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MASTER OF MILITARY STUDIES

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**TITLE:**

**To Win in the Mega-City: What the Marine Corps Must Understand to Achieve Mounted  
Mobility in the Mega-City**

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

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## Executive Summary

### **Title: To Win in the Mega-City: What the Marine Corps Must Understand to Achieve Mounted Mobility in the Mega-City**

**Author:** Major John S. Kinitz, United States Marine Corps

**Thesis:** To counter the complexities presented by the mega-city, the USMC must balance its ground vehicle portfolio. The USMC must develop combat vehicles capable of being operated both remotely or while crewed with capabilities to negotiate complex terrain for successful operations within a mega-city.

**Discussion:** Mounted mobility is a requirement that creates synergy between both mounted and dismounted units for the Ground Combat Element (GCE) to operate across the Range Of Military Operations (ROMO). The mega-city compounds the issue of traditional mounted mobility, and the Marine Corps must balance its ground vehicle portfolio by developing autonomous, remotely controlled vehicles and leverage commercial off-the-shelf technology to create an autonomous option to augment manned vehicles currently fielded. The GCE must be equipped to operate in any of the '3 Blocks' of war. Looking forward to predict future operating environments, the Marine Corps anticipates having to operate in the 'mega-city'-a complex, 3D environment often found near coasts that presents unique mobility, C2 and survivability challenges. The USMC must be postured to operate with the required mobility to support GCE operations. From their inception of use in World War I, combat vehicles have added three immeasurable effects on the battlefield: speed, mobility, and firepower. As technology improved over the decades since World War I, combat vehicles evolved to provide the means to apply precision fires, enhanced command and control capability, and survivability. There are numerous models and variant of combat vehicles that each provide capabilities that allow the GCE to accomplish its mission while employing combined arms. Each model of combat vehicle serves a primary mission with overlap into other areas. For example, an AMTRAC's primary role is troop transport, but it also provides command and control capability with its power amplified radios and direct fire support from its heavy machine guns. The M1A1 tank provides precision direct fires and its crew tremendous survivability, and has a significant physiological effect on enemy forces. The environment created by the mega-city will further magnify all combat vehicles' weaknesses.

**Conclusion:** Emerging technologies must be applied to existing combat vehicles to experiment and understand how technology can compliment existing tactics to achieve mounted mobility in future operations in mega-cities. The US military has a significant breadth of historical experience operating in urban environments with combat vehicles, and has the doctrine and leadership to be successful operating in mega-cities. The USMC must be forward thinking with its future concepts for combat vehicle designs now that will replace aging combat vehicles in the 2030s and beyond. Future concepts for combat vehicles must incorporate a balanced table of equipment for unmanned ground combat vehicles and CRS, crewed combat vehicles that have the capability to be operated remotely to reduce risk to the force. Effectively incorporating advances in sensing, disrupting, and weapons technologies will allow a mounted force to achieve mission success in a mega-city.

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## *Preface*

After four combat deployments with LAR battalions, mounted maneuver is an important topic to me. Having operated in urban, mountainous, desert, and 'green-zone' terrain in both Iraq and Afghanistan, the USMC must posture itself for future fights in any contested environment. As the warfighters of today, we anticipate where we will fight changing in the future. We now must examine what requirements will drive capabilities needed in our combat vehicles.

Fighting in contested environments will be a significant challenge. Where we have fought in 'desert' or 'mountainous' or 'jungle' or 'urban' environments as we have for decades, the rapidly advancing, easily acquirable technology of today and the future is now the game changer. The nature of warfare is not changing, but the tempo at which information is now shared and simple technology can counter our advantages that range from training to will to technology has. I do not think the Marine Corps must be prepared to conduct large scale clearing operations in a mega-city due to the sheer mass it would take and attrition that would likely occur. We neither have the Marines or assets to do so, or the national will to risk harm to civilians or infrastructure. We must be prepared to enter a mega-city for purposes that range from Humanitarian Assistance/Disaster Relief missions in a semi-permissive environment to targeted kinetic operations to achieve a specific effect. In order to maintain the center of gravity technology provides, belligerents will no longer hide in the mountains, jungles, and deserts but where they can apply their technological edge over their targeted population and maintain a sense of personal security.

I would like to thank Lieutenant Colonel Wardman of the Ellis Group for his perspective as I began and finished this project. His insight gave me a reference point to start from, and perspective helped me validate my thoughts at the conclusion of this project. I would also like to thank Doctor Swanson for his mentorship and perspective provided during the first semester of CSC. I would also like to thank CWO5 (Gunner) Beltran for his input and perspective on this topic with his years of experience. Lieutenant Colonel Juarez also served as a sounding board on this topic, providing input to this project in its latter stages. I also must thank my wife Hilary for the hours of proofreading and editing she has put in on all the papers and assignments I've written at CSC. Her eye for sentence structure, passive voice, and split infinitives made my writing easier for others to read.

Lastly, Doctor Gordon's efforts to get me to this point have been tremendous. His experience with the MMS program at CSC has been invaluable, and provided me quality feedback and challenged me to examine all facets of this topic. His diligent efforts have been critical to my completion of this paper.

## **Mounted Mobility: A Military Requirement**

*"The obvious thing for the cavalryman to do is to accept the fighting machine as a partner, and prepare to meet more fully the demands of future warfare."*

General George S. Patton, United States Army

Mounted mobility is an integral part of military operations. During the interwar period between World War I and World War II, industrialized nations transitioned from relying on horses and foot movement to movement by rail and foot, and finally to combustion engines powering wheeled and tracked vehicles. Post-World War I, the industrialized nations of Germany, France, and the United States (US) developed differing employment philosophies for their combat vehicles. For example, during the interwar period, France viewed its tanks and other combat vehicles as primarily defensive in nature, while Germany focused on developing its combat vehicles for offensive purposes. The United States, able to leave the European theater after World War I, returned to its secure mainland and did not have to quickly re-orient on developing philosophy and doctrine for emerging combat vehicle technology. As World War II loomed on the horizon and became a reality for the US, military leaders began experimenting with combat vehicle technologies to develop warfighting philosophies and concepts of employment. United States Army Major General Wood, Commanding General of the 4<sup>th</sup> Armored Division, was a key innovator who recognized the full utility of a mechanized force.<sup>1</sup> Wildly successful in the European campaign during World War II, Wood led his division to numerous victories in both rural and urban environments by exploiting his mechanized forces' speed, firepower, and command and control through mission command, or what would be called maneuver warfare today.<sup>2</sup>

In each of the subsequent wars fought after World War II, the United States military was eventually drawn into operations in urban environments and utilized combat vehicles. Examples of operations in urban environments post-World War II are the amphibious landing at Inchon and subsequent offensive actions in Seoul during the Korean War, Hue City during the Vietnam War, operations in Baghdad, Fallujah, and Ramadi during Operation Iraqi Freedom, and operations in Marjeh during Operation Enduring Freedom.

If historical operations provide indications of the future operating environments, the United States Marine Corps (USMC) must be postured to conduct operations in the critically challenging environment of the mega-city. For the United States Marine Corps' Ground Combat Element (GCE) to operate across the range of military operations in a mega-city, mounted mobility is a requirement that creates synergy between both mounted and dismounted units. To counter the complexities presented by the mega-city, the USMC must balance its ground vehicle portfolio. The USMC must develop combat vehicles capable of being operated both remotely or while crewed with capabilities to negotiate complex terrain for successful operations within a mega-city.

### **Why the USMC Must Be Postured to Operate Within Mega-Cities**

*“More than 80 percent of the world’s population currently resides within 100 miles of a coastline—and the proportion is increasing. In many cases threats to our interests may require expanding the concept of littoral maneuver to hundreds of miles inland to resolve crises.*

*Expeditionary Force 21*

The USMC must be postured to operate in mega-cities. A mega-city is defined as metropolis with a population of more than 10 million people.<sup>1</sup> *Expeditionary Force 21* (EF 21) identifies that 80% of the world's population lives within 100 miles of the coast. Expeditionary Force 21 also envisions a force postured to conduct contingency response and small-scale operations. Additionally, the USMC must be capable of conducting major combat operations.<sup>3</sup> This envisioned operating construct, coupled with population growth demographics shifting from rural areas to urban centers, many of which are situated near the coast, demonstrate the requirement to operate in urban environments. To defeat the enemy, the US military needs to be prepared to operate in a highly urbanized environment. The USMC and United States Army (USA) have operational experience in cities such as Fallujah and Baghdad. Pre-war population estimates of Fallujah and Baghdad were 350,000 and six million residents respectively.<sup>4</sup> The sheer challenges of magnitude brought by the population of a mega-city as well as architectural feats such as high-rise buildings and city engineering force the USMC to consider constructs for operating in such an environment.

### **Likely Employment Scenarios of USMC Forces in a Mega-City**

*For the Marine Corps to remain effective as the nation's forward-engaged and ready for crisis force, we must align how we operate with the conditions imposed by the evolving security environment. These conditions will pose challenges that the Marine Corps will meet by providing conventional deterrence, conducting proactive engagement, and performing crisis response as part of a larger naval force.*

*Expeditionary Force 21*

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<sup>1</sup> All sources utilized for this paper agree on this portion of the definition. Obviously, there is no other commonality between various mega-cities other than the population figure mainly used to define them. When focusing on the military problem presented by the mega-city, the human dimension created by the mega-city's population is typically the theme source authors focused on.

Due to the world population shifting to the littoral, costal regions of the world, Marines are likely to find themselves operating in mega-cities. Looking to history to predict the future based on population trends, the United States (US) military anticipates conducting humanitarian assistance / disaster relief (HA/DR) in the aftermath of natural disasters first and foremost. If US forces are invited to operate within the host nation's borders, potential existing hostility between factions operating in the mega-city adds to the complexity and risk to US forces. A mounted force will be required to move large quantities of goods and equipment to potentially isolated segments of a mega-city due to critical infrastructure damage to bridges and roads. In addition to negotiating existing urban obstacles, the mounted force must be equipped to defend themselves and civilians near the force within the rules of engagement from potential criminal elements that could be present due to lack of basic security services after a disaster. Likely threat weapons employed in such a scenario would range from small to medium caliber semi to fully automatic weapons acquired by looting of local police or security forces.

Situations with more potential kinetic possibilities range from non-combatant evacuations (NEOs), peacekeeping operations, counter-insurgency (COIN) operations, or while conducting targeted operations<sup>2</sup>. Should forcible entry operations be required, organized military resistance, coupled with potential militia or insurgent actions would significantly decrease the US military's ability to maneuver freely in a mega-city. The complex nature of the mega-city amplifies US military mobility challenges while

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<sup>2</sup> Page viii of JP 3-60, *Joint Targeting*, defines two types of targeted operations. **Deliberate targeting** prosecutes planned targets. These are targets that are known to exist in the operational environment with engagement actions scheduled against them. **Dynamic targeting** prosecutes targets of opportunity that are identified too late, or not selected for action in time to be included in deliberate targeting but, when detected or located, meet criteria specific to achieving objectives.

conducting permissive, semi-permissive, or targeted operations in such an environment. Operations such as these increase the dynamic of survivability for the mounted force as likely targeted kinetic operations would be employed against the mounted force as it executes its mission. To operate successfully in these types of environments, the mounted force must be able to defeat threats employing direct and indirect fired weapons to include rockets and anti-tank missiles, as well as improvised explosive devices.

### **Nature of War and the Mega-City**

*"Failing to prepare for military operations in dangerous megacities could leave a future president without the means to do something that he or she considers to be in the national interest."*

Steven Metz, *Strategic Horizons: How the U.S. Military Might Get Involved in a Megacity*

Mega-cities are not changing the nature of human conflict and war. Prussian military theorist Karl von Clausewitz's description of war as a duel on a larger scale is applicable to all wars fought since he published *On War*. Modern war theorists have grappled with technology's impact on the evolution of warfare, and ultimately come to the conclusion that the feeling of personal risk to life is common to all wars regardless of existing technologies.<sup>5</sup> There are no specific causes to why conflict and wars are predicted to be waged more often in urban settings to include mega-cities, but four inter-related trends that lead to expectations of conflict in urban settings have been identified. They are population growth, urbanization, littoralization and connectedness.<sup>6</sup> Often, the compartmentalized terrain associated with urban terrain and mega-cities impedes military units ability to mass forces, keeping actions focused at the small unit, tactical level. This reinforces the unchanging nature of how to conduct combat operations in a mega-city based on our historical experiences in urban warfare.

What must be accounted for in mega-cities to enhance mounted maneuver are the five dimensions of warfare. Colin Gray, author and international relations professor, defines the five dimensions of warfare as political, socio-cultural, technological, historical, and strategic.<sup>7</sup> As all levels of war intersect in the mega-city, politics play a part at the strategic, operational and tactical levels of war in terms of access into it by a force. For example, at the strategic political level, a sovereign ruling authority may or may not grant a military force access to a mega-city. Below the strategic political level, factions within a mega-city may choose to physically deny or limit access to specific regions of the mega-city. The mega-city is a technological feat, and is likely to be able to sustain its population in some fashion for extended periods of time with food and water stores, energy production capabilities, and near instantaneous communication methods for individual, group and mass-media communication. History binds group dynamics, civic planning, and political structures together in a mega-city. Lastly, warfare in a mega-city will be strategic for several reasons such as geographic location and regional importance of the mega-city, certain social and mass media communications, and impact on the population within the mega-city.

### **Effects of Physical Characteristics in Urban Environments and Mega-Cities**

*Generally, a modern city magnifies the power of the defender and robs the attacker of his advantages in firepower and mobility. A city can ingest an invading army, paralyze it for weeks on end, and grind it down to a state of ineffectiveness.*

2d Battalion, 26th Infantry, at Aachen, Germany; October 1944

The mega-city is the most challenging operational environment for any type of force, and particularly a mounted force. Due to the sheer size of a mega-city, purely dismounted operations are inconceivable. Combat vehicles provide protection to their

dismounted force, and keep the mounted force from getting bogged down by enemy small arms fire due to its protection. With its protection, a mounted force is afforded more flexibility to potentially move through ineffective fire being directed at it. This protection affords the mounted force the decision to potentially not return fire, thus reducing the potential for civilian casualties.<sup>8</sup>

The commonly understood challenges that apply in military operations in urban terrain (MOUT) will continue to apply in the mega-city. These challenges presented to a mounted force in any urban terrain stem from channelized terrain, which in turn reduce weapons ranges, visibility, ability to command and control forces, and ability to mass forces on an objective. The mega-city compounds this primarily in regards to its massive human population of ten million or more people. The mega-city is the intersection of terrain, infrastructure, and the most dynamic factor: society. Army Field Manual 3-06, *Urban Operations*, identifies seven physical zones in an urban environment: the outlying high rise area, residential area, industrial area, commercial ribbon area, core periphery, core, and military area.<sup>9</sup> These seven physical zones each create groups of people with varying interests, needs and goals, and have their own hierarchy of influence and control associated with them. Combine the groups of people's situation with needs, interests, and technology, and a mounted force can easily be swallowed by a permissive section of mega-city and an unarmed, demonstrating mass of people who were cued to a certain location by social media to harass a relief convoy travelling near their zone in a mega-city. Add an armed enemy force that is opposed to any operations conducted in a mega-city that possesses limited command and control capability, coupled with the natural and existing urban terrain, and chances of mission success will drastically decrease.

## Historical Studies of Mounted Operations in Urban Terrain

### Sadr City, Iraq: USA Operations During OIF

*As soon as we crossed into the militia stronghold of Sadr City, that twenty minutes we had was all the time to hit our objective, grab our target, and get the hell outta Dodge. After that, the hornet's nest was stirred. When that ran out, every breath we took had to be earned with a fight.*

Konrad R. K. Ludwig, *Stryker, The Siege of Sadr City*

Operations in Sadr City, Iraq illustrate the requirement for a mounted force in combat vehicles. Perhaps the nearest example to what urban combat in a mega-city would be like, 2.4 million people lived in Sadr City during USA operations conducted there from 2004-2008. At 26 square kilometers, Sadr City is comparable in size to Philadelphia or Dallas, but larger in population than both US cities.<sup>10</sup> Sadr City was primarily a slum with a high concentration of Shiite Muslims and Kurdish minorities living there, with a separate sector where more affluent Sunni Muslims lived. It had poor sanitation, security, and little means for economic growth with a large population of unemployed men, all likely conditions to be found in mega-cities of the future, according to David Killcullen, a counter-insurgency expert. A large population of Iraqi refugees who settled in shantytowns compounded these conditions. With no true governance, Muqtada-al Sadr emerged and overall applied control in Sadr City with his militia, Jaysh-al Mahdi (JAM).<sup>11</sup> The USA conducted large operations in 2004 focused on general regional stability, and 2008 focused on removing JAM influence from Baghdad. To counter the population difference and account for the massive size of Sadr City, mounted mobility with combat vehicles was imperative. In each operation, Sadr City's population significantly outnumbered the USA soldiers. Each time, the USA soldiers were able to physically isolate key sectors of the urban terrain by walling off the small prosperous

section of Sadr City's market region to allow it to recover and provide a sector of stability. To construct the project, the USA units established a deliberate defense, incorporating combat vehicles to provide precision direct fires to isolate the construction sites first. During construction and subsequent operations, the USA encountered significant attacks, and killed an estimated 1,700 and 700 JAM insurgents in 2004 and 2008 respectively. Bradley Fighting Vehicles and other armored vehicles were critical to operational success in both instances, providing precision fires, survivability, and mobility.<sup>12</sup> Also key in the 2008 operation were critical technological improvements such as drones, aerostats, and aviation assets providing both sensors and close air support.



Left Photo:<sup>13</sup> Aerial view of Sadr City, December 2005. Combat vehicles would have ability to rapidly cover ground on four-lane improved surface route. Right Photo:<sup>14</sup> Soldiers' perspective on the ground in Sadr City while on patrol in 2008. Mutual support from a combat vehicle would provide the patrol overwatch with observation and weapons systems in order to execute dismounted tasks with reduced risk to the force.

## Gronzy, Chechnya: Soviet Invasion, 1994

*I'd been to a number of war zones before in my life, but I had never been in one as terrifying as Chechnya.*

Scott Anderson, US journalist

Where operations in Sadr City highlight successful employment of combat vehicles to achieve mounted mobility in an urban environment, Russian operations in Gronzy, Chechnya highlight failure to operationally employ combat vehicles effectively. The Russian army's tactical employment plan was to utilize their combat vehicles in doctrinal fashion as an assault force or in direct support of the infantry. Utilizing combat vehicles in these roles achieves firepower, survivability, and mobility. Chechnyan fighters planned to exploit the urban terrain and a sympathetic civilian population by allowing Russian forces to enter the city. Russian forces departed their assembly area under observation of Chechnyan fighters. The Russian combat vehicle formation traveled in an administrative vice tactical formation, and did not alter its formation despite Chechnyan rebels destroying the lead tanks in the column after they crossed the Sunzah River Bridge. Russian forces continued to their objectives, only to encounter significant resistance the further they pushed into the city. According to Izvestia, a Russian newspaper, the Russian army lost 20 of 26 tanks, 100 of 120 armored personnel carriers (APCs), and suffered 1000 casualties, which ranged from wounded, killed, or missing in action.<sup>15</sup>

## **Challenges to a Mounted Force Created by Current and Future Mega-Cities**

*From a planning perspective, commanders view cities not just as a topographic feature but as dynamic entities that include hostile forces, local population, and infrastructure. Planning for urban operations requires careful IPB, with particular emphasis on the three-dimensional nature of the topography and the intricate social structure of the population.*

*Army Field Manual 3-0*

Civilian non-combatants must be accounted for when examining the two previous historical examples, and the majority of other operations conducted in urban environments. They were present in both Sadr City and Chechnya, and forced the USA and Russian forces to consider what tactics were available to employ against hostile forces in the urban terrain. Russian forces did not appear to have considered the presence of visibly unarmed civilians continuing on with their daily lives.<sup>16</sup> A mounted force operating in a mega-city must anticipate that the civilian population has grown accustomed to a level of chaos in their day-to-day lives, as Chechnyans did to the Russian forces. The human presence in a mega-city, both civilians the mounted force does not want to harm, to criminal or hostile elements who attempt to keep US forces from achieving their objective, force US planners and visionaries to create means to achieve our objectives in a mega-city. The US military can negotiate the physical terrain offered by the mega-city's environment, but it must be able to negotiate the physical terrain once the human dimension of the mega-city applies an effect to it.

The most significant human consideration that impedes our ability to maneuver as a mounted force in a mega-city is the application of technology found in our daily lives employed by the mega-city's population. The first element of technology to examine is technology that builds individual or group situational awareness. Examples of such

technology are cellular phones, tablets, and laptop computers that operate using wireless or satellite telecommunications networks. All are fairly secure methods of communication, as evidenced by terrorist networks being able to communicate, plan, and execute attacks last year in France. Where these pieces of technology were not present in Chechnya in 1994, they evolved and were certainly a factor in Sadr City. Cell phones likely were employed by lookouts and spotters to report US troop movements, and even to initiate improvised explosive devices (IEDs). Cell phones proliferate societies globally today. For example, a survey conducted in 2011 shows that 25% of Somalia's population has cell phones, and a large market of telecommunication companies to provide services.<sup>17</sup> Cell phones and Internet connectivity allow a mega-city's population to communicate with multiple applications (aps) such Skype, WhatsApp, WeChat, Facebook Messenger, and Twitter. This poses significant risk to a mounted force's mobility. Operational Security (OpSec) is compromised by any individual who 'Tweets', 'posts', or 'texts' about seeing a mounted force conducting operations or just moving from one location to another.

Due to the networked connectedness of a mega-city, people who range from civilian to a hostile element the US forces are to engage build the situational awareness of those they are connected to via social media. Anyone with a smart phone can connect to outlets such as Facebook, Twitter, Google Hangouts, or a myriad of other sites. Couple this message with a photo or video, and overall situational awareness improves. Overlay a message with video and geo-location services that often 'tag' or attach onto posts, and where a mounted force is moving to and what operations it is conducting become very clear for hostile action to be taken by the mega-city's population. Commercial mapping

applications available to civilian populations such as Google Maps and Google Earth provide high quality imagery that can be used by a hostile element of the mega-city's population to anticipate the mounted force's objective and block or route it away from a protected area, denying tactical and operational access. These mapping applications can be tied to a civilian drone with a camera that can track the mounted force's movements in real-time, providing updates for hostile elements of the mega-city's population to act on.

As if daily-use technology presents enough of a challenge, weapons technologies are proliferating around the world. Improvised explosive device technology has made its way from the streets of Ramadi and the mountains of Kandahar to San Bernardino, California. All required components for constructing such a device are found easily within a mega-city. Criminal networks provide weapons such as guns of any type for purchase if they cannot be purchased legally due to national or state laws. Depending on the level of disorder in a mega-city, there is high likelihood of looting police stations or military armories as was the case in Kinston, Jamaica in 2010 as order broke down surrounding the potential extradition of a Jamaican drug lord to the US.<sup>18</sup> To protect Christopher Coke, a Jamaican drug lord who ran an international cartel, his loyal criminal force created berm obstacles with bulldozers to deny mobility to the area surrounding his residence, and waged an offensive against the police force and Jamaican Defense Force that took over 30 days to quell. Criminal means such as looting or purchasing weapons and optics such as thermal viewers and night vision from criminals are not the only method to obtain lethal instruments. One only has to log onto Amazon or a myriad of other online stores to purchase military or hunting equipment that could have devastating effects on a mounted force.

## **Opportunities for Emerging Technologies that Enhance Mounted Mobility**

*Design is not just what it looks like and feels like. Design is how it works.*

Steve Jobs, former Apple CEO

A thorough understanding of the operating environment is required before resources that aid mounted mobility can be planned for and procured. Many militaries have conducted operations in urban terrain, from which after action reports (AARs) serve as a baseline for our current doctrine and tactics to operate in the urban environment. A key difference between operating in previous urban environments and in mega-cities in the future is the proliferation of civilian technology previously discussed that can have a lethal effect on our force. The mounted force must be able to counter and negate previously discussed technologies that mega-cities' populations will have to retain maneuverability. All unmanned ground vehicles (UGVs) fielded must be designed around the premise to achieve and maintain mobility in a mega-city.

### **Unmanned Ground Vehicles**

*Building a robot that has legs and walks around is a very expensive proposition. Mother Nature has created many wonderful things, but one thing we do have that nature doesn't is the wheel, a continuous rotating joint, and tracks, so we need to make use of inventions to make things simpler.*

Colin Angle, CEO, iRobot

Unmanned ground vehicles are a requirement for a mounted force. Just as unmanned aerial systems (UASs) have been fielded for use below the battalion level, so must UGVs. At the small unit level, UAVs and what few UGVs that have been fielded serve the purpose to primarily reduce risk and gain situational awareness for the unit. Small and mobile, currently fielded UAVs such as the Raven and UGVs such as the US

Army's Small Unmanned Ground Vehicle (SUGV) provide a ground force the ability to view a potential threat from a different perspective, either from the air or close up.<sup>19</sup>

The USMC and USA are also examining remotely controlled or pre-programmed ground logistics vehicles. These vehicles fall under the Ground Unmanned Support Surrogate (GUSS) programs that rely on commercial-off-the shelf (COTS) technology by adding a remote control capability with hardware and software. This creates an option to use the vehicle in either a 'follow me' mode in a convoy as 'tethered' vehicle, or untethered and following a pre-programmed route. There are two main purposes behind these types of UGVs. First, unmanned logistics vehicles, such as the Cargo Unmanned Ground Vehicle (CUGV) relies on commercial off the shelf (COTS) technology to add a remote control capability with either a 'follow me' or pre-programmed route option to a Medium Tactical Replacement Vehicle (MTVR) or High Mobility Multi-purpose Wheeled Vehicle (HMMWV) variants.<sup>20</sup> The primary goal of these vehicles is to reduce risk to crews by reducing or eliminating the requirement for humans to physically operate these vehicles, thus reducing risk and re-allocating overall manpower of personnel available to operational forces. The second type of UGV currently undergoing testing commonly referred to as a 'Gator'<sup>21</sup>. They are four to eight wheeled vehicles, based on civilian models commonly used by hunters and outdoorsmen. The primary purpose of vehicles of these types is to lighten the load of the warfighter, carry mission essential equipment that extends a small unit's operational reach, or to conduct casualty evacuation.



**Figure 2**

From left to right: John Deere's R-Gator,<sup>22</sup> Polaris MVR5700,<sup>23</sup> and MTVR with GUSS technology applied.<sup>24</sup> While these vehicles are a must to experiment with to understand how unmanned technology can be applied to ground vehicles, will these applications increase mobility in a mega-city?

In addition to UGVs focused on reducing risk to personnel operating vehicles in a support role, weaponized UGVs, known as Combat Robotic Systems (CRSs), are being conceived and tested. One example is the Modularized Advanced Armed Robotic System (MAARS). The MAARS is a SUGV platform that is modular and able to tailor weapons systems applied based on a specific mission. It is advertised to carry both lethal and non-lethal payloads.<sup>25</sup> However, being that it is based on a SUGV platform, it only offers a limited solution to increase a small dismounted unit's mobility at the sub-tactical level in a mega-city as its carrying capacity is rather limited.



**Figure 3**

Right: MAARS CRS.<sup>26</sup> Although small in size, it conceptually may drive solutions to increase mobility in a mega-city by providing situational awareness to dismounted troops and a mobile fire support platform.

After action reports from experimenting with the above mention systems show several technological gaps. First, when applying GUSS technology to existing vehicles and programming them to operate autonomously along a pre-designated route, several common friction points were identified. They are loss of signal, which cause the vehicle to stop along the route, unanticipated obstacles along the route that cause the vehicle to stop for reasons unknown to the operator, and lack of 360-degree field of view by cameras to provide situational awareness to the operator.<sup>27</sup> When examining the CRS platforms, adequate visibility concerns are valid considerations and concerns. A remote operator must be able to positively identify a combatant in order to engage with lethal and non-lethal force within the rules of engagement. When considering a three-dimensional environment present in a mega-city with towering structures, reflective glass surfaces, and the potential for large numbers of people to be present, this is a significant challenge for a remote operator. A similar construct exists for Forward Air Controllers (FACs) and Joint Terminal Air Controllers (JTACs) employing close air support (CAS) as they engage targets.<sup>3</sup> Forward Air Controllers and JTACs must positively identify the target or set the conditions for safe weapons release. Due to limited visibility from the sky, CAS is a limited option to enhance mobility in a megacity. A solution is maintaining traditional combat vehicles such as the tank and other turreted, stabilized gun platforms like the Light Armored Vehicle (LAV) that are capable of operating as a

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<sup>3</sup> JP 3-09.3, Close Air Support, page I-2, identifies three methods of TAC a FAC or JTAC must follow prior to executing a close air support (CAS) mission.

**Type 1 Control.** Type 1 control is used when the JTAC/FAC(A) requires control of individual attacks and the situation requires the JTAC/FAC(A) to visually acquire the attacking aircraft and visually acquire the target for each attack.

**Type 2 Control.** Type 2 control is used when the JTAC/FAC(A) requires control of individual attacks and is unable to visually acquire the attacking aircraft at weapons release or is unable to visually acquire the target.

**Type 3 Control.** Type 3 control is used when the JTAC/FAC(A) requires the ability to provide clearance for multiple attacks within a single engagement subject to specific attack restrictions.

crewed vehicle or as a CRS.

### **Required Attributes of the CRS, Crewed Combat Vehicle**

*War is, above all things, an art, employing science in all its branches as its servant, but depending first and chiefly upon the skill of the artisan. It has its own rules, but not one of them is rigid and invariable. As new implements are devised, new methods result in its mechanical execution; but over and above all its mechanical appliances, it rests upon the complex factors of human nature, which cannot be reduced to formulas and rules.*

Captain Francis V. Greene, 1883

First, CRS, crewed combat vehicles must operate with similar purposes to currently fielded equipment within the GCE. The shock value of a tank cannot be denied in an urban environment, and was integral when used in conjunction with dismounted infantry while conducting clearing operations during Operation Phantom Fury in Fallujah, Iraq. The Amphibious Tractor (AMTRAC) and its replacement, the Amphibious Combat Vehicle (ACV), serve the purpose to mass troops on an objective with speed and the support of crew-served weapon support. Currently, autonomous mobility applique systems are being experimented with to apply logistics vehicles previously mentioned and the MRAP All-Terrain Vehicle (M-ATV). However, significant challenges likely exist to fully integrate turreted combat vehicle's functions to vehicles such as M1A1 tanks and LAVs. These vehicles were built on 1970s technology, and with service life extension program (SLEP) upgrades such as global positioning system (GPS) targeting systems, communication suites, common operational picture (COP) technologies, and counter-radio electronic warfare (CREW) devices, adding additional power requirements significantly taxes the vehicles current capabilities. All CRS, crewed combat vehicles must be able to sense, disrupt and shoot in order to maintain mobility in the mega-city.

For a CRS, crewed combat vehicle to achieve its full operating capacity, it must

be able to act as a sensor. For such a vehicle to operate 'tethered' or on a pre-programmed route, the 360-degree field of vision problem must be solved in order for the operator to be able to see what caused the vehicle to stop, or identify obstacles well in advance of the vehicle coming to it so it can be re-routed. Integrating such sensing technology onto a platform such as a tank or LAV is imperative in order to use the organic weapons platform of the vehicle remotely should the crew choose to operate dismounted from the combat vehicle. The ability to wholly separate the crew of a combat vehicle from its combat vehicle allows a mounted force significant flexibility.

At the tactical level, the ability to separate a crew from its combat vehicle could reduce risk to individual crews by allowing them to occupy survivable and concealed positions while covered by their combat vehicle's organic weapons platforms in a more survivable, urban position. To adequately crew a combat vehicle, three individuals are required today: a driver, gunner, and commander. By being able to 'un-tether' a crew from its combat vehicle, nearly another platoon-sized dismounted element could be constituted from every ten vehicles. In turn, this dismounted unit could execute additional tasks while controlling their combat vehicles as CRS's as a FAC would control a UAS. Additionally, un-tethering a crew from its combat vehicle will improve mobility through greater situational awareness by being able to see terrain masked by urban obstacles firsthand from a dismounted perspective.

At the operational level, a commander could utilize assault support aviation to deliver troops to an objective, and have their combat vehicles remotely routed to a cordon or a link up point in vicinity of the objective. An operation utilizing an air-assault task force (AATF) insert and marrying it up with its combat vehicles to exfiltrate with or

conduct follow-on missions with its combat vehicles provides significant deception to the mega-city's population. This flexibility reduces certainty of communication by the mega-city's population, be it benign social media chatter of the civilian population to reporting by criminal or enemy elements within the mega-city. Other benefits to this type of operation are reducing the aviation requirement by half, and reducing risk to the ground force through use of AATF tactics to reach the objective.

Complementing the ability of the CRS, crewed vehicle to 'sense' through imaging capabilities is the ability to disrupt the mega-city's population to communicate the mounted force's actions. The first means to disrupt a population's ability to communicate the mounted force's actions is a passive method; the use of effective camouflage on its vehicles. The CRS, crewed vehicles of the future must employ 'reactive camouflage' to be effective in any environment. HyperStealth/ADS Technology advertises such reactive camouflage. The company advertises its camouflage bends light around the object being camouflaged, drastically reducing its visible signature as well as infrared and thermal signatures.<sup>28</sup> This technology came to the attention of the mainstream media during a CNN segment, where this concept was displayed as a potential for use in individual soldier's uniforms. One tremendous benefit to this material is it does not require a power source for it to work.<sup>29</sup> Applied to combat vehicles, this technology could effectively camouflage an entire mounted force, or elements of it that would signal the mounted force's mission.

Another example of passive signature-reducing equipment currently being experimented with on combat vehicles is thermal/infrared-signature reducing technologies. With the proliferation of thermal and infrared optics and weapons

technologies, these must be applied to combat vehicles to reduce their signature and overall ability to be lethally targeted. Currently, BAE Systems is testing a thermal-reduction camouflage system on CV-90 combat vehicles, and European company MBDA Systems have developed applique systems that drastically reduce thermal signatures of combat vehicles.<sup>30</sup> BAE's Adaptive thermal reduction applique requires a power source to achieve thermal reduction, where MBDA System's Multisorb is a bolt-on kit that uses a fabric system to reduce thermal signatures.



**Figure 4**

Left: ADS's HyperStealth used to camouflage a person lying prone in a grassy field.<sup>31</sup> Right: BAE's Adaptive thermal/infrared signature reducing technology applied to a CV-90 combat vehicle.<sup>32</sup> Merging these technologies onto combat vehicles will reduce the population of a mega-city's ability to observe, report on and target a mounted force.

Passive disruption systems must work in tandem with active disruption systems to increase mobility in a mega-city. Passive systems such as camouflage cannot be fully counted on to reduce situational awareness of the population. Active systems that disrupt a mega-city's population's ability to observe and influence a mounted force must be developed as well. As the Counter Radio-Controlled Improvised Explosive Device (RCIED) Electronic Warfare (CREW) system was developed to defeat remote controlled

IEDs for all vehicles operating in the Central Command (CentCom) Area of Responsibility (AOR), similar jamming technology must be developed for employment by the mounted force to maintain OPSEC and freedom of maneuver.

A mounted force must be able to disrupt wireless, digital and radio networks within the sphere of visual observation and enemy weapon's capabilities. Due to the complex, three-dimensional environment of the mega-city, close coordination between the mounted force and aviation assets, cyberwarfare and intelligence specialists would be critical. Aviation assets, such as UASs, would likely have to support jamming operations to ensure signal saturation of high-rise buildings is achieved. Cyberwarfare and intelligence specialists would have to monitor social media posts and electronic signals transmitted for indicators that the mega-city's population has observed the mounted force's operations. The mounted force, with support from enablers, would then target and disrupt specific electronic and digital outlets to ensure its mobility would not be compromised to achieve its mission. Combat vehicles of the future must incorporate emerging active and passive disruption technologies to best enhance mobility in the mega-city.

Combat vehicle's weapon systems must be examined to ensure mounted mobility is achieved in the mega-city. To contend with the human dynamic of the mega-city, a balance of lethal and non-lethal weapon systems must be balanced to achieve effective mobility. Additionally, passive protection systems must be incorporated into combat vehicles.

Concepts for lethal weapon systems do not require much change. Lethality is a requirement in a combat vehicle such as a tank or other large combat vehicle that remains

a constant in any time period or environment. What is required in combat vehicles of the future in regards to lethality is precision delivered fires. A precise fire control system that provides target location and magnified thermal imaging, such as what exists in a M1A1 Abrams Tank or LAV-25, is an acceptable solution. Both vehicles are able to identify (sense) and engage like-size enemy targets easily at ranges of 1500 meters. Beyond that range, with today's thermal sight system technologies linked to global positioning system (GPS) technology, enemy threats can still be sensed, but not accurately engaged. This is due to limitations in existing ammunition's range. As ranges have been increased over time in larger indirect surface and naval delivered munitions, similar efforts must be made to match ammunition ranges with the ability to sense and engage threats. One significant area where ammunition is making significant strides is improved accuracy. The Defense Advanced Research Projects (DARPA) has successfully tested Extreme Accuracy Tasked Ordnance (EXACTO), a 'smart' .50 caliber round. EXACTO is a self-steering round, with a real-time optical guidance system that tracks and directs rounds to their targets by compensating for weather and target movement and other factors that can impede successful hits.<sup>33</sup>

Lethal force, even with existing high quality sensing technology and when applied at range with precision, still has the potential for significant negative effects in the mega-city. Non-lethal weapon systems will be critical to a mounted force's ability to maintain the ability to maneuver within the mega-city. Currently, the Department of Defense (DOD) is focusing its non-lethal weapon systems on Active Denial System (ADS) technology. Active Denial Systems project a focused beam of millimeter waves at a frequency of 95 gigahertz (GHz). This short-waved beam penetrates skin approximately

1/64 of an inch, and causes those targeted to perceive the effects of a hot oven's door being opened on them.<sup>34</sup> This non-lethal option provides numerous examples of deterrence to maintain mounted mobility in the mega-city. Active Denial Systems can disburse crowds from a mounted force's route, allowing them to continue to the objective. These systems can be employed if the combat vehicle is operated traditionally while crewed or remotely as a CRS if the crew is conducting dismounted operations within support of their combat vehicle.

The ADS is critical to conceptually being able to operate the combat vehicle remotely, either as a GUSS or for the dismounted crew 'calling' the vehicle to their position. The ADS gives the operator controlling the combat vehicle remotely the ability to employ a weapon system where the operator may not have 100 percent certainty of the people's intentions who are in proximity to the un-crewed combat vehicle. This defensive use of the ADS ensures the un-crewed combat vehicle, acting as a CRS, is able to perform its function of providing mutual support to the dismounted force. Regardless if the combat vehicle is crewed or being operating remotely, ADS is recognized as a requirement for successful operations in urban environments, and has tremendous potential in the mega-city.<sup>35</sup>

Lastly, passive protection systems are required for combat vehicles of the future. Much of this technology exists and is employed to varying degrees on many combat vehicles of today. Systems such as CREW to defeat RC-IEDs are required to be employed on all vehicles operating in the CentCom AOR. To defeat the most prolific armor-defeating weapon, the Rocket Propelled Grenade (RPG), systems such as Q-Net, Shotscreen, and Trophy systems are utilized on combat vehicles. Q-Net is a 'bird cage'

applique system of lightweight wire mesh with a bracket system designed to create enough standoff from the vehicle to the mesh to detonate RPGs fired at the combat vehicle.<sup>36</sup> Shotscreen, a US RPG defeat system and a similar Israeli product, Trophy, sense incoming RPGs being fired at a combat vehicle and fire a countermeasure of low velocity pellets to intercept the warhead and detonate it prior to impact.<sup>37</sup> This type of protection is critical to keeping combat vehicles operational and able to maintain their mobility in potentially restrictive terrain in certain regions of the mega-city.

### **Challenges to Developing Future Platforms that Enhance Mounted Mobility in the Mega-City**

*In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist. We must never let the weight of this combination endanger our liberties or democratic processes.*

President Dwight Eisenhower, *Military-Industrial Complex Speech*

The most glaring challenge to improving the USMC's mounted mobility in megacities is the current fiscal environment. The post-Long War budget reductions have been noticeable since 2012, and are projected to continue to be in line with the historical trend of downsizing the military's overall footprint at the conclusion of large-scale combat operations. The application of technology is also a significant challenge for several reasons. Technology changes so rapidly today that components of a system face obsolescence more rapidly today. A broad example of this is secure communications equipment. Technology can be created to counter aging equipment once unsusceptible to jamming or eavesdropping. Technical equipment must be developed and fielded quickly enough to counter threat technology. Next, our current contracting and acquisition process hinders rapid fielding and equipping the force with technology relevant on today's battlefield. The time gap of concept inception to product fielding must be

minimized to ensure technologically relevant equipment is fielded.

Along with fielding equipment, the sustainment plan for investment return in a platform must be re-designed. The current construct often awards a large defense contractor both end item delivery and rights to service life sustainment upgrades over the course of the end item's life expectancy. This perpetuates the cycle of fielding dated upgrades through the acquisition cycle. The DoD at large also must determine a balanced approach and way ahead for the envisioned future force. If robotics and unmanned systems are to play a significant role, then the budget must reflect spending dollars on improving GCE mobility options, and apply any savings from manpower reduction to technology. This would be a significant paradigm shift in budget programming that elected officials and military leaders would have to accept, as a significant portion of the budget is planned for based on manpower needs.

This theme also carries over to how military leaders of today envision warfare of the future. Reliance on unmanned systems or CRS, crewed vehicles to wage war on a large-scale level requires a paradigm shift that sets our military down a path of uncertainty and potential failure. Due to uncertainty for how we envision operating in the future, the DoD has not definitively laid out requirements for advanced technology. Instead, we see a myriad of COTs technology and try to bundle it together, or apply it to existing technology.<sup>4</sup>

## **Conclusion**

Emerging technologies must be applied to existing combat vehicles to enable

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<sup>4</sup> Many of the ideas from this section were presented to the author during an interview by the author with Lieutenant Colonel Gregory Wardman, GCE Planner at the Ellis Group, Emergent Force Development, Futures Directorate, Marine Corps Warfighting Lab, Combat Development & Integration Division on 26 February 2016.

experimentation and understanding of how technology can compliment existing tactics to achieve mounted mobility in future operations in mega-cities. The US military has a significant breadth of historical experience operating in urban environments with combat vehicles, and has the doctrine and leadership to be successful operating in mega-cities. The USMC must be forward thinking with its future concepts for combat vehicle designs now that will replace aging combat vehicles in the 2030s and beyond. Future concepts for combat vehicles must incorporate a balanced table of equipment for unmanned ground combat vehicles and CRS, crewed combat vehicles that have the capability to be operated remotely to reduce risk to the force. Effectively incorporating advances in sensing, disrupting, and weapons technologies will allow a mounted force to achieve mission success in a mega-city, and any other environment the USMC finds itself operating in.

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<sup>3</sup> Headquarters U.S. Marine Corps, Expeditionary Force 21: Forward and Ready, Now and in the Future. Staff Study, 2014, 8-9, [http://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/EF21/EF21\\_USMC\\_Capstone\\_Concept.pdf](http://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/EF21/EF21_USMC_Capstone_Concept.pdf).

<sup>4</sup> Micheal Bailey, et al, “A Proposed Framework for Appreciating Megacities: A US Army Perspective,” *Small Wars Journal* (2014): 1, [smallwarsjournal.com/printpdf/15598](http://smallwarsjournal.com/printpdf/15598).

<sup>5</sup> Colin S. Gray, *Another Bloody Century* (London: Orion Books, 2005), 33.

<sup>6</sup> David Killcullen, *Out of the Mountains: The Coming of Age of the Urban Guerrilla* (New York: Oxford University Press, 2013), 28.

<sup>7</sup> Gray, *Another Bloody Century*,

<sup>8</sup> Killcullen, *Out of the Mountains: The Coming of Age of the Urban Guerrilla*, 76.

<sup>9</sup>Headquarters, Department of the Army, *Army Field Manual 3-06, Urban Operations*, (Washington, DC: US Army, 26 October 2006), 2-9.

<sup>10</sup> Christopher O. Bowers, "Future Mega-City Operations: Lessons from Sadr City," *Military Review* (May-June 2015): 10, [http://usacac.army.mil/CAC2/MilitaryReview/Archives/English/MilitaryReview\\_20150630\\_art006.pdf](http://usacac.army.mil/CAC2/MilitaryReview/Archives/English/MilitaryReview_20150630_art006.pdf).

<sup>11</sup> Bowers, "Future Mega-City Operations: Lessons from Sadr City," 12.

<sup>12</sup> Bowers, "Future Mega-City Operations: Lessons from Sadr City", 14-15.

<sup>13</sup> Bowers, "Future Mega-City Operations: Lessons from Sadr City," 13, photograph.

<sup>14</sup> Bowers, "Future Mega-City Operations: Lessons from Sadr City," 14, photograph.

<sup>15</sup> Adam Geibel, "Lessons in Urban Combat: Gronzy, New Years Eve 1994," *Infantry* (November-December 1995): 21-23, [https://www.benning.army.mil/magazine/1995/1995\\_6/fa01.pdf](https://www.benning.army.mil/magazine/1995/1995_6/fa01.pdf)

<sup>16</sup>Geibel, "Lessons in Urban Combat: Gronzy, New Years Eve 1994," 24.

<sup>17</sup>Killcullen, *Out of the Mountains: The Coming of Age of the Urban Guerrilla*, 33.

<sup>18</sup>Killcullen, *Out of the Mountains: The Coming of Age of the Urban Guerrilla*, 90.

<sup>19</sup> John Clements and Lindey Kirkland, "Unmanned Ground Systems," (PowerPoint Presentation, 12 September 2011), accessed from MCCLL 15 January 2016, [file:///Users/johnkinitz/Downloads/AMCB%20UGV%2012Sept2011%20CoC%20main%20slides-CDR-9042%20\(1\).pdf](file:///Users/johnkinitz/Downloads/AMCB%20UGV%2012Sept2011%20CoC%20main%20slides-CDR-9042%20(1).pdf).

<sup>20</sup> Clements and Kirkland, "Unmanned Ground Systems," (PowerPoint Presentation), "[Enhanced Company Operations Limited Objective Experiment 3.3 Final Report](#)", 11 August 2009, United States Marine Corps, Marine Corps Warfighting Laboratory, accessed from MCCLL 15 Jan 2016, [https://www.mccll.usmc.mil/index.cfm?disp=myIdolSearch\\_XML.cfm#divSeclev](https://www.mccll.usmc.mil/index.cfm?disp=myIdolSearch_XML.cfm#divSeclev).

<sup>21</sup>Clements and Kirkland, "Unmanned Ground Systems," (PowerPoint Presentation), "[R-Gator: John Deere Unmanned Vehicle Factsheet](#)," accessed 16 January 2016, [https://www.deere.com/en\\_US/docs/turf/gator\\_utility\\_vehicles/r\\_gator\\_specsheet.pdf](https://www.deere.com/en_US/docs/turf/gator_utility_vehicles/r_gator_specsheet.pdf).

<sup>22</sup>“R-GATOR Unmanned Vehicle Factsheet,” John Deere, 2, photograph, accessed February 12, 2016, [https://www.deere.com/en\\_US/docs/turf/gator\\_utility\\_vehicles/r\\_gator\\_specsheet.pdf](https://www.deere.com/en_US/docs/turf/gator_utility_vehicles/r_gator_specsheet.pdf).

<sup>23</sup> Clements and Kirkland, “Unmanned Ground Systems,” (PowerPoint Presentation), photograph.

<sup>24</sup> Clements and Kirkland, “Unmanned Ground Systems,” (PowerPoint Presentation), photograph.

<sup>25</sup> Clements and Kirkland, “Unmanned Ground Systems,” (PowerPoint Presentation).

<sup>26</sup> Clements and Kirkland, “Unmanned Ground Systems,” (PowerPoint Presentation), photograph.

<sup>27</sup>“[Enhanced Company Operations Limited Objective Experiment 3.3 Final Report](#)”, 11 August 2009, United States Marine Corps, Marine Corps Warfighting Laboratory.

<sup>28</sup>“Quantum Stealth; The Invisible Military Becomes A Reality”, Guy Cramer, President/CEO of Hyperstealth Biotechnology Corp, accessed 25 January 2016, <http://www.hyperstealth.com/Quantum-Stealth/index.html>.

<sup>29</sup>“New Technology Makes Troops Invisible,” YouTube video, 4 December 2012, <https://www.youtube.com/watch?v=Rqi3jpBSyCc>.

<sup>30</sup>“Multisorb Factsheet,” accessed 25 January 2016, <http://www.mbdasystems.com/battlefield-engagement/multisorb/>, “BAE Systems' Adaptive Infra-Red 'Invisibility Cloak' for Military Vehicles,” YouTube Video, 7 September 2011, <https://www.youtube.com/watch?v=lzpVkhm-Otk>.

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<sup>35</sup>Ben Lagasca, Susan LeVine and Brian Long, “Combatant or Collateral Damage? New Technology Offers Urban Ops Advantage,” *Association of the United States Army* (August 2015): 3, [http://jnlpw.defense.gov/Portals/50/Documents/Resources/Publications/Journal\\_Articles/New\\_Technology\\_Offers\\_Urban\\_Ops\\_Advantage.pdf](http://jnlpw.defense.gov/Portals/50/Documents/Resources/Publications/Journal_Articles/New_Technology_Offers_Urban_Ops_Advantage.pdf).

<sup>36</sup>“RPG Defeat Net,” QuinetiQ North America, accessed 25 January 2016, <https://www.qinetiq-na.com/products/militaryprotection/qnet/>.

<sup>37</sup>“Shotscreen RPD Defeat System: Active Protection System,” General Dynamics Ordnance and Tactical Systems, accessed 25 January 2016, <http://www.gd-ots.com/download/Shot%20Screen.pdf>; “Trophy Active Protective System for ACVs,” Rafael Advanced Defense Systems, accessed 25 January 2016, <http://www.rafael.co.il/Marketing/349-963-en/Marketing.aspx>.

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## Glossary

**Active Denial System:** Non-lethal, counter-personnel capability that creates a heating sensation, quickly repelling potential adversaries with minimal risk of injury. Active Denial Technology has the potential to support multiple missions, including, force protection, perimeter defense, crowd control, patrols/convoys and defensive and offensive operations. Definition found at:  
<http://jnlwp.defense.gov/FutureNonLethalWeapons/ActiveDenialTechnology.aspx>

**Active Protection System:** Equipment designed to prevent line-of-sight guided anti-tank missiles/projectiles from acquiring and/or destroying a target. Definition found at:  
[https://en.wikipedia.org/wiki/Active\\_protection\\_system](https://en.wikipedia.org/wiki/Active_protection_system)

**Combat Vehicle:** A self-propelled, weaponized military vehicle used for combat operations. Combat vehicles can be wheeled or tracked. Definition found at:  
[https://en.wikipedia.org/wiki/Combat\\_vehicle](https://en.wikipedia.org/wiki/Combat_vehicle). Additionally, the author uses this term to differentiate between vehicles that are capable of being employed on an objective, and are capable of maneuver, and vehicles that support logistics functions. The author contends that E TAMCN vehicles (tanks, AMTRACs, and LAVs) are combat vehicles, and MTRVs and HMMWVs, while have been adapted to function as combat vehicles, are best suited for logistical and administrative functions.

**Combat Robotic System (CRS):** Weaponized, Unmanned Ground Vehicle (UGV) with the following attributes: remotely controllable, weaponized with lethal and non-lethal payloads, and sensing technology for positive identification purposes. Note: This word/concept was found in the Unmanned Ground Systems PPT presentation referenced in the endnotes. Author contextually interpreted this definition from the brief.

**CRS, Crewed Vehicle:** Combat vehicle that can operate with a traditional crew (driver, gunner, commander, and dismounts if applicable), and can be operated remotely with no loss of function in its ability to traverse any terrain, and sense and engage targets. Note: definition created by author to describe a potential future capability envisioned for this paper.

**Counter Radio-Controlled Improvised Explosive Device (RCIED) Electronic Warfare (CREW):** An electronic countermeasure designed to deceive radar, sonar or other systems such as infrared or laser detection. Definition found at:  
[http://battlefield.wikia.com/wiki/ECM\\_Jammer](http://battlefield.wikia.com/wiki/ECM_Jammer)

**Dismounted Force:** A combat formation capable of maneuver to an objective. It is implied that they were at one point a mounted force that disembarked combat vehicles or aircraft. Note: definition created by author for purposes of this paper based on personal experience.

**Ground Unmanned Support Surrogate (GUSS):** Optionally unmanned and autonomous vehicles that reduce the dependence of dispersed ground combat elements on external resupply, reduce the loads carried by the dismounted warfighter, and aid casualty evacuation. Definition found at: <http://www.torcrobotics.com/ground-unmanned-support-surrogate>

**Mega-city:** A megacity is defined as a metropolis of more than 10 million people. Although megacities have similar overarching characteristics, each megacity is different and those that concern U.S. national and partners' security interests are generally in developing countries. They are described as "ill-structured," featuring a mixture of formal, informal, and illicit structures complicated by rapid growth. Definition found at: [http://www.arcic.army.mil/app\\_Documents/ARCIC\\_Report\\_Unified-Quest-14\\_The-Megacity-Operational-Challenges-for-Force-2025-and-Beyond\\_08MAY2014.pdf](http://www.arcic.army.mil/app_Documents/ARCIC_Report_Unified-Quest-14_The-Megacity-Operational-Challenges-for-Force-2025-and-Beyond_08MAY2014.pdf)

**Mounted Force:** A combat formation consisting of combat vehicles capable of maneuver to an objective, with the capability to carry an element that can dismount and conduct operations independent or with the support of the mounted force. Note: Definition created by author for purposes of this paper based on personal experience.

**Passive Protection System:** Equipment such as ballistic protection, camouflage, signature reducing measures, stand-alone armor, and add-on armor. This definition was adapted from Rheinmetall Defense Industry's definition: [http://www.rheinmetall-defence.com/en/rheinmetall\\_defence/systems\\_and\\_products/protection\\_systems/index.php](http://www.rheinmetall-defence.com/en/rheinmetall_defence/systems_and_products/protection_systems/index.php)

**Small Unmanned Ground Vehicle (SUGV):** A lightweight, man portable Unmanned Ground Vehicle (UGV) capable of conducting military operations in urban terrain, tunnels, sewers, and caves. The SUGV aids in the performance of manpower-intensive or high-risk functions. Definition found at: [https://en.wikipedia.org/wiki/XM1216\\_Small\\_Unmanned\\_Ground\\_Vehicle](https://en.wikipedia.org/wiki/XM1216_Small_Unmanned_Ground_Vehicle). Note: Research for different variants shows the goal is for SUGVs to be man-packable, weighing no greater than 35 pounds.

**Tethered/ Follow-Me Mode:** Unmanned Ground Vehicle (UGV) capable of autonomously following another vehicle being controlled by a human operator. Note: This word/concept was found in the Unmanned Ground Systems PPT presentation referenced in the endnotes. Author contextually interpreted this definition from the brief.

**Unmanned Ground Vehicle (UGV):** A vehicle kit system that advances perception, localization and motion planning to protect from threats and increase performance in autonomous missions. They typically are adaptable to any tactical wheeled vehicle for the purpose of supervised autonomous navigation in either a lead or follow role. UGVs are multi-sensor systems that use registration techniques to provide accurate positioning estimates without needing to rely on continuous tracking through a lead vehicle or GPS signals. When equipped with a UGV, each vehicle is capable of navigation to the

objective independently. Definition found at: [https://en.wikipedia.org/wiki/Counter-IED\\_equipment](https://en.wikipedia.org/wiki/Counter-IED_equipment)