing civilian airspace. This will further challenge deconfliction in an already dense airspace and limit freedom of movement of aircraft supporting ground maneuver, including CAS.

Geographic size does not pose the only challenge to airspace management in urban operations. Communications problems are exacerbated by the verticality of terrain in large modern cities. Even single-digit story buildings create line of sight issues that are difficult to manage.<sup>28</sup> As global population migrates to cities housing infrastructure will continue to develop vertically to meet demand. This complicates command and control if robust communications architecture is not in place. Survivability and weaponeering will also be affected by vertical terrain in megacities. These difficulties require creative solutions to managing airspace. Commanders will be forced to accept elevated risk to aircraft and crews unless solutions are implemented.

With the multitude of varying manned and unmanned aircraft in the airspace supporting joint operations, integration and deconfliction have become highly complex endeavors. Future operations in cities will show that this is especially true for urban operations. Airspace management, control of aircraft and air delivered ordnance, and deconfliction requirements have seen some creative solutions in the past. Further development of solutions to these challenges will be required for each unique situation for success in a megacity environment.

## *Survivability*

Ever since air power has been a means to conduct warfare, many ways to counter it have been fielded. Air superiority, another condition for effective CAS, becomes increasingly difficult in urban combat due to the available cover and concealment of surface to air threats. In this case the relatively compact airspace over cities compared to open battlefields could simplify isolation of the airspace from air to air threats. But, air operations in megacities in support of ground maneuver will be increasingly threatened by simple and easy to conceal surface to air weapons. Dense population, connectivity, and urban sprawl of megacities will simplify targeting by threats armed with highly these proliferated systems.

Aircrew providing CAS focus primarily on two things, friendly situation and the enemy that supported friendlies are engaged with. This is why air superiority is important, CAS aircraft rely on mitigated threat, aircraft countermeasures, and tactics to be able to focus attention on their task. The urban environment complicates this due to the difficulty in identifying friendly and enemy locations. Current doctrine discusses this difficulty, and appreciates that CAS aircrews may have to get closer to the ground engagement in order to sort friend from enemy. One solution for this problem is to minimize the time that aircraft are vulnerable with pre-mission planning and use of sanctuary air space.<sup>29</sup> This method, however, assumes that there are known threat locations. The urban environment coupled with proliferation of small man-portable anti-air weapons makes this a difficult assumption to accept. Maintaining standoff until needed, similar to Fallujah, is an effective tactic in urban combat for not only airspace deconfliction but threat avoidance. JP 3-09.3 CAS recommends using FW marking capability for precision ordnance delivered by RW assets in a “relatively safe battle position,” in this instance RW attack aircraft would not need to leave sanctuary.<sup>30</sup> The geography of a megacity gives this tactic its

first challenge, as response time and weapons effectiveness, discussed in detail later, will be minimized by a larger city. Additionally, if friendly forces such as a special operations team are operating within a city, larger cities may give an adversary the ability to deny access to the airspace needed to provide these forces CAS.

Population density and connectivity of a megacity also contribute to the ability to exploit the urban environment and threaten aircraft. Recent wars show the ease with which non-state insurgent and terrorist organizations blend in with populations of occupied areas. The attacks of Mumbai give an example of the ease a small force with common technology has in exploiting dense connected cities. The same factors benefit air defense operations as well. First, using population and infrastructure as a cover for actions will allow more freedom of movement in a megacity. Close air support aircraft, especially RW, will be the most affected as much of their time in the CAS role is spent in holding areas or battle positions and less in transit. Maintaining position over one area for extended periods of time or establishing patterns increases the risk in any contested airspace, especially urban. Integration with the population also complicates positive identification of enemy targets and increases the possibility of friendly fire, either delaying or preventing an opportunity to engage an enemy in direct contact with friendly forces. Density and connectivity two important characteristics of megacities that require consideration regarding survivability and asset preservation.

Instant communication provided by the internet, which is increasingly proving to be resilient technology, will also complicate the survivability of aircraft in support of ground troops. Similar to the use of cellular phone and handheld radio technology, it provides a simple means to pass information about the whereabouts of any air platform supporting an urban fight. For CAS aircraft this means that unless there is a capability to deny enemy use of this widespread

technology, the element of surprise will be more difficult to achieve. Cellular phone and handheld radio are relatively easy to deny or exploit.<sup>31</sup> As a city grows in geography and population, internet connectivity will become very difficult to deny, giving a defending force a simple cueing method for the approach of attacking aircraft. Using this in conjunction with the concealment provided by urban infrastructure and population will allow defenders to engage aircraft from difficult to detect locations with smaller caliber and man-portable weapons. Joint doctrine discusses this capability and the advantages of three different types of isolation in urban warfare, information isolation being relevant in this case. This involves controlling information flow in and out of the urban area, including denial of service.<sup>32</sup> Information isolation would also need to include management of cyber space for protection of air assets. Communications infrastructure of a megacity and simplicity would make internet denial a difficult endeavor. Additionally, a joint force may or may not prefer to deny this capability for operational and strategic reasons. Negative results of denying civilians established forms of communication may outweigh the benefits of having it available for exploitation to a commander. The 2006 Mumbai attacks show adept use of open source information and social media in combination with a flat command structure.<sup>33</sup> Networks may have to be allowed to remain in order to gather intelligence from this kind of command and control and support information operations.<sup>34</sup> If so, a commander would have to accept risk to aircraft to support the information campaign. Due to these factors, cyber operations need to account for the ability to manage threat networks and provide freedom of movement to CAS aircraft.

The physical landscape of urban terrain also complicates current tactics used to mitigate threats to attacking aircraft. Tactics used to counter threats in open battlefield combine the use of altitude, onboard countermeasures, and the environment by either night flight or terrain

masking. While this basic combination does not change over a city, application becomes increasingly complicated due to the varying heights of manmade structures and ability to mask threats among the infrastructure. Depending on the threat and its known or possible location, aircrew will fly profiles designed to mitigate these advantages, but beginning with altitude these profiles will be challenged by the landscape.

Altitude is also used to minimize the exposure time of CAS aircraft to varying threats. Depending on the method of tracking an aircraft and range of the weapon, different altitudes above ground level (AGL) are used to deny an attacker the ability to target an aircraft successfully.<sup>††</sup> The difficulty caused by urban operations<sup>††</sup> is that a modern city with multiple high rise buildings or a well-developed “downtown” will require drastic changes in altitude to meet the recommendations. During a flight with the New York Police Department Aviation Unit, large altitude change was necessary for transit from a housing area over Brooklyn to downtown Manhattan. Similar to a rotary wing CAS aircraft, large manmade structures required near-overhead observation in order to support officers on the street level, mitigating any standoff capability provided by on board sensors.<sup>35</sup> Altitudes commensurate with effective mitigation of threat are difficult to maintain in urban areas with built up terrain. Typical mitigation measures are challenged with the potential of threats originating from multi-story buildings and will need to be addressed for safe and effective operation. One tactic effectively used by IAF RW aircraft over Lebanon was to fly above 5,000 feet AGL due to advanced Man Portable Air Defense System (MANPADS) threats available to Hezbollah, a different approach than what is accepted in many modern militaries. Effectiveness of this tactic cannot be proved as there is no existing data of attempted MANPADS use over Lebanon, but the only RW aircraft downed due to enemy

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<sup>††</sup> For example, ANTTTP 3-22.3 AH-1 Combat Aircraft Fundamentals recommends different altitudes to defeat small caliber ballistic rifles than it does for Man Portable Air Defense Systems. See Air NTTTP 3-22.3 *COMBAT AIRCRAFT FUNDAMENTALS-AH-1*. March, 2013. I-15, 16.

fire in the 2006 war was an assault support helicopter at low level during takeoff that was hit by an anti-tank missile.<sup>36</sup> Further, this tactic would expose RW aircraft to more sophisticated radar guided missile threats, which Hezbollah did not have at its disposal. Threats originating from the varied landscape of a megacity that provides easy transport and masking will require creative measures such as this to mitigate. Tactical use of altitude will require even more creative solutions due to the variation in vertical terrain posed by a large urban area.

Night flight is another common tactic used to limit the ability to acquire and engage an aircraft. Radar guided threat weapons are not affected by night flight, but MANPADS and ballistic weapons from small arms to heavy artillery require the ability to visually acquire targets. Limitations on night vision devices (NVD) provide another challenge that a megacity will complicate.<sup>‡‡</sup> With the abundance of manmade light a heavily built up area floods these devices significantly impacting visual navigation, collision avoidance, and threat or target detection. While modern aircraft have the ability to navigate on instruments only and some coordinate-guided ordnance allows engagement without visual acquisition or through weather, CAS in urban terrain calls for heavier reliance on visual acquisition of targets and friendly forces to ensure accuracy. Some acquisition is done with the latter type of onboard sensor, but heavy manmade lighting in an urban area makes use of ambient light magnifying NVDs extremely difficult.<sup>37</sup> In an urban area such as a megacity, risk to aircraft relying on helmet-mounted NVDs to navigate, target, and identify friendly forces may prove prohibitive and outweigh the advantages. Onboard sensors will be discussed further with weaponizing, but challenges

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<sup>‡‡</sup> Night Vision Devices are generally broken into two types, those that magnify ambient light to provide a scene not visible by the naked eye and those that detect thermal emission and create a scene based on thermal variation. Devices worn by aircrew for navigation and some targeting sensors are the former. By magnifying ambient light, they provide a scene to aircrew. See Marine Aviation Weapons and Tactics Squadron One, *MAWTS-1 Night Vision Device (NVD) Manual, 9<sup>th</sup> Edition* (Yuma, AZ: U.S. Marine Corps, 14 January 2011), Chapter 1.

associated with the terrain of a large urban area must be addressed for CAS aircraft to be effective support for ground maneuver.

### *Collateral Damage*

Collateral damage is an unfortunate consequence of warfare that has to be addressed at every level. From strategic to tactical operations, the impact on a conflict must be understood to not only minimize the amount of civilian casualties and damaged property or infrastructure, but prevent negative reaction that could cause strategic failure. For the purposes of this paper collateral damage includes both civilian casualties and physical destruction. The Law of War (LOW) states that “anticipated civilian or noncombatant injury or loss of life and damage to civilian or noncombatant property incidental to attacks must not be excessive in relation to the expected military advantage to be gained.”<sup>38</sup> Urban combat among densely populated areas have the potential to be the most damaging to civilians and infrastructure. Concern for collateral damage has become paramount in recent wars due to the sensitivity of harm to civilians.<sup>§§</sup> Collateral damage concerns affect every condition for effective CAS, from effective training to appropriate ordnance. Close air support planning and execution will have to weigh the negative consequences with benefits to an operation, and the megacity will be the most difficult of these operations to plan and execute.

Sensitivity to collateral damage has a two-fold impact on warfare. It has driven innovation in ordnance technology to provide the precision seen on the battlefield today, and restraint in the form of tactics to mitigate collateral damage. However, sensitivity to collateral damage is also used as a tool in conflict. Terrorism, use of human shields, and occupation of

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<sup>§§</sup> A recent example of the sensitivity of collateral damage was the 2009 issuance of the *Tactical Directive* to all of the International Security Assistance Force (ISAF) in Afghanistan that outlined the restraint to be used by ISAF forces when targeting insurgents in the vicinity of civilians. The *Tactical Directive* not only discusses the legal and moral impacts to civilian casualties, but the strategic impacts. See Headquarters International Security Assistance Force, *Tactical Directive*. Kabul, Afghanistan, 2009.

protected or sensitive civilian structures are all examples of disregard for the law of war seen in modern urban areas.<sup>39</sup> Further, modern communication technology has given combatants considerable means to propagate these methods. While they are also possible in open battlefields, heavy population and infrastructure make urban environments ideal locations to exploit technological disadvantage and sensitivity to collateral damage.

Given the possibility of civilian casualties and damage to infrastructure in urban operations, every doctrinal publication in this domain discusses collateral damage. JP 3-09 specifically states that “analysis of potential collateral and environmental damage must be weighed against the importance of the target in achieving operational and strategic objectives.” In regards to aviation operations, MCRP 3-35.3A AUO devotes three pages to collateral damage, fratricide, and rules of engagement. MCRP 3-16.6A JFIRE: Multi-Service Tactics, Techniques, and Procedures for The Joint Application of Firepower gives an introduction to the methodology used for collateral damage estimation (CDE) and JP 3-09.3 CAS also discusses the negative operational and strategic affects.<sup>40</sup> The importance of understanding the possibility for collateral damage and ways to mitigate are only magnified in urban combat and thoroughly discussed in current doctrine.

In regard to collateral damage, megacities will complicate every effort to provide fire support to maneuver and CAS is no exception. Dense population and the existence of sensitive infrastructure among these large cities will force commanders to weigh the benefits of providing air-delivered ordnance with the negative operational and strategic impacts. Modern technology and restraint in the form of rules of engagement endeavor to reduce the danger to civilians and structures, but urban operations continue to be the most destructive. For example, IDF operations in Gaza have been scrutinized by the international community despite thorough

targeting procedures and the exclusive use of precision weaponry in heavily populated areas.<sup>41</sup>

In many ways regarding fire support a megacity is no different than a city of five million or even a few thousand. In others it is much different. Fire support in a megacity can impact more than those in the immediate area due to complexity and interconnectedness of the population and infrastructure. Consider destroying a power generating station or wastewater treatment plant in a highly connected city of more than ten million inhabitants. While these may be deemed valid military targets for a multitude of reasons, impacts on the population could cause anything from mass migration in a war zone to rapid spread of disease.

Resiliency of megacities must also be considered prior to operation. The 2014 U.S. Army study on megacities suggests that resiliency of a city is directly related to the level of integration, that a highly integrated city will be more resilient to the damaging effects of military operation. This idea suggests that a resilient city will be able to recover from the impacts of military action on infrastructure and the population.<sup>42</sup> This may not be true in a megacity. Damage of certain key infrastructure could cause considerably more challenges to the population of a highly interconnected modern city than one that is loosely connected and does not completely rely on essential services. Destruction of a wastewater treatment plant in New York City may have a larger impact than in a less reliant city. It is possible that less of the population would be affected by loss of services if there was already little organized service prior to an operation. Due to the reactive and time sensitive nature of CAS, considerably less time is available to determine the effect of ordnance employment on infrastructure along with the possibility of civilian casualties. Megacity operations will magnify this difficulty and put aircrew and supported maneuver at greater risk of causing unforeseen damage.

Joint collateral damage methodology (CDM) exists to assist commanders in the determination of whether or not to engage a target. It “encompasses the joint standards, methods, techniques, and processes for a commander to conduct CDE and mitigate unintended or incidental damage or injury to civilian or noncombatant persons or property or the environment.”<sup>43</sup> This methodology is necessary in all battlefields to assist in the negative impacts of collateral damage. In the urban environment it is especially necessary, but time-sensitive CAS situations will rarely allow for the full assessment of a situation due to threat to aircraft and short engagement windows. Additionally, comprehensive effects of ordnance employment cannot be predicted given the amount of variables in a city. Due to this, a commander is forced to make tactical decisions that could have strategic implications in a compressed time window. The megacity will challenge traditional use of the CDM by presenting the most complex of situations with fleeting opportunities to respond to them. Due to the uniqueness of each megacity, these densely populated and built up areas will require considerable focus in regard to the impact of collateral damage on an operation in the future.

### *Weaponneering*

Weaponneering in urban warfare is different than that of an open battlefield, and while current weapons and tactics are optimized for use in cities the megacity will challenge them further. Weaponneering is the method for determining which weapon or weapons are best matched to a target, as one of the conditions for effective CAS is appropriate ordnance. Defined as “the process of determining the quantity of a specific type of lethal or nonlethal means required to create a desired effect on a given target,” weaponneering is combined with CDM and law of war rules for proportionality to engage a target and minimize collateral damage when necessary.<sup>44</sup> It considers desired effects, target vulnerability, accuracy, damage criteria, and

reliability to determine the best weapon for a target or series of targets.<sup>45</sup> In order to effectively engage a target, minimize collateral damage, and meet the requirements of the LOW in the urban environment, effects and effectiveness of weapons to be used must be scrutinized heavily. Also, positive identification of a valid military target and correlation between the requesting maneuver forces and attacking aircraft must be achieved. Modern weaponry, sensor equipment, integration development, and innovative use of available battlefield systems have developed to accomplish this. The megacity will challenge these methods and require further development and innovation. Traditional uses of available weapons are sometimes modified to meet these challenges, such as changes in trajectory of artillery. Tactics designed around the capability of current weapons and long range sensing capability of air platforms are also used but will be challenged due to the size and buildup of a megacity. Even weapons currently being fielded that are designed for longer range, higher accuracy, and low explosive yield may not fully address the complexity of employment in this environment. Until innovative solutions are generated for the modern urban fight, weaponeering will be another challenge associated with operations in a megacity.

Fire support available to the commander today includes a multitude of surface to surface and air to surface munitions. Surface to surface weapons include a host of small mortars to artillery and rockets, some of which are precision guided. Limitations to these weapons in the urban environment are their range and top-down only method of hitting a target. Some solutions are available. Rocket artillery is longer range than conventional tube artillery, combined with precision capability it is an effective weapon in the urban environment as long as the target allows for an indirect trajectory.<sup>46</sup> Another solution is to use artillery as a direct-fire weapon, similar to the use of a tank main-gun. This method reduces the range of the weapon, requiring

the weapon to be close enough to fire directly on the target. It is appropriate given there is an ability to place the weapon in line of sight with the target.<sup>47</sup> Surface to surface fire can be an effective form of fire support to a maneuver element, but urban operations complicate conventional means of using mortars, artillery, and rockets.

Air delivered weapons are similar in the sense that there are generally multiple options available. A host of ordnance types exist for support of ground operations, but collateral damage and survivability are among the concerns in a megacity that will limit even the precision afforded by many weapons. In fact, smaller crew served and cannon direct-fire weapons could be the appropriate ordnance in situations where a precision-guided bomb may cause extensive collateral damage or be unable to achieve the desired effects in a built up area.<sup>48</sup> Israeli Defense Force operations in Gaza further display that precision is supportive to collateral damage concerns, but not the solution. Precision guided rockets and missiles also provide a direct-fire capability that is optimal for urban use, but the size of a megacity will limit the standoff capability provided by many of these weapons. Outside of a few available and planned weapons, even the most modern weapons of this type will require CAS aircrew to be exposed to threats in a large city when the target is not near the periphery. Further, standoff with RW CAS aircraft denies the utility of these platforms in observation of friendly and enemy movement, possibly complicating and slowing the engagement. Benefits of RW platforms come from their ability to perform a number of duties and stay close to the friendly forces, but the threat posed by an integrated and heavily populated large city will put them at elevated risk. The catalog of air-delivered ordnance available to a commander is extensive, but these options will quickly be reduced in a heavily built up and populated environment provided by the megacity due to collateral damage and survivability concerns.

Two examples of weapons planned for future availability show that capability can provide necessary standoff, precision, and low yield in some weapons but still lack in others. The GBU 53/B Small Diameter Bomb Increment II (SDB II) is planned to be used by FW and unmanned aircraft. Designed for low explosive yield and standoff, more than forty nautical mile range, and the capability to utilize multiple targeting modes, it will provide an effective option for use in an urban environment.<sup>49</sup> One adverse effect of the standoff of this weapon is the longer time of flight due to its range capability, making it possible for circumstances to change in the target area during flight. Two way communication with the delivery aircraft or other parties in a closed communication system will allow for in flight abort in this instance. This weapon will give the commander with FW support the potential to engage targets without exposing aircraft to short-range threats and multiple avenues to abort when collateral damage becomes an issue during flight of the weapon.<sup>50</sup> The next weapon also provides extended range and multiple targeting modes, but does not give the range benefit of the SDB II. The Joint Air to Ground Missile (JAGM) is the planned replacement for the AGM-114 Hellfire missile widely used today. Initially planned to be available to RW and unmanned platforms, JAGM will eventually have double the range of the Hellfire and be available to FW platforms. This range is quite short compared with the SDB II with up to sixteen kilometers (over eight nautical miles) maximum range at later stages of development.<sup>51</sup> This extended range will give the aircraft and ground commander more flexibility than currently available and more use of onboard sensors that provide target acquisition at long range. The geographic size of a megacity will still challenge this capability and the utility of close-in RW support will be negated by the extended range. Finally, limitations to both of these weapons will continue be evident in the dense urban environment of the megacity. These are two examples of future capability provided by

technology that will increase options but not necessarily solve the challenge of weaponeering for CAS in a megacity. Commanders will be required to consider collateral damage and survivability when weaponeering against a target, and these considerations will limit even future capability.

## **Conclusion**

Trends in urbanization of global population show that as the population of the world grows it will continue to migrate to cities. With this migration likely threats to security will increasingly originate from the cities as this environment provides support and freedom of movement for threat groups. The megacity, a city of ten million plus, provides a favorable environment for these threats to create conflict that will have to be addressed with military force. Increasing numbers of megacities, from 28 in 2014 to over 40 by 2030, make understanding of this environment and the difficulties associated with military operations within it necessary. All facets of military operations in this environment will be challenged, including application of air power, and are worthy of further study and understanding for future success.

Current doctrine and tactical publications that address air operations in the urban environment have been regularly updated to include lessons learned and best practices gleaned from recent operations. Joint doctrine addresses the challenges posed by the complexities of the urban environment and operations within it. Tactical publications further apply recent lessons to provide meaningful and effective means of applying air power within a city. These documents are the foundation necessary for addressing these complex operations. With the rising potential for conflict in a megacity, understanding of this environment will be a necessary addition to these publications. Air operations, and especially CAS, will be challenged beyond what is

addressed and further innovation in the application of urban CAS is necessary to be prepared for future conflict.

In preparation for an operation in a megacity, a commander must consider an array of issues in regards to close air support. There is no single answer to the challenges that will be encountered in a megacity. Each operation will be unique and require solutions tailored to individual urban areas. The first issue to solve will be management and control of restrictive airspace occupied by multiple platforms. Large numbers of friendly ground forces may require prohibitive numbers of aircraft, and civilian airspace infrastructure may need to remain in place to support such a large population. Next, a commander will have to weigh the risk to aircraft and crew of operating in a dense urban area where survivability is challenged by threats with weapons that are easy to move and conceal. The possibility for collateral damage will also increase, affecting tactical through strategic goals and decisions that need to be made for them. Finally, commanders on the ground will be required to make rapid decisions regarding weaponeering which will be complicated due to the large geographic and infrastructure difficulties of the megacity. These challenges are likely not inclusive, and additional issues will rise during an operation. Doctrine for urban operations is purposely vague to allow for flexibility in solving these problems. Each city will present unique variations of these challenges and require individual solutions. Tactical publications also provide best-practices that can be built upon. They give a foundation for planning and execution that, with consideration of the unique challenges of a megacity, will contribute to the success of an urban operation.

Means of addressing these challenges will vary from city to city, but some basic recommendations can be made to better prepare a joint force prior to this type of operation. First, acceptable levels of collateral damage will have to be established. The counterinsurgency

standard for civilian casualties will not be possible in a megacity. Intelligence support for CAS operations will need to include known and predicted threat locations based on urban terrain and enemy capabilities. This will require fusion of urban structural data with threat weapon capabilities. Cyber operations can also be used with the digitally interoperable capabilities of aircraft to maintain situational awareness, pass real time information, and counter enemy cueing capability. Solutions to other challenges not associated with CAS may also be available. Aircraft typically used for CAS can be used in non-traditional roles in this environment, such as crowd control or infrastructure monitoring.<sup>52</sup> Finally, training must include the multitude of scenarios and solutions to these challenges. Current training capability does not allow for full understanding, but use of simulators and training for ground force commanders can overcome many shortfalls.

Close air support will be integral to any operation in the large, interconnected, densely populated terrain of a megacity. Much of the challenges a military will face in this environment are unique and justify continued innovation and preparation. Failure to address these challenges will result in elevated risk to an operation from strategic to tactical levels. The decentralized nature of urban conflict will also require this risk to be delegated to the lowest levels for success, further emphasizing the need for a full understanding of the megacity. In order to be prepared for future conflict in this challenging environment, continued thought and preparation is necessary.

## **Appendix A**

### *Evolution of Close Air Support and Urban Doctrine*

Application of air power in warfare has evolved considerably since early use in the beginning of the 20<sup>th</sup> Century, becoming an integral part of every major conflict that evolves with technology and understanding of its capability. Close Air Support is but one function of air power that belligerents apply in support of objectives but today it has become a highly detailed operation in itself. Urban CAS is no exception and the study of its application becomes ever more important as the population of the world migrates to cities. Joint doctrine for the application of air power in warfare continually updates to meet emerging challenges and integrate new technology. A study of air power history and knowledge of current doctrine will provide a sound foundation in the endeavor to understand and solve the complex problems faced by air operations in a megacity.

Use of air power varied considerably across conflicts and services throughout the 20<sup>th</sup> Century, beginning with World War I.<sup>53</sup> By World War II CAS had proven its utility and both the German and Allied forces employed it with success. War in Vietnam saw the first use of RW attack aircraft in a CAS role, used by U.S. Marine Corps and Army units throughout South Vietnam. Following Vietnam, the USAF A-10 Thunderbolt II jet aircraft assisted in a full acceptance of the need for joint CAS procedures.<sup>54</sup> Modern CAS techniques developed through Desert Storm and have been refined into what they are today through lessons learned in Iraq and Afghanistan.

Current urban CAS doctrine is a reflection of lessons learned dating back as early as World War II, but complexity in its employment and lack of technology prevented extensive use until nearly the turn of the 21st Century. Battles for cities like Seoul, Hue City, and Khafji,

however, gave valuable insight to the fledgling understanding of urban CAS. Khafji, a successful effort by American and coalition air forces in support of Saudi and Qatari forces prior to Desert Storm, displayed the capabilities of a technologically modern air effort against large tank formations. It also gave an early indication of friendly fire and collateral damage challenges that CAS doctrine would have to address before the next major conflict. Russian operations in Grozny just a few years later further highlighted how challenging urban operations can be. Civilian casualties, friendly fire incidents, and destruction of the city combined in the failure of Russian strategic objectives and war crimes accusations even though tactically the Russian military was able to take the city.<sup>55</sup> As valuable as these lessons are, none of the examples available today provide a full understanding of the challenges of CAS in a megacity.

Joint air doctrine before and after Operations Enduring Freedom and Iraqi Freedom show how more than a decade of war further developed CAS doctrine to what it is today. Multiple tactics, techniques, and procedures emerged in the latest versions of doctrine that show the innovation that took place during these wars. As technology and tactics evolved to meet the challenges of counterinsurgency, much of the application of air power in urban environments had to be revisited. During these wars, destroying much of a city and causing heavy civilian casualties were unacceptable courses of action. Along with solutions to limitations on collateral damage, aviation planners tackled difficult airspace management problems over the cities of Iraq and Afghanistan. One example of this was the development of “Keyhole CAS,” a method of expediting CAS to a target and maintaining deconfliction within congested airspace. In contrast to CAS support in WWII or Korea, today's CAS operations can include any combination of Unmanned Aerial Vehicles (UAV's), FW gunships and jet aircraft, command and control platforms, and RW attack aircraft. Keyhole CAS began as a concept by USAF controllers in

Afghanistan and was notably used as a primary form of control of aircraft during the Battle of Fallujah in 2004.<sup>56</sup> This battle was also an example of the importance of limiting collateral damage, with the intent to allow Iraqi civilians to move back into their homes shortly after insurgent forces had been defeated and removed from the city. While much of Fallujah was damaged in the fighting, restraint by U.S. commanders kept the city from becoming another Grozny. What Kilcullen describes as “urbicide,” or killing a city, will no longer be viable for joint operations.<sup>57</sup> Shortly after the battle Iraqi civilians were allowed to return and begin rebuilding what had been damaged.<sup>58</sup> While these operations were shaping U.S. joint doctrine on air warfare, Israeli operations in the last decade provide a recent insight into the challenges facing a modern military attempting to conduct operations in a megacity-like environment.

## **Appendix B**

### *The Israeli Defense Force operations in Lebanon and the Gaza Strip*

Over the course of three major conflicts between 2006 and 2014, operations conducted by the IDF in Lebanon and more importantly the Gaza strip give important insight into some of the challenges facing a modern military conducting air operations in an urban environment in support of ground maneuver. During Israel's 34 day operation in Lebanon in 2006, which relied heavily on air power, the IDF became aware of deficiencies in its CAS doctrine and was able to make considerable changes in regard to the use of IAF assets in support of ground units and overall objectives. Following this, two separate operations in 2008-2009 and 2014 in the Gaza Strip to counter rocket firings by Hamas and other terrorist groups display the improvements made within IDF doctrine to application of CAS in a densely populated urban landscape. These operations, however, were not conducted without difficulty. While Gaza City does not meet the definition of a megacity, population density, infrastructure, and the presence of a large threat group combine to make it a worthy case study in the application of air power in support of ground forces in urban combat.

On July 12th, 2006, a Hezbollah raid into Northern Israel during which they kidnapped two soldiers ultimately led Israel to launch a series of airstrikes against Hezbollah targets in Lebanon. Operation Change of Direction became the thirty-four day campaign conducted in response to this kidnapping.<sup>59</sup> While many objectives of this operation were never met and it was primarily conducted in less densely populated southern Lebanon, it provides a sound understanding of the changes made to the IDF and IAF relationship prior to actions in Gaza in 2008-2009.

Operation Change of Direction began as an attempt to achieve political and military objectives with a preponderance of air power, a standoff offensive. Due to opposition towards a ground campaign after the 18 year occupation of Lebanon until 2000, Israeli leadership was initially reluctant to conduct a ground offensive and decided to launch a combination of artillery, rocket, and air strikes. Not only targeting Hezbollah, its leadership, and arsenal of unguided surface to surface rockets, the IAF went after Lebanese infrastructure as part of an attempt to galvanize the Lebanese government into action against Hezbollah. The air campaign was tactically successful in many respects, IAF strikes came early and often on dozens of targets throughout Lebanon with high accuracy rates and an impressive use of emerging technology to network the aircraft, providing much needed deconfliction in a congested airspace. The IAF was also able to minimize civilian casualties to levels well below what was predicted, attack Lebanese infrastructure with little resistance, and mitigate loss of aircraft due to strict adherence to airspace procedures and attention to the surface to air threat. Unfortunately, for all of its tactical success the operation was unable to eliminate the rocket threat and provoked a massive response of short and medium range rockets on civilian targets in Israel. Major ground operations did not begin until almost a month after the beginning of the operation to drive Hezbollah from southern Lebanon and remove the threat to northern Israel. At this point all CAS support was purely reactive and ordnance delivery during danger close situations had to be approved at the highest levels of IDF leadership. Historically, IAF doctrine was purely strategic bombing and interdiction, not until recently had CAS even become accepted within IDF leadership. Lack of doctrine development over the history of IDF made many in the leadership hesitant to employ CAS especially in urban areas of Lebanon. This lack of knowledge and acceptance became apparent as soon as Israeli army units needed CAS. A cease-fire ended the

combat operations on August 14 and the IDF and IAF immediately began correcting deficiencies learned from these shortcomings on the battlefield. Political mistakes aside, a drastic change in IAF command and control and its relationship with the Israeli Army were required, including controlling and providing CAS.<sup>60</sup>

Realization of the lack of coordination between the IAF and Israeli army resulted in major improvements by the time the IAF began its air operation in Gaza in December 2008. In this instance, Operation Cast Lead was launched to counter increased rocket attacks from Gaza in the two years since Hamas came in power. On December 27th the IAF began an eight day shaping operation prior to a January 3 ground offensive with four brigades of ground troops. Once the ground offensive began, IAF priorities shifted from purely interdiction to an emphasis on CAS with continued pressure on targets beyond the front line. This doctrinal shift from the way the IAF operated in Lebanon two years prior was successful in providing ground forces the maximum amount of fire support possible in the condensed airspace above Gaza. Fixed wing CAS support, almost nonexistent in Lebanon, was provided throughout the operation. Rotary wing attack aircraft were placed in direct support of maneuver units on the ground vice the purely reactive CAS role they played in Lebanon and approval to engage in danger close situations was delegated to the lowest levels. Hamas' lack of anti-air assets compared to Hezbollah also allowed a level of air superiority not previously seen, giving aircraft more freedom to provide support. Due to the doctrinal changes implemented by the IAF in the interim between these two wars, improvements in support and coordination were readily apparent in Gaza.<sup>61</sup>

Operating in a densely populated built-up area like the Gaza Strip proved to be challenging, however, despite the advances made prior to December 2008. Gaza is a narrow

strip of land consisting of four major population centers and an overall density of more than five times that of Los Angeles.<sup>62</sup> Civilian casualties occurred even though the IDF placed an even heavier emphasis on minimizing collateral damage than the 2006 Lebanon war.<sup>63</sup> As indications to the sensitive nature of incurring civilian casualties, the IDF made thousands of phone calls to civilians warning them of air attacks on individual residences and dropped millions of leaflets encouraging civilians to vacate areas occupied by Hamas fighters and equipment.<sup>64</sup> Despite the massive information campaign to warn civilians of the danger, civilian casualties still had an obvious effect on the negative public narrative that Israeli leadership fought to counter after the war as allegations of war crimes surfaced. Dense built up areas also created difficult situations for IAF planners and aircrew to manage as Hamas routinely occupied critical infrastructure such as schools and hospitals inside population centers.<sup>65</sup> While many of the strikes on infrastructure were conducted separately from the ground campaign, much of the threat to maneuver units on the ground originated from illegally occupied civilian structures giving ground commanders and aircrew complex decisions that would affect the strategic narrative. Infrastructure in Gaza city and other built up areas also proved daunting, many areas holding densely packed high-rises that made observation and target acquisition near impossible if a target was not on the roof or in the street. Also, while the operational objective of stopping rocket attacks from Gaza into southern Israel was met periodically, it did not stop permanently. Due to the dense urban buildup and extensive subterranean system that was unsuccessfully targeted by IAF and ground forces, Hamas was never without the capability to launch rockets.<sup>66</sup> In a relatively brief air offensive in 2012 and much larger operation in 2014 the IDF re-entered Gaza with similar objectives- removing a growing rocket threat and shutting down smuggling tunnels and only caused more destruction of urban infrastructure and civilian casualties. Heavily built up urban areas proved to

give freedom of maneuver to a less technologically equipped adversary and complicate targeting without mass civilian casualties and infrastructure destruction. Even the exclusive use of Precision Guided Munitions (PGMs) in the heavily populated Gaza cities was not successful in minimizing destruction and collateral damage to levels acceptable in today's public narrative.<sup>67</sup> Additionally, by 2008 widespread use of the internet made the public information and media campaign considerably more difficult for Israeli leadership to manage. Every citizen and media outlet inside Gaza had the ability to broadcast data about incidents almost instantly after occurrence, prompting the need for a major social media effort by Israeli leadership.<sup>68</sup>

A series of kidnapping and murder of both Palestinian and Israeli teenagers in June 2014 sparked the most recent major conflict which led to the largest invasion and destruction of Gaza since the conflict between Israel and its regional adversaries began. The IDF again responded by shaping the battle with airstrikes followed by a ground offensive. This most recent iteration of the conflict further amplified the difficulty in conducting operation in a densely populated and developed urban environment. In an attempt to decrease popular support for Hamas within Gaza the IDF increased use of air strikes against infrastructure and housing developments. These strikes all but eliminated basic essential services such as electricity and water and even reduced multiple high-rise buildings to rubble. Civilian casualties due to the fighting also nearly doubled that of the 2008-2009 offensive further calling into question the effectiveness of heavy air power in an urban environment.<sup>69</sup> Israel believed this was the proper course of action despite the obvious negative reaction that would come from such a large and destructive campaign and possessing a larger more technologically advanced army. Ceasefire in late August ended the hostility, but multiple media reports call its effectiveness into question as threat organizations continue to prepare for future conflict.

Israeli operations in Lebanon and Gaza over the last decade provide insight in the application of airpower against a determined enemy among dense urban infrastructure and population. After operation Change of Direction in Lebanon, IAF innovation optimized command and control, utilization of attack aircraft, and employment of precision-guided ordnance during the subsequent operations in the Gaza Strip. But, these operations prove that challenges due to the environment are wide-ranging and require further understanding and refinement of tactics to meet them. Even though Gaza does not meet the definition of a megacity, it is important to understand these challenges to prepare for future urban conflict.

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<sup>8</sup> United Nations, "World Urbanization Prospects: the 2014 Revision," 9.

<sup>9</sup> David Kilcullen, *Out of the Mountains: The Coming Age of the Urban Guerilla*, 35-36.

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<sup>16</sup> Captain Scott Destafney (AH-1W Pilot), interview with the author, February 2015.

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<sup>18</sup> Joint Chiefs of Staff, *Joint Close Air Support*. 1-2.

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