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IMAGERY AND MEASUREMENT AND SIGNATURES INTELLIGENCE SUPPORT TO MILITARY OPERATIONS ON URBANIZED TERRAIN

A Monograph

by

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ABSTRACT

The central question of this monograph is a simple one: does the Army's current imagery (IMINT), and measurements and signatures intelligence (MASINT) surveillance architecture, at echelons division and below, meet the requirements for supporting military operations in urban terrain? A review of the research leads one to believe that the answer to that question is "no."

The monograph considers this question by examining three of the world's larger population agglomerations: Bogotá, Colombia; Lagos, Nigeria; and Seoul, Korea. These urban areas are examined in order to develop three archetype cities: one essentially horizontal (Lagos), one essentially vertical (Seoul) and one that contains many of the elements of the other two (Bogotá). This examination allows the identification of unique requirements, opportunities, and limitations that affect the Army's ability to conduct imagery and measurement and signatures intelligence operations at echelons division and below. The importance in identifying these items is found in an increasingly unpleasant reality of the modern age--the desire to avoid combat urban operations will not be sufficient in itself to avoid such combat. Increasing urbanization on every continent makes it clear that future operations--either combat, humanitarian assistance or any combination of the two--will have some elements of the deployed force operating in complex urban areas that present characteristics markedly different from those present in more traditional military venues.

The conclusions drawn are obvious, urban operations raise complex challenges and the Army's current capabilities are not up to meeting those challenges. The picture is not necessarily gloomy; the means to develop the required capabilities exists. It only takes the will to do so.

The monograph's recommendations describe the existing capabilities that need to be enhanced to give the Army the ability to effectively support full-spectrum operations within the joint operational area. While full spectrum operations are conducted across all three levels of war, the emphasis in this monograph is on intelligence and surveillance assets that are optimized to support the critical tactical mission that lead to the accomplishment of operational-level objectives. It is at this level where the actions of planners and operational artists, commanders, and staffs are translated into discrete results. The Army can be most effective in achieving the desired results if it provides its lower echelon organizations with the tools that are effective in performing the six intelligence tasks currently described in its basic intelligence doctrinal manual, FM 34-1, *Fundamentals of Intelligence and Electronic Warfare Operations.* These six tasks--intelligence and warning, intelligence preparation of the battlefield, situation development, target support and support to targeting, force protection, and battle damage assessment--define the broad sets into which any intelligence or surveillance function can be placed. These tasks also provide a cogent framework in which to assess the Army's current strengths and weaknesses, to allow the necessary objective assessments to be made.

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CHAPTER 1

INTRODUCTION

The contemporary world has a population in excess of 6.2 billion people.[1] Over the next ten months, this figure is expected to increase by an additional 60 million people.[2] This increase in population is greater than the estimated current population of metropolitan France.[3] Perhaps more significant, however, is the fact that despite increasing mortality rates due to endemic diseases in many parts of the world, the world's population continues to increase in country-sized increments year after year. The majority of this increased population will not be found equitably distributed in flourishing rural areas that possess the agricultural and economic ability to support it. Instead, the majority of this population will find itself dispersed through the various and rapidly expanding urban locations that have become the dominant socioeconomic and political characteristics of the developing world. Currently, the world has some 404 urban areas with populations in excess of 1 million people.[4] Of these, between nineteen and twenty-

[1]The actual estimate is 6,250,060,284 people. US Census Bureau, US Department of Commerce, World POPClock Projection [database on-line]; available from http://www.census.gov/cgi-bin/ipc/popclockw; Internet; accessed on 14 September 2002.

[2]Ibid.

[3]US Central Intelligence Agency, *The World Factbook, 2001* [database on-line]; available from http://www.citypopulation.de/Country.html?E-WorldPop$World_Population; Internet; accessed on 14 September 2002.

[4]In the strictest sense, the words "city" and "agglomeration" have slightly different meanings. "City" is defined as the core entity within an agglomeration. Agglomeration is defined as the core city and those developed areas (barrios, suburbs, satellite cities, etc.) that are appended to it. In practical terms, cities are delineated only by lines on maps. Agglomerations represent the aggregate of the metropolitan mass in terms of people, physical features and infrastructure. For purposes of this monograph, the terms city, agglomeration, urban environment, and urban area will be used interchangeably.

two of these complexes have populations in excess of ten million inhabitants.[5] Included in these urban clusters are such core cities as Mumbai (Bombay), India; Lagos, Nigeria; Karachi, Pakistan; Jakarta, Indonesia; and, Cairo, Egypt.[6] The large urban areas of the postcolonial and postindustrial era are the focal points for increased populations in most of the developing world. In many countries, such agglomerations are built on primary cities, themselves representing the primary pole attracting migrants. The result is something akin to a city-state, or a state-within-a-state, in which so much of a country's population is concentrated in a single geographic location that most aspects of national policy are determined by the requirements extent in that single area. Either through immigration from surrounding areas or through high urban birth rates, the populations of the major urban centers of Africa, Asia, and Latin America continue to grow at significant rates with ever-increasing demands being made upon existing (and frequently inadequate) physical, social, economic, and political structures.[7] Despite the frequently decreasing quality of life stemming from such unplanned growth, many such areas show little evidence of stabilizing their populations. As poor as conditions are in large areas of these types of areas, they are frequently no worse than those conditions found in a developing country's outlying areas.

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[5]United Nations, *United Nations Population Information Network;* Internet. available from http://www.un.org/esa/population/publications/wup1999/urbanization.pdf, accessed on 14 September 2002.

[6]Ibid.

[7]United Nations, *World Urbanization Prospects: The 1999 Revision,* 3-4. Forecasts in this publication show estimated increase rates of 1.5 to 3.2% per year in Latin America, Asia, and Africa with the highest rates occurring in Africa. By the year 2015 Lagos, Nigeria, will have moved from the world's sixth largest to its third largest agglomeration. For the developing world as a whole, it is expected that 55% of all Africans, 53% of all Asians and 83% of all Latin Americans will be residing in an urban environment by the year 2030. Internet. Available from www.un.org/esa/population/publications/wup1999/ urbanization.pdf, accessed on 5 October 2002.

Perhaps of even greater significance, however, is the fact the fastest growing urban concentrations are most often found in countries with a history of ineffective government, public corruption, domestic instability--frequently the result of tension between a country's various ethnic and social divisions--and often-inefficient economies.[8] Such countries are likely to be the locations of combat, noncombatant emergency evacuation or stability, and support operations for United States military forces for the foreseeable future.[9] The evidence is rather compelling: the unfortunate reality of the twenty-first century is an ever-increasing requirement for United States ground forces to conduct full-spectrum operations in an urban area. Irrespective of any reasonable scenario envisioned, the Army is going to have to operate in a range of complex and urbanized terrain that will include a requirement to conduct intelligence and surveillance operations above, on, and below the surface of such terrain. Even if the decisive battle is fought in a rural area; power projection, executing sustainment operations, conducting stability operations, and carrying out those activities associated with redeploying the force are going to require combat, combat support, and combat service support elements to operate in urban locations that have, until recently, been largely ignored.

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[8]These countries include Mexico, Brazil, India, Indonesia, Egypt, The Philippines, Pakistan, Bangladesh, Colombia, South Africa, Congo, Sudan, Algeria, Cote d Ivoire, North Korea, Nigeria, and Zimbabwe to name just a few. US Central Intelligence Agency, *The World Factbook, 2001;* available from http://www.citypopulation.de/Country.html?E-WorldPop$World_Population Internet; accessed on 14 September 2002.

[9]Since this monograph was started, this statement has been borne out. In September 2002 US special operations forces conducted a partial noncombatant evacuation of Cote d'Ivoire. This included removing American citizens while combat took place between rebel forces and loyalists in Abidjan (agglomeration population 3,900,000). Internet. Available from http://travel.state.gov/cote_warning.html and www.citypopulation.de/country.htm.?E+World, accessed 5 October 2002.

Further complicating the issue is the fact that a broad range of urban terrain exists. The size of the location, both in terms of population and physical composition, varies markedly from country to country based on the country's history, cultural norms, levels of education, access to natural resources, and its past and present economic position.[10] As an example, the traditional capitals and major cities of Latin America have their roots in either the arrival of Spanish and Portuguese colonists (Bogotá) or the ancient, pre-colonial settlements (Mexico City) of the aboriginal people. Such cities have not been devastated by large-scale modern combat, repeated civil wars, or the effects of de-colonization. Their skyrocketing growth rates have their roots in changes brought about by economic modernization and improvements in a nation's ability to deliver health services to its population. By contrast, such cities as Khartoum, Sudan; Lagos, Nigeria; and Seoul, Korea, have been radically altered by the effects of de-colonization, environmental disaster, and modern civil war.[11] The nature of development, to include methods of construction and level of infrastructure development in these cities, differs significantly from cities that have not been subjected to the same set of pressures. As a result, dramatically different conditions exist even when urban clusters have populations approximately the same overall size or population density. An agglomeration is neither

[10]The impact of these cities and surrounding agglomerations can be found in their populations as a percentage of the country's overall population. Populations for these cities range from a low of 7.7 (Bogotá) million to 20.7 million (San Paolo). This corresponds to percentages ranging from just under 18 percent for Colombia to just over 37 percent for Argentina with the percentages for Brazil, Mexico, and Peru falling in between. David Munro, ed., *Cambridge World Gazetteer*, 81, 98, 365, 410, 540, 571-572; Internet; Available from www.gazetter.de; accessed 14 September 2002.

[11]Khartoum has seen its population civil war from 1956 through 1972 and renewed conflict since 1983; Lagos exploded following Nigeria being granted its independence from Great Britain; Seoul, Korea survived World War II unscathed, but was completely destroyed during the 1950-1953 Korean War; Internet; available from http://www.africa-crisis.org/sudan.html?source=overture, accessed 14 September 2002; Helen C. Metz, *Nigeria: A Country Study,* 134-136; and Andreas M. Savada and William Shaw, *South Korea: A Country Study,* 32, 85-86.

merely an aggregation of people nor is it a concentration of relief features. It is, instead, a synthesis of these elements and many others that serve to create a discrete area that must be considered as such.

For the United States Army and Marine Corps, the challenge that must be faced is the effective execution of intelligence and surveillance operations in such diverse urban concentrations. FM 3.0, *Operations,* clearly recognizes that challenge in describing how leaders will use information, increasingly collected by a range of unmanned systems, to enhance their situational understanding before arriving at decisions on when, whether, and how they will engage the enemy.[12]

In this monograph, three "archetype" cities--Bogotá, Colombia; Lagos, Nigeria; and Seoul, Korea, will be examined. The archetypes represent models of the different kinds of urban environments that represent possible venues for full-spectrum operations. In considering these archetypes, the range of variation in such things as economic conditions, vertical construction and subterranean infrastructure, roads and travel ways, urban sprawl, patterns of migration, population density, and public health systems will be examined to identify how they create discrete venues for military forces conducting full-spectrum operations.

These locales have been selected because they represent a pattern of historic, political, and economic development. As such, they represent a number of locations with similar patterns. A city is a continuously evolving distillation of the historic topographic, political, cultural, and economic forces that have acted and continue to act upon a

[12]Department of the Army, FM 3.0, *Operations,* paragraph 4-12.

region.[13] In addition to being such a distillation, an agglomeration is also a complex system of systems as described in Ludwig von Bartalanffy's *General Systems Theory.*[14] By this, one means that such an area is comprised of a broad number of variables that interact with and upon each other. This interaction represents a small system. As the number of variables increase, the system becomes larger and more complex. In simple terms, some locations represent the successful integration of variables into an essentially functioning and self-adapting entity, system, while others do not. In successful cities, there is the successful integration of transportation systems, public health and safety services systems, employment opportunities, and distribution of goods and services. At the other extreme, some concentrations are essentially a series of closely positioned, but essentially separate or only partially aggregated systems. While large numbers of people coexist in close proximity to each other, there is little credible integration of the systems necessary for a truly functional city. The importance here lies in understanding how some urban areas are able to improve as they grow while others only grow. It is this integration of an areas' subordinate and interrelated systems that ultimately determines both the physical construction and the nature and practical outcomes of human dynamism within any such concentration. Finally, these three cities represent three points on a developmental continuum with Bogotá representing the center point, Lagos the leftmost (and least well-developed and integrated) point, and Seoul the rightmost point. These

[13]Lewis Mumford, *The City in History*, pages 5-6. A bit more prosaically, Mumford describes the essential poles between which human life swings: movement and settlement. Parallel and convergent political, social, cultural, and economic forces throughout history have served as the drivers to determine the size, function, and vitality of cities.

[14]Ludwig von Bertalanffy, *General Systems Theory: Foundation, Development, and Application,* xx.

cities will be analyzed in that order, so that the center can be examined followed by the extremes of chaotic and orderly planning and development and their effects on a city.

Bogotá can be briefly described as two distinct cities with an urban core of well-built colonial buildings, multifamily housing units and a relatively small number of modern skyscrapers built within a traditional grid pattern of streets surrounded by poorly constructed barrios.[15] As an archetype city, Bogotá represents in many ways such locations as Rio de Janeiro, Buenos Aires, Sao Paulo, and Lima, Peru.[16] These all began as regional seats of government with small populations. The end of colonial rule coupled with agrarian economies saw periods of slow growth that did not significantly affect the organization or composition of the city until the middle portion of the twentieth century. With the transition to industrial economies or to commercially viable export economies, these cities saw periods of explosive growth that led to the rise of large, generally poorly developed barrios around the well-developed urban core.

As an archetype, the Lagos area is representative of most third-world cities that simultaneously experienced explosive growth with what has become chronic economic downturn. Such cities as Freetown, Sierra Leone; Ouagadougou, Burkina Faso; Dakar, Senegal; Luanda, Angola; Kano, Nigeria; Abidjan, Cote d'Ivoire; Khartoum, Sudan; and Kinshasa, Congo, have similar physical features and levels of infrastructure

[15]Ibid. Of Bogotá's large buildings, 60 percent only seven have confirmed construction dates prior to 1970.

[16]The most significant point of divergence between Bogotá is found in the scale of vertical development. Where Bogotá has thirty-five buildings classified as skyscrapers, Buenos Aires and San Paolo are essentially vertical cities with over 1200 skyscrapers in each city. As Colombia's economy improves, one can expect an increase in the scale of vertical development within the city. Other major South American cities, to include Rio de Janeiro, Lima and Santiago have between 29 and 94 such buildings. Skyscrapers.com. Internet. Available from http://www.skyscrapers.com/english/worldmap/city/0.9/101089/index.html, accessed on 17 November 02.

development.[17] All of these cities are essentially horizontal, lack subterranean development, and possess a telecommunications structure that is inadequate both in terms of access and level of technology. Additionally, they all are affected by the patterns of migration that have resulted in large numbers of people from diverse ethnic and linguistic groups establishing themselves within them. All of these factors have served to inhibit the integration of systems needed to turn these large population concentrations into modern cities.

At the opposite end of the continuum from Lagos is Seoul. Possessing an exceptionally high level of modern infrastructure, Seoul can be accurately described as a "cutting edge" city. As such it is a viable archetype for those cities of Asia that have experienced either rapid growth or redevelopment during a time of relative economic prosperity. Such cities include Kuala Lumpur, Malaysia; Singapore; Mumbai, India; and Shanghai, China.[18] To a lesser extent (primarily due to either the degree of subterranean development or reduced building heights), it also can be used to describe other

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[17]African Development Bank Group. Internet. Available from http://www.afdb.org/knowledge/statistics/statistics_indicators_selected/country_tables.htm, accessed 19 NOV 02. These country tables illustrate three significant trends the the period 1979-2000: the percentage of urban population increased, the percentage of employed decreased (despite brief periods in several countries where this was arrested for a brief period, in the twelve sub-Saharan countries examined, all but three examined the percentage of population employed in 2000 was lower than it was in 1979. The exceptions: Cote d'Ivoire, Kenya, Sudan) and the economies of all but Congo and Angola operated with a balance of trade deficit. Angola operated with a positive balance of trade in 2000 breaking a twenty-one year period of trade deficits. The impacts of burgeoning population and increasing populations are evident when one contrasts the physical development of agglomerations in such areas against agglomerations in those countries with more successful economies.

[18]Skyscrapers.com. Internet. Available from http://www.skyscrapers.com/english/worldmap/city/0.9/100213/index.html, accessed 21 NOV 02. Singapore, while having some cultural dynamics that don't exist in Seoul, has much in common with the agglomeration physically, to include over 1200 high-rise buildings and a per capita GDP that continues to improve. Shanghai, Kuala Lumpur and Mumbai also share those same characteristics, to include each of these cities having over 500 high-rise buildings. Bangkok, with a cultural underpinning closer to Seoul's than the other cities is less well developed physically, but still containing almost 350 high-rise buildings.

agglomerations that are either essentially vertical in nature or possess large areas that are so constructed. These include Pyongyang, North Korea; Moscow, Russia; Calcutta, India; and Taipei, Taiwan.[19]

To understand the range of intelligence and surveillance issues that stem from diverse urban environments, it is necessary to describe them. Against this backdrop of archetype cities, elements of the Army's current intelligence and reconnaissance architecture will be examined. Does the Army's current imagery and measurements and signatures intelligence and surveillance architecture at echelons division and below meet the requirements for effectively supporting military operations in urban terrain? Are there gaps in the current architecture, to include those elements that are currently being introduced into the inventory (both equipment and unit battle damage assessment)?[20] The overarching objective is to validate the Army's imagery and measurement and signatures intelligence and surveillance architecture against the probable requirements complex urban areas themselves will present as the world and the Army move through an increasingly unstable twenty-first century that is increasingly described as orbiting around dynamic, urban poles. The decision to limit the study to the disciplines of imagery and measurement and signatures intelligence may initially appear to be unduly restrictive. The decision is, however, a conscious one. Two other disciplines signals intelligence and human intelligence also play a critical role in intelligence and electronic warfare operations at these echelons. Additionally, both disciplines offer a range of

[19]Ibid. Pyongyang, while lacking a high number of high-rise buildings is like Seoul, essentially vertical in nature. Such cities as Calcutta, Taipei and Cairo have from between 88 and 147 high-rise buildings and the trend for future development is upward vice outward.

[20]Department of the Army, FM 34-1, *Fundamentals of Intelligence and Electronic Warfare Operations,* 2-7.

research issues that are tied to the broader issue of intelligence and surveillance support to operations in urban terrain. Research into these disciplines, and their capabilities and limitations in an urban area, indicates that their inclusion in this monograph is not possible due to classification requirements. In the interest of utility, these disciplines are therefore excluded from this monograph.

CHAPTER 2

ARCHETYPE CITIES

Bogota, Colombia

Dating from 1549 when Santa Fe de Bogotá became the seat of an *audiencia* within the Spanish colony of New Granada, modern Bogotá is one of the oldest cities in the western hemisphere.[1] Located on an isolated Andean plateau (in contrast to most Spanish colonial cities that were anchored on natural harbors) and overlooked by Andean peaks, Bogotá's first several hundred years were characterized by a small population and a small growth rate. In 1670, the population stood at only 3,000, and by the start of the independence period in the early 1800s, the population had climbed to only 24,000.[2] The significance here lay in the fact that well into the nineteenth century the physical size of the city remained essentially unchanged from the early days of its founding when four churches defined the actual boundaries of the city.[3] Between the mid-nineteenth and mid-twentieth centuries, however, the city underwent a period of explosive growth stemming from changes in the nation's economy and transportation system following the 1899-1902 civil war fought between the country's Liberals and Conservatives.[4] The country's improved economic condition resulted in the migration of people from outlying areas into the country's cities, to include Bogotá. By 1928 the city's population

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[1]Dennis M. Hanratty and Sandra Meditz, editors, *Colombia: A Country Study,* page 8.Gerald Greenfield, editor, *Latin American Urbanization: Historical Profiles of Major Cities*, page 146.

[2]Greenfield. 147.

[3]Ibid., 147.

[4]Hanratty and Meditz, page 137; On War.com. Internet. Available from http://www.onwar.com/aced/data/9999/1kdays1899.htm, accessed 05 December 2002.

approached one-quarter million, and this figure had been tripled by 1951.[5] Growth continued at a rapid rate through the latter half of the twentieth century with the population of the greater Bogotá area reaching an estimated 7.7 million by early 2002.[6]

This figure is significant for two reasons, social and physical. First, there is a significant social impact. Second, there is a physical change that stems from the effort to meet the needs created by the social. The social effect is found in the economic niche much of this population occupies. By the early 1990s, over 46 percent of the area's work force was employed in the so-called informal-service sector of the economy.[7] This included such employment as street venders, hawkers, cottage industries, and similar low-income positions.[8] With so many people working on the margins of the economy, housing became a problem. To accommodate this population, *barrios* or *favelas* were created. Typically, these are blocks or entire neighborhoods of illegally constructed housing built by the poor.[9] The most common construction materials used are scrap and bamboo.[10] As a general rule, these form an "outer ring" around the city. The availability of urban services varies from each neighborhood with some estimates showing 85 percent

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[5]Greenfield, page 148.

[6]Thomas Brinkhoff: *The Principal Agglomerations of the World.* Internet. Available from http://www.citypopulation.de/World_j.html?E, accessed 14 SEP 02.

[7]John D. Kasarda, Allan M. Parnell, editors, *Third World Cities*, page 106.

[8]Ibid., 106.

[9]Greenfield, page 149. These are considered to be illegal in that they are generally built without regard to building codes and are positioned without regard to larger urban development plans. The result is a large percentage of the area's population residing in substandard structures that serve as the nadir of most of the area's sanitation, transportation and public safety problems.

[10]Susana Amaya, "Housing: Rural Roots to Urban Problems." Internet, available from http://idrinfo.idrc.ca/Archive/ReportsINTRA/pdfs/v8n3e/109292.pdf, accessed 17 NOV 02.

of the city's population having limited access to potable water and 75 percent having some access to the cities inadequate sewage facilities.[11]

In contrast to the barrios, "legal" development shows several different patterns. Where barrio dwellings are generally nothing more than poorly built shanties, legally planned and constructed buildings are frequently built of stone, stucco, or concrete. Additionally, they tend to be multistory. Frequently, such buildings will consist of two or three stories built around a small courtyard or large low-rise blocks of multifamily units.[12] These types of buildings provide the majority of the housing for the area's middle and upper-class population. Such planned developments will have planned roads and will be physically linked to the area's larger road network with modern all-weather roads.[13] Additionally, such developments will be linked to the city's formal water and waste system.

Bogotá is primarily a "horizontal" city in that low-rise structures tend to predominate. The city is, however, the site of thirty-five buildings with twelve or more

[11]J. Carlos Segura, "Urban Ground Water Data Base." Internet. Available from http://www.clw.csiro.au/UGD/DB/Bogota/Bogota.htm, accessed 11 NOV 02 and Environmental Data Interactive Exchange, "World Bank Goes to Colombia's Aid." Internet, Available from www.edie.net/news/Archive5123.cfm, accessed 11 NOV 02. Both of these websites describe the impacts of explosive growth on Bogota's water supply and sewer system. Currently, a significant portion of sewage is piped untreated directly into one of three rivers: the Salitre, the Fucha and the Tunejo. Combined with industrial run-off, the effluent flow consolidates in the Bogotá River. The effect of this historically has been to place some 500,000 riverside residents of the Verbenal and Minuto de Dios areas at risk as the Salitre River would routinely overflow and deposit a mixture of raw sewage and industrial waste in the area. The World Bank is currently funding an effort to clean up these rivers and improve the sewage treatment system. Additionally, it is funding a 31-kilometer pipeline to bring potable water from the Andes to reduce the region's current dependence on ground water.

[12]National Imagery and Mapping Agency (NIMA), Commercial Satellite Imagery Library, scene 2001-XX-0017874-1, 13 DEC 00; scene 2000-XX-0005261-1, 07 FEB 2000.

[13]Ibid.

stories.[14] Of these, eleven are primarily dwellings (four residential buildings and seven hotels) with the remaining twenty-four buildings serving as commercial office space. These buildings are located within the historic core of the city and coexist with much of the city's early colonial construction.[15] It is also in these buildings that the most modern elements of the area's telecommunications system are found.

In opposition to the urban core with its logically aligned and paved streets, the barrios tend to have irregular streets that are frequently unpaved and not effectively tied into the broader network.[16] Linking these two areas is a heavily congested road network that is being augmented by a new aboveground mass transit system.

In a major departure to the situation found in many of the developing world's larger urban areas, virtually the entire population speaks a single language--Spanish.[17] This last point is significant for several reasons. For the local government, it simplifies some of the issues associated with trying to integrate elements of the regions infrastructure. For a force conducting full-spectrum operations it can have a marked implication on those operations requiring communication with the local population or the ability to monitor their communications.

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[14]Skyscrapers.com, "Bogotá." Internet. Available from http://www.skyscrapers.com/english/worldmap/city/skyscrapers/detail/0.9/101120/sro0031/rpp10/ht2/bt09/index.html, accessed 17 NOV 02.

[15]Aurelia Fuertes Medina. "Tourism: What to Visit in Colombia: Bogotá." Internet. Available from http://www.ddg.com/LIS/aurelia/coltou.htm, accessed 17 NOV 02.

[16]NIMA, scene 2001-XX-0017874-1, 13 December 2000; scene 2000-XX-0005261-1, 7 February 2000.

[17]Central Intelligence Agency, *The World Factbook-Colombia.* Internet. Available from http://www.odci.gov/cia/publications/factbook/geos/co.html, accessed 5 October 2002.

Finally, as an archetype, Bogotá represents an urban area with a fairly sophisticated telecommunications architecture that includes a combination of the most modern information processing and management technologies working within a broader system of less-sophisticated elements.

<u>Lagos, Nigeria</u>

Like Bogotá, Lagos also has roots in the colonial period and experienced most of its growth in recent years. Originally a small fishing and farming settlement, the city became both the focal point for the West African slave trade and then, in 1861, the site of British administration during the colonial period.[18] From the granting of independence in 1960 through the 1991 move to Abuja, the city served as the capital of Nigeria.[19] Whereas Bogotá saw its period of peak growth between 1951 and 2001 with a tenfold increase in population, Lagos saw a tenfold increase in its population during the 1980s alone with the number of residents reaching 7.2 million by the end of the decade.[20] The impetus for much of this migration was a severe drought that caused the widespread dislocation of much of sub-Saharan Africa's rural population. Eleven years later, the population of the greater Lagos area is estimated to be between 9.25 and 12.9 million.[21]

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[18]Mega-Cities Project, Trinity College, "Lagos, Nigeria: Lagos At A Glance." Internet. Available from www.megacitiesproject.org/network/lagos.asp, accessed 12 October 2002; and, United Nations, "City Profiles: 2001, Lagos, Nigeria." Internet. Available from www.unchs.org/programmes/guo/city_profile.asp; accessed on 9 September 2002. Erla Zwingle, "Cities," *National Geographic Magazine,* November 2002, 78.

[19]Metz, xxx.

[20]Marine Corps Intelligence Activity, *Nigeria Country Handbook*, 99.

[21]Thomas Brinkhoff, "The Principal Agglomerations of the World." Internet. Available from www.citypopulation.de/World_j.html?E, accessed 14 SEP 02. The Mega-Cities Project. Internet, available from www.megacitiesproject.org/network /lagos.asp, accessed 12 October 2002.

This explosive growth has given Lagos two of its best-known characteristics: its sprawling filth and its squalid congestion.[22] Neither condition should be surprising considering that the average population density on the three islands that comprise the city proper within the approximately 300 square kilometer area is over 20,000 persons per square kilometer.[23]

Following the Nigerian Civil War (1967-1970), Lagos began a period of economic growth that was largely based on light manufacturing and an emerging energy industry based on Nigeria's oil production.[24] The skyrocketing price of oil in the early 1970s created the economic potential for Lagos to develop a far-reaching plan of infrastructure and social services to meet its then-existing population's needs. With the world economic recession in 1981 Lagos was hit with two problems. The first was a massive debt that it was unable to service due to the decline in oil revenues. The second was rampant inflation that further eroded the city's economic foundation.[25] It was during this period of virtual fiscal collapse that the first wave of refugees from Africa's drought

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[22]British Broadcasting Corporation, "On the Buses in Lagos." Internet, available from http://www.news.bbc.co.uk/1/hi/world/africa118657.stm, accessed 22 SEP 02; United States Consulate, Defense Attaché Office, Lagos memorandum U-087-00, " Re-certification of FEML, USADO, Lagos/Abjua," dated 16 November 2000 describes some of Lagos' homes for the urban poor as having as many as twenty-two occupants per habitable room as a consequence of the area's housing shortage.

[23]Mega-Cities Project. "Lagos, Nigeria: Lagos at a Glance." To provide a sense of scale, contrast this to the surface area of Wichita, Kansas, 352 square kilometers and a population density of 978 persons per square kilometer or Kansas City, Missouri, 813 square kilometers with a population density of 543 persons per square kilometer. Fact Monster. Internet. Available from http://www.factmonster.com/ipka/A0877666.html, accessed 22 NOV 02.

[24]UN City Profiles: Lagos. Internet, available from www0.un/org/cyberschoolbus/habitat/profiles/lagos.asp, accessed 12 OCT 02 and William D. Graf, *The Nigerian State: Political Economy, State Class and the Political System in the Post-Colonial Era*, pages 43-44.

[25]Ibid.

began to arrive in the city, creating further stress on a city already beginning to falter under the economic demands of the period.

The great increase in population at a time of economic stress overtaxed the city's resources and capabilities. Particularly significant was the effect on the city's waste and water distribution systems. The combination of rapid growth and no funding meant that by the time the growth rate peaked only two percent of the households in the city were connected to any kind of sewage system and less than eight percent had any kind of regular waste collection.[26] This served to impact on the second major issue: a declining public water supply. This results from the city's primary means of waste management--allowing effluent to flow through large open ditches, some wide and deep enough to support fishing, and consolidate along the city's tidal flats.

Other problems were found in the influx of new residents to the city. Whereas the inflowing population into Bogotá virtually all speaks Spanish, that has not been the case with Lagos. Tribalism--its emphasis on obligation--has been a hallmark of both Nigeria and the surrounding states since colonial rule ended.[27] While three major tribal groups comprise over 60 percent of the country's population, there are over 200 different indigenous ethnic groupings in Nigeria alone.[28] Superimposed over this must be additional ethnic groupings from the drought-affected nations of the region that served as the points of origin for much of the city's refugee population. These different ethnic

[26]The Mega-Cities Project, "Lagos, Nigeria: Lagos at a Glance."

[27]David Lamb, *The Africans,* 9. Though publicly disclaimed by many African leaders, tribalism with its emphasis on meeting financial and employment obligations based on ties of kinship remains an ongoing impediment to modern development.

[28]Graf, 5.

groupings mean that over 500 different languages and many more dialects are spoken within a very small geographic area.[29] Besides the problems associated with trying to communicate in so many different languages there are the underlying problems associated with the differing cultural and social norms of these various groups. This creates additional problems for local government as it tries to come to terms with meeting the infrastructure, health, and economic demands of such a diverse--and frequently low-skilled--population. As is to be expected under such circumstances, economic vitality is also impaired. Current estimates are that over 70 percent of the area's population exists in so-called "street jobs."[30] This is almost a 25 percent increase in marginal economic employment when compared with Bogotá. The results of such depressed economic foundations are found in the physical composition of the urban area itself. The lack of money and substandard infrastructure has resulted in most of the population living in either small shanties constructed from wood or locally obtained debris or buildings made of concrete. Dwellings tend to be either single story if a shanty or from one-to-three stories if the building material is more durable. In both cases, the quality of construction is poor when contrasted with Western standards.

[29]Akin L. Magogunje, "Nigeria: Physical and Social Geography," *Africa South of the Sahara, 2000*, page 819. In this article Mabogunje's estimate of the number of ethnic groups runs even higher than Graf's. The distinction comes from Magogunje counting groups and languages that contain less than 10,000 members. While 80% of the country's population come from the ten largest ethnic groups (Hausa-Falani, Yoruba, Ibo, Kanuri, Tiv, Edo, Nupe, Ibibio and Ijaw) there are still some 19,000,000 Nigerians who do not fit into one of these groups.

[30]The Mega-Cities Project: "Lagos, Nigeria: Lagos at a Glance."

Within the city itself are some 2,700 kilometers of road with approximately 1,000 kilometers of that being paved.[31] Built on marshy ground and in a region with exceptionally heavy rainfall, Lagos would have transportation problems under the best of conditions. Exacerbating this problem, however, is an ongoing problem of ineffective cooperation between government agencies and local developers. This had resulted in the ineffective integration of subordinate road networks within the area.[32] In an effort to overcome this problem, the city is attempting to improve its existing metropolitan rail service. This service operates on surface tracks. Unique among many of the world's largest cities the combination of no underground mass transit and no large-scale waste management system makes Lagos a city essentially devoid of subterranean infrastructure.

In terms of vertical development, Lagos is also rather unique. The area has only eight buildings with twelve or more stories with the largest building being thirty-two stories high.[33] All eight of the buildings classified as skyscrapers are office buildings. In contrast to Bogotá where almost one-third of such buildings were used as dwellings, none of Lagos' large buildings provide housing. The effect of this is a three hundred square kilometer agglomeration that is essentially horizontal in nature. In terms of military operations in urban terrain this is a significant characteristic as it serves to reduce the effects of physical relief by placing forces on what is essentially a single level plane that is intersected and dominated by significant man-made relief features in only a few places.

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[31]Josephine Olu Abiodon, "The Challenges of Growth and Development in Metropolitan Lagos," available from http://www.unu.edu/unupress/unupbooks/uu26ue/uu26ue0i.htm; Internet; accessed on 17 November 2002.

[32]Ibid.

[33]In addition to this building, The National Oil headquarters, the city has an additional three buildings in excess of twenty stories and four buildings with twelve stories.

In summary, Lagos can be described as a multicultural urban construct that is in many respects a series of small villages that are closely connected in terms of physical location, if not in infrastructure. Essentially horizontal in nature and devoid of subterranean infrastructure, Lagos represents an urban area by virtue of its human component: an exceptionally large concentration of people. In terms of physical characteristics, it has much more in common with the villages found in rural or other undeveloped areas in that it presents only two dimensions: the man-made physical and the human dimensions. Its limited infrastructure, particularly in terms of telecommunications resources and an effective road network, is again more consistent with a rural area than a large metropolitan one. Further, the low level of government services and direct government influence is more consistent with a traditional rural area than a modern urban one.

Finally, migration patterns to and within the city create additional challenges for local government agencies, as they try and provide essential services while attempting to integrate the regional infrastructure. Lagos represents a level of complexity that exceeds more and better physically developed cities by virtue of the varying range of interactions available between the human elements that comprise the city's most significant dimension. This complexity, in turn, further increases the challenges inherent in conducting full-spectrum operations in an area that is urban by virtue of its population but both primitive and inadequately integrated in terms of its physical infrastructure and its governing institutions.

Seoul, Korea

In contrast to Bogotá and Lagos, Seoul is both the oldest and the youngest city examined. Becoming the seat of Korean government in 1394 during the Chosun Dynasty, the city was spared the destruction of most of Asia's cities during World War II.[34] With the creation of two hostile states on the Korean Peninsula following the war, Seoul became the seat of the Western-aligned Republic of Korea. In the course of the Korean War, the city was essentially destroyed in the wake of repeated invasions and liberations.[35] While modern Seoul boasts a number of historic buildings, virtually all of these are modern reconstructions that have been rebuilt in an effort to provide a link with the city's historic past.

Modern Korean history can be divided into three periods. The first is the period between the end of Japanese colonial rule in 1945 and the outbreak of the Korean War in 1950. The second is the period beginning with the war and ending with the 1981 announcement that the 1988 Olympic Games would be held in Korea.[36] The third period began with the Olympic announcement and continues through today. The significance in these three periods for study purposes is found in the influence both the war and the Olympics have had on the Seoul area. The war effectively leveled the city and efforts to rebuild the city were initially relatively primitive. The priority for development was creating low-cost housing to meet the needs of the large number of refugees who moved

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[34]Korean Overseas Information Service, *A Handbook of Korea,* 538.

[35]Carter J. Eckert et al., *Korea Old and New: A History,* 344-345. Seoul was captured by the North Koreans on 28 June 1950, liberated 28 September 1950, again taken by communist forces on 4 January 1951 and again liberated in March 1951.

[36]*A Handbook of Korea,* 519.

to the city during and following the war. The awarding of the Olympics, on the other hand, served as an engine not only for redevelopment but also for redevelopment with the vision of a state-of-the-art, world-class city as the end result. Coinciding with a period of economic vitality, the redevelopment plan was successful in creating a modern city with a mix of both large-scale vertical and extensive subterranean features.[37]

In terms of population, Seoul is the largest of the cities being examined with a population estimated in excess of 21 million people.[38] This corresponds to almost 22 percent of the entire population of the Republic of Korea.[39] The practical result of this is found in the city's population density, estimated to be over 17,000 persons per square kilometer in 1990.[40] As an indicator of the region's dynamism, this number was 13,816 just ten years previously.[41] This was an increase of over 21 percent. In contrast to Lagos, with its broad mix of ethnic groups and languages, the overwhelming majority of Seoul's population consists of ethnic Koreans, one of the most homogenous populations in the world. The possession of a common cultural identity has served as a major factor that has shaped Seoul's development as the city has served since World War II as a symbol of

[37]Lee Eckert et al, page 388. In 1960 (seven years after the armistice that ended combat, if not the Korean War) the per capital income of Korea was approximately $100.00. By 1990, this number had skyrocketed to over $5,000.00. CIA, *World Factbook, 1999*; available from http://www.photius.com/wfb1999/rankings/gdp_per_capita_0.html; Internet; accessed on 21 November 2002. The latest figure for the Republic of Korea showed a per capita GDP of $12,600. This is in contrast to per capita incomes of Colombia ($6,600) and Nigeria ($960.00) for the same period.

[38]Brinkhoff, "The Principal Agglomerations of the World."

[39]United Nations, "City Profiles: 2001, Seoul, South Korea," available from www.unchs.org/programmes/guo/city_profile.asp; Internet; accessed on 9 September 2002.

[40]One Up Info, "Population Settlement Patterns, Country Study and Country Guide for South Korea; available from http://www.1upinfo.com/country-guide-study/south-korea/south-korea59.html; Internet; accessed on 21 November 2002.

[41]Ibid.

Korean nationalism and progress. While other large urban concentrations, lacking such an identity, have had difficulty in absorbing population increases and integrating them into the regions various economic and social systems, Seoul has not had this problem. As a result, it has been more effective in both integrating the increasing population and developing the interconnected systems necessary to support them.

To meet the demands for housing and the delivery of goods and services to such a population, the city and its modern suburbs have developed on essentially vertical lines in response to the scarcity of land suitable for development and the nature contours of the city. Whereas Lagos is virtually horizontal, much of Seoul is best described as series of concrete canyons that are frequently built en masse. In contrast to Lagos' eight high-rise buildings (twelve or more stories), Seoul has over 674 buildings either completed or under construction, with approximately 20 percent of these buildings providing apartments.[42] With space at such a premium in the Seoul area, the tendency since the late 1970s has been to plan and build large complexes that include dwelling space and commercial space as part of a broader integrated plan. Such developments as the Kwang-Myung Ha, Sanggye, and Sanbon complexes house populations of between 150 thousand and 170 thousand in 38,000-40,000 apartment unit clusters.[43] The buildings housing these apartments range from small five-story buildings to large twenty-five story towers.[44] While similar developments are found within the confines of the city itself, the

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[42]Skyscrapers.com, available from http://www.skyscrapers.com/english/worldmap/city/0.9/100429/index.html; Internet; accessed on 21 November 2002.

[43]Korean National Housing Corporation; available from http://www.jugong.co.kr/web/English/biz-07.html; Internet; accessed on 21 November 2002.

[44]Ibid.

trend of the primary developer the Korean National Housing Corporation is to continue to erect such complexes on the periphery of the urban area. Thus, in contrast to Bogotá, there are no barrio-type developments. Instead, the urban complex is essentially built upwards from the periphery through its heart.

Unlike Bogotá and Lagos, Seoul also has a fairly high degree of subterranean development. Spurred by the awarding of the Olympic Games, the area's metropolitan rail network was expanded from 7.8 kilometers of track in the early 1980s to a current total of 134.9 kilometers of track. The overwhelming majority of this track is underground. Further, the patterns of the track serve to provide subterranean access to the city's core from all directions. The basic design of the city's rail system is that of a web in which strands move out from the city center and into the periphery of the agglomeration while belts exist to allow movement around commercially and culturally significant areas of the city proper. This provides an effective link between the large satellite developments that have been developed in an effort to reduce population density within the city's core.

In addition to the large tunnels providing easements for mass transit, a single large utilities network frequently serves the larger building developments. This provides underground access between different buildings within the same complex. Additionally, the government has undertaken a major environmental management program designed to enhance water quality within the area. This has resulted in the construction of an additional subterranean infrastructure to provide the city with a functioning water and sewage treatment system.[45] The aggregate of all of these features is a sophisticated

[45]United Nations, "City Profiles: 2001, Seoul, South Korea."

subterranean network that supports the large-scale movement of people and material of various types through much of the city.

In summary, Seoul can be physically described as fully modern and integrated agglomeration. The overwhelming majority of development is both highly vertical and cellular in nature. This development takes place within a broader framework that ensures it is linked to the capabilities and limitations of the area's primary infrastructure. Thus, unlike Lagos that consists of clusters of development that are not integrated into the broader city, Seoul's cellular structures are completely linked. This linking gives the population a high degree of mobility. Coincidental with this, the infrastructure is upgraded and modernized to ensure that it is able to meet the varied demands that are imposed upon it. Culturally, the city is also effectively linked by virtue of the dominant characteristic of Korean society: its homogenous population. The cultural barriers that serve to impede effective development in much of Africa and Asia do not exist in Seoul. For the local government, this greatly simplified integrating the various systems existent in the area. For a force conducting full-spectrum operations, the presence of a single language significantly improves the forces ability to conduct operations by simplifying communications issues between the local populace and the force.

An examination of the three archetypes leads to several conclusions that must be borne in mind when evaluating the Army's existing intelligence architecture. First, there is no typical "urban terrain." A review of Bogotá, Lagos, and Seoul shows that they are three very different environments. As such, they pose markedly different tactical challenges and present different intelligence and surveillance requirements. Second, a city in name is not necessarily a city in fact. Bogotá and Lagos both have significant areas that are attached, but de-linked from the cities that serve as their anchors. This serves to create an additional set of variables that must be considered when developing intelligence and surveillance strategies to meet specific mission requirements. This is also a significant consideration when one tries to ascertain how such cities function as part of a broader political, economic, and social system or when one tries to integrate activities into or onto such a system. By default, much of the intelligence and surveillance effort in any area will be tied at one or more points to such systems. Finally, the most dynamic component within any urban concentration is its population. It is the population and its attitudes and economic capacities and opportunities that have, more than any other factor, served to shape these areas and to define the problems and options posed by each archetype. It is also the population that possesses the ability to change actions and attitudes in response to a given set of circumstances. Physical features are static. Infrastructure is either static or binary (it operates or does not operate). The population, on the other hand, is capable of a range of responses that can serve to mitigate or exacerbate conditions within any urban area under a range of acute or chronic conditions. As the Army, in general, and the Military Intelligence Corps, in particular, considers urban areas and the influences of such locations on operations, the population and its ability to demonstrate dynamism must ultimately remain the primary consideration.

The central question is a simple one: Does the Army's current intelligence and surveillance architecture at echelons division and below meet the requirements of military operations in urban terrain? To answer that question, it is necessary to consider the collection disciplines and capabilities found in the divisional military intelligence battalion or military intelligence company providing support to an armored cavalry regiment or separate brigade. In such organizations, four distinct intelligence disciplines are represented. These disciplines are imagery intelligence (IMINT), measurement and signatures intelligence (MASINT), signals intelligence (SIGINT), and human intelligence (HUMINT). In the next two chapters, the imagery and measurement and signatures intelligence resources at echelons division and below will be articulated. In chapter 5, "Conclusions," the ability of those disciplines, as currently resourced, to meet the specific requirements posed by each of the archetype environments described will be evaluated.

CHAPTER 3

IMAGERY INTELLIGENCE

Imagery intelligence is defined as "the product of imagery analysis. Imagery is derived from, but is not limited to, radar, infrared, optical, and electro-optical sensors."[1]

Historically, such imagery has been primarily obtained from sensors mounted in manned aircraft. Since the early 1980s, however, military intelligence has increasingly migrated away from manned aircraft and towards unmanned aerial vehicles (UAVs) as the primary means of obtaining imagery intelligence, particularly at the echelons corps and below.[2] This change in platforms has also been characterized by a change in sensor payloads. In the era of manned platforms, the Army's imaging systems were either traditional cameras or line-scan infrared systems that recorded their imagery on film.[3] With the UAV, sensor payloads are electro-optical and send their imagery directly to the ground for viewing, analysis, and recording. This is a significant change in that it

[1]Department of the Army, FM 34-1, *Fundamentals of Intelligence and Electronic Warfare Operations,* chapter two. Internet. Available from http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/34-1/CH2.HTM#2-3, accessed 23 NOV 02.

[2]Beginning in the early 1980s, the US Army Intelligence Center and School (USAICS) began working with the US Army Field Artillery School at Fort Sill in an effort to participate in the Field Artillery's development and fielding of the Lockheed Austin Divison's *Aquila* Remotely Piloted Vehicle (RPV). This effort culminated with the assignment of the author as one of two noncommissioned officers from USAICS' New Systems Training Office to Fort Sill as Project NCO's and the creation of a composite platoon from to undergo both formal training and participation in the RPV's second developmental and operational tests. The *Aquila* was a disappointment in that it was never able to successfully meet the demands imposed upon it. It was the failure of *Aquila* that led to a shift away from vehicles with complex launch and recovery systems towards vehicles that were simpler to operate.

[3]The OV-1D was the Army's primary surveillance aircraft from the early 1960s through the late 1990s. The aircraft carried a variety of sensors, but the most common types were the KS-113 framing camera, the KA-60C panoramic cameras, the AN/AAS-24 infra red recording system and the AN/APS-94 series of side looking airborne radars (SLAR). While all of these sensors exploited different portions of the electro-magnetic spectrum, all of them recorded their imagery on some form of film, most of which required ground processing.

significantly changed the time relationship between acquisition of a target or target over flight and the time the information gained could made available for use by a tactical commander.

Currently, the Army is planning on operating the Shadow UAV as its so-called tactical UAV (TUAV). As such, it will be part of both the divisional military intelligence battalion and the armored cavalry regiment and separate brigade intelligence and surveillance architecture. The doctrinal employment of these assets calls for them to be used in a direct support role for each ground brigade and or regiment. Placing the TUAV in the direct support role is intended to give a brigade-level commander the ability to focus an exceptionally flexible intelligence and surveillance asset where it can best support his information and decision-making requirements. To achieve this, the placement of these assets within the divisional battalion is with each of the three direct support companies. Within the armored cavalry regiment, the TUAV is found within the assigned military intelligence company. Within the Stryker Brigade Combat Teams, now known as Stryker brigades, the TUAV is placed within the surveillance troop of the brigade's organic reconnaissance and surveillance squadron.[4]

The basic capabilities of the TUAV are an electro-optical (daylight) sensor, a thermal sensor, a ceiling of 15,000 feet (which provides the ability to avoid engagement by most tactical antiaircraft weapons), and the ability to fly a mission of up to five hours.[5] While the sensor payload is capable of movement on all three axes (this serves to enhance both the flexibility of the sensor and improve the vehicles ability to survive by

[4]Correspondence from CPT Prescott Farris, Officer In Charge of Unmanned Aerial Vehicle Training, US Army Intelligence Center, Fort Huachuca dated 10 December 2002.

[5]Ibid.

avoiding direct over flight of hostile targets), the TUAV's electro-optical system, to a slightly lesser extent its thermal system, can be degraded by adverse atmospheric conditions. Such conditions as low ceilings, fog, and smoke can all affect sensor performance. Additionally, some surface weather conditions can limit the ability of the TUAV itself to fly. These conditions include surface crosswinds in excess of twenty knots, low ceilings, and icing conditions.[6] In short, the TUAV provides a commander with a dedicated capability to observe a named or targeted area of interest for up to eighteen hours daily in favorable weather and threat conditions.

When considering TUAVs against urban requirements, however, it becomes apparent that while the TUAV is a powerful collection asset, it is not one with universal application. The three described archetype cities essentially represent three different combinations of physical development. When considering the effectiveness of the TUAV, patterns of development in both dimensions have a significant impact.

In a poorly developed and essentially horizontal location such as Lagos, the physical conditions exist that make the TUAV most effective. This effectiveness stems from several considerations.

The first is the relative absence of significant vertical development. The absence of concrete and glass canyons offers several advantages in TUAV operations. The TUAV sensor has a wider field of view in that large structures do not serve as "shutters" or "blinders" that mask portions of a target area. An additional advantage is the

[6]Ibid. The Shadow does not possess any de-icing capability once it is airborne. As a result, it must be de-iced before flight and returned to its landing site before ice accumulations on the wings destroy the wing's ability to provide lift. The issue is not increased weight, rather it is the disruption of air over the wing.

predominance of single-story structures. This has two effects. The first is that it is easier for a thermal imaging system to image the inside of such a structure, particularly when the roof is of a material that does not tend to dissipate thermal signatures. The second is the significant decrease in shadows. This is important as it becomes more difficult to hide objects from aerial detection. This makes the detection and basic classification of specific items within an area easier.

The second is the ability of the TUAV to rapidly cover a large area and provide a detailed, real-time depiction of surface conditions. In an area, such as Lagos, which is characterized by uncontrolled growth and an absence of accurate maps, this provides a commander with a clear and accurate depiction of the conditions that exist on the ground.[7] An example of this is found in the experience of the Israeli Defense Force's (IDF) use of TUAVs over Jenin, the Occupied Territories, in March and April of 2002.[8] During this operation, the IDF capitalized on the TUAV's ability to serve as a mapping platform to provide its forces with real-time portrayals of Jenin's physical features. This served to provide planners with the information they required to effectively develop credible plans for movement into and through the area and for maneuver units to have an accurate visual depiction of their area of operations.

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[7]"How to Make Nigerian Cities Liveable," *The Guardian,* 21 August 2000. Written by staff journalists of one Nigeria's leading newspapers, this article describes some of the problems that prevent the production of accurate maps of the area. These include the encroachment of slums onto travel ways, the development of large refuse heaps adjacent to roadways and the low priority afforded urban planning operations. The cumulative effect of this is a physical situation very much at odds with all but the most up-to-date maps.

[8]The United Nations, *Report of the Secretary-General Prepared Pursuant to General Assembly Resolution ES-10/10 (Report on Jenin).* Internet. Available from http://www.un.org/peace/jenin, accessed 02 December 2002; and Vernon Loeb, "Lesson From Israel: Drones and Urban Warfare," *Washington Post,* 23 September 2002. Internet. Available from http://www.washingtonpost.com, 17 April 2003.

In contrast to an environment such as Lagos, Bogotá offers somewhat greater challenges to TUAV operations. The results of unplanned urban sprawl and the resultant need for the ability to rapidly image such areas remains essentially unchanged. The higher level of vertical development, however, introduces the problem of target areas being partially masked by high-rise buildings. Additionally, the greater prevalence of low multistory buildings (two to nine stories) makes effective imaging of areas more difficult if the specific information requirement (SIR) or specific order and request (SOR) requires accurately assessing such things as human occupation of structures or the presence of wheeled or tracked vehicles in the vicinity of such buildings.[9] The ability to image specific building faces is degraded as such faces may be masked by adjacent buildings. Similarly, the casting of larger shadows can further obscure targets, particularly in early morning or late afternoon when the sun is lowest on the horizon and shadows attain their greatest length.

When an urban location is essentially vertical in nature, as Seoul is, the problems become significant. In areas of extreme development where tall buildings have minimal separation between them, as is the case in many of Seoul's newer developments, the ability of the TUAV to provide any kind of oblique imagery is seriously impaired. The ability to obliquely image an area is important as oblique imagery provides an analyst with a broader set of identification keys to allow the accurate identification of targets on the ground and of their overall relationship to enemy and friendly courses of action.[10]

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[9]Specific information requirement (SIR) and specific orders and requests (SOR) are the specific elements that provide answers to a priority intelligence requirement (PIR) or information requirement (IR). Department of the Army, *FM 34-2, Collection Management and Synchronization,* 2-5.

[10]Imagery is classified as either vertical, low oblique or high oblique. The significance of this is found in what is imaged. Vertical imagery is a view from directly overhead. It allows the analyst to see the

TUAV effectiveness in such an area is also degraded by the simple fact that significant subterranean infrastructure exists. Such targets as subway tunnels and the large-bore utilities trunks that connect buildings are impossible to image with an aerial vehicle. These limitations do not mean that imagery intelligence operations are less effective in such an area, only that aerial vehicles are inhibited. Imaging sensors in such an area have great utility, if they can be effectively positioned. In an urban agglomeration, such positioning requires ground transported and dismountable and or remote sensors that can be employed in those areas that are effectively masked from aerial sensors.

top of an object. Oblique imagery allows the analyst to see not only the top of the object, but also one or more sides. This allows the analyst to determine with greater accuracy not only the type of object being viewed, but specific variants. The primary tool used by an analyst for military equipment identification is a dichotomous key. The key is used to eliminate equipment items based on the features visible in the image. The more features visible, the more effective the key. Thus, it is frequently advantageous to be able to view an equipment item from several perspectives.

CHAPTER 4

MEASUREMENT AND SIGNATURES INTELLIGENCE

Measurement and signatures intelligence (MASINT) uses information gained from technical instruments, such as lasers, radars, passive electro-optical sensors, radiation detectors, seismic detectors, or other sensors to measure objects or events and measure them by their signatures.[1] Every object reflects, refracts, absorbs, or emanates light or sound within its environment. MASINT seeks to identify objects or events (such as movement) based on an object's or event's unique signatures when compared or contrasted against its background. MASINT is effective in identifying anomalies or events under such circumstances due to MASINT systems being designed to identify and record very small differences between an object and its surroundings. Those differences represent the anomalies that are detected and reported by the sensor. The different types of anomalies that are possible (heat, noise, magnetic interference, etc.) serve as the specific drivers for different types of MASINT sensors.

Currently, the Army has a limited mix of tactical MASINT systems to include active radar systems and several types of passive sensors. The long-term objective is to eliminate the current range of radars and passive sensors and replace them with a single, multifunction collection system. The current systems include the AN/PPS-5 and AN/PPS-15 ground surveillance radars (GSR's) and the Remotely Emplaced Battlefield

[1]FM 34-1, 2-5.

Surveillance System (REMBASS).[2] Both of the radar systems are line-of-sight systems while the REMBASS incorporates a mix of sensors, to include seismic-acoustic, magnetic, and infrared detectors.

The capabilities of these various systems vary significantly. The AN/PPS-5 ground surveillance radar is a vehicle-transported radar capable of detecting personnel at ranges of 50 to 6,000 meters and detecting vehicles at ranges from 50 to 10,000 meters.[3] In contrast, the much more portable AN/PPS-15 GSR can detect personnel who are walking at a range of 50 to 500 meters, personnel who are crawling at ranges from 50 to 300 meters and vehicles at ranges of fifty to 3,000 meters.[4] This ability to detect crawling personnel can become significant in those cities possessing some degree of small- or medium-diameter subterranean infrastructure. Both radars are Doppler-type systems that recognize and display the frequency shift that results from a moving object being struck by a radar beam. This shift is what allows the radar to discriminate between a moving target and a stationary background. The capabilities of the three types of REMBASS sensors vary. The magnetic sensor can detect personnel who are armed with small arms at ranges of zero to three meters, wheeled vehicles at a range of fifteen meters and tracked vehicles at a range of twenty-five meters.[5] The system's seismic-acoustic sensor has greater range with the ability to detect personnel at ranges of fifty meters and

[2]Department of the Army, FM 34-10-1, *Tactics, Technique, and Procedures for the Remotely Emplaced Battlefield Surveillance System (REMBASS)* 2-1; and Department of the Army, FM 34-10-2, *Intelligence and Electronic Warfare Handbook,* 1-6 and 1-10.

[3]FM 34-10-2, 1-10.

[4]Ibid., 1-11.

[5]FM 34-10-1, 2-2.

tracked vehicles at a range of 350 meters.[6] The infrared sensor falls between these two with personnel detection at a range of three to twenty meters and vehicle detection at range of fifty meters. Unlike the magnetic and seismic-acoustic, however, the infrared sensor requires a clear line of sight between its subcomponents.[7]

The ranges of individual sensors are one limitation of REMBASS. An additional limitation of the system is the weight of each senor and its batteries. Each remotely emplaced sensor weighs 6.5 pounds with the battery installed. Additionally, the soldier emplacing the sensor must program each sensor with a specific identity. The unit used to perform this task weighs 2.5 pounds. Finally, the system requires clear radio line of sight between the sensor and the display unit. If this is not attainable, repeaters must be emplaced to create this link. Each repeater weighs forty pounds.[8] The repeater is a critical component of the overall system as each individual sensor has a limited ability to broadcast a signal. The absence of repeaters linking sensors with a monitoring station can render the entire system ineffective. Thus, the load borne by the individual soldier load on a REMBASS team can be significant.

The Army's current MASINT objective is to migrate from these systems to the AN/MLQ-40 PROPHET upon fielding the system's Block IV variant, which was originally scheduled to reach an initial operational capability in 2007 and full operational capability in 2009.[9] The Block IV PROPHET will ultimately incorporate a MASINT

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[6]Ibid., 2-4.

[7]Ibid., 2-6.

[8]Ibid., 2-11.

[9]Headquarters, Department of the Army, *Operational Requirements Document for PROPHET,* page 31. A revised estimate of the initial operating capability of 2009 was provided by the TRADOC

suite capable of integrating remotely emplaced sensor and ground surveillance radar inputs with other data collected to create a fused real-time product.[10] Significantly, these remotely emplaced sensors will represent a broader mix of capabilities than existing REMBASS sensors, as the sensors deployed will be, in part, based on specific requirements identified in urban and complex terrain environments.[11] As with the existing systems, PROPHET will be positioned within the direct support companies of the divisional military intelligence battalion, the habitually associated military intelligence company, or the armored cavalry regiment and within the surveillance troop of the reconnaissance, surveillance, and target acquisition squadron of the Stryker brigade. This allocation of tactical MASINT assets is intended to give the brigade or regimental commander the resources required to develop and implement a flexible and redundant intelligence collection plan.

As with imagery intelligence capabilities, the physical characteristics of each archetype city also has an impact on MASINT collection. Additionally, as MASINT sensors are intended to identify the movement of both personnel and equipment, the human dynamics of an urban enclave also impinge on the employment of MASINT systems. It is this more pronounced human component that distinguishes MASINT from IMINT collection in a densely populated urban location.

System's Manager's Office, PROPHET on 03 December 2002. This shifting of the initial operating capability is due in part to the ongoing development of the future combat system (FCS). Part of the development of FCS includes the possible migration of MASINT requirements into the FCS. Undetermined at the present time is the final impact on PROPHET's MASINT suite and PROPHET's links with FCS-based MASINT suites.

[10]*Operational Requirements Document for PROPHET,* 15.

[11]Hust, correspondence.

Lagos, with its uncontrolled sprawl and high population densities, is arguably the least suitable venue for current MASINT systems. Ground surveillance radars are negatively affected in such an area by the existing short lines of sight, exacerbated by the tendency to construct shanties or erect refuse piles on what are intended to be travel ways. This serves to shorten the effective range of the radar and results in a decision to either accept risk by reducing coverage or employing multiple assets in depth to create the depth of observation required. With only three radars in a direct support company or four radars in a Stryker brigade's surveillance troop, this serves to marginalize the asset by mandating the use of multiple systems against a single series of de facto terrain compartments.[12] The only other option that exists is to clear a lane to allow unimpeded passage of the radar beam. This action allows the radar to function at its maximum range, but presents a clear signature that compromises the radar's location. Similarly, remotely emplaced sensors are initially of limited utility by virtue of the simple fact that the high population densities in much of the city impair the ability of the sensors to detect and accurately record activity. Each of the sensors requires a small interval of time to elapse between the passage of one person and another. With dense populations, this period of inactivity will frequently not exist in an area that has been designated as an area of interest, particularly if the expected time of activity within the named area of interest corresponds to periods of peak activity for the local population. The result is that the sensor will not accurately record events as it will not be able to determine when one event

[12]FM 34-10-2; *TRADOC AIPC General Horseblanket Version 1.1A, Architecture Product-BCTP - 3 (Draft),* dated 25 October 2001. The allocation of ground surveillance radars in the direct support company is based on the standard reorganization objective army division structure of three maneuver battalions in a brigade. This allocation envisioned providing each battalion with a ground-surveillance radar capability. Within the surveillance troop the distribution of radars provides radar support for each reconnaissance troop.

starts and stops. Additionally, the short-detection ranges of sensors mean they must be carefully positioned based on expected movements. In an area, such as Lagos, those routes do not exist. The effects of congestion and sprawl serve to create routes that are simply too broad for the sensors to effectively cover. This can be compensated for to some extent by emplacing sensors in a grid pattern.[13] As with GSR emplacement, however, this serves to reduce the effectiveness of the system by requiring the allocation of a large number of sensors to cover a single-named area of interest.

When compared to Lagos, Bogotá represents a more complex location for MASINT. While within the barrios that ring the city, many of the same basic problems found in Lagos exist. While the population density is less, the nature of construction and patterns of movement serve to degrade the effectiveness of the Army's current MASINT systems by limiting radar line of sight and placing greater reliance on grid patterns for remotely emplaced sensors. Once a force moves from the barrio and into the urban core, the effectiveness of MASINT systems increases. The geometry of the city's grid pattern road network provides longer lines of sight for GSRs. This allows GSRs to adequately cover both the roads themselves and specific named areas of interest while remaining outside small-arms range. Additionally, the buildings themselves serve to provide additional concealment from electronic intelligence collectors by reducing the size of the side lobe emanations from the radar's antenna if the radar is properly positioned.[14] Similarly, the more orderly movement of people in such an area serves to better define

[13]FM 34-10-1, 5-3.

[14]Department of the Army, FM 34-2-1, *Tactics, Techniques and Procedures for Reconnaissance and Surveillance and Intelligence Support to Counter-reconnaissance,* Chapter 3; and Department of the Army, STP 34-96R14-SM-TG, 3-212.

movement routes. This in turn serves to improve remotely emplaced sensor performance by creating better locations for seismic-acoustic and infrared sensor placement.

In contrast to Lagos and Bogotá, Seoul offers broader opportunities for the employment of MASINT systems as a result of its high degree of vertical development. As with Bogotá, the more developed areas of the city are characterized by clearly defined travel ways, particularly in the more recently developed areas where the creation of large urban satellites have resulted in a road network that is much more linear than the preexisting system. Of greater significance, however, is the direct influence of physical development on remotely emplaced sensors. Large, multistory buildings are particularly suited for the emplacement of such sensors by nature of their basic design. A limited number of entries from the outside provides a relatively small number of points that must covered by sensors. Additionally, the small number of stairways and elevators in such buildings provide clearly defined points that allow sufficient coverage of a structure with a minimal investment in manpower and sensors. Such a characteristic makes remotely emplaced sensors particularly useful in monitoring specific named areas of interest within buildings.

A significant advantage for MASINT collection in an urban location with a high degree of development, such as Seoul, is the reduced number of locations suitable for landing and pickup zones for helicopter-borne forces. This reduced number of possible zones makes it possible to employ remotely emplaced sensors to over watch them. Because of the unique acoustic characteristics of helicopters, it is possible to use very low numbers of sensors to provide the required coverage.

Finally, an additional characteristic of Seoul that benefits MASINT collection is the city's underground infrastructure, primarily its subway system and modernized sewage and drainage system. In many respects this is similar to the city's large surface developments in that a fixed number of ingress and egress points exist. In such an environment, ground surveillance radar is virtually undetectable by electronic intelligence collectors. Remotely emplaced sensors have great utility in such an area. A relatively small number of sensors positioned at key points within such a system allows for the continuous monitoring of a large portion of the network. The range of remotely emplaced sensors available for such purposes increases significantly if rail movement through the subway is halted. The curtailment of such service ensures that the technical limitations of the current family of sensors are not exceeded.[15] Similarly, such sensors can be used in other large-diameter utility tunnels, such as sewers and storm drains. Used in a complementary fashion, supported by the required communications and sensor relays, such sensors can effectively establish continuous surveillance of the key points within those subterranean features that can serve as avenues of approach within a modern, three-dimensional entity, such as Seoul.

In contrast to IMINT, MASINT can be highly valuable in an location, such as Seoul. The same features that tend to limit the capabilities of imagery collection are, in fact, enablers for MASINT systems. For MASINT vertical and subterranean development, with the corresponding limitations on area entrance and exit, become an aid in planning and executing collection, not a detractor.

[15]FM 34-10-1, 5-9 emphasizes the limitations of the DT-562/GSQ magnetic sensor if placed along or adjacent to railroads.

CHAPTER 5

CONCLUSIONS

The overriding conclusion is the most obvious one: there is no single template for an urban environment. Though stated in archetype city conclusions, the importance of this conclusion makes it worth restating. Indeed, it should serve as mantra in the Army's efforts to develop more capable methods of solving the range of tactical and operational problems inherent in urban operations. In terms of assessing imagery and MASINT intelligence assets against the requirements created by large urban areas, it is essential that the Army considers the full range of urban locations that may serve as venues for full-spectrum operations. Popular perceptions are that urban areas equate to the concrete and glass canyons of the first world. Most of the world's agglomerations do not neatly fit that construct. In considering the range of urban areas, the Army must also be aware of the most dynamic element within the area--the population. Large cities have population densities ranging from more than 10,000 to over 20,000 people per square kilometer.[1] The impact of population, the only truly dynamic element, can in many cases be much more significant than the physical composition of the city. Irrespective of the intelligence discipline or function being considered, these two conclusions must be carefully considered.

In terms of the Army's current imagery intelligence capability at echelons division and below, the effects of urban developments on the six intelligence tasks are mixed.

[1]Demographia: International Index; available from http://www.demographia.com/db-intluadens-rank.htm; Internet; accessed on 7 December 2002.

The first task (indications and warning) can be effectively performed, weather permitting, with the TUAV in those urban areas that are essentially horizontal in nature. As the surface composition transitions to large vertical structures, the TUAV sensor suffers from the tyranny of physics and becomes decreasingly able to cover named areas of interest. Additionally, in those regions where subterranean development is significant, the TUAV becomes marginalized as it can only provide limited coverage of ingress and egress points.

The second task, conduct intelligence preparation of the battlefield, is a task for which the TUAV is well suited irrespective of the level or type of physical development within the area. The ability to rapidly image broad areas provides analysts and commanders with near-real-time images of the area as it exists. While this is most useful in a large, horizontal agglomeration, it can also be effectively performed in other environments. The key consideration is the ability of the TUAV to provide direct overhead imagery irrespective of lighting conditions. So long as an urban area is inhabited, it possesses a certain level of dynamism. The TUAV provides the near-continuous ability to depict how that dynamism affects surface relief features.

Situation development, the third task, is best supported by the TUAV in the more expansive and less built-up urban areas. Here, however, significant limitations exist in terms of the TUAV's ability to monitor specific events. If the named area of interest is a static object then there are few limitations in an area that is, for all practical purposes, horizontal. If, however, the named area of interest is linked to human behavior (as is often the case in stability or support operations), the TUAV becomes decreasingly useful. This is simply a function of sensor resolution. A TUAV can track a specific vehicle without great difficulty. Tracking individual persons in a crowd, however, is well beyond the capability of the sensor. This may seem unimportant, but in urban areas with population densities in excess of several hundred people per square kilometer this can become a significant limitation. In the more vertically developed areas, the number of suitable TUAV named areas of interest decreases as physical features prevent the sensor from being able to orient on the named area of interest. Clear exceptions do exist, however, such as bridges or other fixed objects that tend to be separated from such physical developments based on their own unique design requirements.

Similarly, the fourth task--target and development and support to targeting--is also affected by the same issues of physical development versus vertical development and sensor resolution as situation development. The key consideration is less one of sensor capability than the ability to position the sensor where it can observe the desired named area(s) of interest.

Irrespective of the nature of development, the TUAV is of limited use in force protection. In horizontal environments, the TUAV can image large areas with few limitations on the sensor's ability to acquire specific targets. If the target, however, is small, then the TUAV is limited by its ability to both resolve such targets and effectively track them. Only in those areas where the threat is mounted or employing fairly large and unique signature items can the TUAV acquire the threat. In simple terms, the TUAV has no difficulty in acquiring a main battle tank at an intersection. It does, however, lack the ability to determine which five people out of a crowd of 5,000 are carrying small arms, rifle-propelled grenades, explosives, or other weapons. In areas with large-scale vertical development, the TUAV becomes even less efficient as local relief features obscure sensor lines of sight. Additionally, the inability of the sensor to image through most roofing materials and the absence of the ability to image most rooms or voids in multistory buildings mean that many threats are undetectable by the TUAV.

The sixth task, battle damage assessment, is well within the capabilities of the TUAV in most urban areas, provided the target being assessed is located on the surface. In the large horizontal target areas, the TUAV is most useful, as most targets will be found on the surface or on a rooftop. In the more developed locales, the ability to perform BDA is somewhat impaired if a high oblique line between the sensor and the target cannot be attained or if that line of sight is inadequate to meet the analyst's requirements. Additionally, if the target is located inside a building, the TUAV is largely impractical. In such locales, TUAV use in battle damage assessment is best performed when the target is a static object (bridge, viaduct, etc.) or large objects that are limited to movement on the surface of the city.

In summary, the current echelon division and below imagery architecture is most efficient in third world locales characterized by outward, as opposed to upward, development. The primary limiting factor in such areas is the population and the inability of current sensors to identify and track specific individuals. As development increases and the city's physical characteristics become increasingly built upwards, the current imagery architecture becomes decreasingly efficient. This is probably a "blinding flash of the obvious," but the Army currently does not have plans for any tactical imagery system beyond unmanned aerial vehicles. Thus, at least for the foreseeable future, units must be prepared to work with limited imagery intelligence capabilities in such conditions.

As with imagery intelligence capabilities, the Army's current range of MASINT intelligence systems also limits the information that can be made available to commanders and analysts.

Indications and warning capabilities vary dramatically depending on the type of urban area. In the much more chaotic horizontal or surface environment, the ability of such systems to provide timely indications and warning is tied directly to the ability of such systems to watch specific named areas of interests. Where the named areas of interest are large or where the patterns of human movement serve to create excessive background signatures, remotely emplaced sensors are of limited utility. Similarly, ground surveillance radars are limited due to the difficulty in classifying signatures, particularly when large-scale movement of people within a named area of interests results in clutter. If the expected indicator or warning is vehicle based, ground surveillance radars are of greater utility, provided they can be positioned with sufficient lines of sight and with little clutter. With the AN/PPS-5 and AN/PPS-15 this is difficult as they lack any practical means of elevating the antenna beyond placing the entire radar assembly on elevated terrain. Due to these caveats, such systems work best when they are employed during periods of reduced activity by civilian populations. As the area becomes more developed, the usefulness of both remotely emplaced sensors and ground surveillance systems improve significantly. Similarly, the ability of such systems to monitor subterranean features makes these systems very useful in those locations possessing subway systems, large-diameter sewage or drainage systems, or significant utilities access tunnels.

The ability of any of the Army's *current* MASINT intelligence assets to aid in intelligence preparation of the battlefield is virtually nonexistent. The word current is emphasized, because this issue will be specifically addressed in the last chapter, "Recommendations." Intelligence preparation of the battlefield is an analytical process that is best supported by graphic products (determining what options are possible on given terrain) or a combination of graphic and signals intelligence products (determining what courses of action are available to an enemy). The current capabilities of sensors and their display formats make them ill suited to supporting the process.

The ability of MASINT systems to support situation development, targeting and support to target development, and force protection requirements is virtually identical. Measurement and signals intelligence systems have limited sensor range and difficulty in discriminating between accidental signatures (the innocent passage of civilians) and targeted signatures (the passage of enemy combatants). In the physical sense, the signatures are virtually identical. The best way to offset these disadvantages is to position sensors where they are able to adequately cover the named area of interest and when the logical presumption that can be made by any acquisition is that the signature can reasonably be expected to be hostile. As an example, placing a seismic-acoustic sensor string in a market place during the day would not provide any meaningful information. Conversely, placing an infrared sensor in the entrance of a building that has been cleared of civilians and then getting an activation just after sunset could provide a great deal of meaningful information about an enemy force attempting to reoccupy the building.

The final task, battle damage assessment, also represents challenges for measurement and signals intelligence systems. Where radar line of sight is possible, ground surveillance radars can confirm or deny the movement of enemy forces either out of an engagement area or their withdrawal. Similarly, remotely emplaced sensors placed in advantageous locations can display similar indications. *Indications* must be emphasized, however, as the sensors only display passage by objects creating signatures. The physical condition of an object passing cannot generally be determined by either remotely emplaced sensors or ground surveillance radars. Finally, the range limitations inherent in each of the current sensors available also serve to undermine the effectiveness of such systems as aids to accurate battle damage assessment.

The imagery and MASINT intelligence capabilities found within the division, armored cavalry regiment, and separate brigade are essentially inadequate. Currently, the Army has the right kind of organizational structure in place, the direct support company and the surveillance troop, coupled with equipment items that are not fully capable of meeting the needs of tactical commanders or analysts in the urban areas described.

CHAPTER 6

RECOMMENDATIONS

Identifying gaps in the current architecture is easy. Making sound recommendations is much more difficult as recommendations need to consider impacts on equipment (materials), training, leader development, and, organizations. Clearly, the most viable recommendations over the immediate term are those that offer improved capabilities with the lowest direct costs on equipment and training.

I have seven recommendations to improve tactical intelligence collection operations that are essentially material based, but take advantage of existing or rapidly emerging technologies. Adopting these recommendations would enhance the Army's ability to conduct the six intelligence tasks at the tactical level. These recommendations are the acquisition of mast-mountable and or man-portable imagery systems, a mast mount for ground surveillance radars, ground penetrating radars, improved seismic-acoustic sensors with greater range, magnetic sensors with greater range, solar panel cells and improved batteries for sensors, and an unmanned aerial vehicle based retransmission capability.

The first recommendation, mast-mountable/man-portable imaging systems, provides the ability to collect imagery where the TUAV is not adequate. Taking the existing TUAV sensor and adapting it to a man-portable mount that can be extended can create the capability to conduct effective imagery intelligence operations in areas currently denied. By using the TUAV as a video relay for the ground-based sensor, the existing UAV ground station and remote video terminals can be employed to receive the imagery from the sensor. By coordinating the employment of ground- and aerial-based imagery sensors, situational awareness and support to targeting would be significantly enhanced by reducing the "shutters" that vertical urban development creates. By providing the ability to position such a sensor on an extendable mast, the system would have greater flexibility in employment and could be used in higher threat constructs by allowing the operator(s) to remain masked from direct enemy observation or fires.

An improved positioning capability for ground surveillance radars is also needed. The development and deployment of an extendable mast would allow the radar antenna to clear masking terrain. A ten-meter mast would allow the rapid emplacement of radar to overwatch rooftop named areas of interest without exposing the radar team to direct observation or fires. In those areas that are essentially horizontal with two-to-three-story buildings as the predominant local relief features (common in such locations as Lagos, Bogotá, or portions of Seoul) this would improve a unit's ability to achieve situational awareness, support targeting, and force protection operations.

Ground penetrating radar would provide a new signatures intelligence capability with great tactical application. Currently used by archeologists and forensic scientists, ground penetrating radar provides the ability to determine the presence of objects through intervening terrain. This capability would improve the Army's ability to conduct intelligence preparation of the battlefield by accurately identifying the presence of subterranean features. It would also improve situational awareness, support to targeting and force protection operations by allowing the sensor team to record images through such intervening features as masonry or stone walls. In many urban regions, particularly in Latin America and the Middle East, dwellings are built around enclosed courtyards.

Deployed in a wheeled or tracked vehicle, ground penetrating radar would provide an enhanced collection capability.

Seismic-acoustic remotely emplaced sensors have great utility in urban areas. Unfortunately, the current family of sensors (REMBASS) is based on dated technology and has limited range and resolution capabilities. Since REMBASS was first fielded, significant changes in computing capabilities have taken place. These changes have not, however, materially impacted on remotely emplaced sensors. Programmable sensors should be developed and deployed. By having the ability to program sensors to respond to certain measurements or signatures, filtering of sensor activity is possible. The ability to filter out irrelevant signatures, in turn, provides analysts with more useful information to support situation development, targeting, and battle damage assessment.

Magnetic sensors have also failed to benefit from improved information technologies. Developing programmable magnetic sensors would afford tactical units the same benefits as fielding improved seismic-acoustic sensors. This would have significant advantages in conducting targeting and force protection operations in urban areas by allowing the early and accurate classification of specific vehicle types at key locations. Again, the ability to filter out certain signatures would improve an analyst's ability to develop the tactical situation.

One of the great limitations with remotely emplaced sensors is their current weight. Much of the weight carried comes from the batteries required to power sensors and repeaters. By developing solar-power panels that can be positioned near the sensor the need for batteries can be eliminated or reduced. Similarly, developing sensors that can properly operate on AA-sized batteries would result in batteries being both lighter and less bulky. Both of these features are advantageous when considering a soldier's load and the requirements to maneuver in some of the restrictive features that characterize well-developed urban areas.

The last recommendation, TUAV-based retransmission capabilities for remotely emplaced sensors is arguably the most controversial. It is also the most important. The simple fact is TUAVs have limitations in vertical areas. Those same limitations create great opportunities for the employment of remotely emplaced or ground-based imagery sensors. The biggest limitation for those systems, however, is the ability to send their information to the processor that allows signals to be converted into information. TUAV-based retransmission systems would offset that problem by providing a retransmission capability that does not have to be manually emplaced. So long as the TUAV had radio connectivity with the ground and the TUAV control station the ability to transmit MASINT, intelligence information would exist. This would provide commanders with maximum collection flexibility, as it would allow for the right mix of imagery and MASINT collectors to ensure successful execution of the six intelligence tasks that support tactical operations. The deployment of a communications relay or retransmission payload for the TUAV does represent a departure in current thinking regarding TUAV employment. This change would, however, provide significant benefits in tactical operations, particularly if the payload was multi-channel capable and could thus retransmit FM tactical communications as well as UHF or VHF MASINT signals.

While these changes in equipment would represent the most obvious changes in IMINT and MASINT capabilities, such changes do not exist in a vacuum. The acquisition of new systems requires corresponding changes in the institutional programs of instruction for both the soldiers who would operate these improved or modified equipment items and the analysts who receive and process the information acquired. This training must go beyond mere technical training on the equipment, but must consider employment tactics, techniques, and procedures within the range of urban environments described.

Of equal importance is the education of the officers who will be responsible for planning and executing urban operations. Improved capabilities are of little value if they are not understood, particularly by the officers who ultimately determine both what information is collected and how it is employed in planning and executing operations. To provide the Military Intelligence Corps' officer leadership with the requisite knowledge of these enhanced capabilities, the officer basic and captain's career courses would require a revision of the current IMINT and MASINT programs of instruction. As the surveillance troop of the Stryker brigade also operates the TUAV, the Armor basic and captain's career course should include the same blocks of instruction. This would provide the using organizations' leadership with the fundamental understanding required to effectively employ these systems. This understanding must not only include the capabilities of these improved systems, but also the most effective employment means to gain the maximum relevant information they can provide.

To provide this understanding the program of instruction must consider the range of *operational environments,* as well as the specific equipment items. The objective of these changes should not be an officer who understands what a TUAV or improved MASINT capability is, rather, it should be an officer who understands what these capabilities mean in *specific* environments. The importance of this cannot be overemphasized as it is this officer's understanding that will enable sound decisions to be made regarding the employment of a TUAV as a communications relay instead of an IMINT collector or employing a ground-penetrating radar as opposed to a ground surveillance radar. Environments affect capabilities; capabilities affect decisions. The full benefit of improved capabilities will not be realized unless leaders recognize that "one size does not fit all" when it comes to collection activities in urban environments. This should be the cognitive learning objective in revised programs of instruction. Additionally, the program of instruction at the U.S. Army Command and General Staff College should be revised to include more instruction in urban operations. The current syllabus (academic year 2002-2003) dedicates only eight hours of formal instruction and a related twenty-six-hour practical exercise to urban operations.[1] This practical exercise is based on a single, arguably uniquely, American city. Revising the program of instruction, with the revision focusing on both the variety and dynamism of urban environments, would equip graduates of this course with the background knowledge necessary to develop appropriate collection requirements. Such requirements could then be matched against improved collection capabilities to ensure that the relevant intelligence information is collected and processed.

[1]LTC Thomas G. Meara, Center for Army Tactics, Command and General Staff College, interview by author, Ft. Leavenworth, KS, 19 February 2003. The focal point for the practical exercise is Lawrence, Kansas. (The city's population in 2000 was 80,098 spread over some 36.64 kilometers for a population density of just over 2186 persons per square kilometer.) U.S. Government Printing Office, *County/City Data Book,* 12th ed. [book on-line]; available from www.lawrenceks.org/pdf/ Budgetinbrief2003.pdf; Internet; accessed on 19 February 2003. This exercise is, in fact, the high-watermark of urban operations education as the planned Intermediate Level Education (ILE) curriculum for the academic year 200-2004 Command and General Staff curriculum eliminates all urban operations instruction.

Finally, the current force structure of the Army National Guard and Army Reserve should be modified by constituting additional military intelligence companies. These companies should be organized as direct support companies provided with the same equipment as their active component counterparts. The objective here is to have a readily available pool of trained units that can augment collection efforts in urban environments. The current direct support company and or surveillance troop organization is fundamentally sound, but the ratio of such companies to brigades and or armored cavalry regiments is less than one-to-one. Organizing and training additional companies in the reserve component would provide the Army with the flexible force structure needed to conduct effective IMINT and MASINT operations in complex urban environments for extended periods.

Should the Army adopt all of these recommendations, tactical imagery and MASINT capabilities will markedly improve. Should the Army opt not to adopt them, it will still be able to conduct tactical imagery and MASINT operations. Such operations, however, will be less effective and provide tactical commanders a lower level of resolution. Increasingly, the Army's doctrine is based on information superiority. Such superiority is not easily achieved when primary collectors of such information are inadequate in both quantity and capability.

JP 3-06, *Doctrine for Joint Urban Operations,* describes the decision to conduct urban operations as an operational-level decision. FM 100-7, *Decisive Force: The Army in Theater Operations,* describes the concept of a division serving as either a Joint Task Force Headquarters. As a result, one must consider divisional organizations as more than mere tactical units when conducting activities in pursuit of operational-level objectives in the urban environment. A small investment in material for these organizations, coupled with corresponding changes in the training of operators and the education of their leaders, can translate into significant returns in terms of a truly multi-disciplined intelligence capability that can support attaining operational-level decisions within the urban area. Can the Army afford to not make the investment?

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