NGA PATHFINDER
KNOW THE [illegible] UNDERSTAND THE WORLD.
Magazine of the National [illegible]
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GEARED UP FOR THE FUTURE:

SAY BUH-BYE TO OLD TECH, HELLO TO INVISIBILITY CLOAKS AND MORE...14

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EDITOR'S MESSAGE

Benjamin Franklin has been credited with saying, "When you're finished changing, you're finished."

Franklin and his contemporaries obviously knew a thing or two about the topic, having permanently altered the world's political landscape and future trajectory. The founding fathers also experienced the profound difficulty of change, understanding full well that pursuing their intentions might cost them their very lives.

Fortunately the changes we seek at National Geospatial-Intelligence Agency are not nearly so dramatic. Many are nevertheless revolutionary in their potential to save lives, protect our national security, and improve the ways in which we work and interact with the rest of the world.

Very often, historic changes have been brought about by developments in technology, either actively or reactively. NGA too has actively sought to innovate and also had to evolve in reaction to technologies developed in other domains. Articles within this issue of NGA Pathfinder address both types of transformation.

The main features in this issue address changes going on outside of NGA that will affect how the agency provides value to its customers in the future. The lead article [page 14] explores mainstream technologies that have the potential to shape the products and services NGA offers. Just as the proliferation of mobile devices and apps has affected the ways NGA currently provides GEOINT to its customers, emerging technologies such as augmented reality and wearable devices are sure to influence future NGA products and services.

A trio of short articles [starting on page 22] targets key facets of the changing business environment for GEOINT and how they are shaping the NGA of the future. GEOINT CONOPS 2022 calls for a fresh look at business practices, organization and mission approach across the four primary areas where NGA delivers value: creating knowledge through analysis, providing geospatial content, creating geospatial services for others and managing the GEOINT function across the U.S. government.

The final feature [page 28] explores the outlook for providing GEOINT to warfighters in the years ahead. Following the lead of the military services, NGA is preparing to provision soldiers to operate safely and effectively inside the expected engagement zones of the future: megacities.

The remainder of articles in this issue provide insight into how NGA is actively developing new technologies and techniques for serving its customers in the future. Examples include new solutions for modeling 3-D object data [page 27], use of crowdsourcing to ensure accurate mapping [page 33] and a World GeoNarrative plug-in to facilitate collaborative analysis [page 37].

Our discussion about the future would not be complete without the admission that all of the change necessary to get us there is extremely hard for us. We get frustrated with our IT systems, confused trying to keep up with changing processes and anxious striving to understand exactly what is expected of us now and going forward. But Franklin's message is as relevant today as it was to the people of his day: change stops only when you cease to exist. As our British friends [page 6] might say, keep calm and change on.

Jeanne Chircop

V/r,
Jeanne Chircop
Editor

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GONE BUT NOT FORGOTTEN: THE TREMENDOUS LEGACY OF THE INTER-AMERICAN GEODETIC SURVEY

By Gary E. Weir, Ph.D., NGA Historian

Collaboration strengthens valuable international ties, enhances the expertise of all involved and demonstrates the value of shared knowledge. If well managed, a collaborative effort provides benefits long after the individual program ends. Such is the case with the Inter-American Geodetic Survey, or IAGS, which launched 70 years ago using backpacks and surveyors' tools, and formed the foundation for today's computer- and satellite-based geospatial mission in Central and South America.

President Harry S. Truman created the IAGS on April 15, 1946, in response to both post-World War II defense requirements and a request from the Pan American Institute of Geography and History to assist Latin American countries in mapping their territory. The U.S. Department of the Army used the IAGS to develop a coherent geodetic control system and to create reasonably standardized, reliable maps in collaboration with Latin American countries for use in hemispheric defense planning.

The IAGS immediately instituted an effort to map uncharted areas of Central and South America as well as the Antilles. Known as MAPPLAN, this program provided essential support, including equipment and supplies, technical assistance and training, to participating Latin American countries. The collaboration produced geodetic, cartographic and geophysical data, as well as topographic and other relevant map products.

IAGS became a well-respected, internationally recognized cooperative venture. The IAGS staff performed collaborative geospatial work that helped lay the foundation for today's field of geospatial intelligence and the National Geospatial-Intelligence Agency in particular.

THOUSANDS OF MILES

By 1956 more than 91,000 miles of first-order triangulation and more than 195,000 miles of level lines were completed. The IAGS and its partners also defined a continental arc, locating the points of continental drift along the west coast extending from the United States down through Central America and on to the Straits of Magellan – a distance of roughly 6,000 miles – then back up again through the Caribbean to Florida.

The triangulation method used in this case determined the location of a point by measuring angles to it from known points at either end of a fixed baseline, rather than measuring distances to the point directly. IAGS used ship-to-shore triangulation

along the Nicaraguan Coast and flare triangulation to connect Cuba with Florida. Level lines revealed the topography, determining relative heights in the landscape. These lines translated into elevation indicators on a map.

Working in Venezuela in 1956, the IAGS also established the first provisional South American datum for topographic mapping. (A datum is a set of fixed reference points on the Earth's surface from which position measurements are made.) By the mid-1970s the IAGS and its allies completed1:50,000-scale topographic map coverage of Central America and the most heavily populated areas of South America.

THE CASE OF PANAMA

The earliest maps of Panama are those of the coastal outlines and adjacent islands drawn by the Spaniards during the explorations of the area in the 16th century. Although engineering companies did surveys during the construction of the Panama Canal, the first concerted effort to obtain accurate survey data of the Republic of Panama began in 1946, in accordance with the provisions of MAPPLAN. According to this agreement the United States would address all necessary photography, geodetic surveys and ground-level work required for mapping control, as well as the compilation and reproduction of maps. At the same time, the IAGS established its headquarters at Fort Clayton in the Canal Zone, along with an international school of cartography administered by the United States.

Concurrently, Panama created a provisional division of cartography to cooperate with IAGS in the Canal Zone and to serve as part of the "Carretera Interamercana," the Inter-American or Pan American Highway Office. In July 1955 the Government of Panama established its first official mapping agency, the "Direccion de Cartografia," under the "Minsterio de Obras Publicas," the ministry of public works. The name was changed to "Instituto Cartografico Tommy Guardia" in 1967.

PANAMA CANAL TREATY

In 1965 disturbances in the Canal Zone protesting American control of the Canal led President Lyndon Johnson to explore renegotiating the original treaty with Panama. President Jimmy Carter signed an agreement with the Panamanian government in September 1977 to end U.S. control of the canal by 2000. IAGS played a critical role.

"Your supervision of the preparation of the treaty maps during the final stages of the negotiations was a very significant accomplishment, and I want to offer my sincere thanks for a job well done," President Carter told IAGS.

With the signing of the Panama Canal treaties in 1977, U.S. military headquarters, including the IAGS, began to move out of the Panama Canal area, leaving the buildings they had occupied since 1947.

On July 25, 1980 Col. Morton F. Roth and a few remaining IAGS staff members completed the headquarters move to Fort Sam Houston in San Antonio, Texas. The cartographic school would remain in Panama at Fort Clayton for another nine years, training Latin American allies and performing cutting-edge cartography. The IAGS was officially disestablished on October 31, 1989.

It is perhaps appropriate that the former IAGS headquarters in Panama now houses the headquarters of the "Ciudad del Saber," or in English, the City of Knowledge. The IAGS left an unparalleled legacy of information about Latin America that has served NGA's geospatial mission well.

See IAGS teams in action during the 1960s at https://www.youtube.com/watch?v=TGY65o3Mm2w

NGA SALUTE: BRITISH ARMY WARRANT OFFICER DALE ROUTLEDGE

By Dale Lehner, Office of Corporate Communications

Partnerships are built on relationships. Getting to know a person might start with a simple greeting of 'good morning, how was your weekend?' It may build to include remembering the names of the person's family members and eventually lead to exchanges of social invitations. For the British the process usually involves the customary tea and toast.

British Army Warrant Officer Dale Routledge understands the value of building and maintaining relationships as part of the valued Allied partnership between the United Kingdom and the United States.

Routledge is a 16-year veteran with several theatre deployments under his belt. Each assignment over his career as a geospatial analyst, or GA, moved him closer to what he calls his "golden assignment" in the United States, specifically as a liaison officer at the National Geospatial-Intelligence Agency.

"It was a long process to get here," said Routledge. "It's one of those golden posts you hear about, but [you] don't know anyone who has been there."

During his last assignment in London, Routledge learned that one of the current British Army liaison officers was leaving NGA.

"I was newly promoted to warrant officer, so I applied," he said. "Luckily my credentials worked out, and here I am."

Routledge's mission-related analytic credentials are extensive and encompass two years in Northern Ireland, two tours to Afghanistan, and stints in Kosovo and Bosnia. Many of these deployments saw him working both GA and leadership roles alongside American analysts, giving him insight into how the U.S. intelligence community operates.

Eight months into his two-year assignment at NGA, Routledge has learned to make critical connections between U.S. and U.K. analysts.

"It has taken about six months to get them [U.S. analysts] to understand what I am doing and why I'm here – building those face-to-face interactions," he said. "You have to build a working partnership before saying, 'Hey, you know that tool you were working, can I have it?'"

Routledge first saw his role as an information conduit between the Allied analysts – sharing best working practices, new research and customer support – focusing on what he could 'feed back' to the U.K. analysts and what he could 'pass forward' from the U.K. to this side of the pond. But his goal quickly grew into facilitating critical sharing connections directly between analysts.

"Now that I am here, I am starting to see the fruits of my labours, starting to get buy-in from both sides," said Routledge.

The British soldier has also earned unexpected respect from his U.K and U.S. colleagues since arriving at NGA Campus East in Springfield, Virginia. An avid road cycler and racer, Routledge cycles 15 miles for his daily commute. One evening on his return home, a car came to a screeching halt in front of him. Coming alongside the driver's side of the car, Routledge heard the driver say, "I think I killed him."

As he reached the front of the vehicle, Routledge jumped off his bike to assist the gentleman lying on the road who had been struck. The man had a head wound and was "not breathing too well."

Routledge's basic military training kicked in, and he moved the man into a recovery position, staying with him until an ambulance arrived.

"At no point did I think about it [helping]," said Routledge. He went into action instinctively.

It was only as he was preparing to leave that he realized, "I had dropped my bike, 'my precious thing,' which I never do."

Also precious to Routledge are the American friends he has made since arriving. Like every service member facing a move, Routledge worried about his family meeting friends and having a support system, especially so far from home.

"The fact that we were very lucky to pick a house based on a good school for the kids, and the right distance from work was a good thing," said Routledge. But to fall "into a close community with several American military members" that welcomed the family into their social circle was an unexpected bonus.

"I was a bit worried about my wife being so far from home and not having other British military wives for support," said Routledge. "But she has so many friends, and our daughters are more settled here than they were in London – so many friends and playdates!"

Routledge also considers himself lucky to live in a community where his family can learn about the American culture and teach their new friends about British culture.

"I am teaching them a lot of the English language," he joked.

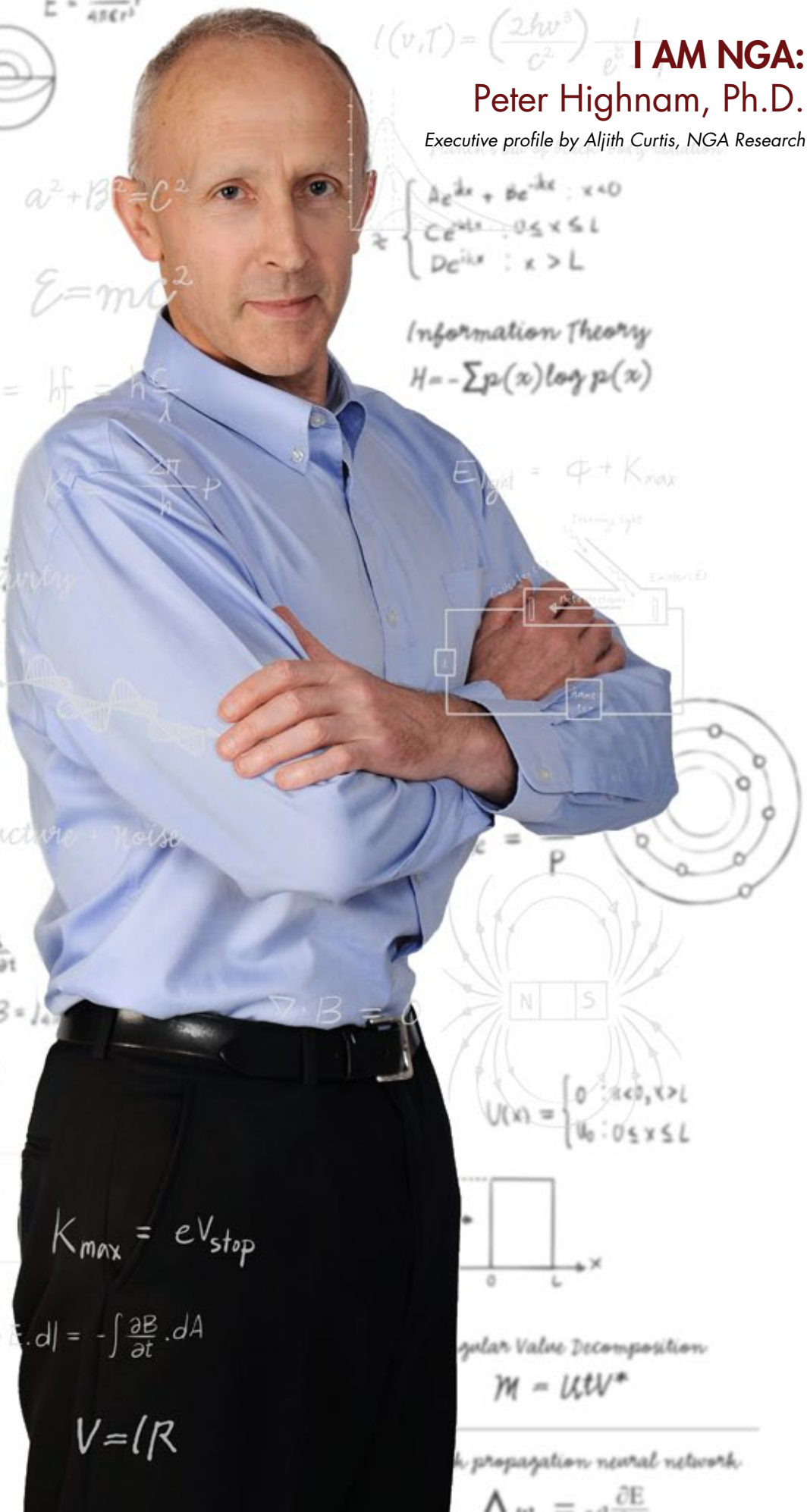
Both his daughters "speak American," said Routledge, which he considers a "breaking down [of] barriers" when they step into school. Their accents are not recognizable, though, which becomes a great conversation starter.

Much like tea and toast.

Know a service member worthy of an NGA Salute? Send your suggestion to Pathfinder@nga.mil.

I AM NGA:
Peter Highnam, Ph.D.

Executive profile by Aljith Curtis, NGA Research



From the outside National Geospatial-Intelligence Agency is not well known for being receptive to new technologies. On the inside it's a different story, especially for Peter Highnam, Ph.D., director of NGA Research.

Highnam left the Intelligence Advanced Research Projects Activity – IARPA – one of the most cutting-edge research groups under the Director of National Intelligence, to lead NGA into the new world of succeeding in the open, partnering with Silicon Valley and evolving the agency in seven focus areas: radar, automation, geophysics, spectral, environment & culture, geospatial cyber and anticipatory analytics. He is leading two development-focused teams – advanced development for operations, and test and evaluation – as well as efforts involving research and technology protection, and flexible acquisition capabilities.

With Highnam at its helm, NGA Research is also partnering with other NGA key components on three special activities that address tradecraft and access to innovative technologies. These are GEOINT Pathfinder, the agency's initiative to solve intelligence questions using only open-sourced data; the In-Q-Tel Interface Center, representing the agency's investment in speeding the deployment of new analytic tools; and NGA Outpost Valley, a new office slated for opening next year in Silicon Valley. (See article, page 19.)

Here Highnam shares thoughts on innovation, managing risk and what it will take to tackle some of NGA's toughest challenges.

WHEN DIRECTOR CARDILLO APPROVED THE STANDUP OF NGA RESEARCH, HE ALSO ESTABLISHED A NEW NGA PORTFOLIO TO MANAGE R&D AS A STRATEGIC PRIORITY FOR THE AGENCY. AS MANAGER OF THAT PORTFOLIO, WHAT ARE YOUR STRATEGIC OBJECTIVES?

There are three, and all require persistence, creativity, careful science and nurtured partnerships. The first is to have substantial levels of automation accepted by the agency. There is really no alternative; the volume of data already available cannot be handled by merely adding people. At the same time, we technologists have overpromised and under-delivered before, so skepticism about automation is not unwarranted. The second is transition of powerful new technologies into practice. In other organizations the most reliable route to transition technology, especially technology that will be part of disruptive change, is to move people as well. In other organizations For a researcher that could mean being willing to take something that you believe in and have worked on, into the receiving organization and work there for a while to actually help change (part of) the world. The third is to break out of the self-imposed restrictions of a narrow sense of GEOINT, which remains anchored in the era of the mapping agency. Thrusts to break conventional thinking can be seen in the agency's new research focus areas. There is great talent and passion to make this happen, both within our agency and in the broader community. I like Director Clapper's comment on the ubiquitous nature of GEOINT, "Everything happens somewhere at some time," with the minor addition that things of interest are not just those visible from above.

WHAT ARE YOUR THOUGHTS ON INNOVATION?

There is confusion in the popular press around the term 'innovation.' Too often the term is used interchangeably with 'new technologies' or 'R&D.' One lesson I have learned from a career as an applied research scientist is that innovation is really about new ways of operating, changes in behavior/culture, which may or may not involve technology. Think of the power that can come from small changes in long-established tradecraft, and how hard it can be to effect those changes. It can be difficult to make technological advances, but I feel my job is easy compared with how challenging it is to change the way people work. We have colleagues throughout our agency who are focused on these hard problems, and I look forward to working with them.

NGA Research started operations a couple of months ago, and we have retained much of the predecessor organization's [InnoVision] internal construct. That will change early in the summer, however, when we move to a completely new structure.

HOW DO YOU SEE NGA RESEARCH SUCCEEDING IN THE OPEN?

In NGA's anticipated future, increasing amounts of data and services will be acquired from commercial sources. Those sources are available to everyone. Commercial synthetic aperture radar sources today are from outside the United States. Small businesses access those sources and produce products that they sell. NGA Research has an essential role in helping to shape that external environment; to push into areas that are not necessarily of commercial value but are of vital interest to our national security.

THE 2016 DNI WORLDWIDE THREAT ASSESSMENT OF THE US IC TALKS ABOUT VULNERABILITIES STEMMING FROM OUR INCREASING RELIANCE ON INFORMATION TECHNOLOGIES. IN LIGHT OF THAT, HOW WILL NGA RESEARCH MANAGE RISK?

As an intelligence community officer who happens to be a scientist, I am acutely aware of the need to protect release of information about research projects that could expose information on capabilities years before we are ready to use them, thereby removing advantage. At the same time, in a world where the vast majority of the leading science and technology is global, we have to understand how to make full use of that expertise, to push the frontiers of science for the benefit of all, and to carefully accept the risks of doing so. Fortunately, others in the IC have walked this path. In collaboration with our Security and Installations colleagues, NGA Research now follows best practices established at IARPA for research and technology protection.

VIEWPOINT

COMBATING THE DANGERS OF BIG DATA ANALYSIS

By Paulo Shakarian, Ph.D., Arizona State University

Editor's note: The views expressed in this article are those of the author and do not reflect the official policy or position of the National Geospatial-Intelligence Agency, the intelligence community, the Department of Defense or the United States Government.

Data is king. All hail Big Data!

At first glance, a big data solution may appear to be a silver bullet for an organization's needs. Certainly, many sectors have urgent requirements that can be addressed with big data. Companies obtain customer information through avenues such as social media, mobile apps and customer relationship-management software. Government agencies, such as National Geospatial-Intelligence Agency, increasingly use big data analysis to derive meaning from the exponentially growing volume of data related to their missions.

In the world of defense, the increased resolution and frequency at which ISR [intelligence, surveillance and reconnaissance] sensors acquire data has the potential to be greatly beneficial but also led to major challenges. The emerging area of cybersecurity threat intelligence may prove to be even more massive: records of network traffic, usage logs and external indicators are constantly growing and will grow even faster as new systems come online.

Analyzing large sets of data using techniques such as machine learning, artificial intelligence and statistics can lead to improved insight and potentially better decisions. But the field is still young, and there are many challenges that must be considered along the way. Of specific concern are cleaning and preparation, causality, model transparency and decision support. Understanding these concerns will lead the GEOINT community to a better big data strategy and selection of technology, and allow for more realistic expectations for how its members will accomplish their missions.

ADDRESSING THE BIG FOUR

Cleaning and preparation

A survey of data scientists conducted by researchers at Sandia National Laboratories found that data collection and cleaning/preparation were the most time-consuming tasks for a big data analyst. Each of these tasks consumes 20 percent of the time in a typical project (median values). Individually, either could consume up to 70 percent of time on some projects. The study results also highlighted that most practitioners viewed these two steps — cleaning and preparation — as the most critical in the process.

Tasks related to data cleaning and preparation can be highly domain dependent as well. For instance, consider a database of individuals that records a variety of attributes. We can represent the age of an individual either as a number (e.g., 21 years old) or as a discrete value (e.g., is the individual 21 years old).

Take two individuals, one 20 years old and one 21 years old, and whether or not they are considered 'similar' by an underlying algorithm. If we are looking at a military or policing operation, both of these individuals would be considered 'military aged' and likely should be considered as similar. If, however, we have a company that sells groceries and we want to target advertisements for beer, we would not want to consider these two individuals as highly similar – because one could legally purchase the product, and the other could not.

Understanding data within the context of the application is critical.

Unfortunately that makes analysis more time consuming. Different decisions might also be made depending on the domain and type of data being analyzed.

Causality

Many pundits extol the benefits of big data analytics, leading to the belief that the more information you have, the higher-quality results you will obtain from a machine-learning algorithm. This is not necessarily true, however; large datasets increase the likelihood of chance correlations. For instance, "Hilarious graphs prove that correlation isn't causation," an amusing piece published by media giant Fast Company, shows that there exists a correlation between the number of films featuring actor Nicolas Cage and the number of drowning deaths in swimming pools – two obviously unrelated things.

One way to resolve this type of false outcome is to consider all potential causes for a given effect. When you are able to consider all hypothesized causes, you can then do a meaningful comparison. In some of our recent work, my colleagues and I conducted this type of analysis to examine the tactics used by the Islamic State. We noted with a probability of 0.67 that Syrian airstrikes were followed by massive arrests by the Islamic State. When Syrian airstrikes occurred along with another hypothesized cause, however, the average increase in probability was 0.91 – indicating that when the Syrian airstrikes occurred, the probability that the effect also occurred skyrocketed.

Transparency

Many machine learning approaches, when applied to data, produce a prediction or attempt to label, classify or organize data in a certain way. These algorithms always provide results that are correct with a certain probability. So, a machine learning algorithm providing a prediction with an associated probability of 0.7 is only likely, not guaranteed.

On balance, machine learning algorithms simply provide a mathematical model, and an old adage goes "all models are wrong; some are useful." One thing that machine learning approaches generally do not provide, for instance, is an explanation of how they arrived at a particular conclusion. This is where secondary analysis may be required for further understanding – something that is often ignored in practice. Even still, it is possible to garner better understanding by examining the attributes of the data. For example, one can examine which attributes of the data are more diagnostic, understand the cases where machine learning algorithms fail, or even utilize a symbolic machine-learning approach – which will often tell the analyst how it arrived at a given conclusion.

Decision support

The current state of the art for big data analytics can provide interesting insights into the data – whether in the form of machine learning prediction, clustering of the data, or statistical methods performed at a large scale. These results are generally descriptive or predictive, however; they do not give insight into a course of action that one may take based on the data. The good news is that the recent trend in game theory, known as security games, explores this problem of decision making under adversarial conditions. For instance in recent work applying game theory to cyber threat mitigation, my colleagues and I used a data-driven model of a malicious hacker to determine a patch strategy for a computer network. Even if such techniques are not available for a given domain, it is important for data analysts to ask the question 'Who cares?' with regard to a particular result. It goes beyond what the data says, to address the question of what courses of action does it imply we take?

WHAT NEXT?

One thing is certain: big data analytics is here to stay and will continue to perform in every aspect of the world we live in. We need to be mindful, however, that the tools of machine learning and artificial intelligence are highly useful, but they do not represent a silver bullet for every problem. Even the best algorithms will not provide good results if the analyst does not understand the domain. In the end, solid analysis depends on the human, not solely the machine. #

Paulo Shakarian, Ph.D. is an assistant professor at Arizona State University's School of Computing, Informatics, and Decision Support Engineering, where he directs the Cyber-Socio Intelligent System Laboratory specializing in cyber-security, social network analysis, and artificial intelligence. He has written numerous articles in scientific journals and has authored several books, including Elsevier's *Introduction to Cyber-Warfare*. His work has been featured in major news media, including *The New Yorker, Slate, The Economist, Business Insider, TechCrunch* and *BBC*. He is also a New America Fellow and recipient of the Air Force Young Investigator award, DURIP award, DOD Minerva award, MIT Tech. Review "Best of 2013," and was a DARPA Service Chief's Fellow. Previously, Shakarian was an officer in the U.S. Army, where he served two combat tours in Iraq, earning a Bronze Star and the Army Commendation Medal for Valor. He can be reached for comment at shak@asu.edu

FOUR BIG-PICTURE REALITIES WILL IMPACT FUTURE NATIONAL SECURITY

By Gary Marx, Center for Public Outreach

Editor's note: *The views expressed in this article are those of the author and do not reflect the official policy or position of the National Geospatial-Intelligence Agency, the intelligence community, the Department of Defense or the United States Government.*

As a futurist, I have been fortunate to travel the world, sharing ideas and theories with many types of people, and studying the overarching political, economic, social, technological, demographic and environmental forces that have implications for everyone, everywhere.

Myriad trends are shaping the global outlook. This article shines a spotlight on four big-picture realities that get scarce attention in traditional national security discussions but nevertheless have profound implications for defining the future challenges our nation is likely to face in the decades to come.

Quickly name three threats to our national security. Your list likely includes things like terrorism and cyber- or mosquito-borne viruses — and as geospatial intelligence officers, you no doubt ponder the resiliency of our satellite networks.

Any futures article focusing on national security has to include at least some mention of technology. After all:

- In November 2015, The Economist estimated an annual cost of $575 billion exacted by 90 million cyber-attacks. The article, "Cyber-Security: The Cost of Immaturity," noted an average lapse of 205 days between an actual breach of a network and the owner noticing the intrusion.
- Concern about identity and privacy has gone through the roof, as personal information is harvested using cookies or other built-in apps.
- A virtual explosion of the Internet of Things is providing an exponentially increasing number of opportunities for hackers, identity thieves, ransomware opportunists, and even terrorists, to access computer systems.

We could delve deeply into the technology trend and many others. But consider this: National security, in large part, depends on a sense of personal security, coupled with fairness, equal opportunity, a sense of belonging and a voice in creating our own futures. So it is important to look beyond the traditional topics of discussion to consider the larger, but perhaps more basic, realities that are too often elephants in the room, so big and obvious that they hardly make the agenda. Among those realities are: exclusion, polarization and ethical breaches, lack of a level playing field, and a massive 'reset' as we move at warp speed into a profoundly different future.

REALITY NUMBER 1: EVERY INSTITUTION IS GOING THROUGH A RESET

Question: "When will things get back to normal?"

Answer: That's not the right question. The question should be, "What will the new normal look like?"

Jeff Immelt, chief executive officer of General Electric, put it this way as we moved into the Great Recession: "The economic crisis doesn't represent a cycle. It represents a reset. It's an emotional, social, and economic reset."

In fact, every institution, including national security, is going through a reset. No one gets a free pass.

Once upon a time, when we were confronted by new ideas and technologies, we could sit back and intone, "It's just a fad. Sit tight. It'll go away."

Now the status quo is fast becoming unsustainable – even a ticket to obsolescence – as we ride the crest of a seismic shift into a global knowledge/information age, even an age of knowledge creation and breakthrough thinking.

New generations of national security challenges are emerging before our eyes. The questions are: How can we identify them? How can we avoid them? How can we deal with them?

REALITY NUMBER 2: NATIONAL SECURITY DEPENDS ON INCLUSION

Our national security, as well as the security of other nations, depends on rallying around big ideas, such as justice, authority, privacy and responsibility. Principles such as 'E Pluribus Unum' and other bedrock values are enshrined in our Constitution. They are basic to our social cohesion; the glue that holds us together.

But that doesn't mean we're all alike. A reality for the United States is that non-Hispanic whites will become less than 50 percent of the total population by 2043. Beginning in the fall of 2014, traditional minorities became the majority of students enrolled in U.S. schools. The face of our nation is changing.

Globally we live in an age of massive migration, as people move from one region to another, hoping to find safety, security and opportunity. Immigration looms as

a test of national character for many countries and has hatched an array of security concerns.

Basic human behavior and tenets of sociology are important to remember. When people know their voices have been heard, they are more likely to feel a sense of oneness with their community or country, a sense of ownership. If they feel their voices have not been heard, they will likely retreat to political, religious, tribal, nationalistic or ethnic groups. Some even find their sense of community in enclaves. A few of the dispossessed, who have lost their sense of belonging and personal or group esteem, may even strike out against society.

Like other countries around the world, if we manage our diversity well, it will enrich us. If we don't, it will divide us.

REALITY NUMBER 3: AN ABUNDANCE OF POLARIZATION AND A SCARCITY OF ETHICAL BEHAVIOR ARE STANDING IN THE WAY OF PROGRESS

Polarization is eating our lunch. All around the world, shouting matches – or worse – too often replace civil discourse. While social media theoretically open the door to a world of connections and information, growing numbers of people program their dashboards for apps and websites that do nothing more than justify narrow, pre-determined conclusions or biases.

Looking at our role in the big picture, we swear on the one hand to the absolute necessity of developing good citizens of our families, schools, colleges, communities, nations and the world. On the other, we shamelessly shortchange civic education and the social sciences at every juncture. Thinking, reasoning and problem-solving skills, coupled with ethical behavior, are essential to the future of civil society. So is the know-how to resolve conflict peacefully and democratically. For democracy to work there must exist a commitment to engage people in discussion, to listen to their ideas and views – and to govern accordingly.

REALITY NUMBER 4: A LEVEL PLAYING FIELD IS A FOUNDATION FOR NATIONAL SECURITY

In 2014, 22 percent of school-age children in the United States were living below the poverty line. That was about 15.7 million kids. More than 50 percent of all U.S. public school students are from low-income families. [Low-income is an amount that is double the poverty line.] Globally, the statistics are even more somber.

Our individual and collective security is threatened by a lapse in equal opportunity and a profound shrinking of the middle class in nearly all industrialized nations. Statistically the rich have gotten richer, and the poor have gotten poorer. Nurturing talent, ability, aspirations and hope for a better tomorrow cannot be the exclusive purview of those in the world who have a great deal and want *more*. A commitment to making possibilities available to all, including those who have very little and want *some*, has outsized and even existential implications for the future of nations and their security.

When we frustrate human potential and limit possibilities, we all lose. We lose the ideas and the drive that help us create an even brighter future. That in itself could become one of our greatest threats to community and national security.

PUTTING KNOWLEDGE INTO ACTION

Certain implications of these big-picture realities for national security are clear. As trends converge, however, we discover new knowledge about threats. That same convergence triggers breakthrough thinking about opportunities and solutions. With a wide-angle view of the big picture, we are more likely to put our daily barrage of paradox, controversy, complexity and constant change into perspective. Seeing knotty or simmering problems in context helps us to sort them out and find creative ways to manage or even solve them.

Trendspotting, trend analysis, issue analysis, historical/defining moments analysis, flexibility/innovation analysis and gap analysis – all important aspects of geospatial intelligence – can help us put a finger on projectable threats and opportunities. By engaging these futures 'tools,' we can stimulate 'what-if' and 'then-what' questions about our assumptions as we form scenarios, which are, at their best, plausible pictures of alternative futures. Exploring new ways to resolve those questions will keep us safely ahead of whatever threats the future holds. #

Gary Marx is the author of, among other books, "Twenty-One Trends for the 21st Century … Out of the Trenches and into the Future." He has provided futures, communication and leadership counsel, and energizing presentations on six continents. Marx is also president of the Center for Public Outreach in Vienna, Virginia. He can be reached for comment at gmarxcpo@aol.com.

Have an idea for a GEOINT or national security Viewpoint contribution? Send your query to Pathfinder@nga.mil.

GEARED UP FOR THE FUTURE:

SAY BUH-BYE TO OLD TECH, HELLO TO INVISIBILITY CLOAKS AND MORE

By Shelley Wilson, Ctr., Office of Corporate Communications

It sounds like science fiction — contact lenses with built-in cameras, optical camouflage blankets that can make buildings disappear from sight and augmented reality gear that changes how wearers perceive the very space they're in.

This might seem like a description of a government research and development program, but it's not. While federally funded technology is at the forefront of things like space exploration and the development of alternative energy sources, it is often the private sector that leads the way in creating new gee-whiz products that ultimately become universally used. Think mobile devices and wearables, for instance; both of which are drastically changing the ways in which geospatial intelligence is gathered and consumed.

Predicting what new innovations will launch in the consumer market and how federal agencies might use them or be affected by them in the future is almost like betting where the ball will land on a roulette table. We know the ball will always land on the wheel; we just don't know exactly where. We also know consumer technology will always evolve. The tricky part is predicting where and how it will intersect public sector needs – and how to leverage it.

The symbiosis of consumer electronics and GEOINT was underscored during the International Consumer Electronics Show in Las Vegas in January 2016. National Geospatial-Intelligence Agency Director Robert Cardillo used the forum to reach out to consumer electronics manufacturers and suppliers to invite broad collaboration in addressing national security challenges. NGA reps have also participated in public events such as South by Southwest, and the agency has consulted multiple industry titans about emerging technologies and best practices. What follows are several broad technology areas where commercial products might affect GEOINT tools and tradecraft in the future.

VIRTUAL AND AUGMENTED REALITY

Ironically one of the most prevalent technologies can trace its roots back more than 175 years. Virtual reality, touted by many in the consumer electronics trade press as the next 'big thing' at the 2016 CES, began as a tourism tool in the late 1830s. Artists created 360-degree panoramic paintings to give viewers the sense of being on location in some far-flung destination. Virtual tourism took a leap forward with the 1939 patent of the popular View-Master, which flipped 3-D film 'reels' of places on cardboard disks.

VR took a quantum leap into the computer age with the debut of immersive videogaming in the 1980s. The military quickly began using this high-tech VR for training purposes and today utilizes the technology to mimic dangerous situations where warfighters need to react. VR enables a safer, more realistic and less costly training environment than do traditional methods. VR is used for flight simulation, medic training, battlefield operations, virtual boot camp and treating post-traumatic stress disorder, according to the U.S. Department of Defense.

Today's VR creates a three-dimensional, computer-generated environment that appears so seamless that the person experiencing it forgets the computer, headgear and accessories are there, and becomes immersed in the virtual environment. But the recent

innovation in VR is really in the size and type of display products.

Recently released Google Cardboard offers an affordable VR experience through a simple fold-out, pop-up cardboard viewer headset that uses a smartphone. Even the old View-Master is planning a comeback; Mattel and Google announced a collaboration to produce a new iteration of the View-Master using smartphones. The View-Master Viewer DLX is scheduled to be released in fall 2016, according to prelaunch promotional literature.

On the opposite end of the spectrum and outside the traditional consumer sector, Honeywell has partnered with DARPA [Defense Advanced Research Projects Agency] to build a VR instrument panel that replaces glass windows with display technology. Known as Ground X-Vehicle Technologies, or GXV-T, the panels have the potential to provide drivers of military ground vehicles with an enhanced, 360-degree view of the world around them. Honeywell says the first phase of the virtual windows development began in July 2015 and is nearing completion.

GXV-T is one example of the biggest evolution of VR since the '80s – augmented reality. While VR simulates a real-world environment, AR involves viewing the real environment, but with the addition of computer-generated sensory input such as GPS data, video or graphics, and even sound and smell.

Mark Zuckerberg, founder and CEO of Facebook, which purchased VR giant Oculus in 2014, spoke at F8, the company's annual global developer conference, in April 2016 about an expansion program that will blend augmented reality and VR.

"Over the next 10 years, the form factor's just going to keep on getting smaller and smaller, and eventually we're going to have what looks like normal-looking glasses that can do both virtual and augmented reality," Zuckerberg said.

Samsung apparently aspires to go even further, revealing through a patent application that it is exploring the development of a contact lens that can overlay images directly into a wearer's eye. A built-in camera will enable the wearer to take photographs with the blink of an eye. According to press surrounding the patent application, the lenses will be able to connect wirelessly to a smartphone, enabling the wearer to use on-eye navigation instructions to search online for more information about whatever is being looked at in the real world.

While the concept of a contact-lens VR/AR display is more than a decade old, tech journalists say the technology is closer to becoming a reality due to advancements in smartphone technologies over the past few years.

WEARABLE TECHNOLOGY

Beyond contact lenses, wearable technology can now provide much more than fitness tracking, health monitoring statistics, navigational tools, purchasing applications and travel details. Wearable devices are an integral part of the Internet of Things, the logical evolution of the cloud and big data. The idea, according to technology watchers, is to enable sensor-equipped 'things' to communicate with one another and convert physical information, gathered by location wave beacon technology, into data values – data that can be shared in various ways for various reasons, including GEOINT.

Several companies are currently making plans to incorporate wearable technology with drones. One in development now is the small GPS- and camera-equipped drone Nixie, also known as the wearable selfie drone, which launches a camera from the wrist that will fly in a preprogrammed mode to take photos or a video, and then return to the user who launched it.

Global design and strategy firm, frog, predicts that wearable drones will be in common use by around 2030.

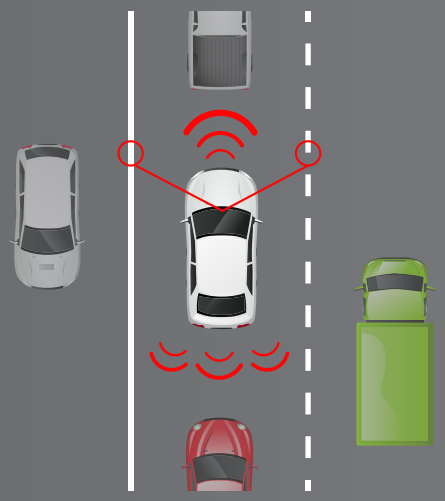
"We can anticipate that more technology and devices will be taking to the sky," Adam Pruden, interaction designer at frog, said at the South by Southwest Festival. "We must carefully plan and design these objects to improve our lives rather than disrupt them."

Drone use has the potential to both benefit and challenge NGA and its partners in the future. Microdrones can make it faster and more cost-effective to map and survey areas, especially in support of partners involved in disaster relief and humanitarian efforts – times when landscapes can dramatically change in a matter of minutes. The challenge comes from the growing number of for-profit commercial drone pilots who now have permission to pursue emergency services missions with their drones. According to the Center for Study of the Drone at Bard College, the number has grown from 500 operators in June 2015 to nearly 4,000 today. Whether these for-profit operators ultimately will help or hinder official operations has yet to be determined.

Current drone designs depend on technology to perform; however, research to use the force of one's mind is being done closer than in a galaxy far, far away. University of Florida recently held the first brain-controlled drone race, using brain-computer interface software to control a group of DJI Phantom drones. BCI technology isn't really new, as the healthcare industry already uses it, but combining it with emerging drone technologies makes it of potential interest to protectors of national security. The University of San Diego is researching military weaponry using BCI technology, thanks to a DOD grant. The technology under study can use a soldier's brain signals to navigate small unmanned aerial vehicles used for various military operations.

The Carnegie Mellon Human Computer Interaction Group is also working to develop new ways to connect technology to the human body. The group's SkinTrack project combines a smartwatch with "skin buttons" projected onto the arm of the wearer. The technology lets the wearer touch and swipe his or her forearm as though it is a touchscreen. Tilting and twisting the watch will let users control it like a joystick.

Moving from technology for seeing things to technology for making things unseen, several companies are making strides in creating so-called invisibility cloaks or optical camouflage blankets. While technologies began developing a decade ago and are still far from ready for market, many are based on already-proven technologies, such as the blue or green screens used by TV weather forecasters and Hollywood film directors. Others follow known scientific principles such as those behind the appearance of mirages in hot sand environments.



AUTOMOTIVE INTELLIGENCE

At first blush it might not seem like automotive intelligence has much to do with GEOINT, but the drive toward autonomous cars has many relevancies. For one thing, a vehicle capable of driving itself frees up its passengers for performing tasks other than driving – a benefit of particular relevance to warfighters and first responders. For NGA, there's also the issue of eventually providing safety of navigation data to driverless vehicles used by the agency's customers.

It may come as a surprise that the leader of these self-driving prototypes is not an automobile manufacturer, but rather a search-engine company most of us use every day – Google.

Google has created the first fully functional autonomous car prototype that features cameras and LIDAR technology, and includes temporary manual controls for a back-up driver. The software in the cars classifies objects based on their size, shape and movement pattern, predicts what surrounding objects might do next, and then chooses a safe speed and trajectory for the car. Some pieces of the software already exist in car models like Toyota Prius, Ford Focus and Tesla, which can park themselves, but it is yet to be determined when a completely driverless car will be ready for purchase.

Gill Pratt, a former program manager at DARPA, is a consultant to Toyota on its research efforts to build autonomous systems. He stressed that it is important to build accountability mechanisms into new designs.

"People have reasonable fears about whether technology will work in their best interest, or if it is competent to do the jobs we assign," Pratt said. "We need to be sure that the autonomous agents given the power to make decisions are capable of being audited. We can't trust what we don't understand, so we must build cars that can explain their actions."

ARTIFICIAL INTELLIGENCE

The current and future state of artificial intelligence in general has raised both excitement and fear for what 'intelligent' machinery can and will ultimately do. Some people may think of AI as the Hollywood version of a humanoid robot (e.g., "Terminator," "I, Robot") that will try to overcome and outsmart mankind. In reality AI is already used in very popular forms, such as personal tech assistants like Apple's Siri. It is also integral to commonly used online platforms such as Facebook, Amazon Echo, OK Google and Google Now.

"Artificial intelligence is one of the hottest technologies in Silicon Valley, where executives and engineers say it can enable computers to make inferences and decisions, versus simply following

instructions programmed into them," wrote Wall Street Journal reporter Jack Nicas in a May 2016 article on the topic.

Wired's Kevin Kelly credits AI's emergence to the convergence of three breakthroughs: the advent of cheap parallel computation (that started with the creation of intensely visual videogames), big data and better algorithms. The result? Deep neural networks of hardware and software that "chat" with each other to learn tasks and get smarter by analyzing vast amounts of data. These networks learn and create rules to apply in similar situations, using brain-inspired mechanics to achieve brainlike function.

At the first National Security Forum held last year by the Center for a New American Security and Defense One, military leaders said they hope AI will power the cyberbattle of the future but also admitted the military lags behind the commercial AI market.

"The Department of Defense is a follower. The commercial world has already made this leap. We have to catch up with them quickly," said Deputy Defense Secretary Robert Work. "You cannot have a human operator operating at human speed fighting back cyber tech. You are going to need have a learning machine that does that."

On the other hand, Work also said that humans, not machines, should continue to make the big decisions, such as when to use lethal force.

CROWDSOURCING

Big networks of people chatting with each other can also lead to powerful data collection. Crowdsourcing, which originated with the advent of social media and proliferated along with smartphone technology, can harness the power of millions of people to provide real-time, on-location situational awareness about events and conditions.

In addition to gathering knowledge, crowdsourcing is a cost-effective solution for gathering and providing data. The popular traffic application Waze reports it employs less than 100 people but harnesses the power of more than 70,000 volunteer map editors and 15 million users who are driving the roads while inputting and interacting real-time traffic data.

Companies and government agencies alike are using crowdsourcing to gather important feedback from their customers. Procter & Gamble uses its crowdsourcing platform for worldwide input during development of new products. Some lawmakers are looking at crowdsourcing to get constituents more involved in creating and editing laws. More than 80 federal agencies engage with the public on the General Services Administration's Challenge.gov platform. The site lists government challenges and offers prizes for future solutions.

3-D PRINTING

Computer technology is also changing the prototyping, production and shipping of products. Increasingly, 3-D printers will create whatever object is needed by taking a digital file template and joining multiple layers of different material, metals, ceramics or liquid, about 0.1 mm thick, until the object is complete. The technology has been around for three decades in the aerospace, medical, defense and automotive industries, but cheaper and smaller-sized printers emerging in the consumer market are making 3-D capabilities more accessible. Some techies believe the technology will evolve to where it will be able to help the medical field by printing organs, helping law enforcement by printing bulletproof clothing and the military by printing out vehicle parts where and as needed.

Regardless of how 3-D printing and the other technologies identified within this article evolve, the driving force should always be the people who build and use them, according to Gary Dunow, director of NGA's Analysis Directorate. He says the human element will always be the vital key to mission outcomes.

"Machines can't answer why," Dunow said. "Critical thinking will never pull away from the intelligence community. 'Why' is a human motive—no matter how important computers are in automation. We'll never see a time that completely relies on computer generation."

NGA MOVES INTO SILICON VALLEY

By Elizabeth Short, Ctr., NGA Research

Silicon Valley is home to Apple Inc., Pixar, Adobe Systems, Tesla Motors and now NGA. Beginning in summer 2016, NGA will have a presence in Silicon Valley, neighboring major high-tech corporations and thousands of startup companies.

Standing up an outpost in Silicon Valley is one of three ways NGA is committing to partnering with industry, attracting top talent and technology, and developing solutions to its current and future technology challenges. The other two are through the GEOINT Pathfinder project, which focuses on using open-source data, and the Enterprise Innovation Office.

"The partnership EIO has with the NGA Outpost Valley will provide exposure to a new set of skills, research and technology, which will be sent back into larger NGA, driving a cultural change in the way we acquire, develop and implement solutions," said Dave Cacner, EIO director.

The NOV will also strengthen the ability to achieve Director Robert Cardillo's vision for 'Team GEOINT' – the notion that those in government, industry and academia should work together more closely to further the GEOINT enterprise. Over a two-year period NGA scientists, developers and analysts will rotate in and out of the NOV, establishing relationships with subject matter experts, academia and emerging companies. NGA will have a core staff from multiple directorates to support the NOV, including Benjamin Tuttle, Ph.D., from NGA Research, who will be leading the NOV.

Tuttle and his team bring many years of scientific and technology experience – most recently within NGA's Geospatial Intelligence Advancement Testbed, mobile applications and the In-Q-Tel Portfolio teams. Tuttle will also continue to lead the technical direction and development for NGA GEOINT Services, enabling the NOV to be a driving force for leveraging the best commercial innovations in geospatial technology, data and methodologies into the NGA enterprise.

Dear colleagues,

The Geomatics Equipment Loan Program is a data-collection vehicle that is unique throughout National Geospatial-Intelligence Agency. NGA maintains a large and diverse inventory of geodetic survey instruments through which, over the life of the loan program, NGA has acquired more than $100 million worth of scientific data for contractual equipment loan agreements.

A Cooperative Research and Development Agreement, or CRADA – an agreement between a federal agency and a nonfederal entity – with the Woods Hole Oceanographic Institution currently enables WHOI to utilize NGA's scientific instruments for enhanced oceanographic research. NGA and WHOI partnered to explore new ways to provide better foundation data systems and safety of maritime navigation. Using existing sensors and data sources, NGA and WHOI will explore new methods for collecting and exploiting hydrographic and gravimetric data, as well as investigating potential new sensors for collecting maritime data.

WHOI, the world's largest private nonprofit oceanographic research institution, is dedicated to advancing oceanographic knowledge through a wide variety of research and education programs in ocean science and technology, including marine geophysics. WHOI operates two ocean-going research vessels, the R/V Atlantis and R/V Armstrong. The Armstrong replaced the R/V Knorr, which sailed almost 1.4 million miles prior to its retirement in December 2014.

Through its membership in the University National Oceanographic Laboratory System, or UNOLS, WHOI also collaborates with scores of other U.S. oceanographic institutions to regularly observe the ocean environment. The WHOI-NGA partnership is an opportunity for WHOI to utilize NGA equipment on UNOLS vessels, while NGA benefits from new sources of marine gravity data.

Gravity is the largest error source for the Inertial Navigation System, one of two components comprising the targeting and navigation systems of U.S. Defense Department major weapons platforms – aircraft, missile technology and naval surface and subsurface vessels. The accelerometers that compose INS guidance instruments are compromised by Earth's gravity, causing a navigation drift rate of 0.6 nautical miles per hour. For a one-hour flight time this means missing a target by 0.7 miles or 3,646 feet. The NGA Office of Geomatics develops error compensation solutions adjusting for gravitational effects, which is paramount to the accuracy and success of U.S. defense weapons.

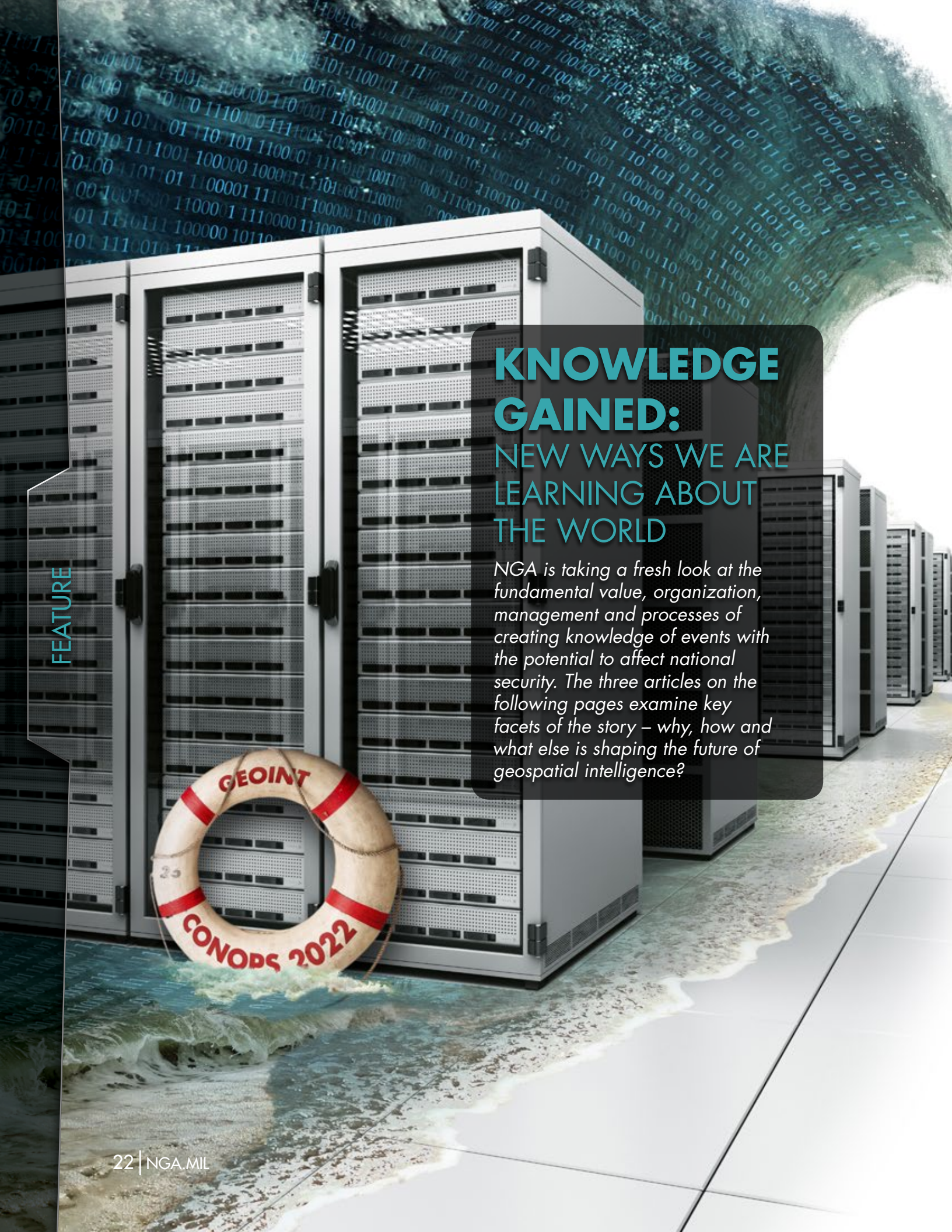
In addition to geomatics-focused interests, studies involving gravity and bathymetry, WHOI conducts scientifically sophisticated research exploring future technologies that may impact NGA mission sciences. These studies are in technical areas relating to ocean chemistry, ocean currents, climate change, dynamic ocean topography, predictive tide modeling and other NGA mission-relevant projects.

This WHOI-NGA partnership will enrich the missions of both organizations for many years to come.

Cedric Sanford
NGA Office of Geomatics

NGA PARTNERS TO STUDY THE SEAS

Photo credits: R/V Armstrong – Bay Aerial;
R/V Knorr – George Tupper/Tom Kleindinst.
Both photos courtesy of Woods Hole Oceanographic Institution.



FEATURE

KNOWLEDGE GAINED:

NEW WAYS WE ARE LEARNING ABOUT THE WORLD

NGA is taking a fresh look at the fundamental value, organization, management and processes of creating knowledge of events with the potential to affect national security. The three articles on the following pages examine key facets of the story – why, how and what else is shaping the future of geospatial intelligence?

WHY: THE CHANGING BUSINESS ENVIRONMENT

By Steve Truitt, Ctr., Office of Strategic Operations

Peter Drucker coined the term 'Knowledge Worker' in 1957, about the time that the intelligence community began experimenting with photographic interpretation and creating the foundations of geospatial intelligence. In that sense, National Geospatial-Intelligence Agency and its predecessor organizations have been engaged in the business of knowledge work for almost 60 years.

As technology improved over time, there has been constant pressure to produce ever-increasing levels of geospatial insight. Throughout the Cold War, the 1990s and early 2000s, insight from overhead imagery provided a unique basis to create knowledge that was available only to government agencies.

The growing wave of geospatial technology that began with commercial GPS data presents both enormous opportunity and challenge for NGA. The 'democratization' of satellite imagery and technology has increased everyone's ability to contribute to the breadth and depth of geospatial knowledge. Anyone with an inclination to do so can now access some type of overhead imagery of just about any place on earth.

This means that what once provided the government with unique advantage over our adversaries is now ubiquitous. Consequently, the government must develop new ways of doing business to keep and grow our body of geospatial knowledge about the world and preserve national security. This puts new and unique pressure on NGA to adapt to new realities while still increasing the depth, breadth and value of its geospatial intelligence services. What brought NGA success in the past simply will not get NGA to the integrated and diversified knowledge-based organization of the future.

To develop and institute new ways of doing business, NGA is taking a fresh look at the fundamental value, organization, management and processes of creating knowledge of events with the potential to affect national security. The NGA strategy and NGA GEOINT CONOPS 2022, which animates the strategy, are the first of many steps down the road to reinvention. The new concept of operations is a first for the agency – a single strategic document that describes the principles by which NGA will do business across the entire agency over the next six years.

GEOINT CONOPS 2022 calls for a fresh look at business practices, organization and mission approach across the four primary areas where NGA delivers value: creating knowledge through analysis, providing geospatial content, creating geospatial services for others and managing the GEOINT function across the U.S. government. Going forward NGA will structure its business on the scientific method and make decisions based on market-based interactions. This will allow all participants in the GEOINT environment to contribute knowledge and value to the greater GEOINT community in near real time.

These principles are driving several strategic changes at NGA – the most visible of which will be an explosion in the diversity of ways users will access and use geospatial information. Analysis and GEOINT services are two ways in which NGA delivers value to its customers. Each of these activities has multiple avenues for providing insight. Based on the principles of NGA's business transformation, there will be unprecedented access to not only finished analysis, but also to the thought processes and tools used to develop that geospatial intelligence.

Content, as well, is undergoing a revolution. The prevalence and diversity of new geospatial data sources make it essential to refine the U.S. government's requirements in a way that allows for combined purchasing power and shared use of not just sources, but the wide variety of commercial and open sources of geospatial information as well.

Functional management, too, is an area of growth for the GEOINT community. As the functional manager of GEOINT for the U.S. government, the director of NGA, currently Robert Cardillo, is responsible for managing GEOINT activities across all agencies and departments. The principles of economic exchange will drive these activities, allowing each provider and consumer to bring their unique expertise and value to the GEOINT environment. This will foster partnerships that will allow everyone to benefit.

Managing all of this change will require strategic planning and coordination, both within NGA and in the wider National System for Geospatial Intelligence. Within NGA, Director Cardillo created the NGA Office of Strategic Operations under the director of plans and programs. This office, along with producing documents such as the GEOINT CONOPS, will help the agency by implementing a coherent strategy for fostering the business changes required to succeed. In the broader NSG, a new strategy released in May 2016 addresses key areas that will transform the business processes for conducting GEOINT across the community.

In the coming months and years, NGA and its partners comprising the NSG will overhaul their business processes. This will require transparency and partnership among all GEOINT stakeholders.

HOW: HARNESSING THE POWER OF THE DATA TSUNAMI

By Evan Frank, Ctr., CIO-T Communications Team

FEATURE

David Bray, Ph.D., the chief information officer of the Federal Communications Commission, visited the National Geospatial-Intelligence Agency's Springfield, Virginia, campus in April for the Armed Forces Communications and Electronics Association's Spring Intelligence Symposium 2016 to share his thoughts on the future of intelligence collection.

Bray, who began his career in government information technology at 15 years old, spoke about this future not as something distant and hypothetical, but as an imminent reality aggressively rushing around the corner on the heels of Moore's law. At the forefront of his discussion was the 'data tsunami,' a term often used by NGA Director Robert Cardillo.

"[In] 2013, there were 7 billion network devices on the planet and 7 billion humans," said Bray. "There are now 14 billion network devices on the planet and 7.3 billion humans. [Jump to] 2020, [there will be] anywhere between 50 and 200 billion network devices on the face of the planet. That's not linear change; that's exponential change."

For the intelligence community, this equates to 40 zettabytes of data, or 1 sextillion bytes, which the International Data Corporation's 2012 Digital Universe Study estimates as the size of the digital sphere by 2020. Described in more familiar terms, this is the equivalent of every person on the planet having 174 newspapers delivered daily.

So how will the IC harness this data? Through dynamics and automation, according to NGA.

GEOINT CONOPS 2022 frames NGA's approach by focusing on automation and machine learning as core components of its future, realized through three phases — integrating a cloud-based GEOINT services platform by December 2017; automating that platform before 2020; and ultimately, shaping automation through the power of machine learning and anticipatory analytics.

"What's changing is that we are realizing that more and more data sources of a 'big' type — e.g., mass media, social media, webs of open sensors — are growing in number and usually contain large amounts of spatial information," wrote NGA data scientist Jon Clark, Ph.D., with the CIO and IT Services Directorate, in a 2016 agency study on the future trajectory of data.

Moore's Law: Gordon Moore, a co-founder of Intel, correctly predicted in 1965 that overall processing power for computers would double every two years.

"The specific challenges here include how to mine the spatial information out of what may be massive amounts of 'noise,' …whether those data are trustable... how much sampling bias is in those data…[determining what is] enough metadata and provenance to prevent inappropriate use of the data," Clark wrote.

These concepts, strategies and studies are not unprecedented.

Every phase of the CONOPS, when applied to the commercial tech sector, has been met to a measurable degree of success.

That's good news for the IC because it allows the community to leverage the best practices of the commercial sector in interoperable cloud platforms, machine learning and predictive analytics developed by companies such as Google, Amazon, Pivotal or Microsoft.

"We can and must learn from many other communities and industries that deal in spatial questions and location-based operations," noted Clark. "We must not reinvent the wheel."

Most important is that the IC collects, stores, shares and exploits exquisite intelligence with unwavering efficacy.

NGA, along with its partners, is in the midst of a full-scale transition to cloud environments at all classification levels. The agency has also already partnered with two of the above-named companies, among others, to build an automated service-orientated architecture — one that can serve as a digital couture that quickly designs and deploys fast, reliable, operationally independent applications, with each app providing intuitive interfaces to well-catalogued, abstracted and algorithmically enhanced data sets linked to an array of attributes.

"NGA has a data strategy to optimize the use of the IC cloud to achieve the greatest efficiencies," said NGA open IT expert Bill Holt. "Data will be decoupled from applications to allow for maximum reuse and tagged for discoverability and usability, all while enforcing sound, secure data access policies."

"In addition, we are piloting efforts to conduct analytics before ingest and only ingest content that is identified as relevant or useful," Holt said.

Holt, who is involved in engineering NGA's data strategy, works closely with a federally funded research and development center, or FFRDC, to plan the agency's future-state data path — from three years to 10 years out.

According to Holt these plans entail a unified, shared and community-accessible source of GEOINT data and resources, with shared analytic results, persistent monitoring of data through

automated systems able to identify anomalies, and more focused application of knowledge and analysis based on geographic region.

These steps lead to a GEOINT environment that selectively and purposefully automates the collection, cataloguing and exploitation of data – all before an analyst ever sees an image.

Clark suggests the application of spatial and temporal algorithms to natural language processing of mass text, so 'where' and 'when' can automatically factor into patterned geospatial trending and targeting. [Most NLP today is based only on word matching, word patterns and simple semantics.] He also proposes automating systems for motion sensors and acoustic arrays for precision mapping based on sources of noise and movement; teaching systems to translate graph data into information models; crowdsourcing through social media; and developing system-dynamic modeling to combine the massive streams of future data for the purpose of predictive analytics.

These technologies are no longer concepts in the field of data science. The challenge is in fostering an NGA culture of applied data science.

Pairing such technology and automation with the good data governance – overseen by stewards and curators with backgrounds in data and library science – is the future of GEOINT.

WHAT ELSE: THE GLOBAL VIEW

By Jessica Daues, Office of Corporate Communications

Someone posts a photo of a beachfront vacation home on Facebook. Another tweets his frustration with construction delays on a busy interstate highway. These social media users – and millions like them -- are contributing to a geospatial treasure trove of information.

This ever-increasing amount of geospatial information presents opportunities and challenges to world leaders, policymakers, business leaders and scientists, according to the United Nations Initiative on Global Geospatial Information Management, or UN-GGIM.

UN0GGIM published a report on future trends in geospatial management in 2013. The report aims to help nations, companies and organizations best position themselves to use all this geospatial data to create economic opportunities, provide emergency services, promote sustainable development, enhance security and more.

"Geospatial information is an essential building block of a country," the report states. "Investment in such information is worthwhile and will generate returns beyond the investment made."

The report says that the number of entities – both public and private – involved in generating, managing and providing geospatial information has risen significantly in the past 10 years and predicts it will continue to rise.

Governments, it says, will continue to play an important role in geospatial data collection and use. People may look to governments to provide a reliable, trusted geospatial information base; to develop standards, methods and tools to ensure quality and provide authority to information; and to establish policies and structures that allow users to easily access geospatial information.

Governments also will benefit from increased coordination and collaboration with the private sector. Still, unlike private-sector companies, governments are in a unique position to consider how best to use geospatial information for society as a whole, rather than simply get the most return on its investment, the report says.

Governments might also reinvent how they collect, manage and distribute geospatial data.

"Given the proliferation of additional sources of data and potential competition from other sectors," the report states, "we may see government providers of geospatial information taking on a role that shifts more towards a policy, advisory and procurement role. … Governments may increasingly no longer see it necessary to collect all geospatial information required themselves."

To make best use of all the geospatial information available, the report suggests establishing training programs to instill the new and ever-changing skills needed to sift through and capitalize on geospatial data.

The report notes the potential for a deepening of the 'digital divide' between the countries with the infrastructure, expertise and resources available to take advantage of geospatial information and the countries without.

"There will be potential major roles for nongovernmental organizations and development agencies in ensuring that the skill base necessary to ensure all countries reap the benefits of a spatially-enabled society is developed globally," the report notes.

To view the full report, visit http://ggim.un.org/docs/Future-trends.pdf.

CHANGE DETECTION AS THE FOURTH DIMENSION OF GEOINT

By Dennis Campbell, Source

Geospatial data have been depicted both historically and consistently in three dimensions, i.e., longitude, latitude and height and/or depth. This static representation of reality has required analysts to function and operate within these dimensionality constraints. In effect, they 'live' only within their data.

Introduction of the time element, when immersed with current and historical geospatial datasets, will increasingly lead us to consider a fourth dimension – that of change detection – so that we can more easily determine where and how to focus our geospatial intelligence efforts. By focusing on what has changed in place and time, analysts will be able to prioritize areas for updates, and revise maps and feature databases more quickly and effectively than ever before.

EXPLORATORY ASSESSMENTS

In the simplest terms, changes to the earth's surface can be categorized into two forms – natural and unnatural. Unnatural land surface changes are most commonly produced by human-induced construction activities, such as road infrastructures and industrial facilities.

Change detection technologies that locate, in varying degrees, human-induced changes on the ground are finding success across a broad spectrum of types and levels of analyses. Used as exploratory tools, they enable quick and efficient broad-area searches to identify features of interest and prioritize areas for updates. Using change detection – also known as tipping and cueing – data layers in conjunction with other data layers saves analysts significant amounts of time, as they can hone in on those features that have changed since the last update.

ANTICIPATORY ANALYSIS

Considering four dimensions instead of the traditional three facilitates the formulation of scenarios that may be modeled and enhanced to reveal consequential insights. Looking forward, I believe that change detection data, which inherently present a set of consistent chronological dates with time ranges, facilitates the engagement of a number of anticipatory geospatial and statistical methodologies. Ultimately, change detection technologies and related future innovations are uniquely positioned to become important tools for modeling and predicting customer consequence.

Dennis Campbell is one of many foundation GEOINT specialists working to evolve the analytic tradecraft by incorporating useful and time-saving technologies.

WHAT'S YOUR STORY?

Tell us your personal, unclassified version of the work you or your office does for NGA for possible inclusion in the next Pathfinder. Send your 600 word or less account to Pathfinder@nga.mil. Submissions may be edited for clarity and length.

NEW SOLUTION MODELS 3-D OBJECT DATA

By HakJae Kim, Ph.D., NGA Research/IARPA

Timely access to geospatially accurate three-dimensional object data is a significant challenge. Without this data, however, it can be difficult to maintain global situational awareness, provide military intelligence or plan humanitarian assistance.

The U.S. government has invested in developing better ways to exploit 3-D data for geospatial intelligence. Researchers in academia and industry have also attempted to develop ways to capture the 3-D geometry and surface properties of objects on Earth more efficiently. Despite these various efforts, automated methods lag behind manual ones for creating 3-D models, extracting mission relevant information and understanding scenes.

Manually constructed models are accurate and reliable, but making them is time consuming. Of particular concern, the manual process cannot accommodate the provision of models to support rapid-response military efforts or humanitarian crises, especially in areas where up-to-date models do not exist.

This is exactly the type of highly challenging research problem the Intelligence Advanced Research Projects Activity tackles under the Director of National Intelligence. IARPA's mission is to envision and lead research that delivers innovative technology for future intelligence advantage.

Understanding both IARPA's propensity for pursuing high-risk, high-return innovation and the government's need to devise a solution for timely access to accurate 3-D data, I pitched the idea of CORE3D to IARPA soon after joining the DNI activity on joint-duty assignment from the National Geospatial-Intelligence Agency.

CORE3D has the goal of providing precise physical and functional modeling of 3-D objects of any region of the globe quickly and accurately. Objects modeled in CORE3D are invariant and large in size. Examples include buildings, roads, bridges, towers and dams. The program doesn't stop with showing a model of the object, though; it also models the object's material, texture and functionality.

The functional models in CORE3D focus on manmade object recognition and scene understanding. The program aims to develop methods to automatically recognize, tag and update predefined object categories from satellite imagery. The system currently has about 30 different defined facilities and hopes to expand to 50-plus facilities based on NGA's object database.

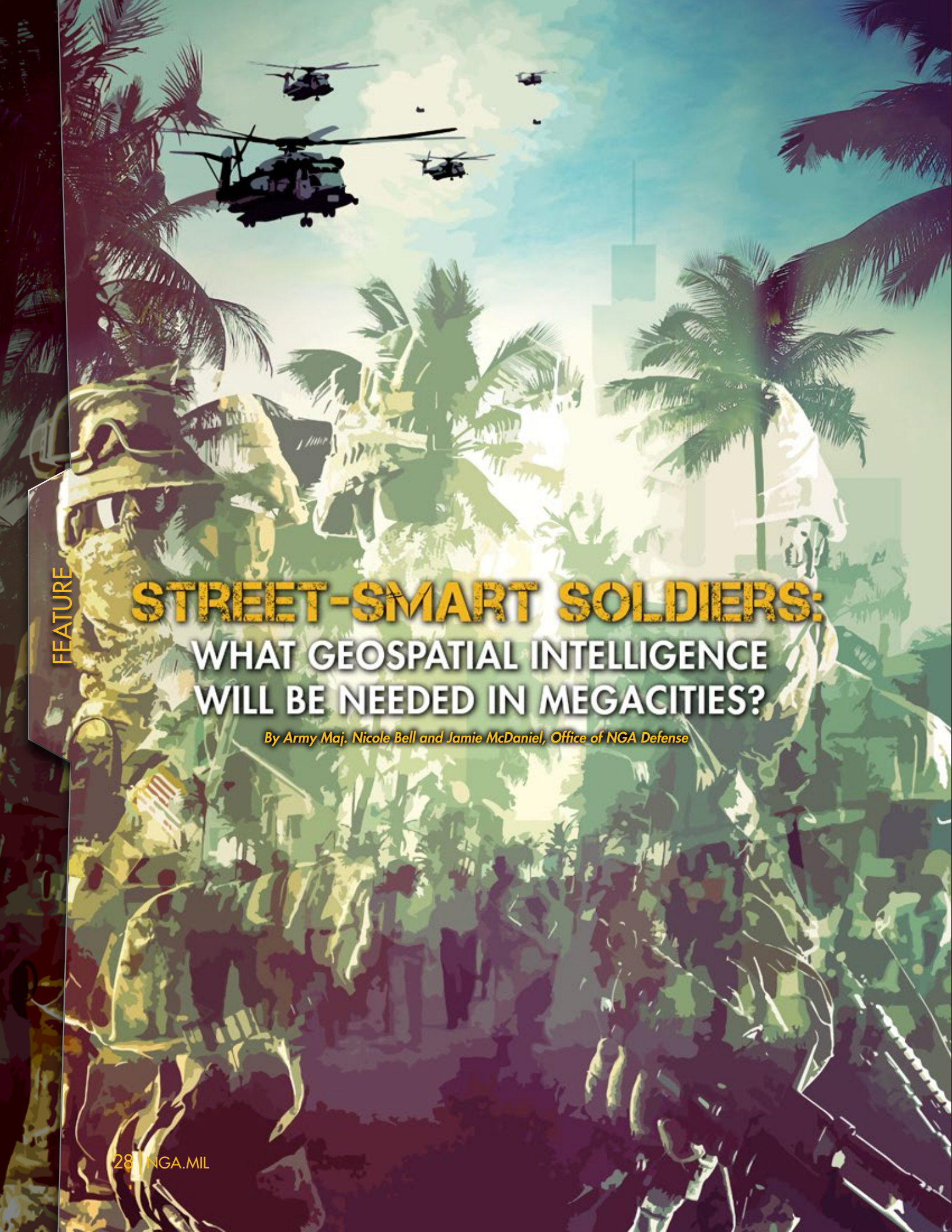
I announced CORE3D at IARPA's Proposers' Day at the end of March. The event provides a forum for presenting rigorously vetted programs to industry members who may be interested in partnering to work on the solution. Known elsewhere as an industry day, IARPA's Proposers' Day includes:

- A presentation from the contracting agent about the contracting process;
- An audience consisting of potential research performers and other interested parties who can ask clarifying questions of the program manager; and
- A chance for potential performers to meet and interact, which can facilitate the formation of teams of researchers who will work together to solve the problem.

For program managers, Proposers' Day allows for the gathering of feedback to fine-tune their concept before issuing a Broad Agency Announcement by which IARPA will solicit proposals for basic and applied research that is evaluated by a government panel.

The CORE3D Proposers' Day presentation slides are available on IARPA's unclassified website, http://www.iarpa.gov.

Scientist HakJae Kim, Ph.D., is on a joint-duty assignment from NGA Research to IARPA. He first became interested in IARPA as a result of his work to incorporate results from an IARPA program into a similar one he was building at NGA.



FEATURE

STREET-SMART SOLDIERS:

WHAT GEOSPATIAL INTELLIGENCE WILL BE NEEDED IN MEGACITIES?

By Army Maj. Nicole Bell and Jamie McDaniel, Office of NGA Defense

Retired Air Force Maj. Gen. Perry M. Smith, a noted military commentator, says, "Understanding future warfare is the most important responsibility of those who must defend a nation from future enemies."

The task requires careful analysis and planning, balanced with innovation, adaptability and the ability to forecast, among other things: Who will the enemy be? What will the threat and associated challenges be? What information is needed to enable military operations? When, where and why will crises occur requiring military operations? How will the responding forces be postured?

NGA can facilitate understanding for the Department of Defense with respect to where future warfare will likely occur and what geospatial intelligence the military services will need to effectively succeed in their missions. But to do so, NGA must first have an understanding of the future posture of forces and the operational challenges they are likely to face.

DESTINATION: COASTAL CITIES

In 2014 the Megacities Concept Team, Strategic Studies Group, under the Office of the Chief of Staff of the Army, identified that 60 percent of the world's population will reside in megacities — populations of 10 million or more — by 2030. Of that population, 60 percent will be under the age of 18.

As of 2015 there were 35 megacities identified in the world through multiple sources for population statistics. Of these, 86 percent of them are situated along coastlines or in littoral zones, i.e., near coastlines. Twenty-five of the 35 megacities are located in the Middle East, Africa and Asia.

These statistics suggest the inevitability of future armed conflict occurring in a megacity and within a coastal or littoral zone.

PREPARATION: HOLISTIC, COLLABORATIVE

NGA and its partners are preparing for the future conflict environment by collaborating on a Joint Intelligence Preparation of the Operational Environment study. The JIPOE thoroughly examines significant land, sea and air challenges that are likely to arise.

"Joint Publication 3-06, Joint Urban Operations" outlines the holistic challenges and planning considerations for the future force in joint urban operations. By extension, the JIPOE serves as planning for NGA.

First, how will the future force be postured? The Army's Training and Doctrine Command – TRADOC for short – describes the land force of 2025 and beyond as being rapidly deployable, regionally aligned, expeditionary, smaller, decentralized, joint, interorganizational, multinational and able to respond to multiple threats from both state and nonstate actors, all while maintaining homeland security.

The Army recently held a collaboration seminar with fellow services, international partners, academia and the private sector focusing on the future operational environment through 2040. This dialogue will drive future technology investments, Army training and tradecraft. Known as the Mad Scientist Conference, it was held at Arizona State University in April and focused on the future of warfare in megacities and dense urban areas.

In this collaboration, TRADOC defined anticipated missions in megacities as non-combatant evacuations, humanitarian assistance/disaster relief, raids, denial of adversary objectives, operations to counter weapons of mass destruction, military engagement and security cooperation. The future force will provide a global stabilizing presence, supporting civil authorities in addition to contributing to counterterrorism and counterinsurgency missions. Looking into the future, "the tasks have not changed, only the conditions have," said Col. Jake Conway, Army NGA Support Team chief.

ON THE SEAS

In parallel with TRADOCs future posturing, navies and marines around the world are embarking on major transformational maritime initiatives. As our allies and adversaries modernize their fleets and operating principals, the competition for the United States to adapt and adopt rapid technology development and insertion capabilities is critical for preserving U.S. strategic influence in key regions, waterways and areas near the coastal/littoral zones of the world's megacities. GEOINT is essential for safety of navigation, as well as for kinetic and nonkinetic military operations. To that end, NGA and the GEOINT community are transforming in response to the maritime forces paradigm shift.

The Navy Submarine Force finalized a consolidated strategic planning document in December 2015. "Commander's Intent for the United States Submarine Force and Supporting Organizations" describes the global environment, where approximately 70 percent of the world is covered in water; 80 percent of the population lives within a few hundred miles of an ocean coast; 90 percent of global commerce travels by ship; and over 95 percent of intercontinental communications travel via underwater cable. These facts define and influence the maritime domain associated with the megacities concept.

In the January 2016 strategy document "A Design for Maintaining Maritime Superiority," Adm. John M. Richardson, the U.S. chief of naval operations, describes future maritime challenges using three global force categories:

1. **Rapid expansion of classic maritime navigation** through burgeoning global economic markets, which has significantly increased traffic on the oceans, seas, waterways and the sea floor.
2. **Proliferation of global information systems** that connect the world through dynamic technology riding on highly capable servers, undersea cables, satellites and wireless networks, which has empowered individuals, organizations and nations to quickly engage and influence national defense and security.
3. **Global development, standardization and adoption of cutting-edge information technologies**, including hardware, software, web-based applications, new data types and related technology.

The nexus of these three factors has implications for the composition and posture of global maritime forces. Maritime operations in the 2025 timeframe will demand highly capable ship-to-shore future warfare systems that are designed for flexibility and agility to meet these maritime challenges. Understanding this provides NGA, the Navy, Marine Corps, Army and Coast Guard with insight to better plan for the future.

ON THE GROUND

For ground forces, challenges associated with future armed conflict in megacities include constrained advantages in detection, standoff, freedom of movement and precision firepower, as noted by TRADOC. "JP 3-06" outlines additional considerations for air operations, such as combat identification, propensity for collateral damage, preservation of infrastructure and line-of-sight obstructions.

NGA has the resources and experienced staff to contribute to JIPOE development in support of DOD in dealing with these challenges. "JP 3-06" and its companion, "JP 3-02, Amphibious Operations," detail intelligence requirements for future warfare in megacities and littoral zones. Requirements include nontraditional terrain analysis, with focuses in critical infrastructure, service infrastructure, human geography, sea base sustainment, littoral charting and land-based natural/urban terrain features. Each broad requirement encompasses more specific requirements:

- **Critical infrastructure analysis** must focus on transportation networks — streets, airports, seaports, bridges, rivers/canals, subways, bus/taxi systems, highways, railways — utilities, government buildings, hospitals, schools, food processing and distribution centers, communication facilities, and phone and electrical lines — vertical obstructions. This includes city and street pattern analysis.
- **Service infrastructure** — police, fire, government services, food and water availability and distribution, medical services, fuel and electricity, sanitation, education, information flow — and the **electromagnetic spectrum** — air traffic control, emergency communications, navigation systems — must be analyzed.
- **Human geography** must account for traffic patterns and travel analysis beyond typical demographics and densities, cultural/political/religious/social lines, criminal activity, refugee concentrations, etc.
- **Sustaining sea bases** — maintaining a distributed maritime presence to minimize destabilization — by providing reserves, force protection, logistics and administrative functions in support of urban operations. This will require NGA to conduct thorough analysis and produce planning charts for both the seaward avenues of approach and the coastal waterways.
- **Natural terrain features,** such as coastlines, rivers, lakes and mountains, influence city designs and patterns, and therefore must be analyzed. "JP 3-06" further specifies that urban terrain features include the airspace, super surface, interior, exterior, surface and subsurface layers. **Urban functional zones** include outlying high-rise areas, industrial areas, residential areas, the core periphery, commercial zones, the urban core and the military area. Further, building displacement must be noted.

AT NGA

NGA's contributions to the services' non-combatant evacuation operations provide excellent examples of the importance of NGA products, data and services to the current and future success of each of the military services, especially when operating in a megacities environment. NGA's NEO support to the Navy and Marines is augmented by NGA-developed web-based apps capable of operating in both connected and disconnected environments. Among the most relevant apps are Disconnected Interactive Content Explorer and GLIMPSE, as well as the proven Mobile Awareness

GEOINT Environment, known as MAGE. All of these examples are available to the services through NGA's open-source GitHub mobile application account. [See box for descriptions of each app.]

FUTURE WARFARE SUPPORT

The Army's Megacities Concept Team noted that DOD intelligence community "efforts focus not on cities but on countries, regions, adversaries and other trends of concern to decision makers."

NGA's Future Warfare Systems Division recognizes an opportunity for NGA to support the DOD IC with a robust megacity database on the unclassified and secure internet protocol router network — a.k.a., SIPRNet — for both all-source military analysts and geospatial analysts. According to division personnel, such a database would have to address the aforementioned critical/service infrastructure and subterranean analysis, sea base sustainment, littoral charting, human geography, urban and natural terrain analysis, and extensive 3-D mapping. It could be incorporated into the Map of the World GEOINT content tool, along with crowd-sourcing capabilities from across the IC and joint forces.

They believe the database would be most valuable if aligned with locations of increased indications and warnings, or in other words, places where the future conflict or crisis is likely to occur — the identification of which is also an NGA capability. It also could maximize input from the Army's regionally aligned forces units and Geospatial Planning Cells.

Whether creating unique databases or open-source apps, NGA is engaging on many fronts with the joint forces, industry, academia, and interagency research and development teams to anticipate and deliver integrated GEOINT capabilities for the future.

NGA-DEVELOPED APPS SUPPORT MILITARY OPERATIONS

The following apps are among those available through NGA's open-source GitHub account.

- The Disconnected Interactive Content Explorer app enables tactical users to interact with feature-rich content — including interactive maps, videos, charts and data — in a disconnected/offline environment. The DICE app fills a key gap for disconnected Navy and Marine planners who are continuously updating maps and charts used in NEO operations.

- The GLIMPSE mobile application allows tactical users, such as first responders and security teams, to simply and securely share live video streams and broadcasts, which can be viewed by multiple users simultaneously on Android mobile devices or desktops. GLIMPSE enables teams to share live feeds of events without transmitting across public services.

- The Mobile Awareness GEOINT Environment is a full-stack, open-source mobile situational awareness capability that allows users to quickly geotag field locations and observations directly on photos, video, audio and other document attachments. MAGE helps its users meet mission needs for responding to natural disasters or investigations, or for supporting major security or special events.

EXPEDITIONARY TECHNOLOGY SHARPENS THE TACTICAL EDGE

By Anne Helms, Ctr., Expeditionary Operations Office

FEATURE

Along with its military service partners, NGA is marching double-time ahead of socio-political trends and global-scale threats that challenge the boundaries of traditional intelligence analysis. Fueled by the frenetic pace of 21st century communication, the shape-shifting of world events has launched GEOINT and the people who deliver it into the deep end of the information age.

The key to staying ahead of the intelligence tsunami, not surprisingly, is to work more quickly and smartly. Underpinning NGA's irrefutable human capabilities is its determination to explore and develop forward-leaning technology solutions to apply to unique customer problem-sets. Delivering real-time, fused intelligence moving forward will depend more and more on the agility and tools to rapidly access, process, visualize, transmit and share key commodities and analytical products.

It's no mistake that a large portion of the agency's tech innovations are ignited and incubated as result of its forward-deployed, expeditionary role. Working alongside military and other government customers, deployer embeds and NGA Support Team personnel must navigate frontline challenges firsthand. In what are frequently austere and disadvantaged environments, where low network bandwidth and connectivity issues present some of the greatest obstacles for our analysts and partners, NGA is a crucible for needed advancement. We have the unique opportunity in these settings—outside the boundaries of bureaucracy— to employ new and emerging technologies and to engineer and test custom solutions that enable access to GEOINT data and services on warfighter and coalition networks.

As deployers return to NGA, "they obviously bring back the mission with them," said NGA Director Robert Cardillo.

This combined onsite and reach-back support encourages customer adoption of novel GEOINT solutions, while challenging DOE and NGA at-large to refine offerings and delivery methods that can tackle new mission requirements. The agency's highly touted Ship Rider program, for example, introduces NGA's enterprise GEOINT services to a growing number of afloat operations, improving GEOINT analysis and safety of navigation. During the program's pilot aboard the carrier USS Roosevelt, the OCONUS Data Center's streaming imagery services were enlisted and have significantly reduced the time to access new imagery at sea for immediate operational impact.

In Afghanistan, Iraq and across Africa, NGA is working to expose and employ the Protected Internet Exchange to an increasing number of coalition partners. PiX offers low-bandwidth geospatial services and is optimal for coalition sharing because of its internet accessibility and minimal training required for use.

NGA's expeditionary construct, which ensures the ability to deploy in response to crises within just hours, pivots around the continual upgrade of existing equipment with new data and technologies. NGA personnel are currently testing a service that will enable analysts to create 'smart data bricks' for rapid deployments. These GEOINT data-loaded hard drives, along with micro SD flash cards, provide quick access to standard and nonstandard foundation data. Smart bricks will allow automatic updates for most locations, which is especially critical during disconnected operations or when using mobile devices.

As the demand for military-provided communications continues to grow and outstrip supply, the ability to take advantage of commercial communications is also becoming a substantial catalyst for our success. To ensure that the agency is able to deploy communication and production capabilities worldwide via the lightest, most flexible deployment packages possible, NGA is leveraging the commercial Internet to the widest extent possible. The agency is championing the development of deployable systems that can tunnel secure global communications over commercial Internet connections, decreasing the time to provision communication and reducing the NGA deployment footprint.

"Where the expeditionary mission is dependent on the ability to access data and services, adapting our technology to immediate requirements—no matter how difficult they are—is a top priority," said Chris Jarvis, director of the NGA Expeditionary Operations Office. "Our deployed work pushes us to continually reinvent how we deliver geospatial intelligence to and from the tactical edge, to get it to the right people in the right place on time."

THE 'IN' CROWD: NGA ADOPTS THE CROWDSOURCING MODEL

By Will Mortenson, NGA Foundation GEOINT Group

For more than 60 years National Geospatial-Intelligence Agency and its predecessor organizations have been the standard-bearers for building quality maps to support both military and senior decision-makers throughout the government for a variety of missions.

But the world of map-making is changing, and the government is playing a less-centralized role, as more and more commercial entities become dependent on geographic information systems — a.k.a. GIS — data to meet their business needs. As far back as 2012, Business Insider reported that Google employs more than 7,000 people to work on maps that generate dynamic content.

More recently, The Future of Maps report, commissioned by NGA Research and the Army Geospatial Center, highlighted the growing role of nongovernment entities. It noted that improved communication capabilities have led to innovative solutions across the various sectors of the open-source geospatial community. As a result, NGA has been busy identifying future investment and implementation strategies to harness the power of such interconnectivity for producing foundation geospatial data.

One of the underlying forces driving change within the GIS industry has been the adoption of the Wikipedia model to GIS data production. This trend achieved mainstream academic acknowledgment by University of California Santa Barbara's Michael Goodchild, who is credited with defining the concept as Volunteered Geographic Information, or VGI.

The prevalence of VGI has grown exponentially through the evolution of web technology and social media, resulting in the creation of free and publicly available geospatial information — places of interest, transportation networks and geo-tagged multimedia. Platforms such as Wikimapia, OpenStreetMap and Google Earth have been key enablers of VGI, drastically reducing the time and cost for creating, managing and updating geospatial information traditionally reserved for professional cartographers using specialized software.

Recognizing the rise of VGI tools and capabilities, NGA Foundation

GEOINT Group Director Kevin Hope established a pilot program to determine how VGI could be used to support NGA and its partners in the future. This program, operating since October 2015, has developed a collection approach called the VGI TRIAD, which is composed of active and passive VGI components, and a community-sourcing component. The active component queries the public on questions relating to specific features on Earth; the passive component provides data to the public for further VGI enrichment. The community-sourcing component establishes a collaborative mapping environment where analysts worldwide can collaborate simultaneously on shared datasets.

These three components will feed what will be known as NGA's NSG Open Mapping Enclave – NOME for short – a current work in progress. The Foundation GEOINT Group based NOME on the successes of the nonprofit OpenStreetMap Foundation and has begun developing an internal crowdsourcing environment for NGA and its mission partners.

Together, the NOME services allow GIS experts and entry-level users alike to generate and discover foundation GEOINT at the unclassified level via a centralized repository that is automatically accessible across the community. For example, a first responder could add information about a damaged building or road observed during a disaster relief mission, and render said information immediately available to all fellow aid providers regardless of where they are.

This new environment has already received recognition and praise from external partners who value its means to conduct outreach and collaboration.

"In our opinion this is a huge win for the entire intelligence community…the leading edge of technology for the IC," said Terry Busch, a DIA division chief for integrated analysis and methodologies.

Those involved acknowledge that achieving such milestones will require a cultural and technological change in the way GEOINT data is created and disseminated. Sharp changes in direction are difficult in large organizations such as NGA.

But as retired U.S. Army Gen, Eric Shinseki said, "If you don't like change, you will like irrelevance even less."

NGA HELPS KEEP THE WORLD ON COURSE

By Richard Salman and James Brown, Ctr., Foundation GEOINT

Every day as many as one billion people use a mapping or navigation device to find something. Most people know that the GPS (Global Positioning System) feature on their devices provides their position, speed and direction to follow – but they may not know that their GPS device can't tell which way they are facing.

"That is one problem with GPS," says James Friederich, a senior officer in the National Geospatial-Intelligence Agency Office of Geomatics. "It's great at positioning, but it can't do orientation: Here I am, but am I facing north, or am I facing east?"

WORLD MAGNETIC MODEL

To solve this problem, navigation devices use magnetometers (high-tech compasses) to determine direction within the Earth's magnetic field, a technique used for hundreds of years in navigation. There are several complicating factors about the Earth's magnetic field, however; the north magnetic pole does not coincide with the north pole of the earth. It is approximately 400 miles to the southwest in Canada. As a result there will be directional offset, called declination, between magnetic north sensed by a compass and true north defined on maps. To further complicate matters the north magnetic pole is moving approximately 35 miles per year northwesterly towards Siberia.

The NGA Geomatics Office helps keep navigation devices accurate by providing the World Magnetic Model. The WMM is a representation of the Earth's large-scale magnetic field, including the computations required to compensate for the north magnetic pole's drift and the offset from true north. The WMM comes pre-installed on Android and iOS devices to correct for the magnetic declination.

The Earth's magnetic field arises from many sources, some external and some internal, that vary with location and time. Specialized instruments onboard dedicated satellites and at ground observatories that are capable of measuring the Earth's magnetic field strength and vector components collect the data necessary to create the model. The WMM is produced at five-year intervals and is distributed by the National Centers for Environmental Information on behalf of NGA. The current WMM expires in 2019, and a new model will take its place.

The utility provided by the WMM for navigation is an indispensable complement to maps, charts and GPS devices used by the Department of Defense, the U.K. Ministry of Defence and NATO, as well as the International Hydrographic Organization and a wide array of civilian navigation applications.

WORLD GEODETIC SYSTEM 1984

The WMM is one of several systems within the World Geodetic System 1984, also known as WGS 84. WGS 84 is the official geodetic reference system for the National System for Geospatial Intelligence, or NSG, and the activities of Notice to Mariners collections, mapping and charting, safety of navigation and targeting. The NGA Geomatics Office produces and maintains WGS 84.

WGS 84 is an ellipsoid model rather than a sphere that defines our latitude, longitude and ellipsoid height system. A single defined ellipsoid ensures that military mapping grids in meters are properly linked to the latitude and longitude degree-minutes-seconds system. Different-shaped ellipsoids yield different positions on the earth.

The WGS 84 reflects our dynamic physical earth and takes into account geodynamic motions such as plate tectonics and the daily movement of the spin axis of the earth. Although WGS 84 may sound 30 years old because of its name, NGA geodesists update it daily.

EARTH GRAVITATIONAL MODEL

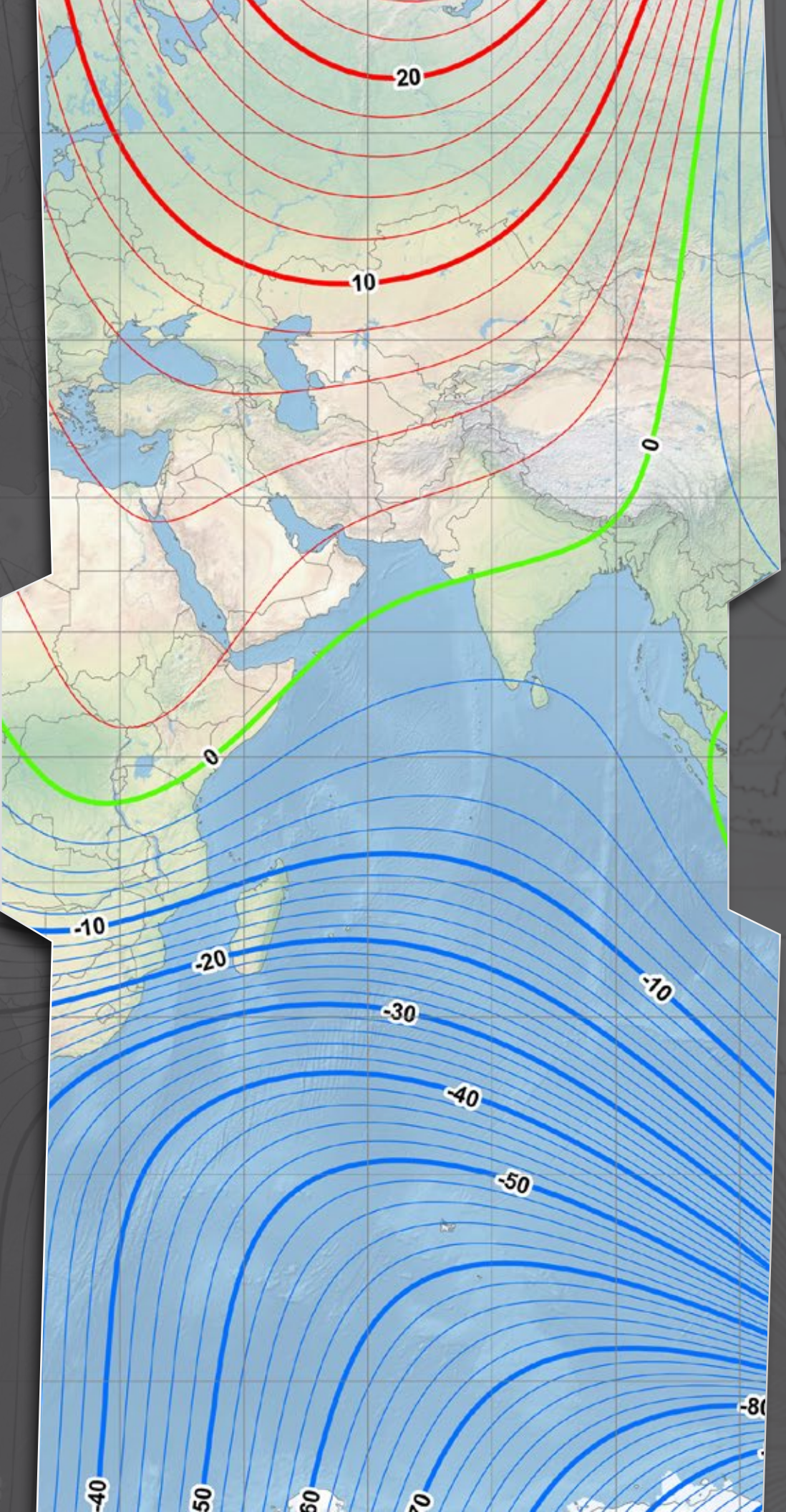
Another system within the WGS 84 is the Earth Gravitational Model and geoid model. The EGM represents a highly irregular surface whose shape results from uneven mass distributions within the earth. Although gravity is not an actual physical surface you can see or touch, the effects of gravity on NSG systems is real.

Similar to the effect that gravity from the moon and sun has on ocean tides on the earth, the gravity forces of uneven mass distributions in the earth – mountains, valleys and various rock strata in the crust – cause what can be described as 'permanent tides.' These permanent tides force water to pile up where gravity is higher and to be pulled away where gravity is lower, to form an irregular, lumpy, bumpy surface for the oceans.

If we measure gravity everywhere, we can model how the oceans will lie and we can define a mean sea level. The EGM thus serves as the defining vertical reference surface to represent global mean sea level heights for NSG operations.

Beyond its use for mean sea level, the EGM is used directly to predict and correct for disturbances in the regular movement of satellite orbits due to the Earth's gravity anomalies. It is also used as the basis for more advanced gravity correction models for high-accuracy DOD inertial navigation systems.

NGA maintains the world's largest gravity database. The agency is currently working with several partners to build the next model, EGM2020.



DID YOU KNOW?

The Global Positioning System, or GPS, has become the world standard for geolocation. The traditional geodesy and photogrammetry skills practiced by NGA and its predecessor agencies made GPS possible.

In 1984 one of NGA's predecessors, Defense Mapping Agency, participated in creating WGS 84, a geodetic reference frame that enabled scientists to identify the Earth's mass and the location of its center to within the size of the average postage stamp (a 22 mm by 19 mm space). The accuracy of WGS 84 set the stage for the emergence of GPS as a fully operational capability in 1995.The multi-satellite GPS constellation remains in its proper configuration because of daily geodetic support from NGA.

GEOINT On the Rise 20 1996 NGA 2016

DOD served by long-term joint mapping tool

By Eric Young, CIO and IT Services

Over the past decade more than 250,000 Department of Defense warfighters and decision-makers have used a commercial joint mapping toolkit to devise mapping solutions used on aircraft, aboard surface warships and submarines, in static headquarters, and on both mounted and dismounted platforms for ground forces. A mobile solution also exists for handheld and tablet devices.

National Geospatial-Intelligence Agency and its predecessors partnered with several commercial partners years ago to support the toolkit. While the long-term commercial contract expired at the end of 2015, NGA will continue to provide support to DOD customers through a legacy sustainment contract.

HISTORY

In the mid-1990s DOD began consolidating several mapping, charting, geodesy and imagery software components for command-and-control systems into what became known as the Joint Mapping Toolkit. The JMTK supported applications that ran on the Defense Information Infrastructure Common Operating Environment used in all the DOD command, control, communications, computers, intelligence, surveillance and reconnaissance systems at the national, joint and service levels.

In the 1999 Defense Authorization Bill, Congress directed that future versions of the JMTK be based on commercial technology to increase interoperability and collaboration. In June 2002 the National Imagery and Mapping Agency, NGA's predecessor, awarded a development and lifecycle support contract for the Commercial Joint Mapping Toolkit, or CJMTK. This award represented the adoption of the ArcGIS platform as the recommended toolkit for the management, analysis and visualization of geospatial intelligence for the DOD command, control and intelligence – C2I – community.

The CJMTK is not a single product but a comprehensive set of geospatial software components that form an integrated GIS platform. Developers have been able to choose the appropriate parts of the ArcGIS architecture that best fit their requirements.

ACHIEVEMENTS

CJMTK, through its nine major releases, has provided the community with tools that support advances in technology and achieve the goal of increased interoperability and collaboration. Operating systems have changed and other upgrades have occurred at no extra cost to the government or user community. At the same time, and as a tangible example of government-industry collaboration at its best, CJMTK users also influenced the evolution of commercial products used for embedded mission products.

In the past decade, more than 50 operational C2I programs have fielded with CJMTK technology, for an estimated end-use count more than twice the original expectation. An additional 60 programs are working on their own implementations of the technology. These include the Army's Distributed Common Ground System, DOD's Generic Area Limitation Environment, the Marine Corps' Command and Control PC [personal computer], the Navy's Consolidated Afloat Networks and Enterprise Services, and the Joint Mission Planning System used by both the Navy and the Air Force.

The program has supported multiple exercises, joint-capability technology demonstrations, coalition warfighter interoperability demonstrations and technical symposia. Across the enterprise, CJMTK assisted the Army Geospatial Center as a center of excellence for terrain reasoning, which has evolved into the current Situational Awareness Geospatially Enabled program.

FUTURE

The CJMTK contract ended at the end of 2015, after more than 13 years of collaborative success. NGA continues to provide CJMTK GEOINT services to the DOD community through a legacy sustainment contract. The software, acquired through a blanket purchase agreement, is being provided by the Esri ArcGIS Platform, along with regular software updates and full technical and lifecycle support.

CHOOSE YOUR OWN ADVENTURE:
The future of collaborative analysis

By Amelia Cohen-Levy, Ctr., Analysis

Imagine a way to combine the best parts of a discussion – the questions, the give and take, even the argument – complete with imagery and geospatial data. That's the concept of the GeoNarrative standard: immersive, digital storytelling that is query-able, traceable and transparent.

Intelligence Community Directive 208, "Write for Maximum Utility," calls for the distribution of intelligence products that "provide the greatest use to customers." Information must be easy to discover, use and share. ICD 208 also calls for "innovative product organization" with the goal of enabling "tailored reuse of the product."

In summer 2016 NGA Research, the key component within National Geospatial-Intelligence Agency that focuses on exploring emerging capabilities, launches its Map of the World GeoNarrative plug-in to help NGA meet those requirements. This homegrown solution is an example of cross-agency teamwork at its best: NGA Research made the sparks, Source provided a collection of GEOINT data for kindling and Xperience fanned the flames. Now, Team NGA can come together and make knowledge production a social endeavor.

The GeoNarrative tool turns static snapshots into a conversation. The resulting dialogue, and ultimately the end product, thrives when people contribute to, interact with and challenge the data. Users at every level of understanding, from decision maker to connoisseur, can connect in a way that suits them, choosing their own adventure.

Connecting the GeoNarrative to MoW necessitated a change in ownership from Research to Xperience, but paid off by leveraging GEOINT Visualization Services' robust operating environment.

"Since the development was already being done in InnoVision [now known as NGA Research], it was a natural progression to explore GeoNarrative as a plug-in for MoW," said Marti Spaulding, the GeoNarrative product owner in Xperience.

Both the GeoNarrative standard and plug-in encourage the reuse of data, which saves production time and increases the quality and depth of analysis for customers. This focus on the democratization of information reflects ICD 208, NGA's strategic call to succeed in the open, and MoW's commitment to open standards.

"The end-state goal for having this open architecture is to ensure that we can leverage sources from everywhere – academia, industry and government," Spaulding said. "We don't want to miss out on any capabilities that may lead to analytic revelation."

Intelligence community production transformation is hardly a new concept; much of the thinking behind the GeoNarrative standard was inspired by Chris Rasmussen and the idea of 'living intelligence,' a model where a range of information is mixed together in a transparent common space and the intelligence topic is constantly updated. Rasmussen, who leads NGA's GEOINT Pathfinder 2 initiative, which strives to answer intelligence questions using only open-source data, saw the value in building a community knowledge base a decade ago, but at the time, the ask was too much.

"Innovation has nothing to do with technology," Rasmussen said. "It's a people process and only works if people stop being wedded to legacy systems and make the shift."

To realize the geo-narrative concept on its own terms and avoid settling for whatever options industry provided, Team NGA had to roll up its sleeves.

"The build way is hard," said Josh Trampier, Ph.D., an NGA Research scientist. "It represents a different kind of agency commitment – to a standard, to an ideal – and it takes a certain amount of courage."

When Cort Stowe, the geo-narrative technical lead in Research, spoke about taking the vision from prototype to implementation, he kept returning to the idea of using the software to increase analytic efficiency.

"If we eliminated a lot of the overhead, automated the data gathering and had a community ready to collaboratively create the narrative, you could leverage existing stories and simplify the tasks analysts usually find cumbersome, allowing them to instead focus on accurate and detailed reporting," Stowe said.

This is exactly the thinking NGA Director Robert Cardillo called for in his September 2010 article for *Studies in Intelligence* titled "Intelligence Community Reform: A Cultural Evolution." Cardillo wrote that the IC needed to focus its efforts on the future state and drive changes accordingly.

"In the IC, *our analytic tradecraft is our culture*….There must be some demonstrable change in our tradecraft – our actual daily business processes," Cardillo said. "It is the responsibility of IC leaders to set the conditions that will allow the newest, talented generation of analysts to help our customers succeed."

Our pictures are accompanied by a thousand words because there are lessons in the narrative – just ask any analyst. The team behind the GeoNarrative tool hopes it provides another way to tell that story.

14,000 VESSELS TRANSIT THE PANAMA CANAL, GENERATING OVER $2 BILLION IN REVENUE.

THE 30 COUNTRIES ACCOUNT FOR APPROX. 600 MILLION PEOPLE IN THE COMMAND AREA AND OVER 20 LANGUAGES AND DIALECTS.

THERE ARE OVER 31 MAJOR ACTIVE AND INACTIVE VOLCANOS ALONG THE EASTERN RING OF FIRE.

THE LARGEST EARTHQUAKE EVER RECORDED WAS 9.5 AND OCCURRED MAY 22, 1960 OFF THE SOUTHERN COAST OF CHILE.

60 PERCENT OF THE WORLD'S RAINFORESTS ARE LOCATED IN BRAZIL

USSOUTHCOM

INFORMATION PROVIDED BY NGA OFFICE OF GEOGRAPHY

SOUTHERN COMMAND'S AREA OF RESPONSIBILITY ENCOMPASSES 30 COUNTRIES, 11 TERRITORIES/ PROTECTORATES AND COVERS ONE-SIXTH OF THE WORLD'S LANDMASS.

12 OF THE WORLD'S LARGEST CITIES ARE LOCATED IN CENTRAL/ SOUTH AMERICA, INCLUDING RIO DE JANEIRO, HOME OF THE 2016 SUMMER OLYMPICS.

3 OF THE WORLD'S LARGEST MILITARIES ARE LOCATED IN CENTRAL/SOUTH AMERICA.

"...THE U.S. MILITARY IS SUPPORTING INTERAGENCY EFFORTS WITH LATIN AMERICAN AND CARIBBEAN STATES TO PROMOTE REGIONAL STABILITY AND COUNTER TRANSNATIONAL CRIMINAL ORGANIZATIONS."

– THE NATIONAL MILITARY STRATEGY OF THE UNITED STATES OF AMERICA, 2015

COMMERCIAL IMAGERY SUPPORTS ANOTHER FIRST PLACE

The 2016 Summer Olympics will mark another first for the Maracanã Stadium in Rio de Janeiro, Brazil. The stadium was built to host the first FIFA World Cup in 1950. This summer it will be part of the venue for the first summer Olympics ever hosted in a South American city.

The upcoming Rio Olympics actually mark several firsts in terms of location. These will be the first summer games held entirely during a host country's winter season. They will be the first held in a Portuguese-speaking country, and the first since 1968 to be held in Latin America.

In addition to hosting the 1950 World Cup, Maracanã Stadium hosted the opening and closing ceremonies of the 2007 Pan American Games, and volleyball matches in 1980 and 1983 between Brazil and the former Soviet Union. Several major musical events have also been held at the stadium over the years, including performances by Frank Sinatra, KISS, Sting and Madonna. Both Paul McCartney and Tina Turner attracted such large crowds to the venue in the late 1980s and early 1990s that they made the Guinness Book of World Records.

National Geospatial-Intelligence Agency routinely provides geospatial intelligence support during events such as the Olympics. The agency partners with commercial imagery providers and others to support security personnel as requested. NGA typically provides support through mobile apps, its Map of the World content tool, and other data and web-based services provided to partners.

To learn more about how NGA supports public safety during special events, visit http://www.nga.mil

GEOINT

On the Rise

1996 NGA 2016

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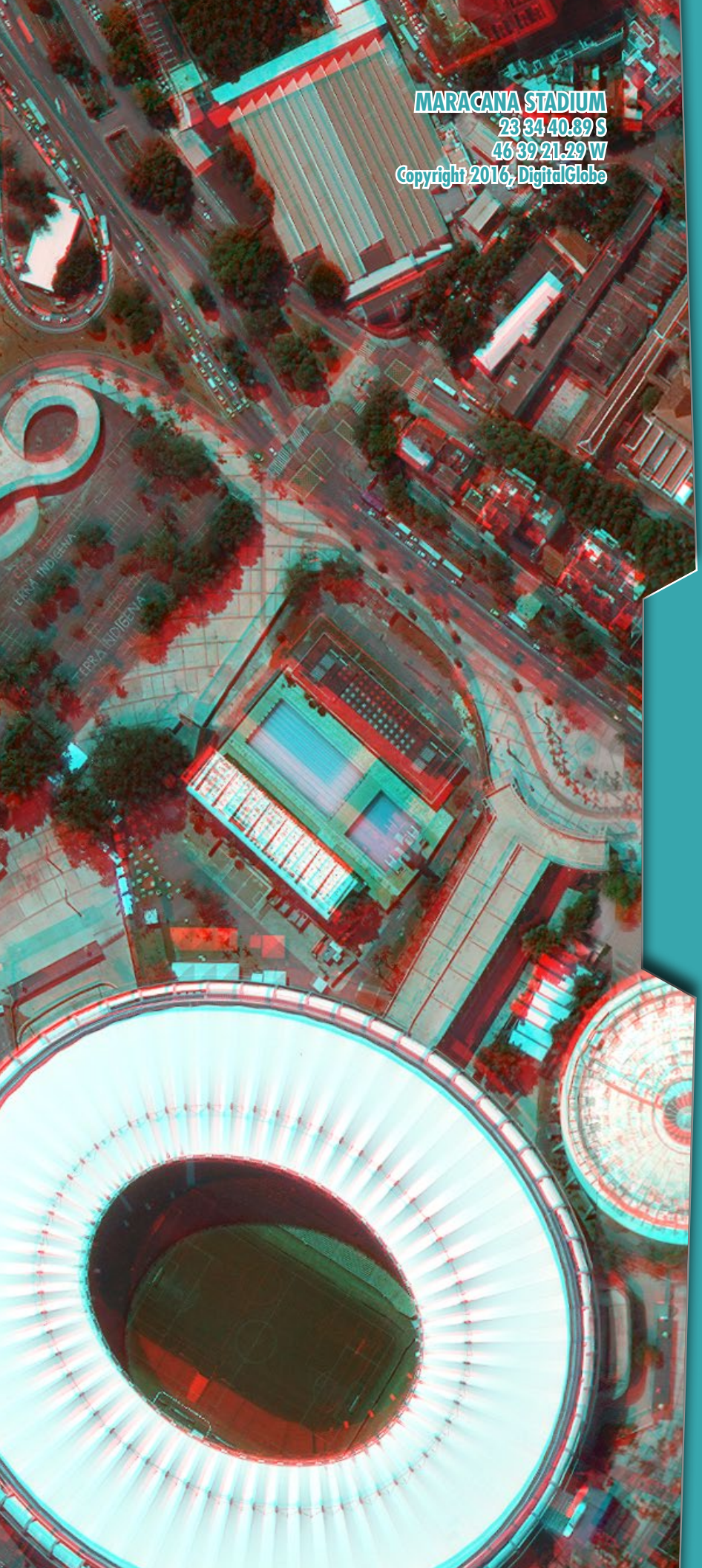

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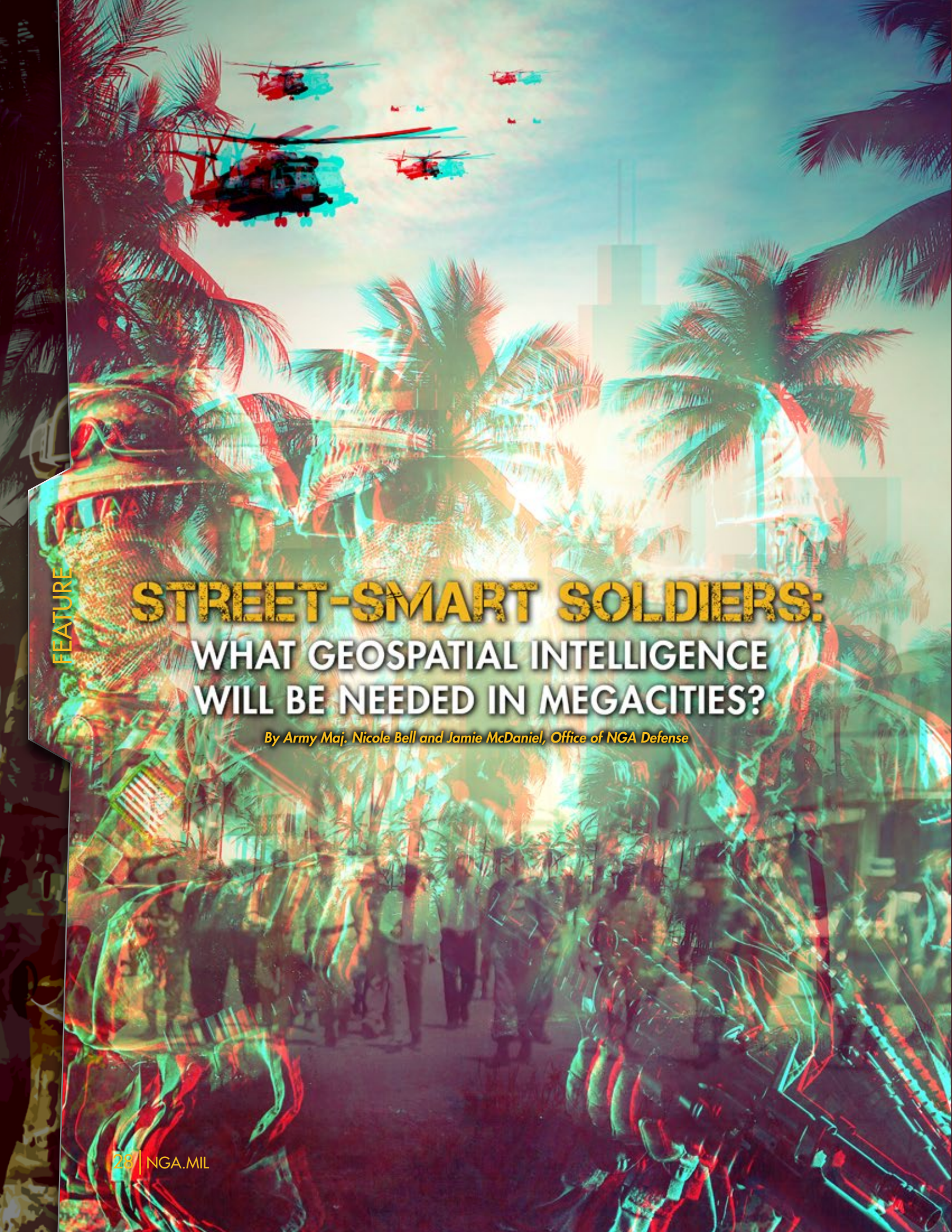

FEATURE

STREET-SMART SOLDIERS:

WHAT GEOSPATIAL INTELLIGENCE WILL BE NEEDED IN MEGACITIES?

By Army Maj. Nicole Bell and Jamie McDaniel, Office of NGA Defense