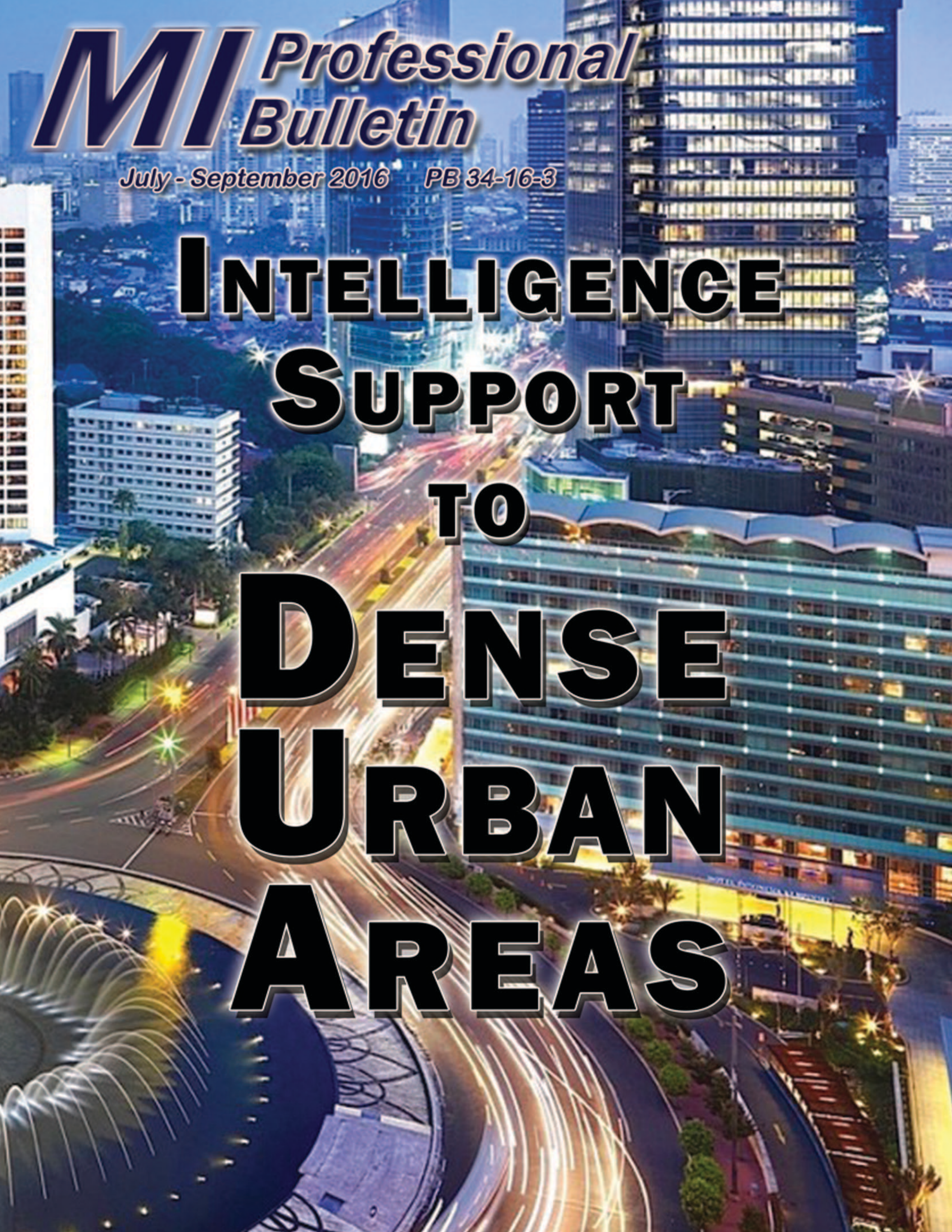
MI Professional Bulletin

July - September 2016 PB 34-16-3

Intelligence Support to Dense Urban Areas



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Purpose: The U.S. Army Intelligence Center of Excellence publishes the **Military Intelligence Professional Bulletin** (**MIPB**) quarterly under the provisions of **AR 25-30**. **MIPB** presents information designed to keep intelligence professionals informed of current and emerging developments within the field and provides an open forum in which ideas; concepts; tactics, techniques, and procedures; historical perspectives; problems and solutions, etc., can be exchanged and discussed for purposes of professional development

By order of the Secretary of the Army:
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Chief of Staff

Official:

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Administrative Assistant to the
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1620204

From the Editor

I will be retiring in September, it's been a very rewarding job due in great part to the many contributors to the Bulletin. I want to thank all the writers and others who have made this Bulletin happen.

The following themes and deadlines are established for:

January March 2017, *Intelligence Training Management*, deadline for submissions is 29 September 2016.

April June 2017, *BCT S2 Ops*, deadline for submissions is 30 December 2016.

July September 2017, *Division and Corps Intelligence Operations*, deadline for submissions is 7 April 2017.

Articles from the field will always be very important to the success of MIPB as a professional bulletin. Please continue to submit them. *Even though the topic of your article may not coincide with an issue's theme, do not hesitate to send it to me*. Most issues will contain theme articles as well as articles on other topics. Your thoughts and lessons learned (from the field) are invaluable.

Please call or email me with any questions regarding your article or upcoming issues.

Sterilla Smith
Editor

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5

28

FEATURES

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DEPARTMENTS

Always Out Front

by Major General Scott D. Berrier
Commanding General
U.S. Army Intelligence Center of Excellence

One of the running threads across my various MIPB columns is the growing complexities we will face in future operations. In my last column, I specifically mentioned demanding environments such as megacities. A megacity is a city with a population of 10 million people or more. U.S. forces have operated in many urban areas but not in as challenging an environment as we will face in megacities. We may have to operate in one or more dense urban areas (DUAs), or "megacities", because those areas are the centers of global political and economic power. Additionally, future threat forces or entities will invariably live and operate in DUAs to mitigate U.S. capabilities. While not insurmountable, operating in a megacity or a DUA will present a formidable challenge to the Army and our unified action partners. The Army and the U.S. Army Intelligence Center of Excellence (USAICoE) have already started tackling the challenges of operating and winning in this environment.

By 2030 more than 60 percent of the world's population is expected to live in cities. According to a world urbanization report published in 2011 by the United Nation's Committee on Economic and Social Affairs, there will be 40 megacities by 2035. However, there are already 36 megacities. Karachi, Pakistan and Lagos, Nigeria both have populations nearly 30 million each, with population densities as high as 70,000 people per square kilometer. The 840 "middleweight" cities with populations of 500,000 to 10 million pose almost as daunting a challenge. The intelligence problems we will face are proportionate to the population density, physical infrastructure, associated information, means of communications, and other unique dynamics. Facilitating situational understanding in this type of environment will stress the intelligence warfighting function. Before we can adequately prepare for these future conflicts, we must first study, analyze, and find solutions for operating within DUAs.

In 2013, then Chief of Staff of the Army, General Odierno, tasked his Strategic Studies Group (SSG) to address megacities and the challenges they pose to Soldiers, our capabilities, and ultimately our ability to succeed. The goal of this and other urban area studies is to set the foundation, conduct analysis, and develop tactical and strategic solutions before we start operations. Early conclusions during the study support that our current readiness constructs will not adequately prepare our forces for missions in DUAs. Currently, DUAs are not a critical element of operational planning, scenario development, institutional education, and federated intelligence analysis.

As a result of the SSG and the Army Operating Concept, USAICoE began studying operating in megacities and the associated challenges to the intelligence warfighting function. As part of our 30-year modernization strategy, we are working with academia, industry, and other governmental agencies to exploit a variety of resources to analyze issues and conduct experimentation. These collaborative efforts will help us to gain insight on new technologies, new ideas, and potential solutions to address specific challenges. USAICoE and the Communication-Electronic Research, Development and Engineering Center, Intelligence and Information Warfare Directorate, partnered with Arizona State University (ASU) to establish an analytic framework for DUAs. ASU also hosted the U.S. Army Training and Doctrine Command (TRADOC) G2's Mad Scientist Conference on megacities, which examined the operational complexities and difficulties associated with megacities. Additionally, the National Ground Intelligence Center has developed a city analytic framework and started applying it to various cities to better understand and map those cities.

In the end, technology and new conceptual solutions alone will not provide all the answers. As we move forward with finding solutions, part of our strategy is still attaining excellence as we perform the fundamentals of intelligence. A deep understanding of the intelligence process and core competencies, building regional expertise, seamlessly leveraging the intelligence enterprise, operating with unified action partners through joint operational phases, and properly setting the theater are all part of the ultimate solution. All of us have a critical role to play in tackling these issues and building Army readiness. We look forward to continuing to work these issues with TRADOC, the intelligence community, and the rest of the Army. I know that together, we will meet these formidable challenges and accomplish the mission no matter how complex.

"Always Out Front and Army Strong!"

CSM FORUM

by Command Sergeant Major Thomas J. Latter
U.S. Army Intelligence Center of Excellence

Megacities: Building a Foundation for the Inevitable

According to Joint Publication 2-0 the "six categories of intelligence operations are: planning and direction; collection; processing and exploitation; analysis and production; dissemination and integration; and evaluation and feedback." Why am I talking about the basics of intelligence operations in this issue of MIPB dedicated to Dense Urban Areas (DUAs) or "megacities"? The answer is, the better you are at your foundational skills, the quicker you will be able to adapt to a changing environment.

The concept of conducting military operations successfully in DUAs is daunting, especially when taken as a whole. Reams of documentation analyze the effects the complexities of a megacity will have on intelligence operations in all of the disciplines: All-Source Intelligence, Human Intelligence (HUMINT), Signals Intelligence (SIGINT), Geospatial Intelligence (GEOINT), Measurement and Signature Intelligence (MASINT), Technical Intelligence (TECHINT), Open Source Intelligence (OSINT), and Counterintelligence (CI). Therefore, break it down to your foundation as an intelligence professional.

Collection in megacities will need to be precise. There is simply too much information available to pull it all in to analyze. Thus, we need to hunt for information instead of gathering everything available. The key to this is knowing what your commander's priority intelligence requirements (PIRs) are. Then, letting those PIRs provide the direction to plan your collection management based on the assets you have available. As we develop better capabilities in the future to operate in a DUA you will need to remain current on how to best employ those capabilities in this environment.

Every intelligence professional needs to become more knowledgeable and creative in operating in the cyber domain to support collection in their intelligence discipline. Think of PIRs you have had in the past, now apply them in an operating environment of 100,000 people all living in a two block square high rise. Everyone acknowledges that the tools we have in our inventory today have limited effectiveness in a DUA, but the mission will still need to be accomplished. Developments in the cyber domain will be essential to successful intelligence collection operations in a megacity. Whether enabling targeted HUMINT Source Operations; CI surveillance; access to SIGINT collection using established networks; using building plans and construction archives to fill in missing GEOINT data; historic power usage for MASINT comparison, or indications and warning from OSINT on current activities, intelligence operations in the cyber domain will be tied to successful military operations in megacities.

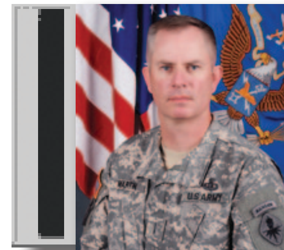
Intelligence preparation of the battlefield will be instrumental in operating effectively in a DUA, but we need to go beyond the layered approach we currently use. As an intelligence professional you are trained to break a complex environment down into its component layers through IPB and provide the commander a clear intelligence picture when you reassemble it for them. In a DUA you will not only need to weave the layers back together, but also show the extensively interdependent environment, infrastructure, and population of a megacity to give your commander situational understanding. Intelligence professionals need to expand their interaction with the rest of the staff by staying integrated with Operations, Signal, Information Operations, Engineers, Aviation, Logistics, Fires (to include cyber), etc. to provide actionable intelligence to a commander in a DUA.

The recent U.S. Army Training and Doctrine Command G2 Mad Scientist *Megacities and Dense Urban Areas Initiative: Data Collection and Analysis* commented that "Western military technology and training is designed for more open environments, current military operating procedures and perspectives may not be adequate to overcome the challenges of megacities…and traditional methods of individual (scout, leader observation, etc.) as well as platform (imagery and intelligence) observation, two-dimensional mapping, and population surveying may no longer be sufficient." As the U.S. Army Intelligence Center of Excellence continues to develop better collection platforms, analytical tools, and simulation and modeling technology to support military operations in the future, megacities will be an increasing factor in determining capability requirements. However, it is the foundational intelligence skills of each intelligence professional which will be needed to incorporate updated,

(Continued on page 17)

Technical Perspective

Chief Warrant Officer Five Matthew R. Martin
U.S. Army Intelligence Center of Excellence



> ***Our Army has experience throughout its history of operating in urban environments, from Aachen to Seoul to Baghdad. We have not, however, operated in urban areas with populations of over 10 million people–the megacity.***
>
> ***–General Raymond Odierno***

While accurately predicting the complexities of our future operating environment (OE) remains a challenge, historical trends indicate the world will experience increased urbanization and the continued growth of megacities. Our national security interests and their enabling functions depend on the stability of global cities. However, many of the world's largest cities are vulnerable to volatile swings in economic, political, and military power. The global trend of urbanization further exacerbates volatility in these already unstable regions increasing the probability that the Army will be forced to operate in the megacity in the future. The complexity and increased velocity and momentum of human interaction of the megacity are unprecedented, and will require the Army to develop new doctrine that adapts existing operating principles to the size and scale of operations in the megacity OE.

Dense urban areas (DUAs) are interactively complex OEs that resemble the Army Operating Concept's "complex, unknowable, and constantly changing" ideas. They're not simply threat-centric environments. They are catalysts of the environment that will shape operations and effects, with or without the catalyst of a system of opposition. This requires the Intelligence Warfighting Function (IWfF) to have both the technology and tradecraft to monitor and analyze both the threat and environment simultaneously.

The Army does not have the resident expert knowledge or an established doctrinal framework to operate in a DUA without significant risk. DUA operations require a concerted and continuous intelligence, academic, and operational focus to establish a baseline for situational understanding (SU) and to assess the implications on the range of military operations. The density of people, physical infrastructure, and spectral clutter in future cities will limit commanders' lethal and non-lethal options for combined arms maneuver and wide area security missions. Current capabilities, such as analyzing and processing big data, and leveraging existing public sensor structures organic to cities, such as traffic cameras and media outlets, are untested in this environment.

In the *U.S. Army Functional Concept for Intelligence*, we identified complex and urban terrain as one of three major challenges for Army Intelligence in the future OE. The capabilities of many of the sensors in our inventory are degraded when introduced to dense urban terrain and our sensor capabilities may not be optimized to collect on the relevant signatures. Commanders will need creative strategies and adaptive technically expert warrant officers to effectively employ and synchronize limited sensors.

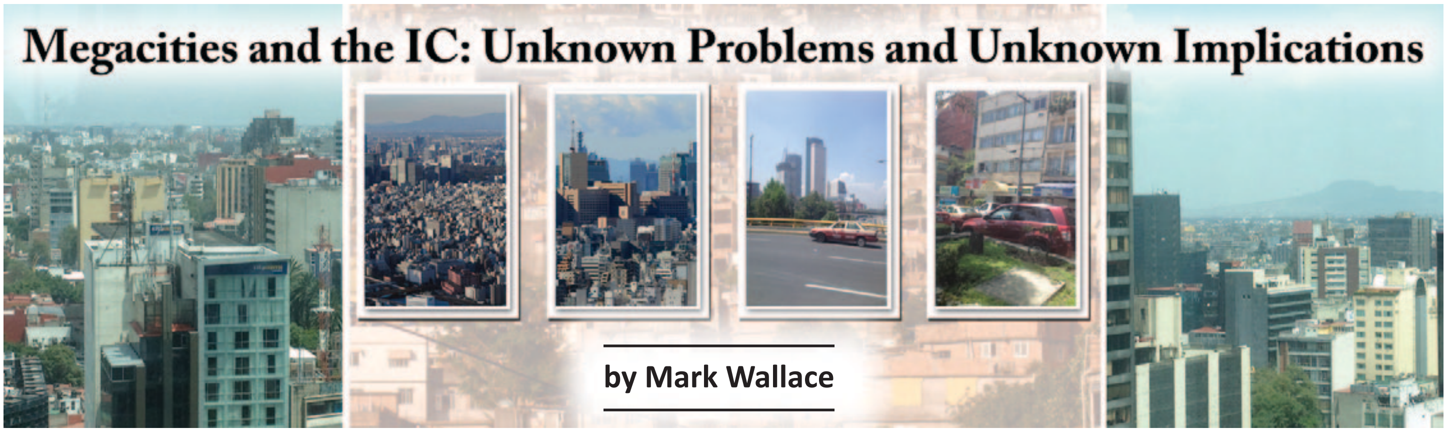
We also know the problem isn't just about sensors and collection. Continued investment in sensors, without complementary investment in improving analytic capabilities will not address SU gaps in cities. Interactively complex OEs like DUAs present challenges in analyzing and processing sources of big data. The Army is not in a position to increase analyst manning to handle increased volume, depth, and complexity of information requirements. The U.S. Army Intelligence Center of Excellence (USAICoE) is pursuing an adaptable framework to meet the challenges of the urban environment, rather than trying to define the environment using existing doctrinal frameworks. We will also pursue technologies that automate analyst workflow processes using both quantitative and qualitative methods to resemble the complexities of cities.

DUAs portend complex problems in achieving SU. Commanders and senior intelligence officers will lean heavily on their warrant officers to address the technical aspects of these challenges. The data we need on most global cities is available although resident in non-standard sources of information. Warrant officers will have great opportunities to creatively employ their systems and personnel to analyze and operationalize non-standard sources of information and make the urban environment a focal point within organizational training, operational planning, and intelligence collection requirements.

A special thanks to CW4 Morris Tyson and the USAICoE Requirements Determination Directorate Team for leading the IWfF's developmental efforts in support of DUA concepts. They strive for clarity within a future that remains very uncertain.

Always Out Front! Army Strong!

Megacities and the IC: Unknown Problems and Unknown Implications



by Mark Wallace

Introduction

Megacities with a population of 10 million or more inhabitants, are the extreme manifestation of an on-going global urbanization trend and may soon become the epicenters of human activity on the planet.[1] To use the term “dense urban areas (DUAs)” over simplifies the basic megacity problems of magnitude of scale and complexity. The term DUA ignores the basic premise of the Chief of Staff of the Army’s Strategic Study Group (CSA’s SSG) findings on megacities, which clearly indicated that size does matter. As cultural and economic hubs, megacities may likely generate most of the friction that will drive future military intervention. It is both plausible and probable that threats to U.S. interests abroad, and to the homeland itself, will emanate from these globally connected and chaotic urban centers. This article addresses some of the megacity challenges the Intelligence Community (IC) will face and offers suggestions as to how the Army might decide to proceed in the future.

The CSA’s SSG has advanced the proposition that Army doctrine, specifically intelligence preparation of the battlefield (IPB), is inadequate to the challenge posed by megacities and that urban systems modeling is the solution. This is largely an unproven hypothesis and still requires objective validation. At present, there is no unified, vetted, and approved megacity problem statement for the Army, and most of the U.S. Army Training and Doctrine Command (TRADOC) proponents have paid scant attention to the issue. Therefore, the question is: *What does the Army need to model?* More work is necessary across the TRADOC community, particularly among the proponents, to do the hard thinking and critical examination to ensure the Army has the megacity problem statement correct. Once the problem is accurately defined and agreed upon, meaningful work can then begin on a focused approach to identifying and resolving doctrine, organization, training, materiel, leadership and education, personnel, and facilities and policy (DOTMLPF) challenges.

The joint community is not yet fully on board either. There are individual pockets of interest but there is no universal agreement on the problem nor a coherent approach. Besides the Army, only the U.S. Marine Corps appears to be considering the problem seriously. The implications of the problem are different for each stakeholder (Army and joint). Current indications are that the Air Force may not be thinking about how they will deal with this issue, and that could pose long term problems for any ground force dependent on standoff technical intelligence, surveillance, and reconnaissance (ISR) support. See the U.S. Air Force ISR Whitepaper *“Revolutionizing AF Intelligence Analysis”* for how they see themselves in the mid-term.[2]

We contend that future operations in megacities are increasingly likely, and that from an intelligence standpoint, we are ill prepared to provide the necessary support that the joint force will demand across all phases of an operation. The Army and joint force have not devoted the necessary effort to study the problem in detail and determine if it is a unique problem and where our shortfalls lie.

If the CSA’S SSG proposition that the Army is ill prepared to conduct IPB to the degree necessary to set conditions for successful operations is accurate–then the likelihood of success for any future operation in a megacity is highly doubtful. It is probably going to be an extremely high-risk environment–not one where the Army simply shows up and then figures it out by performing actions in contact among the people.

The Army has a multitude of doctrinal and operational challenges that need to be resolved before the Army is prepared to operate effectively in this complex, dynamic environment. These challenges range from providing situational awareness to mission command and maneuver. Responding correctly to megacity challenges is not business as usual and finding cogent solutions is not merely a one-and-done problem. It will require considerable analysis and study to understand completely the diversity, proper mix and magnitude of required capabilities. The caution is simply that before the Army starts proposing solutions, we need to adequately define and scope the problem. The concern is that our predisposition for quick, easy wins often results in ill-defined problems and correcting deficiencies that may not exist. This tendency leads prematurely to hasty answers that may not withstand scrutiny, or cost lives and treasure down the road. The upside here is the Army has infinite opportunities if we get the problem definition right on the front end.

Megacity Intelligence Problems

In order to achieve situational understanding, the IC must have the right collection and analysis tools. The IC currently has considerable capabilities to address megacity ISR requirements; however, these concepts and diverse capabilities must be tested and validated during realistic war games, exercises, and experiments to provide confidence in our ability to provide timely and accurate situational understanding.

Hypothetically, some megacity intelligence problems may include:

- Interactive, rapid information exchange between disparate actors locally and abroad.
- Matching sensor-to-shooter timelines and engagement decision loops to extreme transience of targets.
- Finding and identifying the enemy, and an individual's ability to disappear into a crowd.
- Enemy's ability to alternate between guerrilla, mobile, and positional warfare.
- Increased reliance on Human Intelligence (HUMINT), interrogation, and questioning of civilian population.
- Chaotic multi-spectral environments making communications and Signals Intelligence unreliable.
- Building density and canalization requiring long dwell, persistent coverage with vertical lift and hover capability.
- Signal density and big data overwhelming analysis capacity.
- Unknown numbers of foreign languages to interpret.

Other conditions may include:

- Inconsistent opportunity to exploit the "internet of things" and safety/security infrastructure.
- Sensor look angles and signal bounce are situationally dependent.
- Enemy employment of subterranean spaces and tunnels.
- Number of sensors needed to track diverse threats could be cost prohibitive if the Army doesn't figure out how to build cheap, multi-disciplined, disposable sensors.

Until the Army conducts rigorous war games, and experimentation and analysis, the Army and its supporting Intelligence Warfighting Function (IWfF) have limited general, hypothetical knowledge, and no validated answers to actual required capabilities.

Photo credit: James Cridland/Flickr

Army intelligence should lead the way in providing situational understanding for dense urban areas and push to arrive at a TRADOC consensus as to what the actual problem is for the Army. It may be a long, hard debate over competing priorities and will require thorough analysis to make the case. It is incumbent upon the larger IC to lay out the specific challenges that impact the Army's ability to set conditions for the joint force to conduct operations–combat or otherwise. IPB done in Phases 0/1 to provide situational understanding may well make or break future joint and Army operations in this environment.

Intelligence Shortfalls in Megacities

Photo credit: Morio/Wikimedia Commons

While primarily a ground force problem, the Army intelligence force relies on theater and national ISR technical capabilities to understand the operating environment until Army assets arrive. This is especially true during Phases 0 (Shape) through 2 (Defend and Seize Initiative). The other services help set conditions prior to the introduction of any ground force and throughout the duration of its operations. Failure to do so places a force introduced into a poorly developed situation at significant risk. Figuring it out once we get there is not an acceptable option–especially in combat operations.

The Army cannot assume that there will be adequate joint, interagency, intergovernmental, and multi-national HUMINT; that our special operations forces counterparts are on the ground during Phase 0/1 as is common practice in many scenarios; or that the "internet of things" will provide required access and fidelity. Setting the conditions for success in densely populated urban areas will require the Army and IC to take a long-term approach to both building a strategic appreciation for each unique megacity environment and developing regionally focused, urban-competent forces for the particular regions and cities where they may operate.

In addition to the doctrinal IPB shortfalls previously mentioned, the IC focuses on countries as the primary unit of analysis–not cities. Although cities and their host nation share attributes, each city is ostensibly unique and should be thought of as an interconnected ecosystem. The IC should prioritize the cities where the Army would be most likely to deploy based on specific agreed upon criteria (e.g., treaties, instability, susceptibility to disaster, etc.) Then, as recommended by the CSA's SSG, conduct comprehensive "city-as-a-system" analysis supported by intensive modeling and simulation of the operational environment.

The IC has several challenges to address. Megacity scenarios may require unique collection capabilities such as:

- ✦ Stand-off, persistent, vertical, subterranean, see-through structures/walls, acoustic, and precise geo-location sensors.
- ✦ More sophisticated cell phone network collection and jamming capabilities.
- ✦ More precise intelligence support to targeting for precision weapons and effects.
- ✦ Advanced combat identification capabilities to identify friends.
- ✦ Capture/kill requires biometrics and forensics capabilities–especially the ability to detect, tag, track, and identify people and equipment at stand-off ranges in a crowd.

Additionally, big data mining will be more of a challenge requiring pattern and behavior filters and visualization tools. Cyber threat identification and ability to predict/prevent an adversary's next move will be crucial. Moreover, at the grass roots level, how many named areas of interest can a brigade combat team cover with three Gray Eagles and three Multifunctional Teams? The answer depends on METT-TC (mission, enemy, terrain and weather, troops and support available, time available, and civil considerations), so until the institutional Army studies these challenges in detail–no one can provide a good answer.

The IC, as part of a joint force, must identify capability gaps through realistic and methodical examination of the complexity of the dense urban area problem through war games, experiments and exercises. These focused urban analyses will facilitate the development, and integration of informed decisions and innovative DOTMLPF solutions to urban operations challenges.

Potential IC First Steps

Army Intelligence must satisfy a diverse set of information requirements across the range of military operations. Megacities are fundamentally different, extremely complex, and present unique challenges to the IWfF. The Army must learn how to adapt and innovate intelligence support capabilities to accurately describe the environment; then, correctly identify challenges and gaps, in order to define clearly DOTMLPF capability solution sets.

It is generally understood that there are some 25 megacities today. This may be a slight understatement. Correctly identifying those locations that contain a densely populated urban area that is probable, or has a future potential, where the Army might actually perform operations is the key. That group is significantly smaller than 25, but may increase as smaller cities grow and interconnect with other urban complexes. As the Army takes a closer look at the problem, the population density "tipping point" where the Army is forced to operate differently in fact, may be far lower than the 10 million threshold for megacities. There are 577 "middleweight cities" of 150,000–9.99 million that contribute more than half of the global growth to 2025, gaining share from today's megacities.3 This will require the efforts of TRADOC G-2, the U.S. Army Intelligence and Security Command, and the National intelligence agencies to identify, validate, prioritize, and describe the candidate cities, both mid- (2025) and far-term (2040). The next step is to produce baseline assessments and products so we know what "normal" looked like before chaos precipitates a deployment of U.S. and coalition forces. Getting this correct is critical due to the frequently encountered argument that our doctrine says, "The Army bypasses or isolates cities–we won't go there." The IC does not have the luxury of denying the problem any longer. Megacities are here today and they are bastions of regional and global instability.

Photo credit: Popolon/Wikimedia Commons

Megacity Problem Definition and Way Ahead

The proposed Army problem statement is: The U.S. Army, as part of a Joint Force, must identify DOTMLPF capability gaps through realistic and methodical examination of the complexity of the megacity environment through war games, experiments, exercises, analysis, and study.

The supporting proposed problem statement for Army intelligence is: *Military Intelligence is ill prepared to conduct IPB to the degree necessary to set conditions for successful operations in megacities.*

To study successfully the megacity challenge in its entirety, the Army should build an environment conducive to the examination of our doctrine as part of a joint force performing a wide spectrum of missions to gauge doctrinal deficiencies and identify conceptual DOTMLPF solutions. Ideally, it is recommended that the Army conduct a series of war games staged within legitimate contingency plans in and around identified megacities/DUA. These war games need to address all phases of a joint operation in permissive, semi, and non-permissive environments to include both limited objective and sustained combat operations in a large city. The threat should be a realistic portrayal of whatever scenario threat is under examination. This first effort is critical to accurate problem identification and subsequent Army wide, especially maneuver community, buy-in to the problem set. Without the support of Combined Arms Command (CAC) for division and above, and the Maneuver Center of Excellence for brigade and below, the larger effort will fail.

A Possible Approach to Problem Examination

TRADOC and the IC must conduct war games and experimentation in order to identify properly the required capabilities needed to ensure effective support to future ground operations in large, complex urban environments. By doing this through detailed war games and experiments, we will ensure the Army answers the right questions with required capabilities. Therefore, TRADOC is still very much in the problem definition phase from an Army capability develop-

Photo credit: Ahron de Leeuw/Flickr

ment standpoint. Any rush to arrive at potential DOTMLPF solutions at this point is premature.

In support of the overarching Army efforts, the IC may take the following steps as a potential course of action:

1. Define the megacity problem for the IC starting with the previous Joint Forces Command work by:

- Establishing an Urban Intelligence Studies Program (Working Group/Community of Interest).
- Engaging with TRADOC (Army Capabilities Integration Center, TRADOC Intelligence Support Activity and Analysis Center, and CAC) for dense urban area scenario framework supporting both institutional Army (professional military education oriented) and operational training domain; entails expansion of regionally aligned forces test and evaluation scope.

2. Articulate the impact of that problem for the joint force by:

- Working in conjunction with TRADOC to conduct war games and experiments in complex, interactive operational environment scenarios that support identifying new DOTMLPF required capabilities and concepts.
- Collaborating as necessary with academia and industry for subject matter expertise.

3. Take the necessary actions to focus IC capability development efforts near, mid, and far to support the joint force by:

- Codifying doctrinal urban analytic model frameworks (each accounting for unique megacity variables and complexity) based on relevant operational variable application.

Conclusion

Success requires the IC to take a long-term approach to both building a strategic appreciation for each unique megacity environment; and developing regionally focused, urban competent forces for the specific regions and cities where they will operate. Army intelligence should strongly support conducting experimentation and exercises in order to identify correctly the required capabilities needed to ensure successful support to future ground operations in large, complex urban environments.

Understanding how these environments may become magnets for international instability and demand military intervention will aid military planners in avoiding future strategic surprises. The growing significance of large, complex urban environments will naturally make their stability critical for U.S. policy objectives and global equilibrium. Failure to focus attention on these places today will create strategic vulnerability for the U.S. tomorrow.

The U.S. Army Intelligence Center of Excellence (USAICoE) Concepts plans to continue to pursue this topic long term by engaging with the Army, Joint, and the Department of Defense IC to push for a coherent approach to identifying the problem, and then looking at potential DOTMLPF solutions.

Endnotes

1. This is outlined in the SSG paper (page 2) as well as by the United Nations report, "World Urbanization Prospects 2014," accessed 8 January 2015. At http://www.un.org/en/development/desa/news/population/world-urbanization-prospects- 2014.html.

A megacity is defined as a city with a population of 10 million or more. Although the exact number of megacities varies, for the purposes of this paper, it will follow the figures presented by SSG.

2. Deputy Chief of Staff, Intelligence, Surveillance, and Reconnaissance White Paper, Revolutionizing AF Intelligence Analysis, January 2014.

3. Richard Dobbs, Sven Smit, Jaana Remes, James Manyika, Charles Roxburgh, and Alejandra Restrepo, "Urban World: Mapping the Economic Power of Cities," March 2011, The McKinsey Global Institute. At http://www.mckinsey.com/insights/urbanization/urban_world.

COL (R) Mark Wallace is a retired Military Intelligence Officer. He is currently a Senior Intelligence Analyst in Concepts at USAICoE. Mr. Wallace is a U.S. Army War College graduate (2006) with an MA in Strategic Studies. He also holds an MA in Computer Resources and Information Management from Webster University and a BA in History from Western Illinois University.

Photo credit: Morio/Wikimedia Commons

by Joel Lawton, Matthew Santaspirt, and Michael Crites, Edited by Ms. Lori Shields

The views and opinions in this article are those of the authors which were derived from insights captured from the 21-22 April Mad Scientist conference. Therefore, the opinions may not be reflective of any Department of Defense or U.S. Government agency.

All scenarios are fictional for illustrative purposes. The scenarios are not based on actual operational/contingency planning and do not reflect the intent to conduct operations in any particular location. Discussion of any particular country is only intended to provide an open forum and facilitate thought and does not necessarily reflect an official assessment of or U.S. position on that country.

Background: The Mad Scientist Initiative

As a learning organization, the U.S. Army routinely studies the global environment to think, learn, analyze, and implement changes to its doctrine, training, and capabilities. *Mad Scientist* is a U.S. Army Training and Doctrine Command (TRADOC) Army Deputy Chief of Staff for Intelligence (G-2) initiative organized around themes, problem sets, and challenges the Army expects to face in the future operating environment (OE). Mad Scientist enables continuous dialogue between the joint military, international partners, academia, policy institutions, and private sector organizations to assist the Army in exploring the evolution of the OE through the year 2050. Furthermore, it examines the effects of technology in the far future OE to inform near-term capability investments. Mad Scientist supports this through exploring innovative ways to improve the effectiveness of the future force to ensure it can accomplish a diverse set of missions throughout the full range of military operations (ROMO), to include operating in megacities and dense urban areas (DUAs).

Building upon previous work, to include a 2015 report completed by the Chief of Staff of the Army (CSA) Strategic Studies Group on megacities, TRADOC G-2 partnered with Arizona State University (ASU) Foundation, the ASU Research Enterprise (ASURE) and the U.S. Army Intelligence Center of Excellence (USAICoE) to conduct a Mad Scientist Conference, 21 through 22 April 2016, with a focus on "Megacities and Dense Urban Areas in 2025 and Beyond." This event was critical in supporting megacity and DUAs concept and capability development. The conference was used as a venue to validate assumptions or propose concepts to interested academic, material developer, and joint communities. Speakers at this event included senior military leadership, ASU professors, engineers, and other world renowned experts. In order to ensure that the presenters were subject matter experts in their respective fields of study, a call for papers was conducted during the selection process.

The event was organized around four overarching problem sets for future land forces operating in megacities or DUAs. These problem sets additionally served as the conference's objectives:

- Gain situational understanding.
- Enable future force freedom of movement and access.
- Conduct expeditionary operations.
- Mitigate future training challenges.

These problems sets were generally defined and were used as a basis to explore concepts and capabilities to match the complexities of these environments.

Vignette: Calling in the Note

On December 7, 2041 the superpower creditor nation, Red, sees an opportunity to ascend to the position of premier superpower in the world. Red calls for payment of all debts from superpower debtor nation, Blue. The same day, Red successfully seizes the Tokyo Stock Exchange with an attack in cyberspace.

Acceding to Red's demands, Blue begins selling off assets in all foreign stock exchanges. This action, combined with the threat of cyber-attack from Red, throws all markets into turbulence with the exception of White's market, which is within one megacity-state (island) in south Asia. This one market owes its stability to an elite division of cyber defense troops that successfully defeats Red's cyber-attack.

Red uses all the wealth gained from Blue to accelerate economic development of Africa, including feeding, clothing, housing, and medically treating Africa's impoverished masses. Red's information warfare campaign wins approval of global mass media.

The center of world trade, within Blue boundaries, barely survives a cyber-attack from Red. With the danger mounting, Blue requests a detachment of cyber defense troops from White. White sends a regiment in exchange for ground warfare protection from Blue.

Red determines that controlling the global economy (by uniting its own two stable major markets with the Tokyo market and the White market when captured), can be accomplished with minimum bloodshed, maximum metal carnage, and localized environmental destruction in White. The key to a Red victory involves defeating Blue's vaunted robotic forces. The key to a Blue victory involves killing Red's human leadership. These factors place Blue at a distinct disadvantage in public affairs, propaganda, and information war. Blue forces moving to deployment must fight demonstrators at home.

Red moves a proxy army into attack positions on the ground north of White and a proxy navy in the South China Sea because only a physical seizure on the ground can gain control of the White stock market intact. Blue lands three armored divisions on the ground in White composed of 25 percent armored humans and 75 percent robots. Blue establishes a massive air base in White with air forces composed primarily of drones with only a small percent of command aircraft manned by human pilots. Humans are all leaders while robots are all non-rates. The reverse 75-25 composition characterizes the opposing Red forces. Red gains public sympathy by exposing more humans to combat, thus strengthening its information warfare position.

The White megacity-state's electronic warfare envelope extends forty kilometers in every direction from the White Stock Exchange. Military units of any attacker cannot communicate with each other inside the electronic warfare umbrella except by using ancient technology like land line, or at sea, flag and light signals or underwater cable. White's stock market sits four kilometers north of the shoreline. Geography makes an amphibious landing the most likely method of attack, compared with the challenge of fighting infantry through forty kilometers of dense urban area without communications.

Any alliance of Red with Green (superpower with proxies of criminal gang armies) or Black (regional hegemon with religious militia proxies) represents the most dangerous threat course facing Blue-White.

Mad Scientist Megacities and DUAs Synopsis

As in the opening vignette, the complexities of land forces operating in megacities and DUAs are exacerbated by geopolitical factors, proliferation of advanced technologies, terrain, demographics, and a potential mix of state, non-state, and hybrid actors. Urban areas are centers of commerce, transportation, politics and perhaps most importantly large portions of a nation's population. The Army has over time developed concepts, doctrine, tactics, techniques, and procedures for operating in them. ATTP 3-06.11 Combined Arms Operations in Urban Terrain, recognizes the importance of the Army being proficient in conducting urban operations. "Urban operations are among the most difficult and challenging missions" and goes on to propose ways to "plan, prepare, and execute offensive, defensive, and stability operations."[1] However, preparing to conduct operations in a megacity or DUA presents a worst case scenario for the Army and joint force. Challenges are multifaceted and numerous. Future Army forces will have to conduct diverse mission sets not only in complex terrain, but against hybrid threats, contested areas, and huge numbers of noncombatants with embedded malicious actors, and potentially against enemy overmatch technologies.

The types of tasks that the Army may be required to perform in megacities or in DUAs include: non-combatant evacuation; humanitarian assistance/disaster relief (HA/DR) missions; raids; deny adversary objectives; counter weapons of mass destruction operations; conduct military engagement and security cooperation; provide a global stabilizing presence; provide support to civil authorities, and counter-terrorism/counterinsurgency missions.[2] Urban operations doctrine currently considers large cities to have populations from 100,000 to 20 million, where the Army will have to prepare to conduct operations in varying scale, scope, range, and in any OE.[3] Preparation does not imply intent or desire to operate in these environments, but current trends in urbanization increases the possibility for the Army and the joint force to have to conduct operations in megacities and DUAs.

One of the unique aspects of megacities, examined aside from less populous DUAs, is that they are economically interconnected to global systems. At the strategic or national level, megacities are "inextricably linked to global economic prosperity… warrant[ing] significant attentions across all tenets of national power."[4] Some cities, such as New York City (NYC) for example, exceed some nation states in gross domestic product and flow of commerce. A crisis in a city such as NYC can have global implications. During September 11, 2001, global trade markets lost incalculable amounts of money. Losses to NYC itself exceeded $95 billion, the insurance industry lost more than $40 billion, and another $92 billion was lost to jobs and the economy as a direct result.[5]

Megacities may hold the world's concentration of commerce, goods, services, exchange of ideas and information inherent in the aggregation of the best and brightest of a nation in close contact. The problem is that not all of these cities are as resilient (the population's ability to adapt, overcome, or respond to emergency) to crisis as others.[6] The Army, joint force, and global community must be prepared to react and protect these economic powerhouses. Therefore, the Army should similarly be prepared to operate in DUAs (i.e., cities with populations less than 10 million), but further be able to respond to the scale and scope of a megacity in order to protect the world's flow and exchange resources and finances throughout global markets.

Megacity and Dense Urban Areas Problem Sets and Event Objectives

As mentioned in the Background information at the beginning of the article, four problem sets were identified as conference objectives. These are discussed in detail in this section.

✦ ***Gain Situational Understanding:*** Megacities are defined as population centers with ten million or more residents.[7] Currently, 55 percent of the world's population lives in urban areas and 13 percent live in some 24 megacities.[8,9] By 2025 there will be nearly 40 megacities throughout the world, posing challenges to some host nation governments to "effectively deal with their explosive growth and maintain security."[10] Globalization, domestic cultural shifts, the ubiquitous flow of information, pervasiveness of criminal networks, and social or ethnic demographic pressures will further obfuscate clear geographic separation between inhabitants.[11]

Photo credit: JKT-c/Wikimedia Commons

Dense populations, critical infrastructure, and the proliferation of technologies that operate within the electromagnetic spectrum pose many challenges to future forces. Army forces will not be able to rely on a "template or checklist of reconnaissance targets to reveal the nature" of a city.[12] Stressors, networks of people, lines of communication, flow of commerce, and the capacity (resilience) for a city to overcome challenges will vary throughout a single city. Intelligence preparation of the battlefield (IPB) will have to evaluate a variety of operational data layers that incorporates "multiple dimensions simultaneously (surface, subsurface, air, space, cyber, information, etc.) to achieve required effects."[13] Intelligence frameworks must adapt interactively to "complex OEs, like dense urban areas, using both urban operational data layers and city as a system context and perspectives."[14]

The identification and securing of structures or infrastructure may not be easy within a megacity or DUA. Forces may have to operate within larger structures, sub-terrain, or hundreds of feet up within a building. The Army will have to consider how to employ and integrate networks of sensors with socio-cultural data, leverage multiple collection means, to develop methods that identify these areas.

Every DUA or megacity should be considered "unique and must be understood within its own historical, cultural, local, regional, and international context."[15] Ergo, the Army will examine how to achieve situational understanding under conditions it will have to operate within.

✦ ***Enable Future Force Freedom of Movement and Access:*** Current doctrine presupposes that Army ground forces will have complete control over "the location and circumstance of its next engagement."[16] This prediction assumes that Army task organization, formations, and execution of those mission sets will be adequate in any environment. The potential for large-scale HA/DR missions, the "dichotomy of threat conjoined with growing criticality will produce a complex security environment," and the resources to sustain operations in population centers exceeding 10 million people will challenge mission command and Army planners.[17] The

Army will have to consider how to organize its forces to unique situations, varied missions, and rapidly changing tactical conditions.

Megacities and DUAs will be frequently "challenged by threats to their stability" that could require an Army intervention.[18] In circumstances where the Army must commit air or ground forces, the complexity of a dynamic threat may pose unforeseen risk to, for example, Soldier and vehicle protection. A one-size fits all approach to armor and protection systems may not suffice to defend against a host of potential threats in densely populated areas.

Further, both conventional and hybrid threats may employ a host of capabilities that can include: chemical, biological, radiological, nuclear, and explosive capabilities; armor and anti-armor capabilities; improvised explosive devices; air and anti-air capabilities; directed energy weapons; personal armor defeating small arms rounds, and a multitude of other advanced and conventional military technologies employed by non-state, state-sponsored hybrid, and state actors.[19] "There is no silver bullet, no magic material, or countermeasure" that will protect all Army units, vehicles, and Soldiers.[20] The Army will have to explore new modular protection systems; new personal armor; moveable or adjustable armor; augmenting or replacing forces with robotics, artificial intelligence, and other technologies that can "dynamically respond to threats, rapidly reacting to changes in the threat picture."[21]

It must also take in account how to manage or protect large population centers through defense support to civil authorities; security cooperation activities; large-scale operations; protecting critical infrastructure; isolating combatives from the general population, and being able to provide rapid HA/DR response.[22, 23] The Army must consider the integration of special operation forces to develop capable formations designed to operate in a diverse and dynamic OE. Therefore, the Army must find solutions to enable freedom of movement and access through developing capabilities that efficaciously balance protection with mobility and lethality.

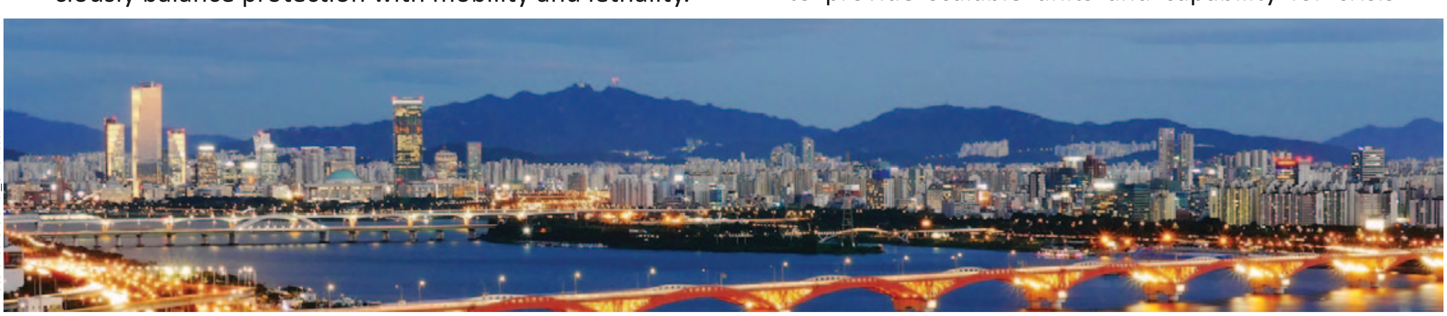
✦ ***Conduct Expeditionary Operations:*** Expeditionary forces operate as an agile, integrated, and rapidly deployable force, able to conduct a wide range of operations, from peacetime to high-end forcible entry operations. Expeditionary operations are decentralized in nature requiring adaptive mission command in order to project power across all warfare domains. The Army Operating Concept defines expeditionary maneuver as the rapid deployment of forces, "positioned forward… [to] respond and resolve crises, defeat enemies, establish security, and consolidate gains." [24] In order to conduct expeditionary operations within megacities and DUAs, the Army will have to consider new size, weight, and power applications; invest in new vertical lift abilities, and the synchronization "of capabilities critical to accomplish the mission."[25]

In order for the Army to achieve sustained expeditionary operations across the ROMO, solutions must focus on the integration of the Army's unique capabilities with naval expeditionary forces over four specific areas:

1. Forward deployment of expeditionary forces. Shape the OE; be actively prepared to defuse a crisis, and defeat adversaries.

2. Sea basing operations. Forces will have to use the sea as a base from which to conduct the full ROMO and provide sustained logistical support to forward deployed forces. Currently, around 40 percent of the world's population lives near coastlines and "population density in coastal areas will continue to increase in the future."[26] Sea basing allows naval forces to physically 'be there' but be off shore. Sea basing will allow the Army, Navy, and Marine Corps forces to strengthen international partnerships and ensure access to critical regions while reducing visibility and dependence on land bases. With naval forces controlling the sea, expeditionary forces are capable of presenting the adversary with a mobile and multi-dimensional threat.

3. Scalability of forces. Expeditionary forces need to provide scalable units and capability for crisis



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response, up to and including forcible entry operations deep into the enemy territory. This allows commanders to tailor force footprints to evolving conditions, composite forward and merge rapidly deploying forces into a unified force scaled to the mission. The scalability of forces will also require decentralized mission command solutions.

4. Integration. The Army will need to integrate institutional and operational capabilities, with unified actions partners, to execute joint combined arms operations.[27] Each of these focus areas requires new concepts and capabilities to support the Army in sustained expeditionary operations in megacities and DUAs.

Mitigate Future Training Challenges: The Army will have to seek new or innovative ways to train the future force to conduct land, sea, air, cyber, and space operations in megacities and DUAs. For example, "the Army-at-large must expand the training of young officers and noncommissioned officers to include the fundamental concepts that enable design methodologies" for solving complicated tactical problems in these environments.[28] Building military-operations-in-urban-terrain (MOUT) training centers "is impractical to impossible to fully recreate [for] megacities (as we do with MOUT sites) or to get access to real-world cities for live training."[29] The Army will have to consider ways for Soldiers to think critically about their environments and how to adapt to the complexities in these terrains. It will have to consider technology enabled solutions such as virtual reality, immersive gaming, and modeling and simulation.

Insights into Conference Problem Sets and Objectives

Through presentations by subject matter experts on various megacity or DUA related issues, open discussion, and attendee discourse, we were supplied with insights, technological solutions, and issues to consider as they relate to the event's four core objectives.[30] Some insights/issues from conference speakers are provided below.

Gain Situational Understanding: In order to effectively operate in a megacity or DUA, the Army needs to understand the environment–physical terrain as well as human terrain.[31] In the era of ubiquitous information, intelligence can be derived from a myriad of open source channels. For instance, through the mapping of geo-located tweets, future forces can gain a picture of where incidents are occurring (e.g., natural disaster, terrorist attack; etc.), what areas are access denied, and what type of aid is needed. Further, all of this information can be received, updated in real time, and coupled with full motion video from networked traffic cameras that are already emplaced throughout cities.[32] This type of information gathering and analysis can save time, fuel, and, most importantly, lives through early alerts and optimal route planning. This type of technology is already available and will only become more accurate in the future.

Photo credit: ahenobarbus/Flickr

Future forces would also benefit from high resolution 3D mapping that not only represents the physical terrain found in the area of operations, but also the history.[33] Organizing the data in space as well as time will provide increased situational understanding that allows the Soldier to recognize and appreciate how the past relates to the present.[34] A terrain map augmented with cyber-social geography and historical events that is laid out spatially and temporally would afford the Soldier with a full suite of tools to achieve mission objectives in a megacity or DUA without being hindered by cultural or social obstacles.

Enable Future Force Freedom of Movement and Access: Megacities and DUAs impose unique restrictions on access to the battlefield due to the density of tall buildings and people, as well as the use of subterranean transportation and infrastructure. The use of smaller unmanned vehicles will be crucial in the future fight. Evacuating personnel will be of vital importance, and unmanned vehicles may be able to do so in denied areas. If evacuation is untenable, and treatment is needed right away, Soldiers could use an unmanned vehicle that is remotely operated. An unmanned system outfitted with sensors and video link would allow medical personnel to diagnose and administer treatment to a victim from a safe distance.[35] To fully realize this idea, the Army could take a system of systems approach to the matter.[36] That is, a suite of biometric sensors working in conjunction with an unmanned vehicle to diagnose and evacuate victims from the crisis area to a medical center where autonomous medical treatment can be administered while under the observation of a human (either in person or via video link).[37, 38] These highly integrated teams will set the Army apart from our adversaries and provide overmatch.

Conduct Expeditionary Operations: When forces are deployed abroad, the challenge will lie in fully understanding the geography as well as the formal and informal social networks. Cities in which the Army is likely to operate in the future will have geographical indicators that will be invisible to those unfamiliar to the region.[39]

In the field, Soldiers could take advantage of virtual humans to aid in face-to-face interactions and interviews, as well as assist in decision making.[40] A human-machine hybrid will outperform either a group of humans working together or a computer working independently. These virtual humans could help to interface with the local populations and increase the amount and accuracy of information received compared to a system that used only humans.[41] Being able to effectively use the local population as a resource will prove invaluable.

Mitigate Future Training Challenges: One of the unique characteristics of a megacity is its sheer size and density. Because of this, the Army will have a significant challenge in accurately representing a megacity or DUA, both physically and virtually, that provides a realistic training environment.

On the virtual side, current modeling and simulation capabilities simply cannot address all the complexities and details that an urban metropolis contains.[42,43] The future megacity or DUA will have thousands of buildings, and in the megacity with more than 10 million people, and miles of infrastructure (both underground and aboveground). Complicating things further, the interior layout of each building is of vital importance and must be known and mapped out to be of benefit in a training environment.

Perhaps most importantly, each megacity will be distinctly different from every other megacity or DUA. This means that creating and training in a virtual model of NYC may not adequately prepare Army forces for operating in a city like Lagos, for example. In order to build a capability for the future force, the Army will have to identify and incorporate only those parts of a megacity or DUA that will matter. Simulations can be used to compartmentalize a city and experiment on certain pieces to determine what parts are of operational significance.[44]

As stated in the 'expeditionary operations' section, the barriers between humans and computers are lowering and machines and people are beginning to merge.[45] A human-machine hybrid will outperform either a group of people working together, or a computer working independently. It is crucial to take advantage of this improvement, but we must start now to train our forces on how to act in concert with machines.[46] Virtual humans (computers that act autonomously and mimic human behavior) have been proven to elicit more honest responses from human subjects and were even reported to make subjects feel more comfortable and open than a real person.[47] This technology would prove very useful in training our Soldiers on person to person interactions and interviews. It could potentially improve the efficiency and effectiveness of Army training while offering potential cost savings by way of being mostly virtual.

Way Forward

The complexities, challenges, and unique environments that megacities and DUAs pose to future land forces may require new concepts, capabilities, training, and doctrine.[48] The Army must seek new efficient and effective science and technology solutions accompanied with innovative training methods and supporting doctrine in order to operate in these environments.

The four overarching problem sets that Mad Scientist examined–situational understanding, future force freedom of movement and access, expeditionary operations, and training–are emblematic of most Army, academic, and subject matter expert concerns for future land forces operating in megacities and DUAs. These focus areas will require Army and joint innovation champions to advance elements of our capabilities, training, education, and leader development. Partnerships between the DoD and academia, as well as the greater materiel development communities, will have to be codified and championed by senior DoD leadership to be successful. Using Mad Scientist as a venue and vehicle to explore outside perspectives on this problem set, the Army and future force will be able to augment its current approach to "combined arms operations in urban terrain."

Currently, the Maneuver Center of Excellence (MCoE) and USAICoE are leading the Army in concepts and capabilities dealing with the megacity and DUAs problem sets. For instance, MCoE has established an Urban Training

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Detachment at Fort Hamilton, NY and is working in collaboration with USAICoE to implement megacity OE characteristics at combat training centers.[49]

The Mad Scientist Initiative, ASU Research Foundation, ASURE, and USAICoE have informed an Army Capabilities Integration Center white paper to the CSA that addresses megacity environments, future Army operations in megacities, and required capabilities for those environments.[50] Finally, USAICoE in partnership with ASURE is reviewing doctrine to implement new procedures, processes, and methods to conduct IPB in megacities and DUAs.

Endnotes

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28. *"Megacities and the United States Army: Replicating the Home Field Advantage,"* 36.

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30. For a list of the presenters and their topics, please visit the Mad Scientist, All Partners Access Network website for agenda, speaker presentations, videos, and biographies at https://community.apan.org/wg/tradoc-g2/mad-scientist/p/mc.

31. Abe Usher, HumanGeo Group.

32. Frank Prautzsch, Velocity Technology Partners LLC.

33. Dr. Chris Tucker, Map Story.

34. Ibid.

35. Mr. Nathan Fisher, The Geneva Foundation.

36. Dr. Brett Piekarski, Army Research Laboratory.

37. Frank Prautzsch, Velocity Technology Partners LLC.

38. Dr. George Poste, ASU.

39. Dr. Russel Glenn, Australian National University.

40. William Swartout, USC.

41. Dr. Brett Piekarski, Army Research Laboratory.

42. Dr. Fran Zenzen, ASU Research Enterprise and John Watkins, Dignitas Technologies LLC.

43. Dr. Amy Krakowka-Richmond, USMA.

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45. Dr. William Swartout, USC.

46. COL (Ret.) Kevin Felix, The Roosevelt Group.

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Ms. Shields currently serves as the Strategic Communications Director and as a Financial Management Analyst for the Naval Expeditionary Warfare Division, OPNAV N95. Ms. Shields left Active Duty in 2010 and continues to serve in the Army Reserve as an Engineer and holds the rank of Major.

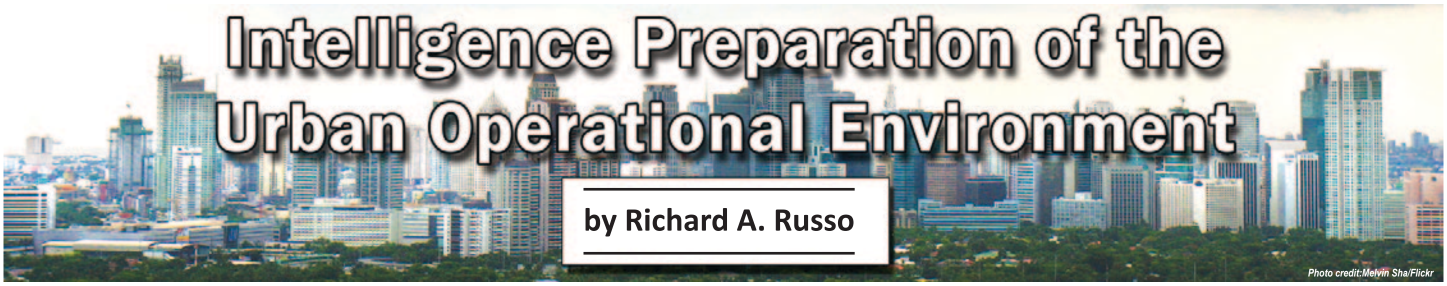
CSM Forum

(Continued from page 3)

tactics, techniques and procedures to effectively employ any new technologies to support intelligence operations in a DUA.

Look at the adaptability of our military intelligence professionals in historical context, including the last 15 years. We have never accurately predicted the next war we will be in, but the speed with which we have adapted to our adversary and environment is directly related to the competence of our intelligence professionals' ability to do their core tasks with the resources available. Whether you are in a regionally aligned force or not, continue thinking about how to use what you have to meet the challenges posed by megacities; sooner or later that will be our operating environment.

"Always Out Front and Army Strong!"



Essentially, all models are wrong, but some are useful.
–George E. P. Box,
"Empirical Model-Building and Response Surfaces"

Introduction

Unified land operations within complex urban terrain is fast becoming a reality that Army formations must contend with in the near future. Strategic Studies Group (SSG) II identified a gap regarding intelligence focus on megacities and other complex urban environments: Cities and megacities are not currently a unit of analysis within the intelligence community (IC) of the Department of Defense (DoD).[1] Mission focused analytic efforts focus on trends and threat groups which transit through these spaces, not on the spaces themselves. This creates a deficit in understanding the impacts of the environment on friendly and enemy courses of action.

Urban environments are not static. Unlike naturally occurring environments, such as the arctic, jungle, or desert, the nature of the urban environment is constantly changing. Megacities or any dense urban terrain are as much an actor as the threat forces which may occupy them. Each city is unique and must be approached in its own context. There is not "the megacity"–there is Dhaka, there is Lagos, there is Tokyo. Moreover, even within the city, the complexity of these environments does not scale in a linear fashion. An approach used in one part of a city might not work or may be counterproductive in another part of the same city.[2]

A fundamental change in analytic culture is required to properly represent megacities and other complex urban terrain. The Army Capstone Concept (ACC) and Army Operating Concept both call for agile and adaptive leaders who can function in complex environments.[3] Current doctrine does not provide the dynamic tools necessary to understand, visualize, and describe their dynamically complex operational environments (OEs).

Current Intelligence Preparation of Urban Environments

Field Manual 3-06 Urban Operations makes clear the requirement for detailed understanding of a city prior to engaging in operations within it:

> ***"The first requirement, and a continuing requirement throughout the conduct of urban operations, is the assessment and understanding of the situation. Commanders should base this understanding on detailed information regarding the particular urban area."*** [4]

Visualization products must provide commanders, in all OEs, the information to enable operational adaptability as described in the ACC.[5] Current analytical constructs for joint intelligence preparation of the environment (JIPoE) are reductionist frameworks which seek to lend clarity to the environment by distilling the complexity from it through a process of constant and reactive refinement.[6] Research conducted by SSG II found that megacities are, by their nature, dynamically complex.[7] Using reductionist frameworks which show the system at rest or holding still inherently under represents the environment for commanders. While JIPoE is a "whole of staff" effort to create context regarding the OE, it must begin with intelligence preparation of the battlefield (IPB).[8] The most recent version of the IPB manual, ATP 2-01.3 describes the focus of IPB:

> ***"In order to focus IPB and what is important to the commander, the staff identifies and defines the aspects of the enemy, terrain, weather, and civil considerations of the operational environment to determine the significance of each in relation to the mission; essentially building an environmental model as the framework to conduct and then present analysis to the commander. This prevents unnecessary analysis and allows the staff to maximize resources on critical areas."*** [9]

The limitations of IPB stem from its focus on the mission, rather than the OE. This doctrinal guidance takes appropriate steps towards "modeling" the environment, yet it introduces an artificial constraint to urban systems analysis by focusing on the mission instead of the environment. This artificial centrality then marginally appreciates complex interactions which occur throughout the urban environment and assumes the mission is the major factor in action. This creates a myopic perspective which assumes only certain parts of the city are germane to the commander and ignores the interconnectedness of the urban system.

Aside from improvements in technology, JIPoE *methodologies* have changed little since World War II.[10] Intelligence professionals still rely on static maps (paper or electronic) and a series of geo-rectified information overlays or annotations to represent aspects of the terrain which may affect the mission. Understanding of the environment's complexity (the interrelation of the displayed data layers) still must be inferred and developed independently by the analyst. Current doctrine requires IPB to describe and define the "interrelationships, dynamics, and interactions of these variables [which] cause changes in the operational environment."[11] Yet, practitioners are still reliant on static visualization techniques to display and support understanding of a dynamically complex environment. The Army needs a new method of data visualization to understand megacities and complex urban terrain.

Understanding Urban Systems

As cities expand globally, an interaction between the city's physical, social, and virtual structures occurs which creates globally connected and interconnected dynamically complex *urban systems*. This complexity is unique to each urban system and can confound Army efforts to achieve strategic success across the range of military operations. Understanding this complexity can improve the Army's ability to provide strategic solutions in these environments and allow it to serve as the joint force's lead proponent for operations in large cities. Detailed study of individual megacities and other dense urban terrain can support development of prognostic models which measure environmental dynamics. These simulations can inform military planning and reduce unintended impacts of military intervention in urban population centers, thereby increasing the effectiveness of military operations.

Combining intelligence with modeling and simulation to support decision making is not a new concept for the Army. According to the Army Modeling and Simulation Office, modeling and simulation are, "used throughout the Intelligence Community to support Acquisition, Analysis, Experimentation, Operations & Plans, Testing and Training."[12]

Other frameworks have shown the requirement for modeling and its utility. The Delaware Valley Intelligence Center (DVIC) and other city government agencies have heavily leveraged geospatial mapping to produce a detailed terrain estimate of Philadelphia, Pennsylvania. Their urban mapping solution currently exceeds any capability resident in the U.S. Army inventory with regard to detail and comprehensiveness. Their city-wide estimate includes data points for all 21 police districts in the metropolitan area and can ingest any geospatially enabled feed–from traffic reports to weather to active fire incidents and their respondents, current bus, trolley, and train locations.[13] The Philadelphia solution can also simulate the effects of natural and manmade disasters on the city by leveraging spatial modeling. Interactive data sets can show diversion of utilities and road traffic as well as the number of homes and citizens impacted by the incident.

The solution was developed with flexibility in mind using *Esri's ArcGIS Server* technology. Data layers or information themes can be displayed or hidden depending on the decision maker's requirements. Remarkably, the solution can ingest and reflect near real time positional feeds on activities from hundreds of different agencies within the city as well as regional partners. The solution also integrates with the city's video management system which allows users to view live video feeds by simply clicking on a map icon. The solution took twelve months to compile to its current state and continues to evolve as more data sets become available.[14] DoD has also looked into modeling solutions to inform decision making.

The Conflict Modeling, Planning and Outcomes Experimentation Program (COMPOEX) was a joint venture between Joint Forces Command and the Defense Advanced Research Projects Agency in 2007.[15] The objective of the COMPOEX project was to develop "decision aids to support leaders in designing and conducting future coalition-oriented, multi-agency, intervention campaigns employing unified actions, or a whole of government approach to operations."[16] (See Figure 1) COMPOEX combined conceptual, agent-based, system dynamics, and discrete time models into a family of models to support what was referred to as an "option exploration tool." The system also included a suite of conflict visualization and campaign planning tools.

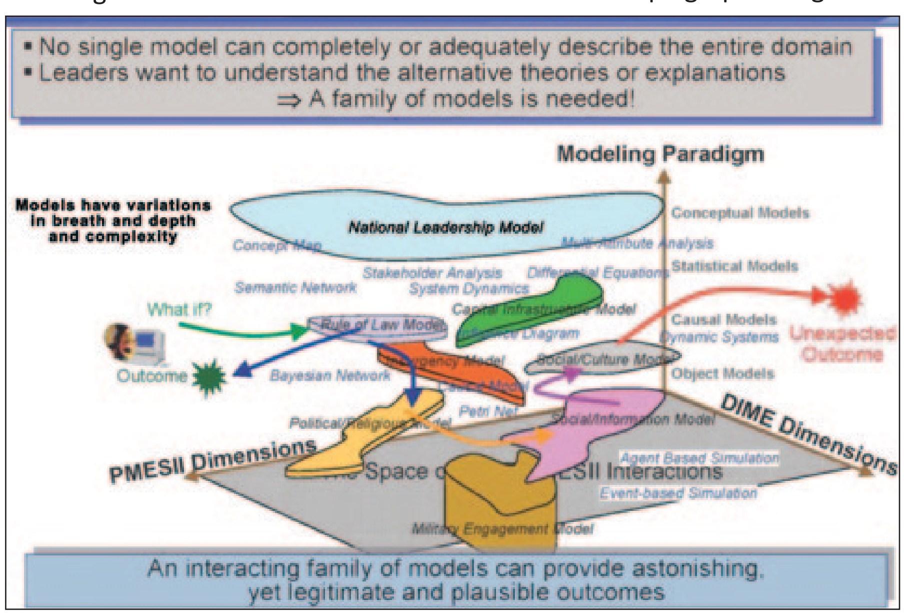


Figure 1. Modeling Post Modern Conflicts

The current status of the project is unclear following the closing of the Joint Forces Command, but COMPOEX demonstrated a desire to use modeling and simulation to support decision making at the strategic and operational levels.

Photo credit: Yodalica/Wikimedia Commons

The IBM Smart Cities initiative has also used computational and physical models to develop intelligent transportation systems.[17] Their model of Stockholm traffic systems used near real time information feeds or "digital traces"[18] from Global Positioning System (GPS) and Wi-Fi enabled devices to produce "dynamic, multi-faceted views of transportation information for the city."[19] The IBM model was designed to reduce uncertainty regarding access and timeliness of public transportation. The team developed the model using fused data sets collected in country during multiple iterations. The effort resulted in an interactive model which could, "process over 120,000 incoming GPS points per second, combine it with a map containing over 600,000 links, continuously generate different kinds of traffic statistics and answer user queries."[20]

These methods are not likely transferable to an Army effort which may be expeditionary in nature and occur during latter phases of a crisis. What the effort does demonstrate is a requirement to access multiple data sets to create a comprehensive perspective on the complex interaction of systems occurring in urban environments.

Current geospatial engineering systems, such as Urban Tactical Planner (UTP) represent a useful starting point within the Army Geospatial Enterprise and should receive additional investment and focus to maximize its potential. For example, UTP uses built-up terrain zones (BTZs) to classify land use and building type. The BTZs are a diluted derivative of the urban terrain zone (UTZ) classification system. BTZs aggregate some of the UTZs, and distinctions between high-rise residential apartment buildings and individual homes are lost. ATP 3-34-80, Geospatial Engineering describes UTP:

> ***"The UTP is a data set that can be viewed as two- or three-dimensional. It consists of imagery, maps, elevation data, and urban vector overlays. It displays key aspects of the urban area in thematic layers that are overlaid on high-resolution imagery or maps. The UTP provides an overview of the urban terrain in the form of maps, imagery, elevation data, perspective views, handheld photography, video clips, and building information. The UTP is produced by the Army Geospatial Center, but geospatial engineer teams have the capability of incorporating new data and imagery into the UTP, and it can be exported to CD for use by non-geospatial engineers."[21]***

While these projects and systems all show promise for better understanding of urban systems, they represent significant investments in time, information, technology, and effort. Projects like the DVIC solution required twelve months to compile.[22] UTP requires at least six weeks to build a baseline estimate of an urban system[23] and the National Ground Intelligence Center's FIRES used a team of three seasoned geospatial analysts and 112 man hours to develop a detailed terrain estimate of Seoul, South Korea.[24]

Additionally the data sets needed to build computational models require collection or screening to determine their veracity should they come from outside sources. The data required to build these models is also cheapest to collect and most reliable during pre-crisis conditions. To this end the Intelligence Senior Leader Conference identified as a key take away, "that the intelligence community must begin to ramp up megacity IPOE now to prevent a cold start. The adequacy of our doctrinal urban analytical models must also be closely examined and updated to account for unique megacity variables."[25]

Moving Forward: A Framework for Urban System Modeling

Modeling and simulation are required to understand the complex interaction of systems within dense urban terrain. *Urban systems modeling is a staff process of creating de-*

tailed terrain estimates of urban environments and combining them with conceptual, agent-based, and system dynamics models to simulate the dynamic complexity of a given cityscape. Urban systems modeling is inherently and heavily reliant on the intelligence warfighting function since the detail required to develop urban systems models is derived from intelligence collection and displayed using traditional JIPoE. Traditional JIPoE methods however, do not provide sufficient detail. This necessitates expertise in modeling and simulation be combined with environmental intelligence products.

Functional Area 57 (Simulation Operations) officers trained in modeling and simulations are already authorized at division/Corps-level G3/5/7 and Army service component commands (ASCC) as simulations/mission command systems integration officers.[26] While there are also authorizations for FA 57s in brigade combat teams, urban systems modeling seems most appropriate when conducted in concert by the ASCC and the aligned division modeling and simulation staff elements with appropriate G2 and national intelligence support.

Urban systems modeling mitigates uncertainty and supports commanders' situational awareness by integrating all sources of information on selected urban environments into detailed terrain estimates and interactive simulations. Modeling provides greater fidelity and context to commanders regarding the dynamic complexity of their environment. Modeling and simulation can show the steady state equilibrium of urban system interactions as opposed to visualizing the system at rest with traditional IPB methods. Seeing the system in action gives commanders a performance measure to gauge the impact or effectiveness of their operations pre- and post-intervention, depending on their desired end state. Modeling and simulation can also provide prognostic outputs to illuminate unforeseen second and third order effects on the city system given different operational or incidental inputs.

Environmental characteristics and complex interactions should be reflected using a new framework for urban systems modeling. This framework should build upon some current efforts to model urban systems which show promise in their utility to support military planning. As an evolution of urban JIPoE, the framework should explicitly describe the physical geometry of a cityscape as well as the demographic information of its population in a detailed terrain estimate of the urban environment. This information is available on most major cities today and is normally reflected in current IPB products.

Detailed terrain estimates should catalog the characteristics of scale, density, threats, and context found within megacities and other complex urban terrain. These characteristics combine within megacities to create complex interactions of agency, connectedness, and flow at an unprecedented scale between the environment, its population, and the forces operating within it.[27] Some of these interactions occur at an appreciable rhythm which can be observed, predicted, and simulated. These interactive simulations would allow commanders to test various strategic, operational, and tactical approaches. This can illuminate possible outcomes of given approaches and insight into how the urban system may react beyond the scope of the approach.

Future Army forces require the ability to gather and synthesize information and intelligence into detailed terrain estimates for cities which ultimately form the foundational layers for urban systems models. Four categories define the urban system taxonomy: information themes, flow processes, causal relationships, and actors. Some data can be represented in multiple categories due to its prominence or agency within the urban system. Religion for example is a human geography factor but exerts, at times, the agency of an actor, as when a religious festival closes several city streets to vehicle traffic.

Information themes form the base map of the cityscape and are those themes that can or should be measured in

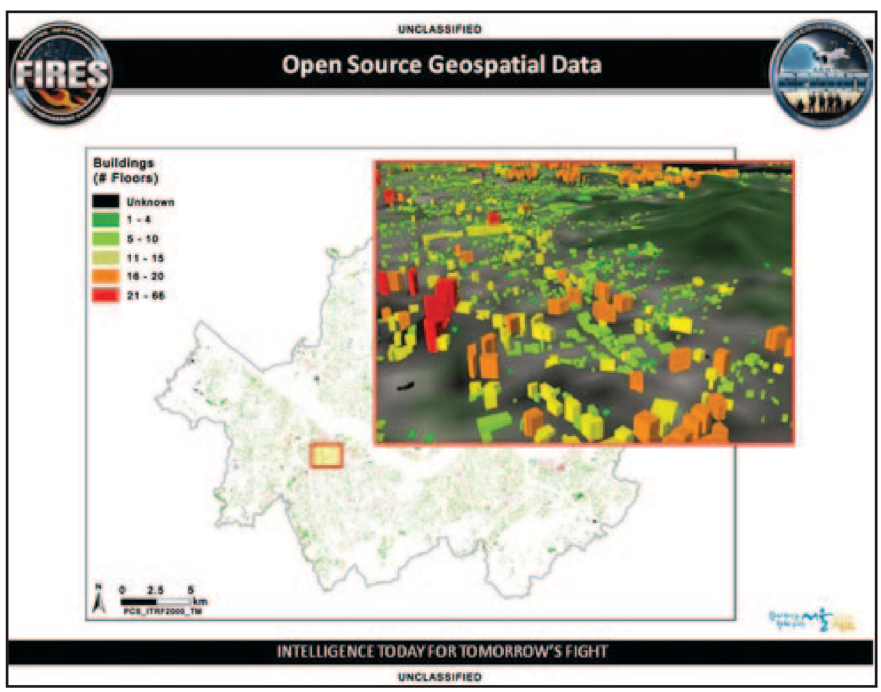


Figure 2. Example of Urban Terrain Infrastructure Information Themes.

the city system. Geographic Information Systems data layers are often called themes and have a specific definition so that the attributes would be the same no matter who was collecting the information. Ideally, they would be defined so well that any consumer of the themes would be able to know exactly what any theme's attribute represents. This information should be at least four dimensional: x, y, z and time, including an explicit representation in the vertical and temporal dimensions where known. Urban computational models almost always contain a temporal component. Information themes can either be directly measured, or be the output of well-defined computation models, especially those models forecasting urban change over time. Forecasting information themes into the near future is a necessary capability for rapidly changing urban environments. These information themes should include (but not be limited to):

- **Facilities, Infrastructure, and Environment.** Physical and structural models of the cityscape shape the detailed terrain estimate (See Figure 2). These themes should be rendered in some community recognized standard like *Topographic Feature Data Management System*, the National Geospatial Intelligence Agency's system for storing data, the *Ground Warfighter Geospatial Data Model,* as an extension of that system, or *Spatial Data Standards for Facilities, Infrastructure, and Environment* for ease of use across the Army, DoD, and IC. These information themes should include (but not be limited to) geospatially rectified data sets which reflect:
  - Land use codified by UTZ.
  - Surface and subterranean structural footprints and characteristics.
  - Transportation layers, physical networks, and lines of communication which permit connectivity and support flows (water, power, road, sewage, telecommunication, etc.)
- **Human Geography of the cityscape.** These information themes should be geospatially rectified socio-cultural data sets which should reflect (but be not limited to) the thirteen human geography factors:
  - Ethnicity.
  - Language.
  - Religion.
  - Demographic and human population measures.
  - Water supply and control.
  - Education.
  - Communications and media.
  - Economy.
  - Land use, cover, ownership.
  - Social groups and organizations.
  - Transportation.
  - Significant events.
  - Health and medical sub-model.

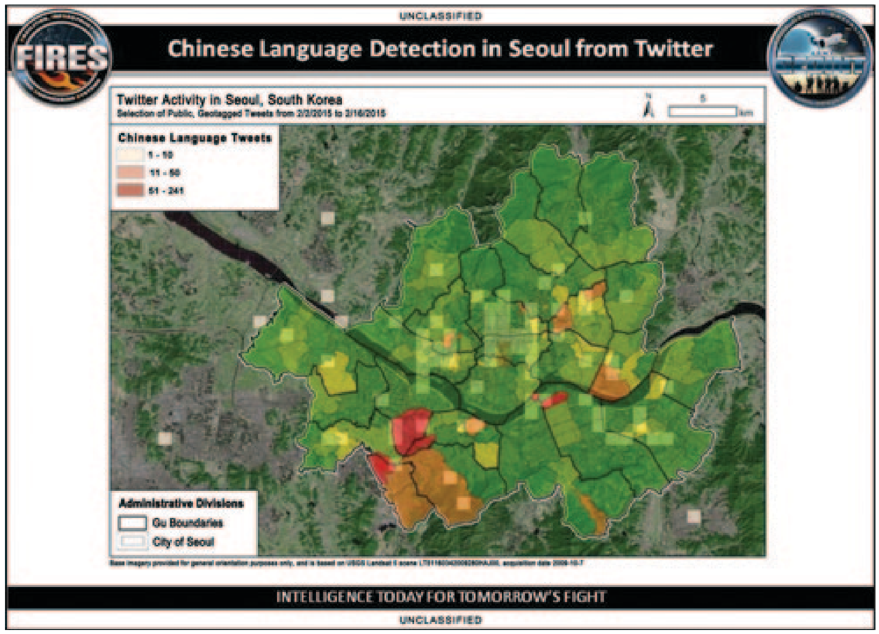


Figure 3. Example of Information Theme Reflecting the Human Geography of the Cityscape.

Flow processes define flows internal and external to the urban space. Flow processes require supporting infrastructure (information themes), are likely dependent in some form on actors, will likely play a role in casual relationships, and may extend outside the cityscape due to the global connectivity of the urban system. By definition they will require 3D or 4D information themes as inputs and output 3D or 4D information themes. Flow processes are always assumed to always be "true," but can be turned on or off by natural disasters or actors. These should include (but not be limited to):

- SWEAT-MSO (sewage, water, electricity, academics, trash, medical, safety, and other considerations) related flows.[28]
- Food.
- Energy (oil, natural gas, coal, etc.).
- Information.
- Varying modes of human and vehicular traffic.
- Commodities and remittance.
- Telecommunications.

Causal relationships are defined by sets of information themes, flow processes, and other processes. They are interactions and feedback loops between personnel, contacts, associations, events, activities, organizations, and transport layers which form key and/or significant correlation. Causal relationships may be so complex that simulation model users might treat them as black boxes if not well defined and described. Users should have enough knowledge so they can understand why output information themes change when input information themes and flow processes change. It is also critical for users to understand the feedback loops inherent in these systems which allow the visualization of causal interactions. "Other processes" represent the set of behaviors or environmental processes that define the inherent operations of the urban spaces. One important process which should be understood among these is infrastructure criticality.

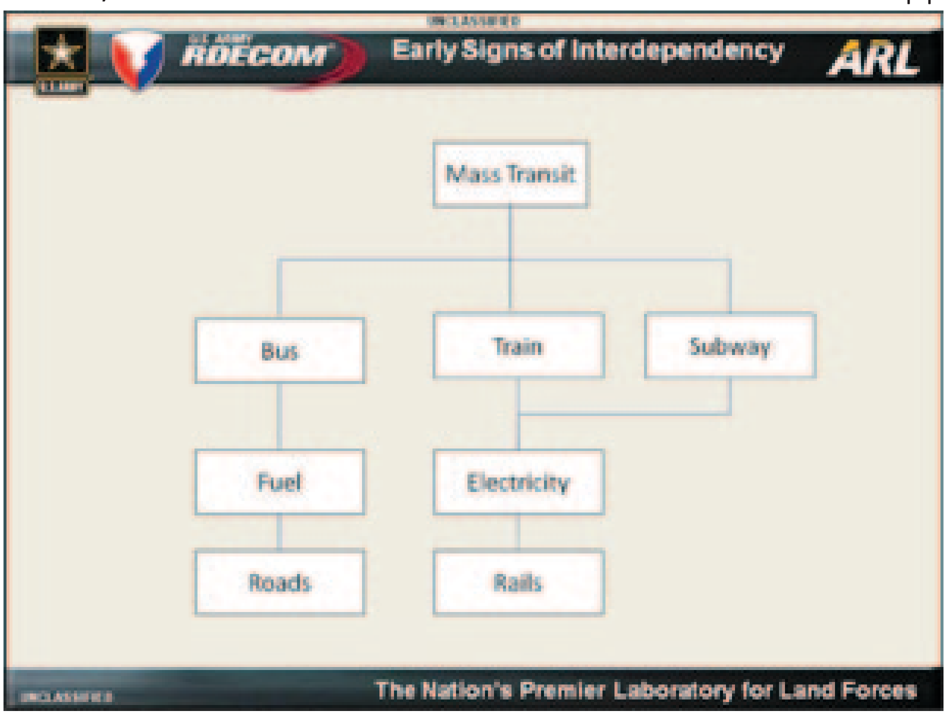


Figure 4. Example of Fault Tree Analysis Showing Interdependent Causal Relationships.

Conducting a criticality analysis of a city's infrastructure can determine which facilities/systems are critical, and how a failure of subsystems/components affects the systems of which they are part. Initially a functional analysis of each subsystem within an infrastructure should be completed. This analysis will determine how each subsystem works and the interdependencies between components and the subsystem. Next a fault tree or failure analysis should be completed to determine how degradation or failure of components affects the function of the subsystem and the resulting system function. Causal relationship models should include fault trees and depict (at a minimum) the following relationships with the urban system:

- Weather to electricity, traffic, and food.
- Traffic to food distribution, commodities, and remittance.
- Electricity to water, traffic, telecommunications.
- Temporal human interaction related to flows (time and calendar events like rush hour, elections, or holidays).
- Feedback loops.

Actors are people and organizations that influence the urban system. People are only actors when they can change the system, not when their behaviors are represented in the system. For example, a religious group (an actor) declares a specific action to be forbidden, the members of that group will either support or ignore the declaration. In this case, the only actor is the group. It is a standard practice in civil affairs to develop profiles on important actors in their areas of operation. The simulation model would provide information themes and flow processes to estimate the proportion of people who follow or ignore the declaration. Ultimately, scenarios must experiment with the decisions and actions being made by actors to understand possible futures. To ignore potential actor's decisions, or assume that actors will act rationally, or believe we know exactly how some of these actors will react is often the cause of unforeseen social "grey swan" events (which are unlikely actions still in the realm of the possible). (The only true "black swan" events are those caused by disruptive technology or actions which have never happened before, and thus couldn't be accurately modeled.) These should include (but not be limited to):

- Local administration (governance, military, law enforcement).
- Religion.
- Business, labor.
- Illicit networks.
- Hostile actors.
- Other human interaction related to flows (calendar events like elections or Chinese New Year).
- Natural events weather, geological, fire, etc.

Combining these elements and displaying their interaction within an urban system will create more detailed apprecia-

Photo credit: David Bjorgen/Wikimedia Commons

tion of the city's complex nature. Detailed terrain estimates of structure and human geography create context through more complete understanding of the cityscape. Simulating the reaction of different characteristics to various stimuli "on top" of these detailed terrain estimates can allow commanders to wargame in a better informed representation of their OE. Taken together, this framework for urban systems modeling represent a logical evolution of traditional urban IPoE which highlights complexity by showing the interrelation of various systems of the urban environment.

Conclusion

Current reductionist frameworks are an excellent start for urban JPoE, but traditional methods cannot capture the complex interaction of systems within a megacity. The Army requires dynamic tools to help commanders understand dynamically complex urban environments. Several efforts to model urban systems have shown promise and may serve as examples for how the Army can evolve doctrine. Urban systems modeling offers one method to reflect this dynamic complexity as a "next step" in the evolution of urban JPoE. Army intelligence and modeling professionals can help provide new visualization methods which can assist commanders in understanding the equilibrium of an urban system as well as the potential consequences of a crisis or military intervention.

The Army must prepare itself for the eventuality of warfare in complex urban terrain. Operations in these environments present challenges which require forethought and judicious application of combat power. The global connectivity of megacities and complex urban terrain quickly turns tactical action into strategic consequence. Unforeseen second and third order effects of even the most discreet military intervention can quickly turn and overwhelm commanders with complexity at a scale which exceeds their capacity. Detailed understanding of these systems can help provide context, shape operational approaches, and identify possible outcomes. The time to study and adapt to these environments is now.

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by Scott E. Packard (USMC, Ret.)

The views expressed in this article are those of the author and do not reflect the official policy or position of the Departments of the Army and Defense, or the U.S. Government.

The most likely future operating environment for the U.S. and our allies will be in the urban littorals–those cities located close to the coast. The trends are clear–more and more of the world's population is contained within cities near oceans and seas. The concentration will draw our military there in response to a range of events, from natural or manmade disaster to major combat operations. Sun Tzu's admonishment notwithstanding, militaries will increasingly conduct military operations in cities. Any commander's desire to bypass cities will no longer be tenable. But while there has been considerable consensus about the dynamics driving the military into urban environments, there has been sparse action to prepare and train our forces for it.

The U.S. Army's Strategic Studies Group (SSG) can be largely credited with re-igniting interest in urban operations with its 2014 study of megacities. While it was neither the original use of the term nor ground-breaking in exposing demographic trends, the study galvanized large portions of the Defense community to shift attention from counterinsurgency and stability operations back to the myriad challenges that urban terrain presents for military operations. It was a shift back, because before the U.S. military was employed in two wars in Iraq and Afghanistan, it was very much focused on dealing with the trends of urbanization.

Despite the cliché of the military's tendency to fight the last war, there are elements within each of the Services scanning the horizon for likely future challenges. Entire groups exist–the previously mentioned SSG and the Naval Research Laboratory are examples. The Marine Corps' version, the Marine Corps Warfighting Laboratory/Futures Directorate, launched the Service's campaign of experiments focused on urban terrain in the mid-nineties. Designed to increase the lethality, survivability, and effectiveness of small units up to battalion task force size in complex urban terrain, the campaign was named URBAN WARRIOR.[1]

From URBAN WARRIOR came a number of fielded systems, new doctrine, and training programs. Some of the fielded systems were the rifleman's combat optic, the personal role radio, biometric enrollment devices, and small unmanned aerial systems for battalions and below. These systems proved useful in the complex operations that followed in Iraq and Afghanistan, in and out of cities.[2] The updated doctrine, Marine Corps Warfighting Publication (MCWP) 3-35.3 Military Operations on Urban Terrain, was published in 1998 covering tactics, techniques, and procedures (TTP) from the individual Marine to the battalion-level operations. The training program, the Basic Urban Skills Training (BUST) that resulted from URBAN WARRIOR provided relevant knowledge and skills to Marines fighting in the years that followed. Prior to Operation AL FAJR in October 2004, Marine Corps forces conducted training based on BUST in preparation for combat operations in Fallujah.

After an interruption of attention brought by the exigencies of immediate crises, the military and academia are drawn to cities once again. The U.S. Army and Marine Corps have poured thought and resources into understanding the urban environment. Both Services have revised their urban doctrine, collaborating on a top tier multi-service publication, as well as each Service developing TTP for small units on their own. The multi-service publication rightly focuses on the importance of the population and the information environment, two areas not previously addressed to sufficient degree. The Marine Corp TTP publication, MCWP 3-35.3, is a fair start; however, it is lacking in several key areas: inventive uses of precision fires, procedures for dealing with improvised explosive devices, and innovative command and control techniques to address episodic communications in the urban canyons. Those gaps need to be addressed; however, they are not the most significant problem facing the preparations for operations on urban terrain.

Pending U.S. Army and Marine Corps doctrine lists five reasons for urban operations: defensive advantage, to destroy a threat, strategic value, symbolic value, and advantageous location. These are distracters. From disaster relief or humanitarian assistance to full-scale combat operations, cities will draw military operations for one simple reason–it's where the people are. The density of people, their needs in crisis, and their contributions to conflict, will draw U.S. intervention. Political support and material resources available in a city rise in direct relationship to the number of people. As more and more people move from the rural to the urban, support for threat networks will likewise become concentrated within cities.

Of the three elements of the urban environment–man-made construction overlaying the physical terrain, a dynamic infrastructure, and dense populations, it is the last that presents the biggest challenge to military operations. The physical environment is dangerous, complex, and interferes with many elements of U.S. technological advantage; however, many of those same disadvantages afflict our adversaries. Additionally, the infrastructure of a city cannot be ignored. The system-of-systems of sewage, water, electricity, academics, transportation, medical and security infrastructure can restrain or limit operations, yet the system is discernible and understandable, and it can be used to friendly advantage and withheld to the detriment of our enemy. The city and its infrastructure, like Spencer Chapman's jungle, are neutral–they offer advantages and disadvantages to both attacker and defender as terrain.[3]

However, the people within and around cities are not neutral. A majority may prefer to simply go about their lives and livelihoods uninterrupted (unless they need something). However, there will be individuals, groups, and networks inclined one way or the other, offering varying degrees of passive or active support to friendly or threat endeavors. So, formal and informal political boundaries will play in operations, and the various actors who hold sway within them must be known and addressed. There is also symbolism tied to a city or parts of a city that are magnified beyond their tactical value, drawing exertions by either side disproportionate to a strict operational calculus. Identifying and understanding these elements present a complex problem for intelligence collection and analysis. As Lieutenant General Flynn and his co-authors noted, the intelligence community must open the aperture of analysis beyond the threat to include the larger populace.[4]

Although the Marine Corps recognizes the importance of urban operations and their ever-increasing likelihood, several concrete steps remain to be taken in doctrine and training. The little training conducted formally at entry-level training venues is good, but is only partially sustained and built upon by follow-on formal training. The Service-level training conducted at Tactical Training Exercise Control Group is now incorporating techniques and procedures for the rifle companies. There are insufficient facilities to train above the battalion level, however. Marine Corps Tactics and Operations Group incorporates a rudimentary urban operations scenario in the Tactical Marine Air Ground Task

Photo credit: Detlef Koester

Force Integration Course, the Service's formal training for battalion and regiment operations officers and operations chiefs, but offers no instruction prior to practical application. Similarly, professional military education lacks any meaningful discussion of urban operations and fails to prepare tactical leaders for their most likely operational environment. Recognizing that formal curricula are like vast ocean liners–slow to make course corrections, the appropriate changes have not yet been discussed in earnest at the Service level within the urban community of interest.

The discussion is worthwhile. If the urban environment's challenge is indeed that of operating among dense populations, then the costs of training for that environment are likely to be considerable. One of the major expenses of counterinsurgency training was the large number of role players required to simulate the human aspects of the Iraq and Afghanistan theaters. Over a thousand paid contractors interacted with Marine units preparing to deploy during unit and Service-level training. In the near-term, similar resources are necessary to properly train both small units and intelligence analysts for the urban environment. Some work has been done in simulating the people within a city, but the challenges to accurately doing so are many. At this point, simulation can only augment, not replace, the experience of operating within dense urban populations.

The densely populated environment requires unique environment-focused training across all warfighting functions: mission command, movement and maneuver, intelligence, fires, sustainment, protection, and engagement. Each of these functions is trained best among many people and the impact of the choices they make, the ever-shifting attitudes they possess, to the symbolism they assign to areas of the terrain. Most "combat town" training scenarios involve a small adversary moving throughout the operational environment, with role players resurrected as necessary to challenge small-unit fire and maneuver. This does little to challenge commanders and their staffs.

A more realistic training environment will teach commanders to truly execute mission command, and the inherent trust in their subordinates it comprises, in the urban canyons that allow only sporadic radio and data communications. Movement over lines of communication impacted by traffic, crowds, and informal power brokers exercising extra-legal control offer opportunities for patience, negotiation, and vulnerability to ambush. Ground forces will learn to operate under constant observation, with observations shared with both a local and global audience, to advantage or disadvantage. A large body of role players gives commanders at all levels multiple opportunities to engage, to message, and counter message, depending on those actions and the

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simulated reactions of a variegated audience. Open source intelligence, adeptly mined, may in the future provide the on-scene commander with relevant information in near real time regarding threats, atmospherics, impediments to movement, sensitive cultural terrain, or key influencers.

Some of these elements can be trained and tested within existing training facilities, although there are very few combat towns of sufficient size to do so above the rifle company. The SSG has partnered with the New York Fire Department for tactical exercises without troops in New York City–this is a model worth emulating elsewhere. Our Reserve and National Guard units are natural conduits for building relationships with municipal governments, law enforcement, utilities, and community leaders to develop training opportunities within U.S. cities.

If we recognize the future operational environment as an urban one, it's time to start seriously preparing our military forces for the city, before attention shifts once again. Ground forces are especially vulnerable to a lack of training for urban operations. The demands on intelligence, maneuver, fires, and command and control can only be truly tested through immersion in a densely populated city.

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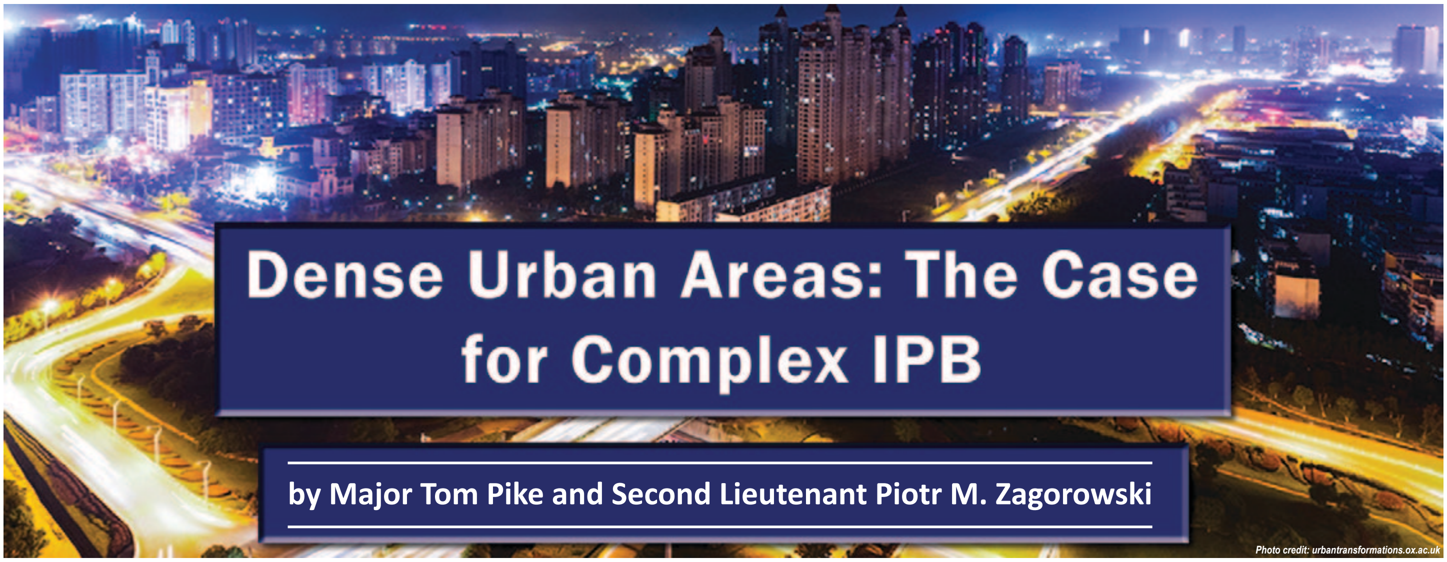

Dense Urban Areas: The Case for Complex IPB

by Major Tom Pike and Second Lieutenant Piotr M. Zagorowski

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On 2 February 2002 a youth in the city of Lagos, Nigeria, who came from the Christian Yoruba slum, was defecating in a Muslim Hausa slum. A Hausa youth confronted him, even though only 4 percent of the city was connected to a sewer. The subsequent fight exploded into a four-day battle between the two slums. Hundreds of individuals were killed, hundreds of houses were burned, and thousands of residents fled the city. Lagos, a city which has grown from less than 300,000 to an estimated 23 million people today, has become the anecdotal megacity of the world.[1]

Introduction

Trying to determine how intelligence analysts can make sense of such chaos appears to be an insurmountable challenge. Underneath this facade of chaos, however, are well-developed rules of human behavior as individuals and groups compete for scarce resources. This dynamic found in Lagos is neither unique nor unprecedented. Stories from London, New York, and Chicago in the 1800s are equally daunting. Regardless of the city or the time, individuals are competing for scarce resources based on their unique situation and capability. Intelligence preparation of the battlefield (IPB) exploits this same dynamic to make a reasonable prediction of adversary behavior. IPB infers from the situation and adversary capability what courses of action (COAs) the adversary is likely to take. The underlying logic of decision making is the same whether an adversary is on the battlefield or an individual is fighting to survive in a dense urban area (DUA).

The challenge when applying IPB to a DUA is the analyst trying to analyze the repeated interaction of millions of individuals instead of the actions of an adversary. Analyzing millions of interactions presents a formidable challenge to intelligence professionals tasked with gaining a rapid and accurate understanding of the area to enable the commander's decision making. Complex adaptive systems (CAS) theory provides insights into the dynamics of populations and cities which reduce the challenges of analyzing a DUA. Taking the view that individuals are trying to maximize their relative power, or fitness function, in the competition for scarce resources, the critical insight CAS provides is that the behavior of an individual is shaped by the individual's interdependencies with other people and their environment. Altering these interdependencies then alters the behavior of the individual. If as Clausewitz stated "the purpose of war is to bend others to our will," then the process to bend them is to change their interdependencies. CAS theory fundamentally shifts the focus away from the composition and disposition of various entities to their relationships and interactions.[2] The implications of this shift are staggering when merged with the underlying logic of IPB.

By focusing on relationships and interactions with other groups, analysts can more effectively identify what is driving the behavior of the population, and decision makers can take more effective action to influence that behavior. In traditional IPB policymakers are provided options to influence behavior via a selection of first order ramifications. A CAS IPB allows the analyst to sort through the potential second and third order ramifications of policy options. Integrating CAS knowledge into IPB improves the analyst's ability to assess the interaction of millions of individuals and the probable behavior of sub-sets and the overall population within a DUA.

Framework for Complex IPB within a DUA

Complex IPB is the integration of CAS into IPB, it maintains the core tasks of IPB while making substantive adjustments to incorporate the effects of group interactions. The IPB steps are Define the Operational Environment (OE), *Describe the Environmental Effects on Operations, Evaluate the Threat, and Determine Threat COAs.* Complex IPB evolves from this foundation, retaining the dynamics of decision making based on situation, capability, and objective. It subsequently adds additional characteristics to the OE such as legal, economic, and cultural dynamics which shapes the interdependencies of the population and governs the interaction of multiple individuals and the consolidation and interactions of groups. The result is a six part framework which provides analysts a framework to more effectively gain situational understanding within a DUA:

1. Define the OE. In IPB, analysts must ''define the OE'' through a description of the characteristics of the OE providing a basis for understanding that evolves as the situation develops. This baseline is particularly well suited for defensive and offensive operations and provides considerable insight into unit level COAs. Complex IPB, however, attempts to understand the micro (individual) level foundation of macro (group, populations, societies) level behavior and can also be leveraged during stability operations. Complex IPB requires a detailed understanding of the geographic, demographic, and political landscapes from the perspective of the individual. The geographic landscape an individual negotiates is understood as a mixture of terrain analysis (OAKOC)[3] and the physical aspects of civilian considerations (ASCOPE).[4] For example, a modern city may have running water in one section, while another section does not. Access to water impacts an individual's decision making.

Some additional questions may include: How many individuals are there? What education levels have been achieved? What are the religious, ethnic, and linguistic breakdowns? Where do they live? How big are their families? Are they employed, and What is the income? Do they have access to telecommunication technology? Finally, the political landscape of a society is considered. Analysts must identify relevant community based organizations. All such organizations have an ideological/political position, membership, strength, and benefits for its membership. As a historical example-being a Ba'athist in Saddam Hussein's Iraq. It was the strongest political group in the country, its collective ideology closely reflected the governments' position, and membership gave one a competitive advantage in the jobs market.

The fundamental difference between IPB and complex IPB is the additional focus placed upon the individual. This approach simplifies the abundance of acronyms pervading intelligence analysis (PMESII, ASCOPE, OAKOCC, SWEAT-MS etc.) Instead of trying to understand everything about the OE all at once from the local to the regional level, analysts focus on how the characteristics of the OE influence the decision making of the individuals within it. Individuals' decision making processes are directly impacted by their station and perceived situation within groups and the greater society. This environment, which captures the physical, legal, social and cultural dynamics from one perspective, is the fitness landscape. As they pursue their own interests and participate in groups the situation on the ground changes as groups' rise and fall in prominence, and wealth and power is created and destroyed, directly impacting the dynamics of law, governance, economics, culture, and conflict. In essence, the characteristics of the OE are readily changed by the behavior of groups within the OE. This elemental shift in complex IPB challenges analysts to consider and understand the relationships between the different parts of the system.

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2. Describe Fitness Landscape Effects. In IPB, analysts use this step to describe how the characteristics of the OE affect friendly operations. As an example, there is only one high speed avenue of approach that can be taken to resupply units moving forward through the OE. Holding key terrain provides the holder a marked advantage over their opponent. The size of a mobility corridor dictates the formation and order of movement for specific units. Conversely, the strength and composition of units provide insight into possible COAs.

In complex IPB, the description of the OE assists analysts in developing the fitness landscape of individuals within a population. We assume individuals are inherently interested in maximizing their utility, and deriving the greatest number of benefits. An individual's fitness then becomes a function of their demographic, geographic, and political variables. As an illustration take two individuals. The first, has access to city services, is employed, completed college, and belongs to the ruling party. The second, is from an ethnic minority, is employed, only completed high school and does not belong to the ruling party. It is clear that the first person is in a more favorable position relative to the second. There is no limit, however, on the number of variables or how they scale relative to one another providing the analyst with the highest degree of flexibility. Furthermore, the number of variables and the complexity of their interaction can be scaled to fit the allotted time constraints within the military decision making process.

Photo credit: Ana Paula Hirama/Wikimedia Commons

By defining the fitness landscape, analysts inherently develop hypotheses regarding the malleable dynamics of demography, geography, and politics and how they influence the utility and preferences of individuals and stability within the OE.

3. Evaluate Major Groups. This portion of complex IPB represents a partial departure from IPB. Instead of one adversary, the analyst must identify and evaluate multiple groups (friendly and adversary) within the population to include their own organization and the local government as additional groups. As individuals make micro decisions, they coalesce into similar groups that share common preference, ideology, ethnicity, employment, or any number of other factors. In addition, how their position varies is dependent on the dynamics of the fitness landscape at that time. For example, in civil war, individuals often become more extreme as they are required to pick a side or ensure their loyalty to one group is clearly evident, else they could be persecuted for being a traitor.[5] The interaction between the changing fitness landscape and the prevalence of certain groups must be constantly analyzed. This becomes particularly evident in stability operations as actions either drive individuals into insurgent groups or siphons individuals away from such groups. Like the adversary in IPB, each group has an array of capabilities. In IPB, capability is determined through an analysis of aspects of the adversary like range of weapons systems, ability to communicate, conduct resupply, or provide air support.

In complex IPB, capability is a function of the group's fitness. The fitness function is dependent upon the relationship the group has with the various landscapes and how those relationships strengthen or weaken them and their position. Group fitness, ultimately, is a function of shared preferences, power, and position weighted by the number of individuals within the group and how effectively they communicate. Such a definition enables the analyst to ask a variety of targeted questions including: What financial resources do they have? How much credibility do they have with the population? What influence do they have to enact new laws, control the police etc.? In complex IPB the analyst implicitly acknowledges groups and their actions can change the behavior of individuals and other groups within the population, which in turn changes the characteristics of the OE.

4. Evaluate Major Groups' COAs. Similar to IPB, the purpose of this portion of the framework is to create reasonable predictions of a group's behavior. In IPB the analyst considers the adversary's doctrinal and situational template. How does the adversary normally act in a given situation? In complex IPB, the analyst should examine similar considerations. If it is a political group, what tactics do they normally employ? What are the normal cultural reactions to the situation? If a terrorist organization, what methods do they most frequently use? What equipment and financial support do they have access too? Who do they target lethally versus non-lethally? Regardless of the group being evaluated, the underlying logic for prediction is similar to the base logic of IPB. What is the group's situation, their capability, and objectives?

This step is more challenging than those in IPB as there are multiple groups instead of one adversary. Additionally, analysts must ask the same questions for their own organization, the government and allied groups, and other organizations. Furthermore each group is actively working to change the fitness landscape to provide the most benefits and seek their own organizational objectives. Failures and successes, however, impact other groups positively or negatively which necessitates changes to their own COAs.

5. Assess Group Interactions. As analysts examine what possible COAs the various groups may pursue, they cannot look at these groups in isolation. Certain groups may form alliances, merge together, or split as they pursue goals. These alliances may result in opposing groups doing the same or adopting different COAs as they face new challenges. Assessing group interactions is effectively wargaming. Analysts will become increasingly aware of the actions and counteractions of the various groups identified. This complex behavior arises from the iterative interactions of groups which change the various landscapes, compelling individuals to pursue their individual interest under new constraints which then impacts group membership, composition, and strength. This dynamic highlights the need for computer models to support analysis. Just three groups with three different COAs, which do not change, result in nine different combinations.

6. Evaluate Population Behavior. Assessing the repeated interactions of individuals and groups under different conditions allows analysts to gain a deeper understanding of the dynamics shaping the behavior of the population. As noted previously three groups with three COAs yields nine different iterations. Computer modelling, however, enables exponentially more complex analysis to be conducted by making changes in two specific parameters. First, each variable included in the fitness landscape can be incrementally changed while the remaining variables are held constant. Second, the duration of the interaction can be changed, allowing analysts to consider both short term and long term effects. Given enough time and computing power every conceivable combination can be analyzed. By completing a global (or quasi-global) sensitivity analysis it is possible to identify the fitness variables that have the greatest impact on the OE.

Applying Complex IPB

After outlining the process of complex IPB, the next step is to practically apply it, while nested within larger Army initiatives. The Chief of Staff of the Army (CSA) directed a study to explore the challenges DUAs will present to the Army. This study developed three lines of effort (LOEs) to provide a DUA research concept.[6] Complex IPB addresses two of these LOEs. The first LOE from the study was *"Develop a Dense Urban Area analytical framework that is relevant, practical, and has application to city systems analysis."* To demonstrate the applicability of complex IPB to this LOE, this article presents a case study of Peru in the 1980s and 1990s. This case study is relevant as Lima, the country's capital, experienced a dramatic increase in population while simultaneously confronting the brutal Shining Path insurgency.

The second LOE was, *"Establish a modeling and simulation basis that examines analytic framework and operating environment assessment against regional variations, factors of instability, and environmental centers of gravity."*[7] The primary tool of CAS theory is agent based modeling (ABM) which can provide a modeling and simulation base for complex IPB. To demonstrate the applicability of complex IPB to this line of effort, this article will use the complex IPB framework to describe the ABM *Slumulation*. Ideally, this article would be able to explore a current situation using a complex IPB ABM. At this time no such model exists. *Slumulation*, however, provides an excellent alternative as it will familiarize readers with ABMs, while providing a model which readers can download and explore at their leisure. The Peru and *Slumulation* ABM case studies, demonstrate complex IPB's applicability to LOEs of the CSA's research efforts on DUAs.

Case Study 1: Peru

Define the OE. The fitness landscape for most individuals of Peru in the late 1980s was one of few options to improve their situation in life. Their fitness landscape was a desert with no water as they tried to survive each day. The government of Peru was that of a failed military dictatorship trying to transition to a democratic society. A key characteristic of the OE was a stifling government bureaucracy which effectively disenfranchised large portions of the population. As an example, the process to legally build a house took 6 years and eleven months and required 207 steps in 52 government offices.[8] Other processes were just as ineffective. It took a couple wanting a marriage license 720 hours or 90 eight-hour days to complete the process.[9]

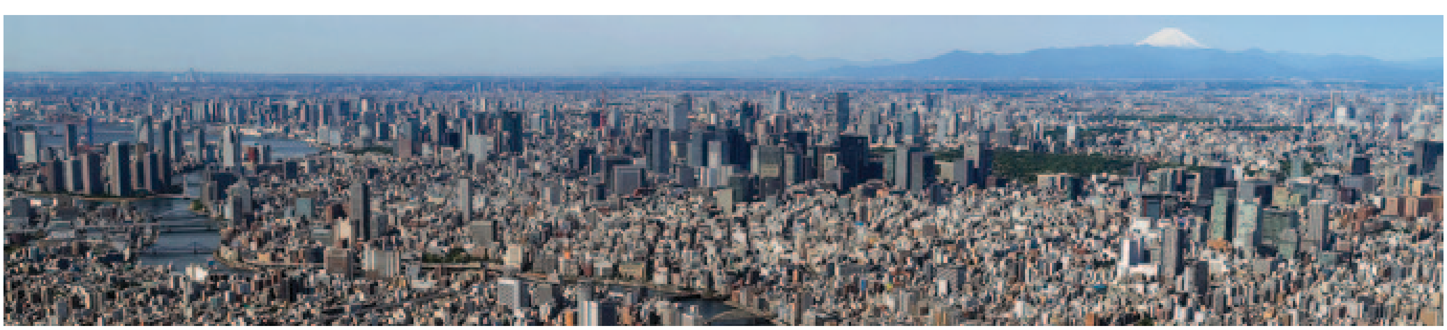

Photo credit: Yodalica/Wikimedia Commons

A nongovernmental organization, the Institute for Liberty and Democracy (ILD), working six hours a day, took 289 days to register a one-worker garment shop. The process cost the team $1,231, which was thirty-one times the monthly minimum wage.[10]

Businesses, in particular small businesses, lacked the capacity to become legal as they could neither afford the process nor spend the time completing the process. The recognized government created impassable terrain for those wanting to be a part of the economy. The characteristics of the OE presented many Peruvians an environment in which they perceived they could not survive.

Describe Fitness Landscape Effects. The ineffective government encouraged members of the population to pursue changes to the political landscape in the hope of improving their particular fitness function. Three such groups provided alternative visions for an improved fitness landscape. The Shining Path insurgent group had already taken over portions of land and initiated a revolutionary upheaval of the fitness landscape to introduce a communist landscape.

Two other groups, the populist and the neo-liberals, advocated government reform. The populists supported charismatic leaders who claimed they could turn the country around. The neo-liberals were the small middle class business owners who advocated economic reform. There were additional groups advocating other alternatives, however, this case study will focus on the three who emerged as dominant. The major effect of Peru's fitness landscape was to create different groups with competing proposals for improving Peru's landscape.

Evaluate Major Groups. There were four primary groups in Peru during the 1980s and 1990s. First, there was the population. The population was the majority of people who were trying to navigate the web of competing efforts to shape Peru. Each person had a varying fitness function and would support the group which gave them the perceived best option to improve their individual fitness function. Second, there was the populist government. Populism, in the case of Peru, was a strong, charismatic leader who sees his appeal and power as above the institutions he should support.[11] The populist leader's fitness function was supported by the people and with a mandate to aggressively take any action he thought best. In this sense, the insurgency was part of the populist's fitness function. The violence and terror they incited made individuals more willing to bestow power to a strong leader who would aggressively fight on their behalf. Third, there was the Shining Path. The Shining Path was a brutal Maoist insurgency working to create a communist state in Peru. Fourth, there were the neo-

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liberals. Neo-liberal, in this context, describes people who advocated a liberalization of the Peruvian economy. (The ILD was created by a neo-liberal group leader, Hernando De Soto.) The small numbers of business owners that made up Peru's upper and middle class comprised this group. The Shining Path, the populist government, and the neo-liberals were all competing to shape Peru and its fitness landscape.

Evaluate Major Groups' COAs. The Shining Path's COA emphasized heavy indoctrination of communism and use of violence.[12] This approach gained them a large following amongst the country's rural and urban poor. The populist government followed the strategy of consolidating power in the president believing a strong and charismatic leader would solve the problems of Peru.[13] The neo-liberal group came from the small middle class who were overwhelmed by the government bureaucracy and wanted reform. From this group came the ILD and their approach was to document and reform the challenges of joining the formal economy by a majority of Peruvians.[14] The population as the majority of people, trying to navigate the web of competing efforts, made choices regarding their local dynamic. Whichever group seemed to provide the best option for their survival would gain their individual support. As each of the groups gained support, either through choice or fear, their relative fitness increased.

Assess Group Interactions. The Shining Path, following the model provided by Mao, maintained an extremist ideology, which made it an all or nothing group. Either individuals in the population joined them or they perished. The neo-liberals wanted to reform government processes and enfranchise the population stuck in the informal economies of the slums growing around Lima. The populists needed a strategy to counter the appeal of the communist ideology of the Shining Path. The situation, enhanced by the extreme brutality of the Shining Path, incentivized the populists to work with the neo-liberals to counter the Shining Path. This alliance produced counterintuitive behavior as populist presidents reduced the size of their government.[15] The population, the disenfranchised, living in the slums of Lima, now had a choice as individuals–support the Shining Path or the Government. The Government was now comprised of populists and neo-liberals who were working together to initiate reforms which altered the economic and legal landscapes through which the Peruvian population had to navigate.

Evaluate Population Behavior. The brutality of the Shining Path encouraged populists and neo-liberals to work together. They reformed government processes reshaping the fitness landscape providing avenues of approach for the population to join the formal economy. The Shining Path was weakened, and then effectively destroyed with the arrest of its leader, Abimael Guzman. As the Shining Path weakened the alliance of the neo-liberals and populists also weakened, with the respective leaders, Hernando De Soto and President Fujimori, eventually having a falling out.[16] By this time, however, the fitness landscape had been reshaped and the population, participating in the formal economy maintained Peru on this economic and legal path. The result was Peru saw a vast reduction in violence and annual economic growth rates which were the envy of South America.

Case Study 2: Applying Complex IPB–Agent Based Models

ABMs are already being used to aid analysis at the strategic levels of the Intelligence Community. The challenge is operationalizing them for wide use across the Army. The metric of success is that a new analyst leaving Advanced Individual Training can use a complex IPB ABM to conduct analysis. At this time, however, there is no complex IPB ABM. To demonstrate the value of ABM for analysis, this article examines the ABM *Slumulation*.[17] ABMs have the potential to be an invaluable decision aid as they provide analysts, staffs, and decision makers an exploration tool. *Slumulation*, and other ABMs, have variables on their interfaces which can be manipulated to see the potential impact of adjusting these variables and can have a profound impact on decision making, particularly as combinations of actions may produce

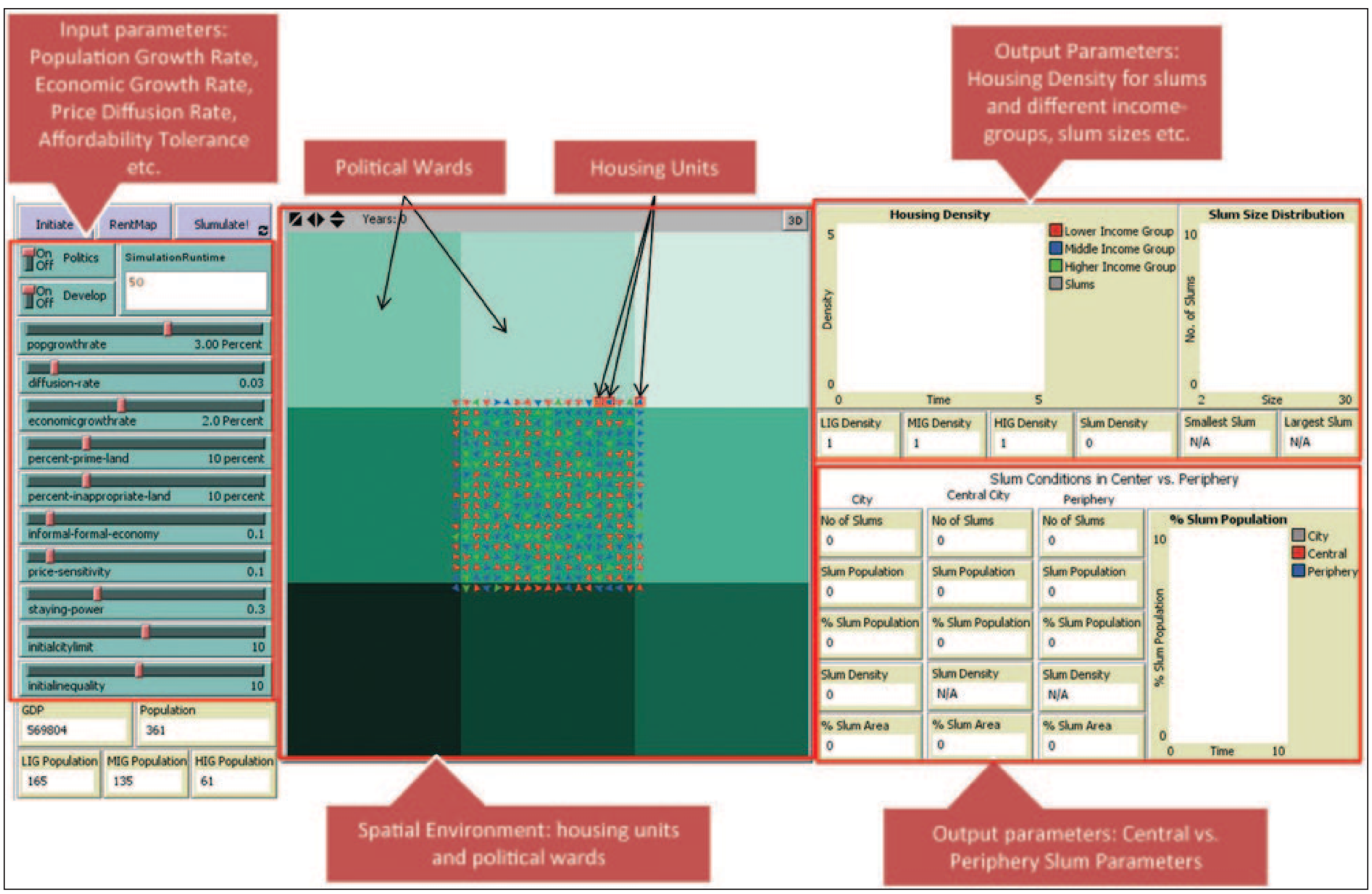

Figure 1. Graphical User Interface for Slumulation. Patel, et al.

unexpected and counterintuitive results.[18] The complex IPB framework is used to briefly describe the *Slumulation* model, with the intent that readers can explore it on their own.

Define the OE. The purpose of *Slumulation* is "to conduct 'thought experiments' and ask 'what-if' type of questions related to slum formation."[19] The fitness landscape of the *Slumulation* model accounts for several dynamics of cities. First is the physical aspect of housing units. How many households are physically available for families? Second, is the political aspect. What advantages might a slum give a politician? Third, is the economics, How is economic growth affecting individuals' incomes and subsequent ability to get a house? The model accounts for both formal and informal economies, where households in the informal economy have less income mobility than the formal economy. Fourth, is population growth, both natural and migratory, where new residents search for housing they can afford.[20] The model captures these dynamics through a variety of mathematical formulas which determine the fitness landscape.

Describe the Fitness Landscape Effects. As *Slumulation* is a research model, the authors designed it to investigate the dynamics of politics, economic growth, and population growth on slum formation. The authors determined at the individual (agent) level what effect these characteristics have on an agent's decision making. Model users, through their manipulation of the variables, change the fitness landscape effects. For example they can dramatically increase population growth, while decreasing economic growth.

Evaluate Major Groups. There are three groups in the *Slumation* model. The visible and primary group is the household agents. The key attribute of the household agent is the income level (low-red, middle-blue, high-green).

Individuals locate to a house based on what they can afford and if the rent rises and becomes unaffordable then they must move. The next group is developer agents. The goal of the developer agent is to make a profit by developing sites. The developers buy empty sites and build new sites with a higher number of units. The final group is politicians. The politicians subsidize slum dwellers so they effectively pay less for their household. This gains the politician more votes to stay in power, while also allowing slums in the informal economy to persist.[21]

Evaluate Major Groups' COAs. The group (low, middle, high income) COAs are mathematically defined to describe the individual agent's choices given certain conditions. If a low income agent is in an area whose rents have risen past their income level then they look to move to an area they can afford. Developers only look to build to make a profit.

Photo credit: Galuboo/Wikimedia Commons

Politicians look to subsidize to increase their votes.[22] Each of the individual agents faces a slightly different situation, but their aggregate decisions impact the makeup of the entire city.

Assess Group Interactions. To assess how slums might form, analysts manipulate population growth, economics, and several other variables to see how those combination of conditions impact the emergence, destruction, or persistence of slums. The low income group in one of the political wards (colored grid in Figure 1) of the model may face a different reality than the low income group in a political ward in the center of the city (center grid in Figure 1). This manipulation shows the strength of ABM in support of analysis. Analysts can manipulate the variables to see not only the first but second and third order effects.

Evaluate Population Behavior. As a final step analysts can present assessments of what variable conditions have the largest impact driving desired results. The authors of *Slumulation* ran the model for 50 time periods using different values for key variables, for 100 times on each setting. They varied population growth, economic growth, initial land supply, and informal/formal economic sector mix. In many cases, the results reflected phenomenon seen in slums of the world today. Although, the model did not reach this point, the goal from the complex IPB perspective would be to inform decision making so leaders could take action to prevent slums formation or set conditions so those in existence are unable to persist.

A Starting Point

Complex IPB argues for one revolutionary change in how Army intelligence analyzes DUAs. Do not try and describe the whole environment. Instead, understand the environment from the perspective of the individual decision makers within it. A description of the whole environment does not and will not allow analysts to understand why the various decision makers are making the choices they are making. Adopting this fundamental shift then has a cascading effect across the analytic process. In particular, analysts will start to focus on the relationships of each group and understand how those relationships are driving behavior. The application of this framework to the case study of Peru shows its potential utility in analyzing DUAs, while the description of the Slumulation ABM model shows how models can enhance the analyst's ability to understand the DUA dynamics and the staff's ability to explore what actions they can take to have the strongest potential effect.

Many readers may be surprised by the lack of discussion about big data, multi-layered geo-spatial maps or other items commonly discussed when talking about DUAs. These tools will absolutely enhance complex IPB and improve situational understanding for operations in DUAs. However, there full benefits will not be achieved without a shift in perspective. Complex IPB is one possible framework, which evolves from current doctrine and aggressively integrates the CAS theory. This framework is in its nascent stages and has a lot of opportunity for improvement and refinement. This includes the development of an accompanying complex IPB ABM which must be able to be employed across the Intelligence Enterprise. Even in its current form, however, complex IPB will improve situational understanding of the underlying dynamics of a DUA and enable more effective action.

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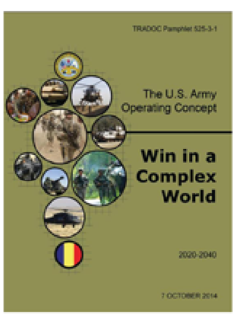
Bringing Sense to the Complex: An Analytic Framework for Operations in Dense Urban Areas

by Command Sergeant Major William Hedges, USA (Ret.)

This article was originally published as "An Analytic Framework for Operations in Dense Urban Areas," in Small Wars Journal, 11 March 2016. The following condensed version is tailored for an Army Intelligence-oriented audience.

Introduction

The U.S. Army Operating Concept, (AOC) *Win in a Complex World*, "provides the intellectual foundation and framework for learning, and for applying what we learn to future force development under Force 2025 and Beyond."[1] The AOC notes two very specific concerns, "What is the environment we think Army forces will operate in and what is the problem we are trying to solve."[2] Additionally, it provides serious consideration to anticipated threats and the future operating environment (OE) by outlining five characteristics significantly impacting land force operations (see Figure 1).[3]



- ***Increased velocity and momentum of human interaction and events***
  - Exacerbated by the large and concentrated populations usually found in dense urban settings; exponential "Big Data" collection and analysis challenge.
- ***Potential for overmatch***
  - A2AD-related challenges; a city's sheer density + human geography multiplied by socio-cultural variable effects.
  - How do you protect and empower the Army's most susceptible formation (Squad)?
- ***Proliferation of weapons of mass destruction***
  - How do you search and secure a large metropolitan area?
  - Neutralizing a CBRNE threat; "MAS-CAS COAs?"
- ***Spread of advanced cyberspace & counter-space capabilities***
  - Countering threat cyber capabilities without adversely impacting civil infrastructure/populace.
- ***Demographics & operations among populations (cities, complex terrain)***
  - Recognition of and counter to threat exploitation of weak governance.
  - "Unmasking" threat/adversary actors within general populace.
  - Understanding congested & restricted urban terrain.
  - Discovery of threat safe havens and support bases.
  - Degraded ability to target threats w/ precision fires.
  - Human Dimension innovations; supporting adaptation and cohesion–Soldiers must "thrive" in an interactively complex OE.

Figure 1. Significant Characteristics of the Future Operating Environment.

The "demographics and operations among populations" characteristic invokes close association with cities and dense urban areas (DUA), with profound implications for the other characteristics when and where linked to a DUA-related environment. This article proposes a tailored analytic framework in support of framing, mapping, and developing courses of action (COAs) for potential operations in DUA.

Megatrends & Dense Urban Areas

Precipitous changes in world demographics are expected to perpetuate significant changes, or megatrends, in the world's diplomatic, economic, and military power structures,[4] potentially creating volatile and uncertain security environments where US interests and related national security concerns are increasingly vulnerable to a variety of actors and a range of threats.[5] Much of the discussion regarding DUA-oriented environments gravitates to the roughly 28 megacities on the planet today. However, the increasing global pace of urbanization is not confined to just a megacities issue or perspective; United Nations studies herald a 60 percent population surge in urban areas by 2030.[6] Despite the ominous scale and complexity of a megacity's 10 million+ distinction, there are almost 850 cities with populations between 500,000 and 9.9 million–in essence "middleweight" cities[7] that also epitomize interactively complex operating environments. Environments featuring a dense and diverse population mix, with complicating factors such as: the potential for loose integration;[8] a growing multitude of networks; and volumes of big data[9] presenting noteworthy challenges for information collection, much less its parsing, characterization, and contextual understanding. It is against this backdrop that one should ask what would constitute a viable analytic framework for developing and placing that understanding into relevant and applicable context.

IPB: A Threat-centric Methodological Approach

The intelligence preparation of the battlefield (IPB) process remains the primary catalyst for the Army's Military Decision Making Process (MDMP) mission analysis step (See Figure 2).

IPB has become process, toolset, and indeed primary analytic mindset as we vector towards a problem and potential resolution towards accomplishing mission command. IPB's emphasis has largely remained threat-centric.

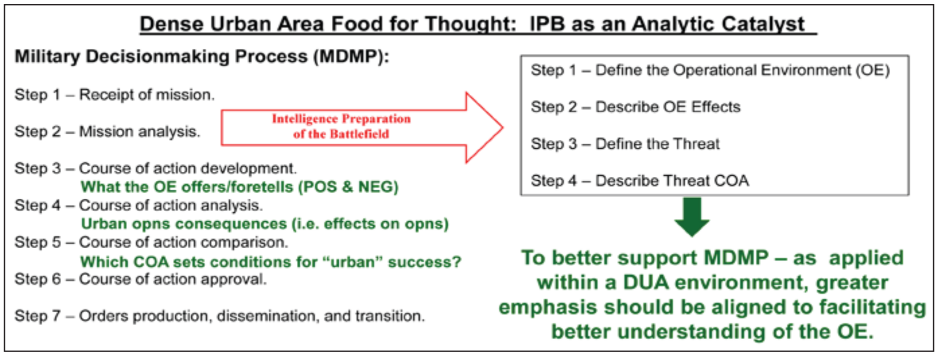


Figure 2. Dense Urban Area Food for Thought: IPB as an Analytic Catalyst.

The Army has revised a great deal of its doctrine in an effort to adapt to an ever-evolving OE landscape, yet IPB continues to be oriented towards the "M" in PMESII-PT, [10] related threat methodology, with distinct linear engagement areas. It remains suited to structured problems, essentially reductionist and deterministic in nature; but, is not suited to revealing the myriad dynamics inherent to interactive or unstructured relationships between the other operational variables and sub-variables.

When half of our analytic framework is threat-centric and the discussion/process is focused on an OE in which the threat has not yet been revealed or is unrecognizable, should an intelligence staff simply default to the first two IPB steps in support of MDMP Steps 3, 4, and 5? An environmentally-driven analytic framework supports all aspects of MDMP with contextual analysis that evolves as the OE evolves. It does not mean one ignores the potential threats; but creates favorable conditions for identifying the threat (or problem system) within the OE's atmospheric context.

Those intimately familiar with joint intelligence preparation of the operational environment (JIPOE) would likely voice dissent to the points above. Though it acknowledges "other relevant actors," JP 2-01.3 first and foremost follows the threat centrality of IPB. JIPOE remains an unwieldy vehicle for operational and mission variable convergence and recognition thereof, specifically the discovery of the "free will" oriented emergent behavior emanating from a DUA's diverse population groups–contributing to why such environments are representative of complex adaptive systems. Every analyst will find the PMESII-PT–ASCOPE crosswalk in ATP 2-01.3 IPB, extremely useful; however, it is a framework "thread," not an analytic framework unto itself. Rationalizing the relationship between PMESII-PT and the Army's Operating Concept should reveal the OE as more encompassing than PMESII-PT, while acknowledging PMESII-PT as a strategic and operational planning tool for DIME (Diplomatic, Information, Military, and Economic)actions and METT-TC as a tactical assessment and planning tool. The precise point of this article is noting the need for greater convergence between the two tools for interactively complex environments under a more robust (and tailored) framework.

The ability to adequately unify diverse elements (like emergent phenomena) while seeking alignment to a threat or system of opposition "sight picture" should be the hallmark of our analytic framework, and indeed process.[11] Operationally relevant example sub-variables like religion, tribal, or familia factors must resonate throughout our analytic framework (and MDMP), so that such data cannot be potentially minimized if it is deemed as having little to no significance in either defining the threat or describing threat COA. The Army's DUA problem approach must be qualitatively and equally focused on city-system environmental challenges and hybrid warfare[12] concerns, by use of diverse heuristics lines of effort rather than the rigidity invoked by the IPB analytic framework.[13]

An Urban Analytic Framework: City as a System

City-as-a-system perspective adoption will require Army doctrine adaptation; one tailored to address the unique operational data layers found within urban centers, their environmental dynamism, and their state of connectedness. One such urban analytic structure has been developed by CAERUS Associates, and championed by the Combatting Terrorism Technical Support Office (CTTSO). Their overarching concept is alignment with systems thinking and focused attention on the relationships between different parts of the environment, while endeavoring to understand the cumulative effects of these interactions.[14]

The framework discussed therein builds upon the merits of the CTTSO/CAERUS framework and incorporates additional elements essential to an intel-oriented approach and is supportive of Army staff action planners throughout MDMP. Such structures greatly assist in drawing to a DUA-centric focus and entail: DUA operational data layers' capture; data layer display and modeling; determination and analysis of city system environmental centers of gravity (E-COG); the potential impact on friendly or threat/systems of opposition COA; and the impact or urban consequences of friendly/threat COAs upon the city systems.

✦ **Framing the Urban Operational Environment.** The framing step begins with the identification of the operational data layers associated with a specific urban environment (See the top table, Figure 3). This initial building block is the PMESII-PT "deep-dive" assessment of existing conditions developed from both operational and mission variable analysis within the commander's area of operations, the area of influence, and the area of interest, and is integral to planning and facilitating friendly force operations. This variable analysis must also address SWEAT-MSO-related variables.[15] Resultant data capture should provide for an initial city-system modeling construct, illustrating individual components within each city-system, eventually leading to the ability to display a layered system-upon-system operational view.

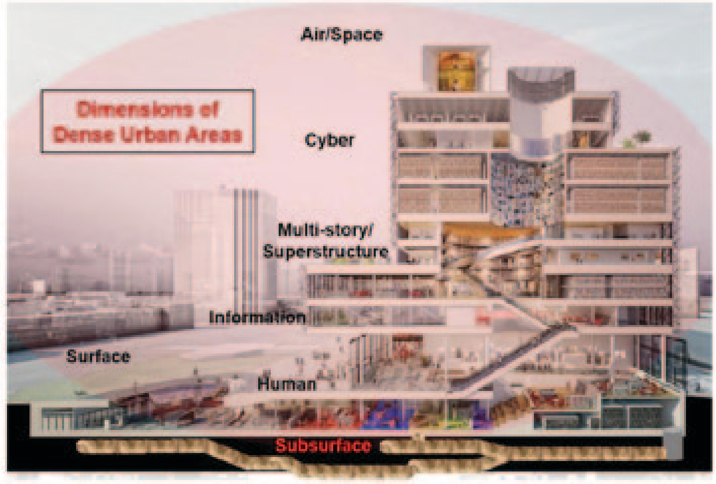


Figure 4.

I. Frame the Urban OE

- Identify Operational Data Layers (ODL)
  - ✓ (Deep-dive) PMESII operational variable baseline alignment + SWEAT-MSO + PT
  - ✓ Mature the process; address Flow-ASCOPE variables and related "city system" analytic descriptors
- Describe effects/impact (positive & negative) of systems-oriented ODL on the OE
  - ✓ Capture of holistic city system current/"steady state"
  - ✓ City system resiliency descriptors
  - ✓ Describe city-systems' effects on friendly/threat forces

II. Map Urban Problem Systems

- Identify problem systems & associated elements (specific OE context)
  - ✓ Primary orientation to F-ASCOPE; ensure alignment to relational mission variables dependent on mission or task, operational phase, and specific echelon
- Conceptually map problem system (problem system flow visualization)
  - ✓ Development of system-specific situation/event-like templates
  - ✓ Incorporate human-centric data as applicable (e.g. domain/behavior/culture mapping)
- Geospatially map problem system (convert system patterns to operational graphics)
- Cultivate understanding (role, impact, & effects) of problem system

III. Develop & Analyze Urban COAs

- Identify city-system E-COGs
  - ✓ System COG determination based on Critical Factors Analysis (CC/CR/CV)
  - ✓ Determination of system flow impact on other city-systems
- Develop COAs
  - ✓ State "Urban Consequences" rationale (incorporated w/in MDMP)
- Analyze COAs
  - ✓ Potential impact on friendly & threat or system of opposition COAs
  - ✓ Impact of friendly & threat COAs on city system(s)
  - ✓ Determine COA acceptability criterion
- Validate understanding of the problem system(s)

Figure 3.

Characterization or context of how the data may apply, assists the process of identifying relevant urban area data layers. Relatively common urban dimension themes aid in guiding the "fit" of a data layer within DUA (see Figure 4). Further "binning" of the data within one of the four urban quad categories (population, infrastructure, physical environment, and information) would greatly assist follow-on analysis, especially for analytic teams not familiar with the subject and perhaps those with unpolished analytic skill sets.

A re-examination or maturation of these data layers would be required in which Flow-ASCOPE is next applied.[16] This flow emphasis is relationship-centric and invokes discovery of the effects of one system upon another, and supports variable/sub-variable convergence–contributing to understanding "city as a system" attributes or capabilities, as well as potential vulnerabilities.[17] This initial "effects" description should be extended to effects on friendly forces and their known systems of support as well as potentially to identified threat forces and/or related known systems of opposition.[18]

The overarching objective of describing the positive and negative effects/impacts of the system on the OE is to holistically frame the systems' current or "steady state status.[19] The resultant "portrait" should describe each systems' resident capabilities, which enable achieving or maintaining a degree of resiliency against internal or external forces/factors. This step may conclude or transition from a city-system examination as federated entities, to one in which specific descriptions of the systems' effects/impact on friendly and threat forces (or systems of opposition)[20] are assessed in order to evaluate the system and glean potential conventional and/or a hybrid warfare context.

✦ **Mapping Urban Problem Systems.** Mapping the urban problem system (See middle table, Figure 3) elaborates on the problem via system map visualization. Transferring this knowledge to a map/picture supports the identification of key accumulators/nodes and flows integral to the problem system itself and our general understanding of the system. This mapping process assists key input to: friendly forces concept of operation; the running intelligence estimate; the development, evaluation, and refinement of priority intelligence requirements; and facilitating the initial construct of an intelligence collection plan.

Mapping should also incorporate data central to understanding complex adaptive systems, essentially alluding to global graph[21] utilization; human domain mapping; human social culture behavior modeling; and emergent state phenomena.[22] The definitive by-product of preparing a concept map[23] is the select identification of each problem system and their respective sub-elements (See Figure 5).

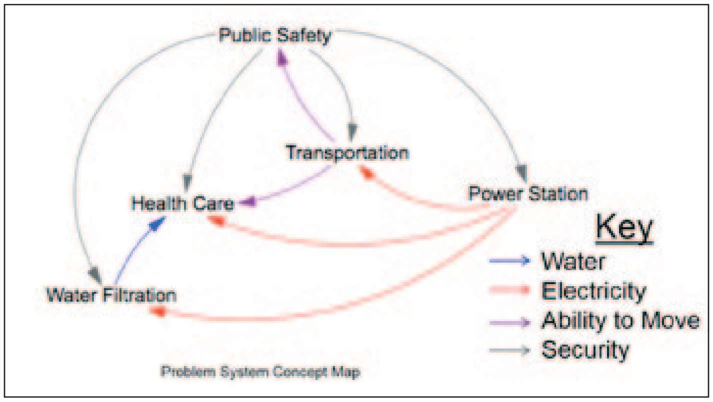


Figure 5.

Transitioning the concept map to a geospatial illustration is representative of converting system patterns of operation (to include potential threats) to graphics. This visualization may take on a form similar to the present IPB process in which situation and event-like templates are generated, thereby illustrating key "terrain," potential objectives, named areas of interest, target areas of interest, and associated decision points. Significant operational data layers (as in Figure 6) can be framed, combined, and mapped in a visual array for a select portion of a city in support of a specific event or activity.

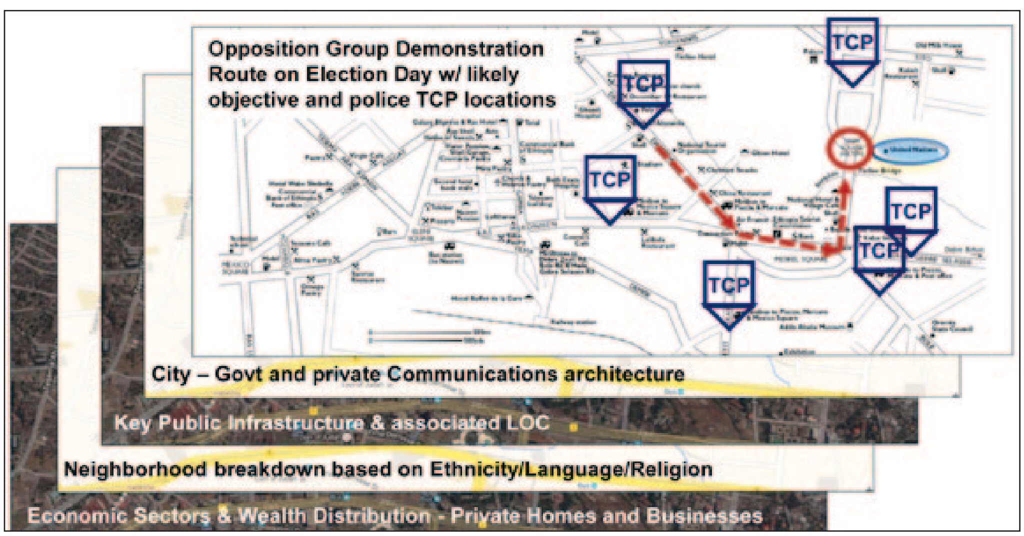


Figure 6. Geospatially Mapping the Problem System.

System-oriented mapping embodies a visual representation of the elements of the problem and their relationships, facilitating and cultivating a deeper understanding of each system's role, impact, and effects. This step affords insight as to how disparate parts of the system interconnect and interact to produce emergent phenomena and provides a visual means supporting systematic study of system parts contributing to a more holistic portrait of the DUA city-systems.[24] Mapping is the catalyst for understanding how the population, infrastructure, and key actors relate to the physical terrain and in turn, assists in revealing the territorial logic shaping the spectrums of key actor behavior, shedding greater insight for each of the city-system's operational data layers.[25] Understanding urban metabolism is intrinsic to a maneuver commander's operational vision and intent as well as the unit's urban battlespace (or engagement space) management.

✦ **Developing & Analyzing Urban COAs**. This framework moves from describing the problem to how to influence it (See bottom table, Figure 3) via identification of environment centers of gravity (E-COGS)[26] E-COG application extends traditional COG analysis from one that is adversary centric to one that embraces a systems-supportive environmental perspective, stemming from the premise that population, infrastructure, the physical environment, and information all provide resources to both friendly forces and systems of opposition, as well as all those who rely on the city-systems for well-being, sustainment, and progress. There may be multiple E-COGs "in play" at the same time within the same DUA, with each or a combination thereof, extremely susceptible to change over time.

The inroad to E-COG analysis is identifying the system objective(s), facilitating greater system context, depth, and understanding (See Figure 7). Alignment of a system objective enables tailored application of critical factors analysis (CFA) using critical capabilities, critical requirements, and critical vulnerabilities descriptions, and renders a refined portrait of system interaction and impact. E-COG/CFA provides a conceptual link between framing the environment, identifying and characterizing the problem systems, and creating a model that incorporates the elements and their parent systems.[27]

E-COG/CFA is integral to the development of tentative COA designed to affect the E-COG and achieve a friendly force desired end-state. Select examples of E-COG-related friendly COAs include degradation of the E-COG to deny resources to a threat or system of opposition, and reinforcement of

Specific system or entity objective is ____________.	
Who possesses the action? COG(s) COGs possess critical capabilities. A CoG performs the action that achieves the objective.	**System must be able to do ______.** Critical Capabilities (CCs) Critical capability – the *ways* or *abilities* employed by a COG that are essential to system objectives.
System cannot lose _______. Critical Vulnerabilities (CVs) Critical vulnerabilities – an *element* within the CR that appears *exposed* or *susceptible* (at risk) to direct or indirect action(s) . . . actions subsequently creating significant effects.	**System requires _______.** Critical Requirements (CRs) Critical requirements – a condition or resource (means) integral for a critical capability to be fully operational.

Figure7. Critical Factors Analysis (CFA): Environmental Centers of Gravity.

an E-COG to ensure that the E-COG contributes positively to the system users.[28]

This step enhances the operations planning staff's ability to determine COA acceptability criterion during MDMP, and acts as a forcing function for ensuring that a COA's rationale addresses the consequences of COA implementation. A COA's consequence may also be assisted by imaginative advanced structured analytic techniques (e.g. outside-in thinking and morphological analysis) to better forecast the COA's 2nd and 3rd-order effects.[29] This step is also a check against system-on-system effects analysis; the analytic forecast for a relationship or COA outcome may not be sufficiently scoped or portends an untenable COA or one not truly vectored to the problem.

Preparing for the AOC's Future OE

This proposed analytic framework provides a structure that incorporates urban operational data layers and city as a system context and perspectives. It is a means towards addressing key AOC questions of an urban-centric nature, especially given the global pace of urbanization and the world's megatrends involving more complex diplomatic, economic, and military power. As the Army's OE landscape continues to evolve, so must the Army's doctrinal framework, processes, and applications evolve as well. This framework is representative of our human domain[30] efforts (e.g., data collection and analysis) for understanding the human interface resident within DUA; it is also an education enabler that prepares the Army for the "unknown."[31] It complements the Army's human dimension[32] leader development effort as well, a pathway towards situational understanding and the knowledge acquisition necessary for managing, influencing, and preparing soldiers for a challenging and relatively unknown problem set. Development of situational understanding for dense urban areas remains a critical component of Army planning and requires a framework appropriate for content application. The cities aren't going anywhere; but they are getting larger and more complex.

Endnotes

1. TRADOC Pamphlet 525-3-1 The U.S. Army Operating Concept, October 2014, i (Foreword).

2. Ibid., iii (Preface).

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5. School of Advanced Military Studies (SAMS), "Readiness in an Urban Era: Implications for the U.S. Army," May 2015, 1.

6. TR Pamphlet 525-3-1, 12.

7. SAMS, i.

8. U.S. Army Chief of Staff Strategic Studies Group (Megacities), "A Proposed Framework for Appreciating Megacities: A U.S. Army Perspective," Small Wars Journal, April 2014. System typology often featuring decentralized and informal systems, low quality infrastructure, and unregulated flow capacity.

9. Luciano Florida, "The Fourth Technological Revolution" (Oxford, UK: Oxford University Press, May 2014), 14-15.

10. Political, military, economic, sociological, infrastructure, information–physical environment and time. ATP 2-19.4 Brigade Combat Team Intelligence Techniques, February 2015, 1-3.

11. Understanding the Threat as a System of Opposition," COL David Pendall, White Paper, January 2014, 4.

12. Frank Hoffman, LtCol, USMCR (Ret.), "The Janus Choice: Defining Today's Multifaceted Conflict," Armed Forces Journal, October 2009. Combat operations characterized by the simultaneous and adaptive employment of a complex combination of conventional weapons, irregular warfare, terrorism and criminal behavior to achieve political objectives.

13. "TRADOC Pamphlet 525-5-500 Commander's Appreciation and Campaign Design, January 2008, 6.

14. "City as a System, Analytic Framework," Version 1.0, CAERUS Associates and the Combatting Terrorism Technical Support Office, June 2015, 1.

15. FM 3-34.170 Engineer Reconnaissance, March 2008, 6-14. Engineer related operational variables: SWEAT-MSO–sewage, water, energy, academics, trash–medical, safety, and other considerations.

16. The civil considerations found within METT-TC: Flow + Area, Structures, Capabilities, Organizations, People & Events. ATP 2-19.4, B-21. F-ASCOPE evaluation and subsequent analysis should be aligned to other applicable METT-TC variables, dependent upon specific mission, operational phase context, and the respective operationally engaged echelon, though identification of critical city system flows may not be readily apparent to a planning staff. The latter point is reinforced by the present descriptors of accumulators and nodes as related, yet hardly interchangeable concepts. Such terms may require doctrinal re-visit in light of the critical application of F-ASCOPE in support of DUA OE analysis.

17. David J. Kilcullen, "The City as a System: Future Conflict and Urban Resilience," The Fletcher Forum of World Affairs, VOL 36:2 (Summer 2012), 36.

18. Capture and analysis of negative effects/impacts regarding operational data layers is key to informing friendly COA development. Conditions or effects found within a city-related system may be so adverse that an environmentally imposed condition akin to area anti-access/area denial is present.

19. Comparing/contrasting current city state with a desired future state, based on mission analysis and a commander's guidance, vision, and intent, may also require a structured analytic outline. (See DIA and CIA structured analytics regarding diagnostic and contrarian techniques, as well as argument mapping.)

20. Pendall, 4.

21. Scalable operational environment-specific database that identifies, stores, and updates the relationships between hundreds of thousands to millions of entities. Global graphs enable understanding of threat and non-threat networks of people, places, procedures, and underlying motivations, and perhaps most importantly, to understanding complex operational environments as complex adaptive systems.

22. Tom Pike and Eddie J. Brown, "Populations as Complex Adaptive Systems: A Case Study of Corruption in Afghanistan," *Small Wars Journal*, August 2011, 3.

23. Concept Mapping is a key component of problem framing and is linked to TR Pamphlet 525-5-500 Commander's Appreciation and Campaign Design.

24. CAERUS, 30.

25. Dr. Rolf Halden, "Dense Urban Areas and Megacities Challenge," Briefing, ASURE, terminology discussion.

26. CAERUS, 37.

27. Urban OE COA comparison will likely yield contrasting elements or system-specific-interaction differences; model-linked experimentation may require a very specific DUA test city and scenario to adequately capture the resultant impact of a critical variable upon the other resident systems.

28. CAERUS, 41.

29. Ibid., 42.

30. Totality of the physical, cultural, psychological, and social environments that influence human behavior to the extent that the success of any military operation or campaign depends on the application of unique capabilities that are designed to influence, fight, and win in population-centric conflicts.

31. Thomas E. Ricks, *The Generals* (New York, NY, Penguin Press, 2012), 346. The author's context was in relation to "FM 100-5 Operations," in which that document was categorized as ". . . emphasized training, which prepares soldiers for the known, far more than education, which prepares them to deal with the unknown."

32. Cognitive, physical, and social (CPS) components of Soldier, civilian, leader, and organizational development and performance essential to raise, prepare, and employ the Army in unified land operations.

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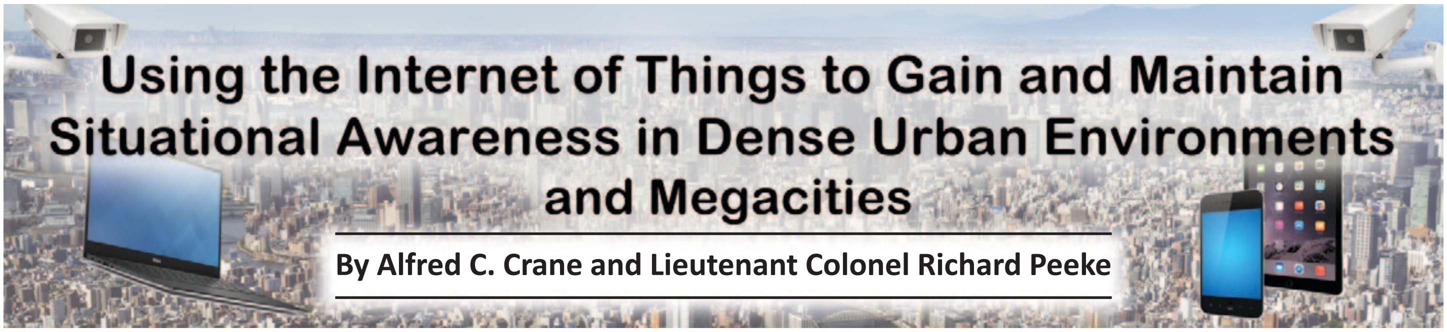

Using the Internet of Things to Gain and Maintain Situational Awareness in Dense Urban Environments and Megacities

By Alfred C. Crane and Lieutenant Colonel Richard Peeke

This article was first published in Small Wars Journal, February 2016.

It may prove beneficial to leverage the internet of things in order to provide our Soldiers, Sailors, Airmen, and Marines the decisive advantage needed to fight and win future armed conflicts. It can be anticipated that connected devices such as game consoles, "baby monitors"[1] and "that smart meter (that) knows when you're home and what electronics you use when you're there,"[2] for example, will be prolific in the future operating environment (OE). With this in mind, the joint force will have opportunities to use these devices to gain and maintain situational awareness in a mega city or dense urban environment. Before Soldiers enter a building or deploy an unmanned system, they may have opportunities to access these existing "sensors" to build a picture of the building's interior. Also, being able to access personal electronic devices of the building's occupants could, coupled with the deployment of unmanned systems, give the Warfighter a better picture of what awaits behind the next door, wall, room or floor.

Not only knowing about the location and patterns of life of enemy combatants in the building and the ability to find out where non-combatants are would increase protection of the Warfighter, as well as reduce the risk of civilian casualties. The data obtained from these connected devices, personal electronic devices and deployed unmanned systems would be rapidly stitched together to render a real-time 3D model of the building, as well as show locations of the structure's occupants. An example of this can be seen in the films "Prometheus" and "The Dark Knight." This would give the Warfighter the needed edge to fight and win in complex urban terrain.

In addition to finding out how many occupants there are as well as their location, the Soldier will also need to gain and maintain situational awareness outside of buildings by being able to access traffic cameras, security cameras, and so forth. Building a comprehensive, living model of a city or even a city block would enhance situational awareness and provide the necessary data for leaders to make rapid decisions and increase the protection of the combat element in an OE. This composited data could also be shared so that the operational commander would have a real-time view of the area of operations (AO). Big Data Analytics and knowledge management/decision making tools will be needed in order to filter and make sense of all of the data being obtained.

Of course these connected devices can be used for defensive as well as offensive operations. By knowing where allies and noncombatants are as well as movement of suspect personnel in an AO by target acquisition and tracking of personnel using biometric sensors and software will give the Warfighter the needed information to be lethal, informed, and protected.

A draw back to this is that without power, access to these connected devices may not be possible. Also, if we have the ability to access and use these connected devices then it can be anticipated that the enemy will have this ability, as well. Counter measures and technologies to spoof, trick, or deny enemy access to these devices will also need to be developed.

One of many challenges in the OE is to distinguish between enemy combatants, non-combatants, and friendly forces. In order to mitigate fratricide and collateral damage, transponders would need to be developed, that are either worn by the Warfighter or are subcutaneous, which can be picked up by friendly forces. These would need to be visible in different spectra and frequencies.

Vignette

In support of ongoing operations, U.S. forces have been assigned to rescue hostages held in a high rise building of a dense metropolitan area. This is part of ongoing operations to remove hostile forces who are attempting to gain control of the capitol building and power grid. Several hostages have been taken in order to pressure U.S. forces to leave. Multispectral, visual, as well as audio signals are used to locate the building where the hostages are being held.

As the U.S. forces advance to the building they contact their Cyber Support Center (CSC) utilizing the cyber support officer (CSO) attached to their unit. As the CSC is contacted, unmanned aerial and ground systems that are organic to the unit are deployed. A call for cyber effects is initiated in order to gain access to the city's security and traffic cameras. This coupled together with the sensors onboard the unmanned systems informs the small unit leader of the best avenue for advance.

Advanced recon to determine patterns of life and develop a target folder are initiated prior to advancement/execution of mission. Simultaneously, an information campaign to provide a plausible cover story or shape public opinion against the hostage takers and delegitimize their insurgent movement is launched.

Once the safest route has been determined, the U.S. led element advances using visual and digital obscurants to cover their movement. A second cyber effect is requested to locate and gain access to connected devices and personal electronic devices in and around the building.

Swarming nano and small unmanned systems are deployed to map out the buildings floor plan and identify location of the occupants. After a few minutes, some cameras are accessed that are built in to game systems, security cameras, mobile phones, smart TV's and baby monitors. Access to these help develop a picture of where the building occupants are located. Two potential locations where the hostages are held are identified based on signals intelligence, cyber effects and the information gathered from the connected devices, mobile phones and unmanned systems.

The U.S. forces enter the building and proceed with caution using the appropriate tactics, techniques and procedures to the two possible locations. After entering the building, U.S. forces talk to a few civilians who have evaded capture and they are able to point out the target location.

A further cyber effect is requested and the location of the hostile forces within the room are identified through their mobile phones, a smart TV and a camera on a office computer. A diversion is created to distract the hostiles and using room clearing procedures, the U.S. forces enter the room, eliminate the threat and rescue the hostages. Less than lethal/area-denial technologies to incapacitate the hostage takers and temporarily neutralize the threat to friendly forces are utilized.

Concluding Thoughts

Gaining and maintaining situational awareness in this age of technology can be challenging. If the Warfighter is left to fight and clear buildings in the same manner, same methods, and same technology as seen in the battles of Stalingrad, Arnhem, Nuremburg, or Fallujah we have failed.

In conclusion, investments in basic and applied research to develop the necessary technologies and software needed to gain and maintain access to personal as well as connected devices (to include denying access of these same devices to our adversaries) and utilizing elements such as Defense Innovation Unit X in Silicon Valley will be needed to make these concepts a reality.

This paper addresses Army Warfighting Challenge #1, Develop Situational Understanding. [3]

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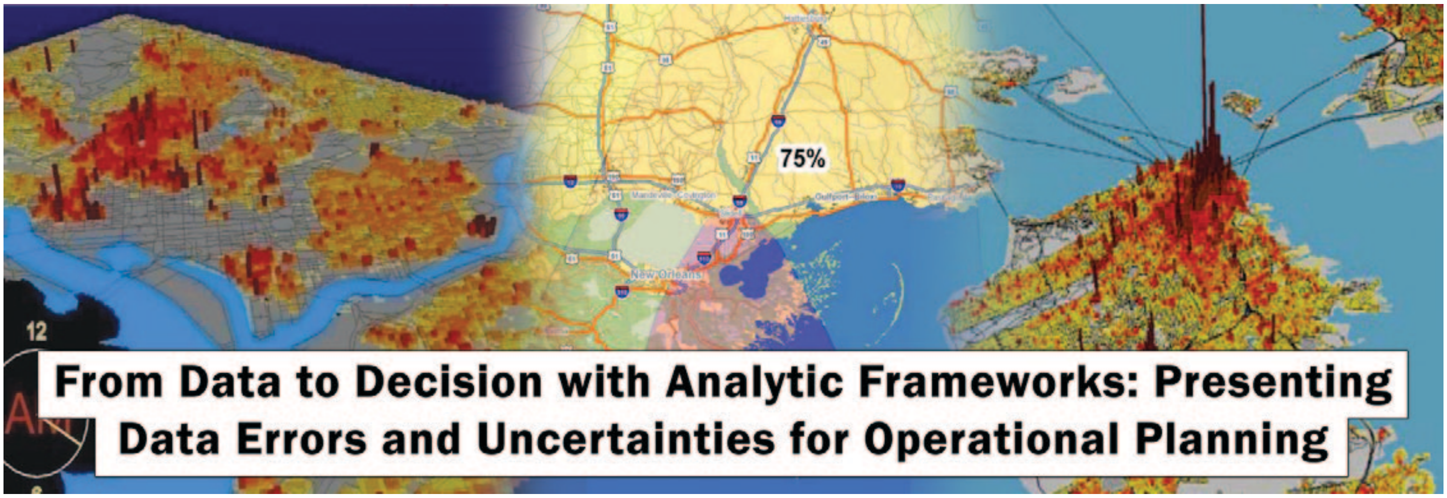
Photo credit: Nikolaj Potanin/Flickr



From Data to Decision with Analytic Frameworks: Presenting Data Errors and Uncertainties for Operational Planning

by Charles R. Ehlschlaeger, PhD, David A. Browne, Natalie R. Myers, Jeffrey A. Burkhalter, Carey Baxter, Yizhao Gao, Dandong Yin, and Mathew D. Hiett

The views expressed in the following article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government. Discussion of any particular country is only intended to provide an open forum and facilitate thought and does not necessarily reflect an official assessment of or U.S. position on that country. All scenarios are fictional for illustrative purposes. The scenarios are not based on actual operational/contingency planning and do not reflect the intent to conduct operations in any particular location.

"All models are wrong, but some are useful."
–Charles Box

"A model can only be useful if you know how wrong it is."
–Charles Ehlschlaeger

Introduction

Combatant commands (CCMD) develop theater campaign plans (TCP) to organize and align operations, actions, and activities that achieve strategic effect. However, structured data is sparse and planners often rely on the qualitative analysis of subject matter experts (SMEs) when developing theater security cooperation programs. A lack of comprehensive information applied across a broad range of disciplines limits both the options identified and the efficacy of TCP. The U.S. Pacific Command (USPACOM) developed several analytic frameworks to connect theater campaign objectives with the data necessary to support strategic planning.

One of these, USPACOM's humanitarian crisis (HC) framework, defines dozens of social, infrastructural, and environmental indicators aligned to USPACOM needs. Many of the indicators are critical to understanding megacities and other dense urban environments in USPACOM's area of responsibility. In addition to the challenge of obtaining sufficient information to populate the indicators, it is critical to understand the quality, or uncertainty, of the information. While commanders are accustomed to operating with uncertainty, the ability to methodically characterize uncertainty offers the opportunity to better connect available data to operational decision making. In this article, the authors describe a systematic analysis method and tools designed to help determine whether the available data provides enough credible information for decision making in the context of humanitarian assistance and disaster relief (HA/DR) planning.

USPACOM HC Framework's Origin and Description

Joint Publication 1, Doctrine for the Armed Forces of the United States, describes joint operational planning as "the way the military links and transforms national strategic objectives into tactical actions." Between 2010 and 2014, the USPACOM Socio-Cultural Analysis (SCA) Team generated a humanitarian risk assessment framework to facilitate identification of susceptible areas and enable more efficient, systematic, and transparent planning by Special Operations Command, Pacific and other CCMD components. Its purpose is to provide analysts and planners multi-disciplinary insights into what matters when it comes to identifying and mitigating HA/DR risk. A fully developed framework aims to identify "hot spots" and assess the seriousness of the risk on three planes: varying degrees of generality-specificity, degrees of certainty-uncertainty, and levels-of-analysis. It is important to note that at present it is intended to serve as a heuristic to help guide critical and systematic thinking regarding assessment of risk to CCMD missions.

The framework considers hazards, populations, and capacity to assess whether a catastrophic event will exceed the ability of the affected community to cope using its own resources. The disasters that lead to such crises can result from natural (e.g., earthquakes, floods, cyclones, epidemics, etc.) or man-made (e.g., dam collapse, chemical spill, famine, economic collapse, etc.) events. Dynamics within a community can help to mitigate or worsen the potential impact of the crisis.

The framework serves to assess risk through the combined effects of two aspects: hazard exposure influenced by societal susceptibilities and adaptive capacities. These two aspects are analyzed by five conditional perspectives: natural hazards, human behavioral impact, services failure, readiness and response inadequacy, and resilience deficiencies. The performance of these conditions is further defined by factors which are quantitatively measured by indicators.

A critique of such a comprehensive framework is that it requires data that is not readily available to analysts, thereby limiting its effectiveness. To offset this limitation, researchers at the Engineer Research and Development Center (ERDC) set out to develop a capability to populate the indicators with available open-source data.

Metrics: Connecting Data to Indicators

Since the indicators identified in the HC framework do not necessarily relate directly to available data sources, metrics are needed to relate available data streams to indicator values. Recently, ERDC developed neighborhood scale metrics for two divisions of Bangladesh for many of the indicators of the HC framework. The ERDC technique used to populate the metrics is named the quantum population geoanalytics (QPG) technique, which allows for the accounting for all input data error sources and model uncertainties. The analysis tool requires that source data be constructed using a spatial-temporal uncertainty model presenting alternative representations of the data layers based on the known errors and uncertainties.

Much of that information can be obtained from host nations' census, and the U.S. Agency for International Development (USAID) or Department of Defense (DOD) sponsored surveys converted into data layers. The analysis tool also requires SMEs to represent the range of framework weighting factors based on their knowledge of the completeness of the available data sources for operational needs. Monte Carlo simulation is then applied to the metrics as they are applied to the SCA framework, creating a range of likely results for each of the indicators, factors, conditions, and categories in that framework.

The presentation of the variability allows decision makers to understand the utility of available data. The results are generated in the form of geospatial thematic maps at a resolution of 200 meters per grid cell contained forecasted values from the most authoritative sources available: censuses and surveys from the USAID and the DOD. Each grid cell contains the range and distribution of possible metric values for the population within 800 meters of that location. Figure 1 is an example of metrics informing one of the HC framework indicators.

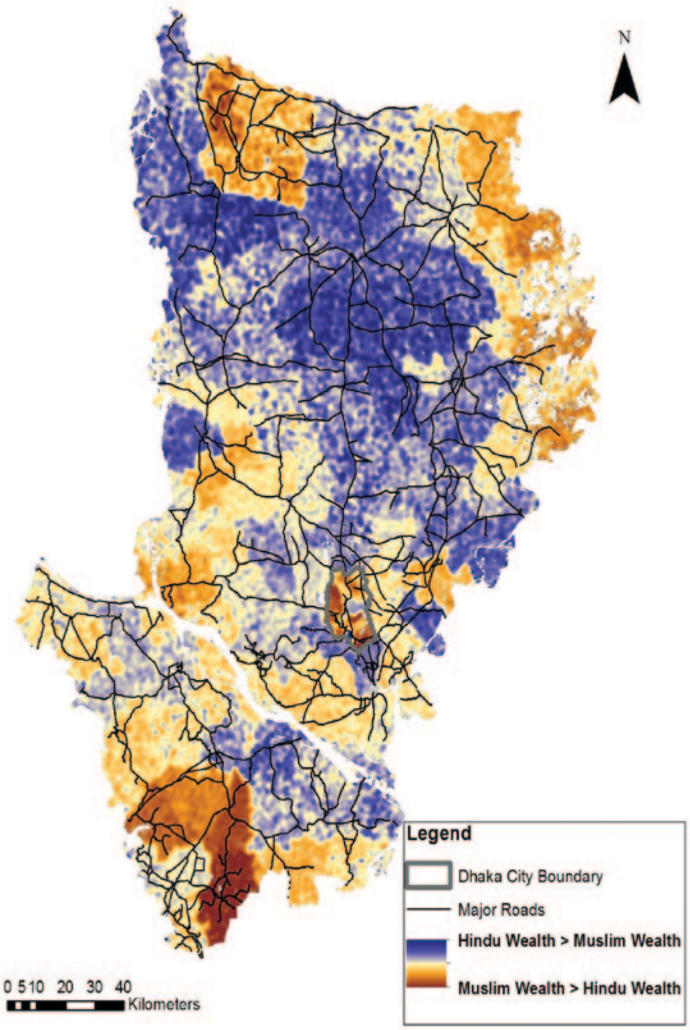


Figure 1. Estimated average wealth inequity between Muslims and Hindus near Dhaka. Other maps indicate estimates of error or utility of this metric.

278 metric map sets were developed for the 59 HC indicators. The original wording of the HC framework didn't align "word for word" with the metrics because the HC framework indicators were developed without knowledge of the available data from the Bangladesh Census, USAID's Demographic and Health Survey, nor a specialized DOD survey querying vulnerable populations. Figure 2 presents the utility of QPG metrics to the USPACOM HC framework based on this alignment. Green indicators were perfectly matched by available survey and census questions, while yellow indicators require a slight rewording of the indicator, factor, or condition to be represented. Gray indicators can

be compiled by existing IC data streams, while blue indicators are being actively researched by various Army research programs.

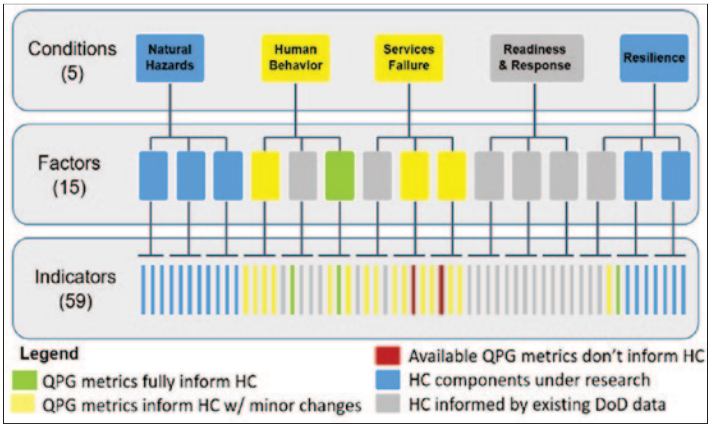


Figure 2. Humanitarian Crisis Framework is organized by conditions, which are represented by multiple factors, which are formed by multiple indicators.

Data to Framework: Using the Example of Inadequate Sanitation

While describing the entire HC framework is beyond the scope of this article, this section describes converting the QPG map layers into indicator, factor, and condition maps. Table 1 depicts the services failure condition in the HC framework. Every Condition, Factor, and Indicator map will be composed of values between 0.0 (extreme risk) and 1.0 (low risk) wherever people live. Framework components in each column are informed by the rows across from its rightward column. For example, the factor map "Utilities Disruption" is a function of the indicator maps "Inadequate Sanitation," "Water Shortfalls," "Lack of Communications Availability," "Energy Deficits," and "Unknown Utilities Disruption Indicator." (The final map represents the information that is not available as well as the incomplete understanding of what "Utilities Disruption" should be.)

Table 1. Indicators to Conditions.

The HC framework is organized by conditions. Factors and indicators are used to evaluate each conditional performance. Multiple conditions make up the complete HC framework, which serves to assess the combination of the probability of a disaster and its negative consequences.

Condition	*Factors*	*Indicators*
Services Failure	Unknown Service Failure Factor	
	Law Enforcement & Policing Deficiencies	Policing/Patrol Deficits
		Inadequate Investigations and Prosecution
		Prisons and Jails (lack of capacity)
		Inadequate Facilities/Property Protection
		Unknown Law Enforcement Deficiencies Indicator
	Health & Medical Service Insufficiencies	Doctor (Health Care Professionals) and Access to Primary Care
		Hospitals/Clinics and Secondary Care (Medical Specialists)
		Availability of Pharmaceuticals (Antibiotics)
		Delayed or Deficient Mortuary Affairs
		Unknown Medical Service Insufficiencies Indicator
	Utilities Disruption	Inadequate Sanitation (See Table 2)
		Water Shortfalls
		Lack of Communications Availability
		Energy Deficits
		Unknown Utilities Disruption Indicator

Like framework components, metric maps represent the level of risk. The metric maps are composed of the information from available surveys, simulated across the entire population in the study area, and illustrate the proportion of people or households with that condition. For example, the "Sanitary Toilet Facility" metric map contains the proportion of households that have sanitary toilets within a radius of 800 meters of that location. The choice of proportion radius is both dependent on the how geographically specific the framework analysis needs to be, and how accurate the analysis results need to be. As the radius decreases, the accuracy of the map will decrease.

If the metrics' range of possible values forces the analysis to be to inaccurate for useful planning, there are four tactics that may be employed:

1. Additional survey data can be collected (in the case of DOD collected surveys).
2. Complementary data must be found to augment the census or survey data.
3. SMEs can be brought in to better refine the framework weights.
4. The analysis can be performed at a coarser geographic scale, which will improve accuracy at the expense of precision.

Table 2 demonstrates how the Inadequate Sanitation Indicator is defined by its four metrics. Each of the metric maps is multiplied by Risk Value raised to the power of its Weight. All metric maps are then multiplied to create the Indicator Map. Risk Values and Weights are given ranges to represent what isn't known about the conditions of that location. Using Table 2 as an example, only an expert on Bangladesh sanitation would know the EXACT Risk Values and Weights to apply. The analysts should increase the ranges the more uncertain they are of the true values. Calibration of Risk Values and Weights can be performed in geographic areas with detailed knowledge of the population, whether based on Civil Affairs units, State Partnership Program collaboration, or trusted SMEs.

The spatial demographic data obtained through the QPG process serve as quantitative metrics for indicators. For example, the state of the sanitation system is reflected by the answers to survey questions: the type of toilet facility (Bangladesh Census), whether the facility is shared with other households (Bangladesh Census), and whether sanitation is viewed as a serious issue (DOD specific survey).

The overall HC Framework model demonstrates the ability to convert raw authoritative data into dozens of high resolution maps providing a relative measure of risk. Each

Table 2. Metrics to Indicator.
The indicator value is measured using a weighted sum of metric values. Similarly, factors values are measured using a weighted product of indicator values, and so forth along the framework structure. Values and weights may be provided as a range (e.g., minimum and maximum). The wider the range, the less certain of the risk contribution. The tighter the range, the more certain of the risk contribution. Random values may also be inserted to account for unknown variables.

Indicator	Metric	Risk Value (min–max)	Weight (min–max)
Inadequate Sanitation	Sanitary Toilet Facility	1.0 – 1.0	0.8 – 1.0
	Shared Toilet Facility	0.2 – 0.7	0.4 – 0.6
	Perception of Sanitation Issues	0.3 – 0.9	0.3 – 0.3
	Unknown Inadequate Sanitation Metric	1.0 - 1.0	0.1 – 0.2

level of the HC Framework is represented as a map containing the range of possible risk values created via a Monte Carlo process, realizing different Risk Values and Weights for each instantiation of the computation model. By including "Unknown" metric/indicator/factor/condition map representations as well as ranges for Risk Values and Weights, a transparent and easily communicated representation of errors and uncertainties of both conceptual framework model and data quality are presented.

Discussion

The tools and techniques described above reflect an attempt to express frameworks with quantitative values in a manner that also incorporates the uncertainty about the operational environment (OE). When conducting intelligence preparation of the battlefield/battlespace (IPB), the PMESII-ASCOPE matrix is referenced as a means to consider sociocultural aspects of the OE. One might consider the frameworks as a mechanism to organize the cells of that matrix in a manner that links larger objectives to elements that can be measured.

The techniques described here also present a geospatial method to link observable data to the indicators, using them to calculate a risk value (and its margin of error). This information can support Step 2 of IPB and potentially course of action analysis. Representing risk geographically is critical to understanding complex social environments, especially in dense urban terrain.

Implementing quantitative measures for the frameworks enables the ability to more easily compare changes as new data is made available. Further, it offers the ability to trace backwards from the factors down to the metrics, so one can explore the impact of changing the weights of different components at the higher level, allowing accurate calibration of the analytic framework. Finally, the explicit accounting for uncertainty at each level allows analysts to more faithfully represent their understanding of the framework values, particularly when SMEs are not available. This reduces the uncertainty of those judgments.

There are likely to be gaps in the framework that are either not obvious or obscured by other framework components. Finding these gaps is vital to ensure the highest accuracy possible. This is a point where the hybrid approach, the incorporation of social science and traditional IPB methods, can identify and address critical gaps in the framework. Both social science and traditional IPB methods inform framework development in distinct ways. The geospatial risk maps provide intuitive methods for calibration and validation via qualitative techniques. When framework map errors are identified, there is an explicit connection to all modeling decisions and data streams to determine whether there is a logical flaw in the framework model or calibration is necessary to improve the analytic framework.

While the frameworks developed by USPACOM may not exactly match the analytic processes implemented in other CCMDs, they serve as a good starting point for linking indicators to higher level planning objectives. With the addition of spatially representing quantitative metrics, incorporating uncertainty, and weighting the importance of individual components, analysts have the ability to more accurately and precisely communicate knowledge of the OE. This, in turn, provides a genuine pathway for the data-to-decisions paradigm.

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Artificial Centrality Bias: Self-Imposed Limits to Understanding Complex Places

by Richard A. Russo

The views expressed in the following article are those of the author and do not necessarily reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government. Article content is not authenticated Army information and does not supercede information in any other Army publication.

The Bias of Artificial Centrality

The bias of artificial centrality is a self-imposed mental constraint in military doctrine. It comes from focusing solely on the mission at the expense of fully understanding the operating environment. This bias causes commanders and planners to assume their military activity is the main cause for action and reaction in the areas around their mission. These assumptions of centrality are especially dangerous in dynamically complex environments, such as large cities, where many factors are already at play. Leaders can mistake correlation for causation.

Artificial centrality bias creates a narrow mindset that ignores the interconnectedness of urban areas by assuming only certain parts of the city really matter to the commander. It fails to appreciate the environment in context and causes commanders to see the city simply as a backdrop to their military operation. Narrow focus prevents planners from realizing that complex environments are not a playground; they are a player. The military operation is but one of many rocks thrown into the urban pond causing ripples and turbulence.

Gaps in understanding local incentive, authority, and flow structures (how things move in a city) will prevent analysts from understanding why things happen the way they do. The resulting ignorance will permeate their mission planning. This produces unforeseen consequences from uniformed military operations. Informal economies can be disrupted, local cultural norms violated, and precious lives wasted. Though many understand bias, it is important to identify its source within military doctrine.

Sources of Bias

Meta-cognitive science is the study of how people think. People project certain mental frames, or biases, on the way they see the world around them that limit their mental flexibility. Sometimes these help people make decisions faster, but unchecked bias can also have an adverse influence on decision making.

Soll, Milkman, and Payne discuss biases produced by flawed "System 2 thinking."[1] They describe System 2 related biases as, "essentially, deliberate reasoning gone awry. Cognitive limitations or laziness, for example, might cause people to focus intently on the wrong things or fail to seek out relevant information."[2] This is true with military doctrine.

Military doctrine is designed to help shape the thinking of planners and leaders. This is done intentionally to focus decision making during time-critical periods of high stress. The U.S. Army defines doctrine as, "the body of professional knowledge that guides how Soldiers perform tasks related to the Army's role: the employment of landpower in a distinctly American context."[3]

This checklist-style thinking has its place, but not every problem should be approached with this mindset. Strict adherence to "finding the textbook answer" can overwhelm planners and cause leaders to miss opportunities. The U.S. Army's capstone publication, ADP 1-01 Doctrine Primer, admits, "Leaders sometimes struggled to determine what was truly important for all professionals and what was important only to a branch or functional area."[4] One reason for these struggles is the tendency of doctrine to enforce fixed mental models on practitioners that limit their understanding. Sengue discusses these limitations in that, "new insights fail to get put into practice because they conflict with deeply held internal images of how the world works, images that limit us to familiar ways of thinking and acting."[5]

A noteworthy historical example of this bias in action is Napoleon's march to Russia in 1812. Napoleon lost 580,000 soldiers during his overland campaign and failed to achieve his strategic end. Nester describes conditions contributing to Napoleon's decision as a, "toxic psychological mix of hubris, security dilemmas, and brinksmanship."[6] Underpinning these topical issues is a bias that assumed Napoleon's army (the largest raised in history at the time) would be capable of marching to Russia and defeating the Tsarist forces. These calculations were focused on the enemy and not the environment. The oversight cost the French over half a million men.

Another example is the German offensive into Russian-held Stalingrad during WWII. German forces conducted aerial bombardment of Stalingrad prior to the ground assault by the German 6th Army.[7] The bombardment was meant to reduce Russian defenses of the city; it instead yielded an unintended consequence. German planners failed to account for how the urban environment would react to their pre-assault fires. Greezicki describes the counterproductive result of the German airstrikes, "intended to make the upcoming assault a walk over, the bombardment had the opposite effect, turning what were buildings into easily defensible piles of masonry and concrete."[8] The Germans were so fixated on attacking the Russian troops that they failed to consider the city. The rubble left by the bombardments increased the difficulty of the German mission. In effect, the Germans complicated the complex environment by not understanding it.

Examples of artificial centrality bias are not confined to the annals of history. In the second Battle of Fallujah in Iraq, Marine Lieutenant General Sattler executed an attack on the city. The intent of the attack was to dislodge insurgents who were using the city as a safe haven for terrorist attacks.[9] The arrayed forces began their operation on the north side of the city and were given separate, supporting lanes of advance which converged on the south side of the city. The coalition advances were supported by a converging effort that approached from the west side of the city.[10] Sattler had intended to clear the city in detail, systematically moving his forces block by block.[11] At the surface, this plan seemed to take the cityscape into proper account. The city, however, provided insurgents additional mobility that allowed them to quickly reconstitute around and behind the advancing coalition troops. Sattler describes the additional effort required to root the insurgents out of the city:

> ***"We cleared somewhere between 15,000 and 20,000 buildings, most about three times. After the initial sweep, the thugs got in behind us, so we doubled back to attack south to north and cleared the same buildings again. Then after we secured Fallujah, we went through every building a final time to make sure we cleaned out all the caches."[12]***

The complexity of the terrain afforded insurgents an unanticipated degree of agility which planners seemed to have underestimated. The planned maneuvers focused on dispersing the coalition troops to ease their movement through the city, but planners failed to anticipate how well the enemy would use the complex terrain against them.

These three examples demonstrate how an inaccurate appreciation for the environment can lead planners and leaders to make erroneous assumptions. Exclusively focusing on what a leader wants to do, as opposed to considering how the environment will react, can have serious consequences for those involved with military planning.

Photo credit: Bobak Ha'Eri

Implications for Intelligence Professionals and Decision Makers

Artificial centrality can obscure the context of events and hamper understanding of correlation and causation within complex systems. This lack of understanding can lead to uninformed risk analysis and plans that address the wrong problems. The nature of complex systems, like cities, is a jumble of interaction among smaller subsystems. Subsystems are made of different groups of people interacting with each other and different physical or virtual systems in the city (such as traveling on the subway or shopping online). These interactions constantly change and grow into what Senge calls dynamic complexity, "where cause and effect are subtle, and where the effects over time of interventions are not obvious. Conventional forecasting, planning, and analysis methods are not equipped to deal with dynamic complexity."[13] Often it is difficult to find a clear bright line between cause and effect in cities, which is why detailed understanding of the environment is paramount.

Understanding the environment means seeing past the mission and into the relationships that form the complex systems. U.S. Army doctrine advises the application of *operational art* by the commander and staff during planning. Operational art is a cognitive approach that draws on the knowledge, experience, and judgment of the commander and staff to integrate ways, means, and ends to form a series of operations or a campaign.[14] Unfortunately, for operations in large cities, this is likely to start the cognitive process further down the road than is practical. Rather than starting with a pre-determined or desired end state, the complexity of modern cities requires an early contextual framing that will allow the commander and staff to know what is possible to affect within the system-of-systems and to what extent it can be positively affected in the direction desired.

Understanding the impacts a military mission may have on a city is crucial to helping minimize mission risk and prevent-ing collateral damage. Leaders and planners must become adept at anticipating consequences in complex systems. As leaders plan operations they must have an adequate appreciation for how their operating environment functions on a regular basis. Achieving this appreciation requires leaders and planners to objectively learn about their surroundings with minimal bias.

Minimizing Artificial Centrality

Soll, Milkman, and Payne give advice on minimizing the impact of biases like artificial centrality in that "you can outsmart your own biases. You start by understanding where they're coming from: excessive reliance on intuition, defective reasoning, or both."[15] For military decision makers this means looking at more than just the mission.

Army design methodology (ADM) is a planning methodology occasionally used as an adjunct to the U.S. Army's traditional planning framework known as the military decision making process. Operational design is meant to help commanders gain a more holistic understanding of a situation before they begin planning in earnest so they avoid planning to solve the wrong problem. Use of ADM, however, is infrequent. Rago attributes this shortfall to a self fulfilling bias:

> ***"Culturally, Army planners and commanders tend to believe that all things are knowable, all problems are solvable, and that the operating force is the first and foremost influencer in any given environment. This likely derives from an inherent "can do" ethos, but tends to lead to reductionist processes that oversimplify or dismiss problems in an effort to more easily convey ideas to commanders. Obviously failing to recognize and avoid these biases is essential to effectively applying the Army Design Methodology."***[16]

This sentiment is echoed by Senge, who discusses use of systems thinking to frame multifaceted environments:

> ***"The essence of the discipline of systems thinking lies in a shift of mind: seeing interrelationships rather than linear cause-effect chains and seeing processes of change rather than snapshots."***[17]

ADM provides commanders and military staffs with an opportunity to learn more about the operating environment through dialogue to provide the necessary insights to continuously frame and reframe an understanding of the environment and problem sets. For ADM to realize its full potential in helping reduce bias, the Army must fully culturally embrace systems thinking and design methodology across the force.

Conclusion

Artificial centrality bias can produce a narrow mindset and dangerous ignorance. Failure to understand the nature of a complex environment, like a large modern city, can lead to unintended and counterproductive consequences. Artificial centrality can prevent commanders from seeing their operation within the appropriate context. This bias can cloud predictions regarding the consequences of military operations and estimates of collateral damage. There are potential solutions to artificial centrality bias. Greater inclusion of Army Design Methodology and systems thinking can help commanders align their perspective to account for complex environments.

Endnotes

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17. Senge, 73.

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Photo credit: Manilaspirit/ Wikimedia Commons

by Mr. Christopher Parrett

Introduction

In 2014, the U.S. Army Training and Doctrine Command published the Army's Human Dimension Strategy and the Army Operating Concept, both of which will trigger significant advances in current ground force doctrine.[1] These documents signal a revolution in how the Army plans to evolve to meet a complex future operating environment (OE), relying on its most important resource, the men and women of the U.S. Army. Future Army leaders must facilitate greater institutional agility and instill innovation and creativity in order to thrive in a complex environment that is increasingly urban and chaotic.[2] The Army's Military Intelligence enterprise will be critical to the characterization and understanding of this complex urbanized world, providing the context and visualization necessary to support the decision making process at all echelons.

Nowhere else in the Army's capability portfolio is the need to change more imperative than in the realm of Geospatial Intelligence (GEOINT). The overwhelming volume, diversity, complexity, and speed at which geospatial data is generated, combined with the requirement for near real-time human interpretation and synthesis into intelligence in order to describe and visualize the OE, will stress the entire Army enterprise. In order to begin to address the issue of the future's massive urban landscape, the Army must rethink its doctrinal approach to GEOINT practices, transitioning away from a discipline doctrinally constrained by multiple single-source stovepipes, and embracing a multi-disciplinary, dynamic, and technology-enabled analytic approach dedicated to addressing complex urban-human terrain.

The Megacity–Dense Urban Terrain

There have been many papers and articles written by military researchers, industry partners, and academic scholars on the topic of the megacity. Therefore, this article will not recap what a megacity is, but rather explore how GEOINT needs to evolve to meet this looming strategic issue. Many articles share the common agreement that the U.S. military is ill-equipped to deal with military operations within a megacity environment.[3] Few, however, focus on the current GEOINT enterprise's abilities to address this immense challenge. Furthermore, while some have argued that any urban operation will undoubtedly be a joint response, the fact remains that operations within the urban environment itself will be a land-force problem set.[4] The Navy and Air Force will be critical enablers, but ground forces will be forced into the unforgiving urban environment. It is imperative that the U.S. Army lead a coordinated and focused effort to establish how to respond to military operations in megacities.[5]

Every city functions as a system-of-systems, similar to a living organism. This analogy has become popular recently, comparing the infrastructure, communication flows, and sustainment to the skeletal, nervous, and vascular systems.[6] Along these same lines, if a city is analogous to a human being, then it is presented here that the intelligence enterprise functions as a physician. To diagnose a patient, the doctor must establish what is normal. Each human being is unique, but shares common core properties such as a pulse, blood pressure, normal body temperature, and breathing. Once the doctor establishes the patient's baseline, he examines each patient differently. This uniqueness derives from different lifestyles, hereditary, and physical structure. Doctors run tests, but do so with the least invasive methods possible. By introducing foreign objects into the system, the doctor knows she actually changes the system, introducing bias into her baseline. Non-invasive methods, such as visual observation, stethoscopes, and touch/pressure provide critical information to allow the physician to establish baselines and start to treat the patient. Treatments will be different for each person, even though the ailments may be similar. Tissue and blood samples, medication, and even surgery may be required based on each patients unique physical composition, but these actions will all have impacts on the entire system, since each system is connected.

GEOINT is analogous to the more non-invasive, visual and remote sensing methods–such as x-ray or magnetic resonance imaging–used in medical examination. Sending foreign personnel into an environment disturbs the natural state, skewing observations and introducing secondary/tertiary effects that are not well understood. However, passively harvesting and utilizing publicly available social media and open-source geospatial information does little to affect the OE. Positioning an aircraft carrier off the coast, or military aircraft overhead, introduces a foreign presence and an unknown system response. Conversely, observing the environment from a satellite orbiting hundreds of miles overhead does little to influence the environment. Using GEOINT to map and analyze these systems offers military planners non-invasive means of mapping, measuring, and analyzing the environment. This analogy highlights the issues of scale and complexity faced by GEOINT applications in support of military operations in a megacity environment.

GEOINT in Army Design Methodology

Operational art relies heavily on commanders and staffs "skill, knowledge, experience, creativity, and judgment" in order to develop strategies and employ military forces.[7] Command teams conducting operational art have multiple tools to use in order to develop strategies to achieve linking their ends, ways, and means. In order to conduct these analyses, Commanders must be able to visualize and understand complex issues to make the best decisions possible. Army Design Methodology (ADM) is a doctrinal methodology for "applying critical and creative thinking to understand, visualize, and describe problems and approaches to solving them."[8] Unsurprisingly, GEOINT's ability to provide sophisticated visualization, analysis, and dissemination of fused views of the OE makes it a key intelligence discipline in the ADM process.[9]

ADM provides commanders with a framework to begin conceptual planning to achieve the desired end state and is typically injected during the Environmental Framing stage. Environmental Framing uses narrative and visual models that describe an OE and depicts the history and culture of the current state, defines the end state, and frames the problem in context of the OE, which facilitates the design of the operational approach and planning.[10]

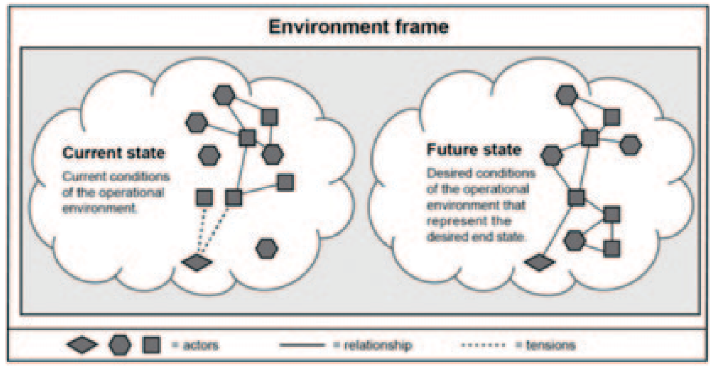

Figure 1. Environmental Framing (From ATP 5-0.1, figure 3-1).

However, unlike the military decision making process which is supported by the structured intelligence preparation of the battlefield, Environmental Framing does not have a structured framework for intelligence to follow.[11]

Megacities are multi-dimensional, complex, and dense urban terrain. Simply trying to establish a basic understanding of each component of a megacity is a daunting task that can easily consume years of analytical level-of-effort. Each city, regardless of population, has varying degrees of vertical elevations, to include both super-surface and subsurface components.

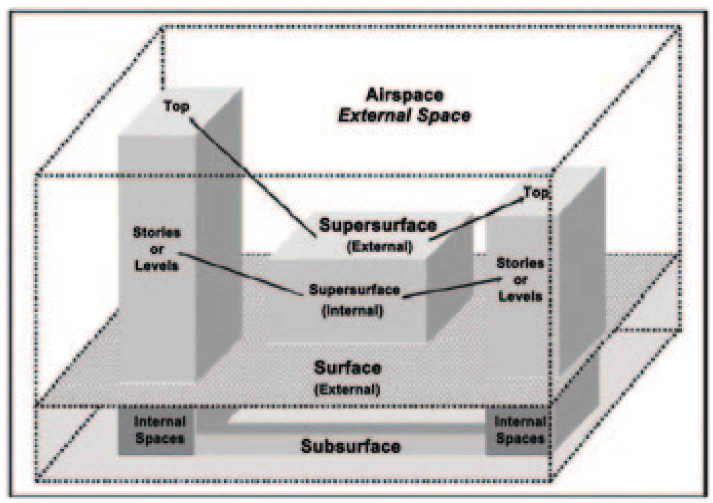

Figure 2. The Multidimensional Urban Battlefield (From FM 3-06, figure 2-2).

Each city has a horizontal component, some exhibiting an expansive land area (New York City's land area is approximately 4,495 square miles) and others occupying much less space (Dhaka has approximately 134 square miles), resulting in different population densities (Dhaka has a staggering 115,200 people per square mile).[12, 13] Cities' population distributions are rarely spatially homogenous, with business districts typically reporting less than residential areas. However, during business hours, business districts may be more populated than residential areas as people travel to work or engage in commerce. The physical geography and infrastructure–topography, weather, water, sewage, electricity, and material composition–all add to the geographical complexity. One simply has to compare NYC-Manhattan's geometrically gridded streets lined with modern concrete and steel buildings to Lagos-Makoko's maze of shanties and floating buildings over the Lagos Lagoon in order to realize the distinct complexities of each environment. The development of this multi-dimensional geospatial foundation is a critical first step to establishing the city's baseline, but it is time and data intensive (both "big" and "large"), expensive, and perishable.

There are multiple doctrinal frameworks available, to include: PMESII-PT (political, military, economic, social, information, infrastructure, physical environment, and time); METT-TC (mission, enemy, terrain and weather, troops available, time available, and civil considerations); SWEAT-MSO (sewage, water, electricity, academics, trash, medical, safety, and other) and ASCOPE (area, structure, capabilities, organization, people, events). These methods present planners and intelligence professionals with elements to consider when assessing the OE, mission variables, and civil considerations of military operations, but combined together they result in an overwhelming number of factors to consider. Just taking the ASCOPE, PMESII-PT, and SWEAT-MSO variables as guides on the data required to baseline a city, an analyst would have to consider hundreds of datasets, each dataset containing thousands to millions of data points. The problem becomes exponentially intensive as the level of detail increases, but scale (megacity) remains constant.

In an attempt to develop a practicable strategic appreciation and typology to categorize a megacity environment, the Army Chief of Staff's Strategic Studies Group presented size common factors: density, scale, connectedness, context, and threats.[14] In an attempt to focus on those core attributes common to every city, similar to the physician using standard human biology as her starting point, organizations have proposed specialized frameworks to geospatially assess megacity environments. Several proposed frameworks utilize a system-of-systems approach, applying a reductionist approach to the problem in order to manage the complexity involved in megacity framing. While these frameworks are considered positive steps that go beyond current Urban Operations doctrine, which simply considers "terrain, the society, and the infrastructure that links the two," the degree to which they scale will be driven by the scope of the problem.[15] In other words–and borrowing from our human analogy–a pediatrician can easily treat a superficial and localized abrasion, but it is a much harder task (exponentially harder) for that pediatrician to treat a victim of a car accident with multiple external and internal injuries. As the defense and intelligence community (IC) moves to establish the city as a unit of measurement, the abstractions that have benefited strategic planners will be removed to reveal a complex and chaotic world drowning in data.

Scale

Framing provides a perspective from which commanders can understand and act on a problem. Current intelligence work is focused on describing the OE and providing key contextual understanding to the command team in order to develop solutions to solve problems. The environmental framing process facilitates constructing hypotheses that focus on the part of an OE or problem under consideration. At the scale of the megacity, these tools benefit from abstraction, where the analysis can simply treat the city as a generalized outline on a map. For instance, for a PMESII-PT assessment of New York City's importance in context of the rest of the U.S., it would probably suffice to list the major demographic groups in a table by percentage, since the spa-

International Space Station

tial distribution of each group is not needed to the single household level. On the other hand, if one were to assess the interactions of every demographic group across New York City, it would be nearly impossible and almost useless in the larger analysis. This fallacy of linear perception is perhaps the biggest hurdle to properly planning GEOINT support.

Large area assessments benefit from abstractions, whereas as one starts to focus inward on a smaller area, the more detailed data is exposed. The classic example of this paradox is the exercise of mapping coastlines, where fractal behavior is observed as the length changes depending on the desired resolution or unit of measurement. Similarly, the USGS Landsat satellite program has been critical in monitoring large-area land cover changes over months and years. Landsat 8 collects large areas of the earth at a 30 meter resolution, enabling it to collect an entire megacity in a single collection.[16] Conversely, Digital Globe's World View 3 (WV3) can collect at 30 centimeters, but covers only approximately 46 square miles, requiring multiple collections.[17] An experienced analyst could utilize Landsat to provide a large area land cover assessment (urban versus forest) in under an hour, whereas locating every tree in a 46 square mile area could take days. Building a high-resolution, geospatial foundation for an entire Megacity, internally and from scratch, would be an extremely long and costly process. The automated processing of collected data to preposition approved products, versus requiring a human to request the processing, needs to be implemented to save valuable analytical time.

Army GEOINT operations typically follow a linear, manual production-line process which efficiently handle a single-source of data sequentially, termed the processing, exploitation, and dissemination (PED) process. Imagery analysts search, download, process, exploit, and then disseminate textual and graphical information. The analyst completes this process, moves onto the next image, thus repeating the cycle. These PED "lines" are often customized to the specific sensor and data type, with a "raw data in, information out" construct to meet timelines and demands.

In the early stages of GEOINT's evolution, which was characterized by government-only strategic space imaging, this process was sufficient to meet strategic intelligence demand.[18] However, the vast wealth of geospatial information, intelligence, surveillance, and reconnaissance (ISR), and the growing flood of commercial imagery data collected over the past fifteen years of conflict in Iraq and Afghanistan, has developed a generation of commanders accustomed to having unprecedented detail of the terrain on which to plan military operations. The commander's reliance on GEOINT PED–specifically the aerial layer's full motion video and moving target indicator–has grown almost exponentially as a result of the multitude of quick reaction capabilities and programmed ISR platforms.

In addition to this, the rapidly increasing commercialization and miniaturization of space imaging is quickly outpacing governmental resources. Current estimates place over 600 satellites in orbit by the year 2023, with some constellations potentially being capable of imaging every inch of the Earth every day.[19] By one account, by the year 2020, it would take every person in New York City monitoring a computer screen 24 hours a day in order for "human eyes to view every image."[20] As of September 2015, Instagram had over 18.7 billion photos in its database.[21]

Using current GEOINT capabilities to build a basic foundation is possible with unlimited time and resources, but more often than not, crises arise where and when they are least expected. Quick baselines could be generated, but it is likely they would only include larger observables and those that are non-perishable–those unlikely to change in the near future. Unfortunately, for the military commander planning to execute a mission within a megacity, these two points present significant risk. Small objects or features obscured by physical terrain or man-made structures which go undetected may impede movement or present dangerous hazards. Construction, destruction, power outages, or floods change the urban environment rapidly, rendering the baseline out of date. The need for current high-resolution GEOINT will remain a top priority for future commanders, but the perishability of the data is a growing concern and temporal persistence is increasingly in demand.[22]

Time

Scale is not the only problem; time presents distinct challenges to Army GEOINT as well. As the speed of interaction increases based on improvements in connectivity, so should the responsiveness of the Army GEOINT enterprise. The dynamic nature of human interaction adds a temporal and virtual complexity, in which a single event in one part of a city may occur over the span of several hours and suddenly dissipate, but leave behind severe, unanticipated side-effects. The city is a system-of-systems, a living organism; its current state of health may imply its possible future state, but it likely will not conclusively define its end state. Multiple interactions between systems result in second and third order effects that are often times unpredictable. This complexity is a result of patterns of interaction among multiple systems over time, and through near-instantaneous means of communication regardless of linear distance. This will require static and linear models, such as PMESII-PT, to be updated iteratively, and routinely. And the closer we look, the harder it becomes…and it is exponential.

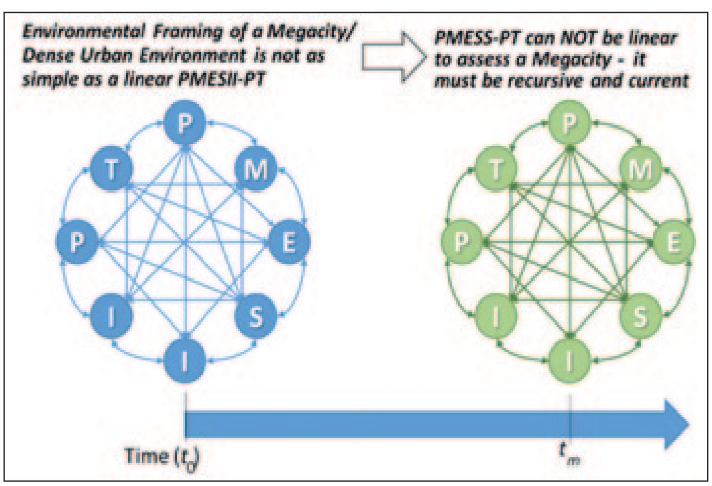

Figure 3. Iterative PMESII-PT. [23]

In a megacity, these flows are dynamic and complex networks that sustain the city, such as the power, trade, technology, people, and information.[24] GEOINT should be able to aid commanders in identifying the critical flows that must be sustained in order to establish or maintain a healthy environment within the urban system, and provide insight on the ability to potentially manipulate flows to shape the environment. Measuring the flows of the system continuously helps to detect anomalies or defects, allowing the physician to diagnose the issue and predict the impacts of the situation. Monitoring the current health of the city is akin to devices such as the heart rate monitor, where the sensors are required to measure (in real-time) the inflow-outflows of the system. For example, traffic flows as a result of road closures are of high-interest to planners when assessing ingress/egress routes for a non-combatant evacuation. Moreover, the ability to regulate the flow of water and power into a city would have significant effects on the ability to maintain social order in an urban environment. GEOINT needs to be able to take these data and present a dynamic visualization that portrays the current state of the city as a whole, and update the state as the system changes.

Complicating the requirement to address megacity flows is the fact that the majority of the data resides on the open internet. The IC's constraints on accessing the internet with classified systems requires data be quarantined and scanned, then moved up to a higher classification. Once this happens, the city is frozen in place and immediately out of date. Any analysis of a megacity environment must be moved as close to the data as possible to mitigate the perishability of data. Furthermore, measuring every function of every component in its systems is akin to testing every cell in the human body for infection. It would be not be feasible–nearly impossible–to test every cell, thus large scans and statistical sampling must be utilized to quantitatively assess the health of the system. Waves of data from the ever-increasing numbers of unclassified handheld imagery sources (smart phones), voluntary geographic information (VGI), and the emergence of real-time feeds from economic and consumer sectors flooding the internet (the "internet of things") will result in a "data tsunami."

Another significant gap is the ability to take PED products, layer them with existing geospatial data, and perform advanced geostatistical and temporal forensics in order to address large, complex intelligence issues in a timely fashion. It is not enough to have mission command or common intelligence picture systems overlay these various PED outputs, intelligence databases, and streaming services from joint and coalition platforms onto a common geospatial foundation. In fact, if this were to happen, the display would quickly become saturated with information, introducing noise into the mission command process. Concepts such as structured observation management (SOM) and object based production (OBP) that feed activity based intelligence (ABI) algorithms could provide the context and understanding of activities to allow for predictive intelligence.25 Spatial-temporal ABI methods could provide a new paradigm for analyzing big data in order to identify trends and locate areas of interest. The Army must ensure that ABI methods and tools be developed to be interoperable with current and future Army GEOINT programs of record to ensure that these technologies support ADM.

Moving GEOINT Forward to Support Megacities

The Army must rethink its entire approach to GEOINT if it is going to be able to "win in a complex world." Over a decade of support to current military operations has placed the Army GEOINT enterprise in a reactive posture, requiring it focus mostly on time-dominant PED of medium-altitude manned and unmanned ISR data. As new threats emerge beyond the scope of current counterterrorism, counterinsurgency, and stability operations in Iraq and Afghanistan, commanders must return to ADM and focus on conducting thorough environmental framing. Unfortunately, the areas they will be faced with will not benefit from almost fifteen years of wartime focus. While they may initially appear data starved, this is not necessarily the case, as growing repositories of VGI and commercial geospatial data are increasingly available.

The Army should focus GEOINT technology and tradecraft development more on automated PED and less on increasing sensor numbers. Current processes exist that are capable of automated PED, extracting computer-derived observations of interest from complex data. These extractions, however, have varying confidence levels, requiring a human interpreter in the loop. The human-reviewed observation must be disseminated through open-geospatial consortium services of its observations in a structured, descriptive manner that is spatially and temporally enabled and available to Army, joint, and IC communities. It is also essential that the Army minimize duplication of effort in this realm, ensuring that one observation is reviewed for validity one time, then published as an authoritative dataset to the enterprise. These human reviewed datasets then feed the ABI tools, maximizing PED resources and pushing from tactical to national levels.

Photo credit: Seb Zurcher/Unsplash

An Army OBP solution should be established that creates the foundation models as open objects, allowing anyone to modify objects as more information is volunteered. This transactional system–similar to Wikimapia, OpenStreetMap–would leverage a wide network of intelligence professionals in order to maintain objects of interest, adding pictures, materials, and internal details for community use. Transactional geospatial databases should be implemented that would enable "crowd sourcing" of these features to enrich their descriptions for the community, for instance, elevating an initial observation of a "vehicle" to a more descriptive "Black 2015 Toyota Hilux." The ability to crowd source across the IC would allow the Army to tap into its network and better mitigate the overwhelming requirements of a megacity. The Army GEOINT tradecraft must not only embrace SOM/OBP, but should help drive the development of the standards and services to ensure they are interoperable with Army mission command systems.

The Army must also lead the advancement of analytical tools to handle Big and Large Data within its DCGS-A enterprise. Rapid evolution of tools and algorithms do not fit into current acquisition models. A move toward light-weight plug-ins or cloud-based applications that can be disseminated without a change to a program's baseline is essential. Furthermore, accepting a "data at rest" paradigm, high-computing environments at a reachback location, could automatically generate high-resolution terrain models from multi-source imagery, and convert the urban landscape into 3D object models that could be used in modeling and simulations.

The ability for the GEOINT enterprise to operate on open internet is essential and cannot be overstated. The ability to harness real-time feeds to maintain currency on the health of the megacity organism is pivotal to understanding the inner workings of the city. Sun Tzu's famous quote that "supreme excellence consists of breaking the enemy's resistance without fighting" infers that one must understand how to break his enemy's resistance.[26] By understanding the critical flows into or out of a city, and how those flows affect the inner workings of the social-urban factor, a commander could potentially shape the OE to achieve his end, avoiding committing a single troop into harm's way.

Army GEOINT tradecraft must be restructured to enforce the need for a multi-disciplinary analyst with strong geographic foundations in geospatial technologies, computational social sciences, and human geography. The current doctrinal divide between the Army's Geospatial Engineer and the GEOINT Imagery Analyst must be overcome; both skillsets are imperative when addressing the megacity. The future Army GEOINT analyst must be able to utilize multiple GEOINT streams, SOM/OBP, and synthesize them into estimates and predictions using statistical and structured methods, ultimately visualizing the results for the planning team. The incorporation of advanced analytics and ABI-based intelligence could then be layered on the shared foundation, providing the planning team an unprecedented visualization of the urban OE. Creating 3D models of the urban environment from the existing geospatial foundation and inserting these into physics-based gaming engines could provide the ability for commanders to predict effects of kinetic strikes or natural events. Create model-based agents to aggregate streams of data simulating human decision making, behaviors, and reasoning to portray potential second and third order effects of a proposed plan before it occurs. While these actions may seem lofty, they are actually efforts underway by academia, industry, and other governmental entities.

Conclusion

The speed of human interaction and the growing complexity of the future OE promise to challenge the nation's intelligence apparatus. With the global population continuing to increase, and the projected global urbanization to reach 66 percent by the year 2050, the Army will need to act expeditiously to develop and sustain functional expertise in megacity analysis. While the megacity is a strategic issue requiring a whole-of-government approach, there is need for a single functional component focusing on urban operations in dense urban areas. There is already a nascent effort underway across the Army community, but GEOINT needs a strong voice to be present during the formation. Combat support agencies are absolutely critical, but this is a ground force issue and an inherently geospatial issue problem set. Army shapes the development of land force doctrine. Any solution should be driven by the Army Intelligence Enterprise to support Army Operations. Finally, the Army must revolutionize its GEOINT enterprise, to place more emphasis on extracting more out of existing data automatically, advancing its enterprise to share geospatial data across echelons and functions, and advancing the tradecraft from traditional imagery methods to a multi-disciplinary applied-geographic approach, rooted firmly in geospatial services and advanced analytics.

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Environmental Framing: Understanding a Complex World

Colonel Ketti C. Davison

The views and opinions in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government. Discussion of any particular country is only intended to provide an open forum and facilitate thought and does not necessarily reflect an official assessment of or U.S. position on that country.

Intelligence doesn't just drive operations; it shapes how we think about them. Environmental framing helps us understand a complex world by answering the fundamental question of why things are happening. Environmental framing underpins operational design, just as intelligence preparation of the battlefield (IPB) underpins the military decision making process (MDMP). MDMP solves problems; operational design ensures we solve the right ones.

The five aspects of environmental framing–historical drivers, current system state, trajectory, change factors, and range of potential outcomes–go beyond analysis to achieve synthesis. Think of historical drivers as the headwaters of a river. Seemingly insignificant at first, myriad run offs, creeks, and streams come together to form tributaries. These tributaries meet and interact to form the current system state of a river. Gravity drives the river as it cuts through terrain and flows toward the sea, just as the force of history bears down on the current system to propel it along its trajectory. Rocks and boulders encountered along the river's course alter its flow as change factors shape the range of potential outcomes. The river's delta, formed as the river pours into the sea, is the outcome. A river has the potential to form in various areas and in various ways, but the shape it ultimately takes is scoped by what it encounters along its entire path. Making sense of a river requires the study of its full journey.

Historical Drivers

History is fundamental to understanding today's complex world. Many of the roots of today's problems have grown out of yesterday's solutions. Exploring the way a system evolved provides insights into how it has adapted to its environment over time, where it was resistant to change or demonstrated latency in response, and when it sought to revert to a previous state, to reorganize along former lines, or to move to something new. Studying these undercurrents enables us to understand what is driving the current context. Consider Istanbul, a multicultural megacity of more than 14 million people, and the economic engine of modern Turkey. The Immortal City was the seat of successive rival empires for almost two thousand years. It has been besieged, conquered, renamed, and repopulated but never colonized. Spanning two continents and controlling key waterways, Istanbul is a source of strength for those who hold it and a challenge for those who do not. As described by Roger Crowley in "*1453: The Holy War for Constantinople and the Clash of Islam and the West*," Mehmut II recognized its value as he prepared to conquer the city and said, "Captured it would be the centerpiece of empire. Without it nothing we have is safe."

Russian President Vladimir Putin reaffirmed Istanbul's place at the heart of regional rivalries and astride key terrain in April 2016 while addressing a Ukrainian Orthodox delegation: "Should Turkey not stop supporting Al-Qaeda's branch in Syria, I am eager to end the job that the late Tsar Nicholas II left unfinished. He sought to restore Constantinople (Istanbul) to Christendom and protect Russian maritime security by liberating the Dardanelles and Bosphorus Straits but fate prevented him." In two sentences, Putin linked the fall of Constantinople in 1453 and World War I territorial campaigns to contemporary security concerns. History exerts a powerful influence on today's events.

Current System State

Whereas history tells us how the present came to be, relationships tend to define the current system state. Relationships give rise to nonlinear dynamics that though shaped by past influences and consistent with evolved identities, may produce novel outcomes. Istanbul's relationship with the central government changed when Mustafa Kemal Ataturk, the first president of Turkey, moved the political capital to Ankara, closer to the center of modern Turkey and farther from the Ottoman past. The rise of Turkish President Recep Erdogan from mayor to president brought neo-Ottomanism to the region and lifted Istanbul out of decline. Erdogan's vision for Istanbul as a global financial hub is being challenged by his relations with various Kurdish factions, the Syrian regime, the Islamist State, Iran, and Russia. Terrorists have attacked Istanbul's tourism industry, refugees have crowded the city's streets, and Russia has imposed economic boycotts and meddled with domestic politics.

All of these actions flow from the past, but current interactions are producing new dynamics. Turkey's positive relationship with Kurdistan President Masoud Barzani makes sense when considered in light of Iran's regional expansion, and Turkey's internal operations against perceived Kurdish separatists stem from fear of additional post–World War II territorial dismemberment. Turkey's relations with Syria's Assad regime changed with the Alawite regime's brutal crackdown on its Sunni majority; Turkey was the leader of the Sunni Muslim world under the Ottoman Empire, and until 1923, the Syrians being oppressed were Ottomans. This same history pits Turkey against the Islamic State, which is attempting to re-establish the caliphate that Turkey cast aside as it modernized. Russia regained the world's attention when it deployed to reinforce its former Cold War ally and secure its only Mediterranean port. Given the wars between Turkey and Russia over the ages, neither Turkey's downing of a Russian fighter jet encroaching on its territory nor Russia's economic and political response goes against the tide of history.

Trajectory and Change Factors

The force of history on current relationships propels the system forward along a trajectory. For Istanbul, this trajectory is one of economic and demographic growth as it weathers volatile storms. President Erdogan is investing billions in infrastructure and development. The city continues to attract both skilled workers and foreign investors. The population continues to grow, as does the economy.

Growth, however, is not inevitable. A series of change factors, either on their own or interacting with one another, could alter Istanbul's course. Some change factors, such as war or disease, tend to recur. Others, such as the rise of a charismatic and visionary Ataturk, may manifest only once. Regional war stands out as a serious change factor, given the presence of Russian forces, Iranian proxies, Kurdish separatists, and Islamist State extremists near the Turkish border with Syria. Natural disasters such as powerful earthquakes or disease epidemics must not be overlooked because they may simultaneously affect the economy, security, and demographic trends. A catastrophic terrorist attack would undermine foreign investments, deter tourists, and inflict reconstruction costs while eroding popular confidence in the government. Marginalized or disenfranchised population segments in the city might foment instability, thereby causing resources to be diverted to maintaining order. If Erdogan's investment in Istanbul's development declines, so will the city's prospects.

Range of Potential Outcomes

Predicting the future is impossible, but understanding the factors that bound the range of potential outcomes is achievable. The outcomes for Istanbul are scoped by how change factors such as regional conflict and internal instability affect the city's current growth trajectory. Istanbul may live up to its reputation as the Immortal City and succeed as a global economic hub as Islam and modernity coexist and security forces protect against internal instability and terrorist attacks. More likely, however, Istanbul will continue its balancing act as investment and development continue but are occasionally disrupted by extremist attacks and sporadic protests.

Implications

In our search for understanding a complex world, analysts must look at the whole picture to understand how things are connected. By utilizing environmental framing, analysts establish a baseline of understanding that enables them to detect meaningful changes in time to inform decision makers. Just as one would not look at a single creek, stream, or tributary to understand the entirety of a river, environmental framing ensures we examine the full journey of the problem at hand. Environmental framing does not replace IPB; rather, it sets the stage for it. The Army's Military Intelligence Corps needs to embrace environmental framing so that intelligence continues to drive operations and solve the right problems.

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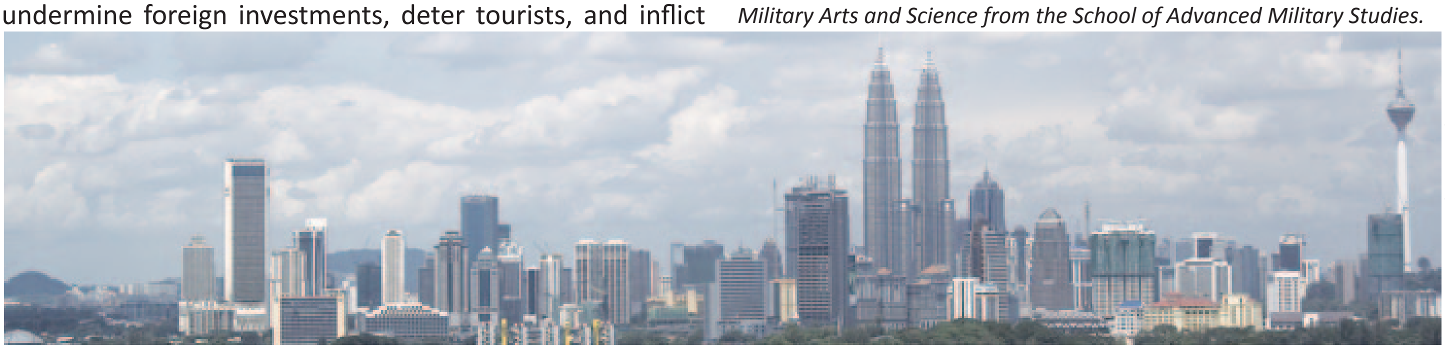

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by Colonel Robert Dixon

The views expressed here are those of the author and do not necessarily represent those of the U.S. Army or Department of Defense.

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Introduction

As the U.S. Army prepares for the future, it has become increasingly aware that operations are more and more likely to take place in large cities. The number and size of cities continues to grow, and are quickly becoming the dominant form of human habitation. Belligerent actors, aware of the West's growing anxieties about collateral damage, have good reason to place forces in or around cities. Further, advanced sensing and weapons systems employed by modern militaries make hiding in remote areas of the world less and less attractive to non-state enemies of advanced powers.

America's enemies see the advantages of the seemingly impenetrable clutter that dominates the modern city. The Army's current approach to learning about this environment is to seek the diamonds scattered amidst this clutter. What we are missing, though, is that the clutter itself is the jewel. Enormous amounts of readily available data can reveal more about a city, its population, and the nefarious actors residing there than we could have imagined before. To truly understand this environment, the Army must fundamentally change its approach to understanding it. The Army must adopt a holistic approach enabled by big data analytics.

The Army, however, seems hesitant to embrace 21st century data analysis, instead relying largely on the same micro-level methods it has used for decades. This must change if the Army wishes to maintain the ability to "see first" and "understand first" in the modern urban arena.

The Urban Challenge

Political leaders and security forces have always gathered data to better understand their environment. Yet cities have presented a particular challenge to data gathering with their constantly changing infrastructures, myriad subcultures, and ample places to "hide in plain sight." Censuses and geographic mapping are centuries old techniques, and have always been time consuming and lacking in accuracy. Time delays between gathering and analyzing data and presenting conclusions have too often produced unreliable and out of date information, causing well-informed, real-time decision making to be difficult at best. Even in today's operations, the U.S. Army still relies heavily on traditional methods of individual (scout, leader observation, etc.) as well as platform (imagery and intelligence) observation, two-dimensional mapping, and population surveying. In the past, these methods were deemed sufficient as there were no alternatives.

However, the modern urban environment is changing, further challenging past methods of seeking understanding. Rapid urbanization across the globe has given rise to megacities (defined as cities with more than 10 million residents) and mega-regions in which major cities "grow together" forming regions of dense population that stretch hundreds of kilometers and can encompass over 100 million people. The rapid growth in urban areas produces more demand on the infrastructure and flow systems, more waste, and increased urban density. It also increases the likelihood that the Army will be tasked to operate there.

While the term "megacity" has a specific definition, there is nothing magical about that specific distinction. Some urban areas with fewer than 10 million people pose as significant a challenge to operating forces, while other, larger urban areas may offer more straightforward approaches. The scale, density, connectedness, complexity, and threat all contribute to the nature of the problem and the potential solutions. Size is but one of the relevant factors.

Traditional methods of collecting data about a population largely rely on sampling, often by surveying individuals within that population. Sampling provides fairly reliable insight about a population in the macro sense, but is deficient in providing insight into subgroups or the micro level. With sampling rates typically around n=*a few hundred* (often representing a tiny fraction of the population), the extrapolated information lacks depth. With big data analytics, analysts can now approach n=*all,* giving them the ability to subcategorize and deeply investigate correlated or anomalous data. More importantly, data derived from involuntary sources (e.g., cell phone data or financial transactions) reveal a more honest picture than survey driven sampling. It shows what people *actually* do as opposed to what they say they do.

Behind the Big Data Curve

Technological advances over the past decade have changed one aspect of the modern city more than anything else–cities are producing enormous quantities of data and data analysts are learning how to use it in new ways. Recent progress in big data analytics, the proliferation of automated sensors, the ubiquity of mobile technology, the democratization of information, and the "datification" of nearly every social, economic, and logistical transaction provide previously unimaginable insight into modern urban ecology. Big data analytics may have made many traditional methods of collection and analysis all but obsolete.

Photo credit: Mark Fischer/Flickr

Cities and corporations produce much of their own data as a byproduct of normal operations, and have invested heavily in acquiring relevant data produced by others. Capturing and databasing enormous data sets, as well as data sharing among stakeholders, are becoming easier and more commonplace with technological advances. Indeed, there are thousands of publicly available data sets that are available to any user wishing to access them. Failure to develop capabilities to exploit this data practically ensures that the Army will be far behind other actors in understanding the environment.

One of the most significant sources of data lies in mobile communications. The ubiquity of smartphone technology means that enormous amounts of data are generated continuously, even in the least developed cities. There are currently almost 7 billion mobile subscriptions worldwide, nearly overtaking the world's population. While access to the data that this brings can be useful in rural areas, it is truly invaluable in large urban environments where aggregate data can reveal social trends, groupings, and fault lines that give leaders significant clarity about the social and physical landscape. If used correctly, it's like handing the commander what MIT's Sandy Pentland calls a "socioscope" that allows him to see and track things in real time that he could never see before.

Governments and major corporations routinely collect billions of data points every day, even within the poorest cities, with the quality and volume increasing exponentially. Humans are now producing more data every year than we produced throughout all of history. Urban leaders use big data analytics to plan infrastructure and improve service delivery. Corporations use big data to increase value by making information transparent and more accurate, and as a tool to understand and segment value-chain stakeholders. Both government and commercial users of big data aim to achieve the same goal–better understanding of their environment. Seemingly, the Army currently lacks the resources, expertise, and approaches to investigate and exploit the reservoir of information available in modern cities. This must change.

As the world continues to datify, vast storehouses of data become more vast. While military and intelligence analysts sometimes venture into these data sets, they are typically searching for individual nodes or linkages, attempting to find the virtual needle in the big data haystack. What they are ignoring is the value of understanding the dynamics of the haystack itself. This "micro-bias" dramatically limits the value inherent in large data sets. While big data analytics tends to produce insights that are vastly more reliable than traditional methods, the Army seems stuck in the traditional methods.

Plugging In, Switching On

As the scale of modern urban areas continues to increase and the absolute number of land forces in Western armies continues to decline, militaries must come to terms with their limited abilities to operate in urban environments. Current Western expectations about the conduct of war require modern militaries to seek ways of accomplishing their goals without resorting to targeting populations and the infrastructure that supports them. A robust, sophisticated understanding of the urban ecology is necessary to identify the appropriate pressure points to apply force against. This understanding, along with modeling and operational feedback loops, can provide future commanders with a learning mechanism that not only helps identify targets, but also suggests the right tools (lethal or nonlethal) for acquiring them. Moreover, sophisticated models maintained by real-time sensors and big data analytics enable a self-awareness commanders have long needed, near instantaneous feedback on the effects of their operations.

Properly equipped, a commander can now gather, analyze, map and model a city's infrastructure, population dynamics, and sub-group behavioral patterns in a matter of days or weeks instead of months or years. More importantly, once gathered, modeled, and monitored, commanders can observe changes in these systems in real time as data streams are updated continuously. Most importantly, this could be accomplished with a minimal military presence in the city itself.

While powerful, big data has limits and leaders should avoid being lured into committing the "sin of McNamara" where a leader becomes so obsessed with the power and promise of data analytics that he fails to appreciate its limitations. Big data will only improve decision making if leaders apply it correctly. Data analytics typically reveal *correlation,* but does not speak definitively about *causation*. Leaders still have to decide how best to use the information garnered from analytics.

In reality, though, over-reliance on data analytics is rarely a problem. In fact, few leaders in crisis situations rely heavily on data to inform decision making. Media reports and politics still dominate decision making in most crisis responses. Leaders tend to rely on experience and intuition to make decisions, despite the availability of data.

Moving Forward

The Army must study megacity environments in earnest. It must expose leaders to the megacity environment as often as possible. Developing expertise in urban planning, the science of cities, and big data analytics will accelerate institutional learning. The Army must also invest in research and development that furthers its ability to analyze big data sets and helps it determine which factors are the most relevant in the urban setting.

The Army must move beyond crude models and develop big data modeling for simulation training, exercises, and supporting planning and decision making. Relying on simplistic models reinforces one-dimensional thinking and reductive hypotheses, and too often amplifies problems rather than resolving them. While the Army has conducted some simulation experiments in and around megacities in the past few years (most notably the Army's annual Unified Quest experiment), these efforts have been far too simplistic, often aggregating large numbers of disparate social groups into a few manageable ones, and wishing away many of the complexities inherent to the modern urban environment.

Certainly the Army has begun working towards developing better understanding and approaches to megacities. The work done at the U.S. Army Training and Doctrine Command's Army Capabilities Integration Center Future Warfare Division and the Chief of Staff of the Army's Strategic Studies Group, among others, have done much to highlight the Army's challenges in these areas. Army thinkers have begun debating the importance and potential effects urbanization brings to military operations, evidenced by the Spring 2015 *Parameters* issue featuring three articles on the topic. Outside the Army, U.S. Special Operations Command's work with Caerus in developing structured approaches that attempt to account for the relationship between physical, socio-economic and operational aspects in urban areas shows some promise. Indeed, Caerus' insists that trying to use Excel or PowerPoint to analyze urban systems is wrong-headed. Acknowledging this is a huge step in the right direction. Yet, there is little evidence that the Army is developing any capability to conduct rigorous big data-driven analysis, instead relying largely on the same reductionist models (see PMESII) that limit holistic thinking. This must change.

Finally, the Army must select, train, and develop leaders who think holistically about complex problems in large urban areas. It must develop leaders who are open to new ideas, willing to innovate, and comfortable operating in uncertain and ambiguous environments. An understanding of big data analytics will help future Army leaders trust the models produced by big data, and ultimately arrive at better decisions within this complex terrain.

COL Dixon is an Army Engineer officer currently serving as the Corps Engineer for I Corps. He has served as a strategist and planner at the Combined Joint Task Force, Division, and Combatant Command levels, and served on the Chief of Staff of the Army's Strategic Studies Group. Colonel Dixon is a graduate of Florida Institute of Technology, American Public University, the School of Advanced Military Studies, and the Army War College where he was a member of the Carlisle Scholars Program.

Photo credit: Diego Delso/Wikimedia Commons

Proponent Notes

Leading Language Training Software Available at No Charge to All U.S. Government Personnel

The Joint Language University (JLU) is a language training portal serving the U.S. Government. By registering with a *.mil* or *.gov* email address, users have access to the most comprehensive language training resource available today. Accessible on the site are 17 different resources that encompass the entire gamut of the Interagency Language Roundtable Scale.

The CL-150 Technology Matrix for Critical Languages, a leading software suite for serious language learners, instructors, and language program managers is available at no charge to all U.S. Government personnel and programs via the Department of Defense JLU web portal. Previously, the CL-150 was only licensed for use by certain language intensive U.S. government communities, including the Defense Language Institute, Special Operations Command, and Joint Foreign Area Officers.

"Access to CL-150 for anyone with a .gov or .mil address is a major event," according to Dr. Donald Fischer, former Provost of the Defense Language Institute Foreign Language Center. "CL-150 has all the tools necessary to present materials, to practice language, and to track student and group progress. The folks behind JLU deserve a lot of credit and thanks for making this resource available to all government people."

The U.S. is famously weak in language skills, and in today's global environment language deficiency significantly reduces opportunities and increases risk for U.S. personnel and organizations. The human, operational, and monetary costs of language deficiency are enormous. CL-150 improves the economics and effectiveness of language learning for both general use and for special purposes, such as humanitarian relief, international relations, or military liaison.

For over ten years, Transparent Language's "research based, experience driven" CL-150 has been developing innovative, unique capabilities and then honing those capabilities in real-world use at some of America's most stringent and rigorous language schools and programs.

To access the CL-150, users create an account on JLU at http://jlu.wbtrain.com/. A *.mil* or *.gov* email address or government sponsorship is required to register. Once registered, the CL-150 will appear at the top of the Resources list as JLU's Featured Resource. The CL-150 offers hundreds of thousands of learning objects, along with a deep and broad array of learning activities for many languages and curricula. Use is synchronized across web, laptop, and mobile devices. More information can be found at www.transparent.com/government.

About JLU

JLU is a Department of Defense language portal that serves all of the U.S. Government. Some materials on JLU are available to all visitors. Others, such as the CL-150, are licensed resources available only to registered users. Registration requires a .mil or .gov email address or U.S. government sponsorship. JLU is on the web at https://jlu.wbtrain.com. Click on "Need an account?" to register.

The Office of the Chief, MI (OCMI), the Personnel Proponency Office, is located at Fort Huachuca, Arizona. The U.S. Army Intelligence Center of Excellence and Fort Huachuca Commanding General, as the MI Proponent, enlists the help of OCMI to monitor promotions, recruitments/accessions, and retention as they affect our enlisted, officer, and warrant officer force.

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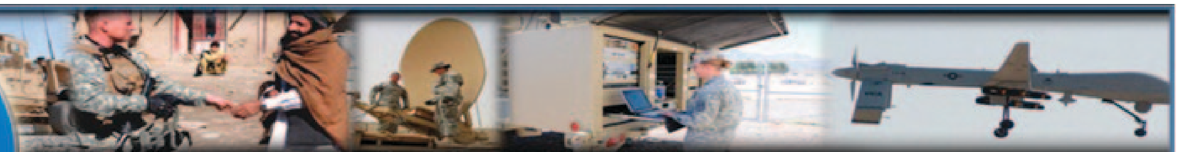

Before ~~After~~ Action Reports

by Mr. Chet Brown, Chief, ICoE LL Branch

Lessons are useless unless they are applied to effect a positive change. This column describes a mechanism you can use to apply lessons in order to increase your probability of success in the operational environment (OE.) The U.S. Army Intelligence Center of Excellence (USAICoE) uses lessons to effect positive changes in the capability areas of Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, and Facilities (DOTMLPF). Senior leaders at USAICoE recognized Military Intelligence (MI) lessons were being applied to training more rapidly than the other DOTMLPF capability areas and decided to place the Lessons Learned (LL) Team under the Training Development and Support Directorate to increase the efficiency of integrating lessons and best practices (L&BP) into institutional training.

To provide the same L&BP information and benefits to the Operating Force, as those given to the Generating Force, the USAICoE LL Team routinely scours various "patch charts" to identify units preparing for major operations or training events. The LL Team primarily makes contact with brigade combat team (BCT) S2s to share lessons, best practices, and other resources (training plans, standard operating procedures, PACE Plans, after action reviews, etc.) units have allowed us to make available to the force. We share these information items (and sometimes the contact information of the information sources with their permission) to facilitate direct collaboration. MI leaders also contact USAICoE LL Team as they seek pertinent lessons to assist in developing plans or preparations to embark on a training or operational deployment. Being able to assist a unit early enough in its planning sequence to enable them to be trained and operate at the highest level possible is one of the most rewarding aspects of serving in a lessons learned position. Conversely, one of the most disheartening aspects of working lessons learned is learning of an incident or issue which could have been prevented by applying a lesson already known.

Sending (pushing) and exchanging lessons to, and with intelligence professionals is becoming more common. USAICoE, the Center for Army Lessons Learned (CALL) and others throughout the LL enterprise have routinely endeavored to provide L&BP information to assist leaders in training and preparing their units for operations. CALL has recently coined the term Before Action Report (BAR) to identify the L&BP products provided to units and personnel before they embark on, or begin planning for, key events. As mentioned in the preceding paragraph, providing information to help a unit prepare for a major event is neither novel nor new to the USAICoE LL Team. What is new is CALL's formalizing the BAR concept and implementing it throughout the Army's LL enterprise.

The key to the BAR concept's effectiveness is to provide pertinent L&BP to leaders in enough time to positively influence unit training plans. Just as a priority intelligence requirement has an associated latest time information is of value (LTIOV), so too does L&BP BAR information. Absent a specific suspense included in requests for L&BP information or assistance, the USAICoE LL Team considers the BAR LTIOV to be at least one day prior to the unit forming its event-specific training plan. The type of specific events we're asked to provide L&BP include but are not limited to combat training center (CTC) rotations, Warfighter exercises, mission readiness exercises, certification exercises or operational deployments. CALL recognizes the importance of early support by instituting a "D- (minus) 220 Push Package" provided to units before major training exercises, CTC rotations, pre-deployment events, etc. The Push Package serves as the BAR. While USAICoE's LL Team has had some success in unilaterally providing Intelligence Warfighting Function-specific L&BP to intelligence personnel, being able to integrate into CALL's formalized BAR Push Package Process will help us reach more (quantity and warfighting function type of) units and leaders than we're able to do on our own.

To maximize the value of USAICoE BAR information we must together identify the types of L&BP with the most potential to be most pertinent to your training plan. The training plan is the scaffold upon which you (your unit) build effective training strategies, events, and assessments which ultimately lead to successful mission accomplishment. Units and personnel from which we've compiled the information comprising the BAR expect us to share their experiences so that others can avoid mistakes (lessons) and capitalize on proven strategies for success (best practices). Without exception commanders and leaders of the units observed by the USAICoE LL Team are consistent in their unselfishness and insistence that we use their lessons, challenges, issues, and best practices to improve DOTMLPF development and inform the entire force. There have been no attempts to censor or redact an observation which could be considered unfavorable to the unit. On the contrary, the common expectation of leaders is for the LL enterprise to view, and use, assessments of training and operational events to drive improved performance, and then share the resulting L&BP with the field. The field's interest in knowing how their lessons are being applied caused us to change the USAICoE LL Collection Report format. We now include specific disposition recommendations for each observation in our reports.

The most critical assessments of individual and collective performance are often shared directly among colleagues, peers, and mentors. Direct communication continues to be the strongest and most responsive collaboration channel to obtain L&BP. This phenomenon was true during the last decade of combat operations and continues to be the case in current operations and recent pre- and post-CTC rotation emails to which we've been privy. We do not seek to interrupt the direct transfer of L&BP; however, the USAICoE LL Team can augment this direct channel by providing BAR products. We've received very positive feedback on BAR information used to prepare for a CTC rotation. Providing a BAR is the start to applying L&BP.

Some leaders believe CTC rotation performance is becoming the measure of success that once was demonstrated by a successful operational deployment. The emphasis inherent in changing from on an 'Army of Execution' to an 'Army of Preparation' supports the increasing importance of CTC rotation results being used (by some) to assess the competence of units, staffs, and warfighting functions. We have also noticed the change in how some rotational training unit (RTU) personnel perceive a CTC rotation from being an event at which you *are trained prior to deploying* to an event in which you *demonstrate how well you have been trained*. Some RTU MI leaders perceive performance at a CTC rotation to be an evaluation of their individual competence or their respective unit's collective performance. This condition increases the value of BAR to BCT S2 and MI company personnel and forms the majority of requests for information sent to the USAICoE LL Team. There is nothing subversive, underhanded, or unfair with sharing L&BP provided by RTU or CTC publications or Observer/Controller/Trainer personnel. BARs and CTC trends (enduring observations) reports do not contain secrets or inside tips on "how to beat the OPFOR." The overarching characteristic in BAR L&BP is the emphasis placed on unit training management principles. The emphasis remains achieving superior performance in, and mastery of the basics whether described as individual Soldier tasks, leader's tasks, or key collective tasks.

There are instances when we have been asked for BAR information after the unit has started its training program. We've faced similar challenges in providing L&BP as key personnel rotate in and out of their respective positions, or we receive a request for support shortly before a unit's deployment date. The BAR LTIOV is variable. If you've already begun your planning or preparations some L&BP may be useful to you or the unit to which you provide intelligence support. As in all other self-development measures the first step is entirely yours.

Visit the ICoE LL Homepage at https://army.deps.mil/Army/CMDS/USAICoE_Other/CDID/Lessons%20Learned/SitePages/Home.asp or contact the LL Branch Chief at (520) 533-7516; DSN (314) 821-7516 to determine how we may be able to provide BAR assistance.

Moments In MI History

The Army Closes the Military Intelligence Training Center at Camp Ritchie, Maryland

by Lori S. Tagg, Command Historian, U.S. Army Intelligence Center of Excellence

In October 1945, the U.S. Army decided to close the Military Intelligence Training Center (MITC) at Camp Ritchie, Maryland. The war had ended, resources were declining, and the need to continue dedicated training for intelligence specialists seemed unnecessary in time of peace. The school had trained more than 19,000 intelligence personnel in only three years, an incredible feat considering that little intelligence training had existed prior to its establishment.

During World War II, general supervision of intelligence training rested with the Training Branch of the War Department's Military Intelligence Service (MIS), the operating agency of the Army's G2. Unfortunately, going into the war, the War Department did not have a dedicated intelligence school. The MITC, which began operations on 19 June 1942, came closest to fulfilling MIS's long-neglected need for a centralized school.

Panoramic View of Camp Ritchie in late 1944.

The initial class of students, all officers, gained admission based on letters of recommendation from their commanders. All subsequent classes were comprised of both commissioned and enlisted students to meet the demand for a variety of trained intelligence specialists overseas. Students either applied for admission or received an assignment on a quota basis from the Army Ground Forces and Army Service Forces. U.S. Marine Corps and international students also attended MITC.

The General Intelligence Course ran about eight weeks in length. The first five weeks focused on basic instruction in intelligence procedures, while the remaining three were reserved for specialty training. The school's curriculum changed to meet the express needs of field units overseas and to incorporate lessons learned. It began with courses in interrogation, interpretation, and translation, and quickly expanded to include terrain studies, signal communications, captured document analysis, staff duties, order of battle, photograph interpretation, and familiarity with enemy small arms.

In February 1944, the Secretary of War gave the MITC the added mission of training division intelligence personnel. MITC staff inaugurated a month-long course to teach foreign maps and equipment, enemy tactics, prisoner-of-war interrogation, photo interpretation, counterintelligence (CI), order of battle, staff work, and the employment of specialist intelligence teams.

Counter Intelligence Corps (CIC) personnel also trained at MITC beginning in 1944. Unfortunately, the majority of the nearly 1,200 CIC officers and enlisted students who attended through 1944 enrolled in MITC's General Intelligence Course. Consequently, agents received only about 80 hours of specialist training. This lack of focus on CI training decreased the effectiveness of field agents. Despite MITC's attempts to develop more CI-focused courses, by July 1945, the Intelligence Division of the Army Service Forces established a new CIC Center and School at Fort Meade. The CIC Center moved to Camp Holabird shortly thereafter.

MITC used the 30 Series of field manuals published just prior to the war as the basis for its lesson plans. Teaching methods included lecture, conferences, demonstrations, plays, practical exercises, and the use of training aids and films. When possible, instructors incorporated captured documents, maps, German prisoners, and G2 reports from the theaters, and brought in guest instructors from Allied countries. Courses concluded with field exercises ranging from two to eight days, depending on the specialty of the students. For realism, MITC had full-scale models of German and Japanese armored vehicles and tanks, and a life-size replica of a German village square for street fighting and specialized CI training. An Indoor Combat Firing Course, Infiltration Course, and Silent Movement Course also aided training in combat skills.

For realism, some training took place in a replica of a German village.

Overseas, commanders gave the training mixed reviews. Because of the short classes, MITC's graduates were only minimally satisfactory at theirduties and, in particular, lacked basic military training. To give them the added knowledge and skills for intelligence work in a combat zone, an supplemental training program was set up under the general direction of the Training and Operations Branch, G2 Section, European Theater of Operations, in the spring of 1943.

When the MITC at Camp Ritchie phased out in October 1945, the Army once again lacked a general intelligence school. The Army Ground Forces, however, activated an intelligence school at Fort Benning, Georgia, that same month to alleviate the gap and capture the lessons of World War II. The following month, the school moved to Fort Riley, Kansas, to operate under the administrative purview of the Commandant, The Cavalry School. The new Intelligence School opened there on 1 July 1946.

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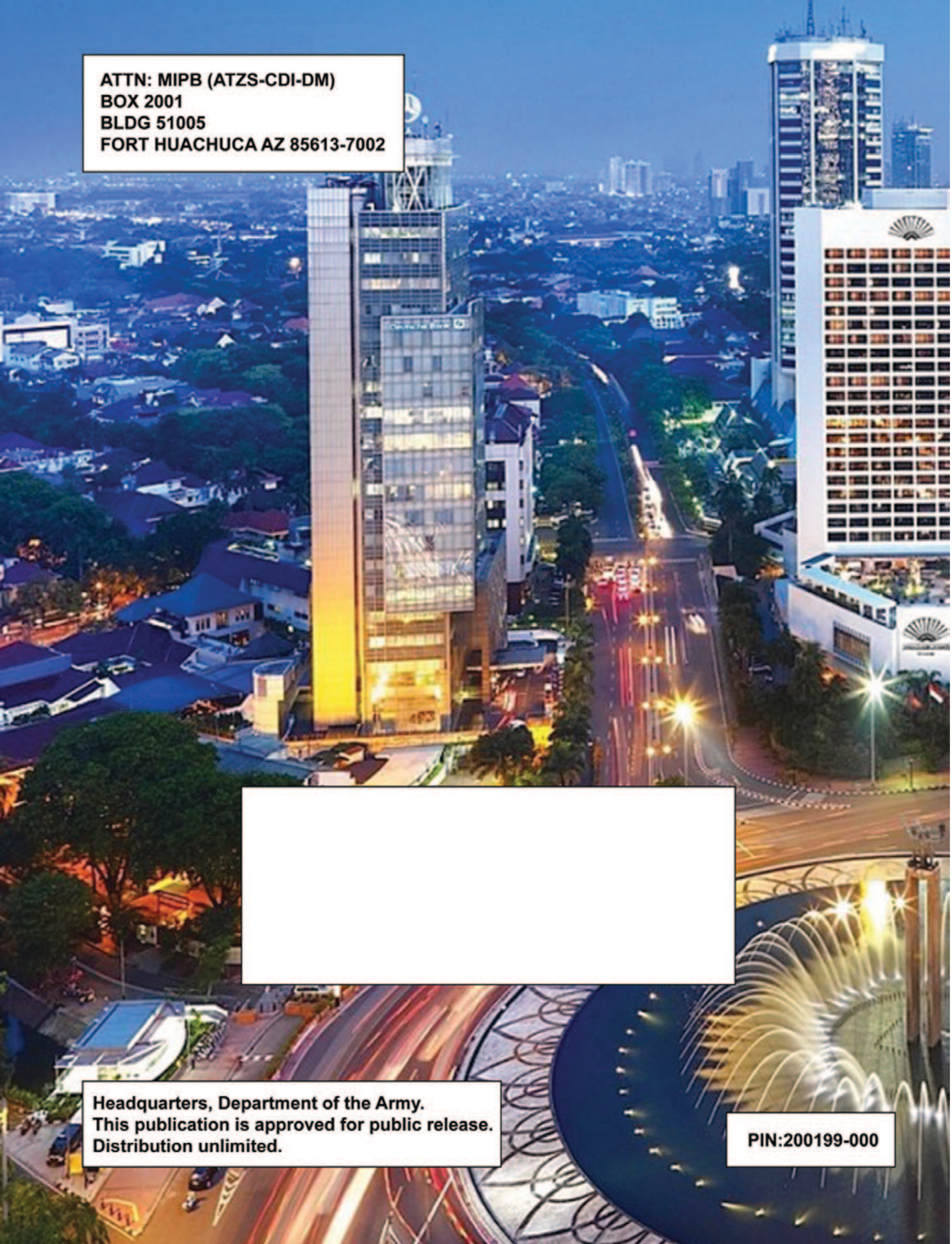

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