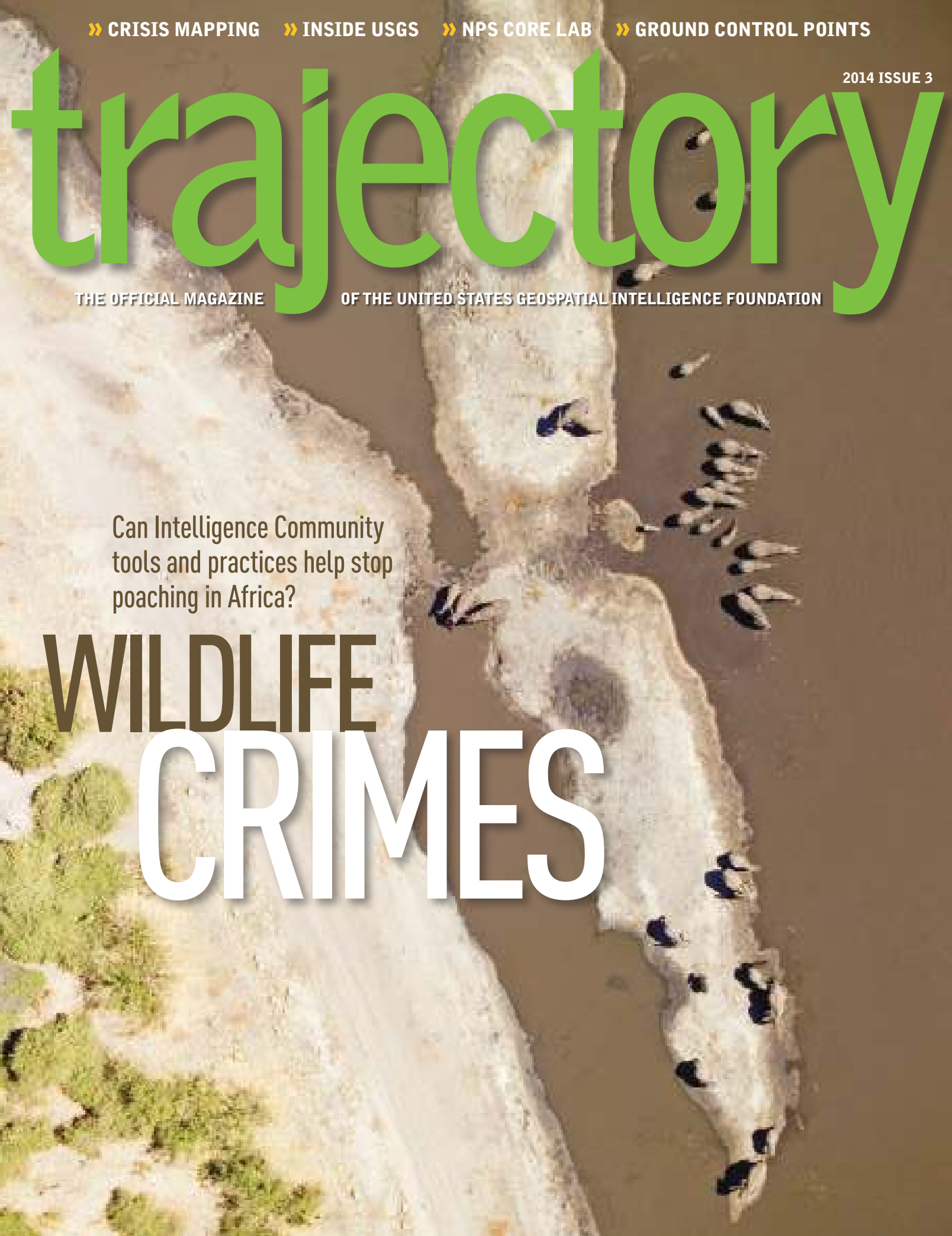
» CRISIS MAPPING » INSIDE USGS » NPS CORE LAB » GROUND CONTROL POINTS

2014 ISSUE 3

trajectory

THE OFFICIAL MAGAZINE OF THE UNITED STATES GEOSPATIAL INTELLIGENCE FOUNDATION



Can Intelligence Community tools and practices help stop poaching in Africa?

WILDLIFE CRIMES

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Elephants on the Chobe River in Botswana, Africa.
©GETTY IMAGES

IMAGE ABOVE: A Falcon UAV is bungee-launched on a demonstration flight for the World Wildlife Fund's Wildlife Crime Technology Project.

TRAJECTORYMAGAZINE.COM

VIDEO
The Enough Project investigates elephant poaching by Joseph Kony's Lord's Resistance Army.

PRESENTATION
Josh Campbell discusses the coordinated campaign for action behind MapGive.

INTERACTIVE
USGS has created a range of interactive mapping web tools for free public use.

TRAJECTORY APP

DOWNLOAD
the free *trajectory* tablet app to view bonus material and integrated multimedia content.

READERSHIP ANALYTICS

Recently, while flying home from a great family vacation in the Pacific Northwest, I waited until my wife and children were asleep to crack open the 2014 *trajectory* reader survey results. Fresh off USGIF's successful data analytics workshop, I was actually kind of jazzed to have the opportunity to work on some analytics of my own.

Thanks to the USGIF culture of being transparent and responsive to our members, partners, and event attendees, we generally get a relatively robust response for surveys of all types. I'd like to share some observations with the *trajectory* readership based on the most recent survey data.

First, we learned more about how our readers prefer to receive and access *trajectory* content. You are very interested in both the print and web editions, and appreciate getting updates via LinkedIn and our e-newsletters. Based on this, we've increased the *trajectory* e-newsletter frequency from quarterly to monthly and are considering expanding our LinkedIn presence. The *trajectory* website recently won an award, and we'll continue to work hard to ensure the site is a great way to access content, especially all of the great bonus content we can't always fit into the print edition.

We're certainly aware of the slow adoption rate for the *trajectory* app, which is disappointing because the medium is truly interactive and rich with added content. It was interesting to learn that although 64 percent of you own tablets, only 15 percent use the *trajectory* app, and only 5 percent use a tablet as your primary method of content consumption. Based on this feedback, we are re-evaluating the resources applied against the app. Perhaps they can be better allocated for an interesting suggestion several of you made: to work to get *trajectory* articles posted on SIPRNET and/or JWICS.

GEOINT is both a vertical intelligence stovepipe and the horizontal underpinning for intelligence integration and operations of all types.

In general, the messages from the survey were clear. However, there was some dissension in the data with respect to content. There were equally loud calls to broaden the reach of the content, as there were to better delimit subject matter to focus solely on NGA and GEOINT. We don't see these as mutually exclusive. GEOINT is both a vertical intelligence stovepipe and the horizontal underpinning for intelligence integration and operations of all types. Therefore, *trajectory* will continue to offer a broad array of topics, all ultimately related to imagery, imagery intelligence, and/or geospatial information.

Please enjoy this issue, which includes a look at the potential for GEOINT to help stop animal poaching, a crisis underappreciated as a national security issue. Additionally, take the opportunity to get caught up with advances in crisis mapping and learn more about a great USGIF partner, the U.S. Geological Survey.

Finally, thanks so much for your survey responses and ongoing support for the magazine, in all its forms. Please stay in touch—don't wait until the next reader survey to send us feedback. We at USGIF are at our very best when engaged in ongoing conversations with readers, attendees, volunteers, and other representatives from across the broad array of our member companies, organizations, and academic institutions.

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@geointer

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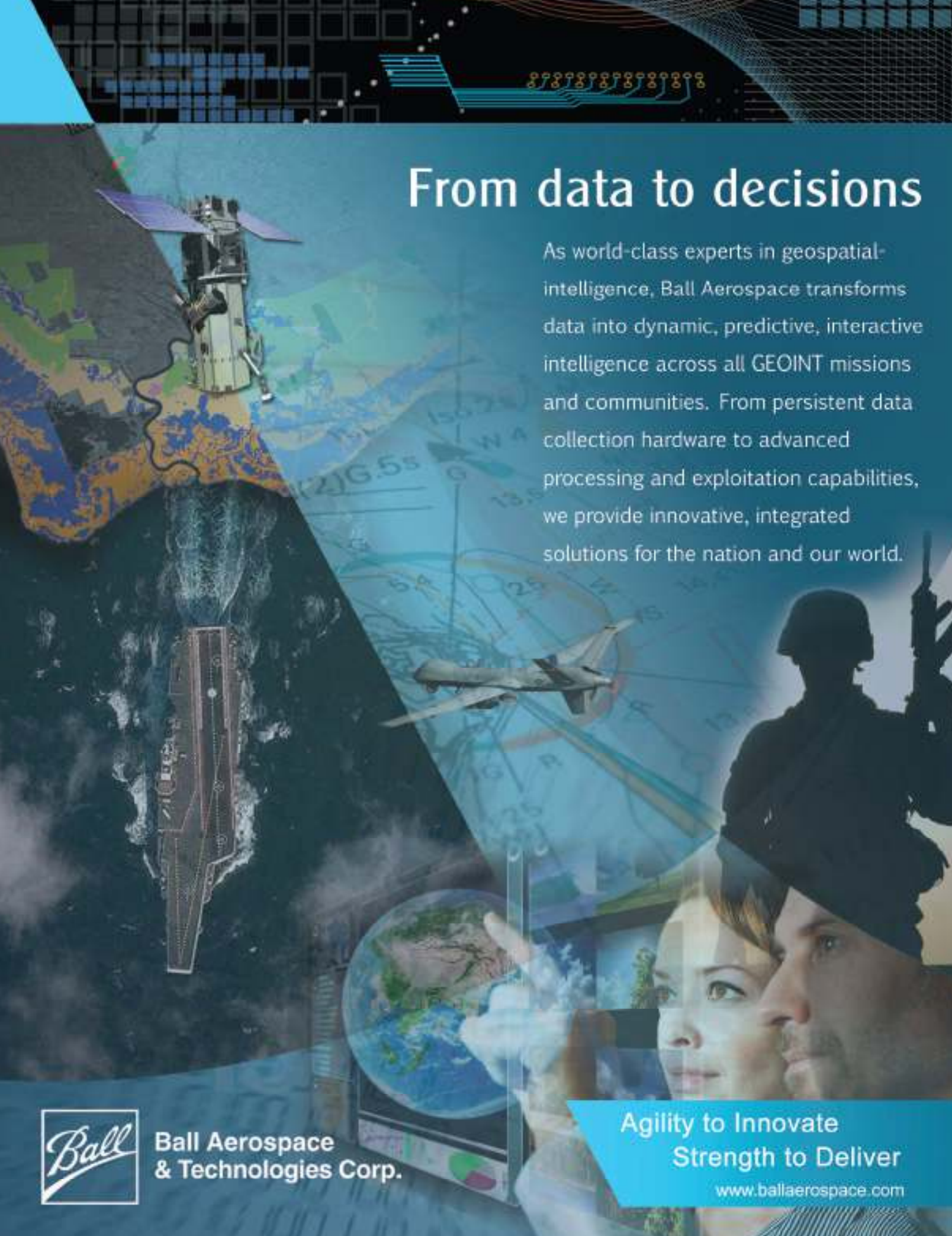
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INSIDER

NEWS UPDATES AND HIGHLIGHTS

A UNITED LAUNCH ALLIANCE
Atlas V rocket carrying DigitalGlobe's WorldView-3 satellite launches from Space Launch Complex-3 at Vandenberg Air Force Base, Calif.

IMAGE COURTESY OF UNITED LAUNCH ALLIANCE

RESOLUTION LIMITS LIFTED, WORLDVIEW-3 LAUNCHED

On June 11, the U.S. Department of Commerce granted DigitalGlobe's request to modify its license, enabling the company to sell its highest-resolution commercial satellite imagery. This approval permits the sale of imagery to all of its customers at up to 0.25-meter panchromatic and 1.0-meter multi-spectral ground sample distance. WorldView-3 launched and successfully deployed Aug. 13 from Vandenberg Air Force Base, Calif., aboard an Atlas V rocket. DigitalGlobe's WorldView-3 is collecting super-spectral imagery at 0.31-meter resolution, which was previously prohibited by the 0.5-meter resolution limit. The company also announced plans to accelerate the WorldView-4 launch date to mid-2016, anticipating increased demand for commercial imagery products in the wake of eased resolution limits.

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1,159 satellites are expected to launch in the next 10 years.

DAN DONEY, DIA chief innovation officer, talks about the new Open Innovation Gateway platform during the agency's Innovation Symposium June 25.

PHOTO BY NAVY LT. JEFFREY PRUNERA

DIA UNVEILS OPEN INNOVATION GATEWAY

The Defense Intelligence Agency (DIA) unveiled its Open Innovation Gateway at the DIA Innovation Symposium in June. The Open Innovation Gateway is a web-based program where any potential vendor can apply for an account and demonstrate technology directly to a specific DIA-mission user. The gateway model allows potential vendors to present their technology in a safe environment, while making the process easier and more efficient. Eight companies have been chosen to test the new system.

GOOGLE ACQUIRES SKYBOX IMAGING

In June, SmallSat start-up Skybox Imaging announced its pending acquisition by Google, which became final Aug. 1. The acquisition price is reported at $500 million, with Google seeking access to Skybox's high-quality, real-time imagery and video for its Google Earth and Google Maps services. Subsequently, Skybox Imaging released the first images from SkySat-2, the second in its planned fleet of 24 high-resolution commercial SmallSats. The images, taken 48 hours after launch, were of Bangor, Maine, and Port-au-Prince, Haiti.

SKYSAT-2 Image of Port-au-Prince, Haiti, acquired July 10, 2014.

IMAGE COURTESY OF SKYBOX IMAGING

PROCRASTINATION TOOLS

MAP WARPER

The New York Public Library (NYPL) has uploaded thousands of maps of many U.S. locations to its website. The online tool rectifies historical maps from the NYPL's collection to match maps of the present day. Enter a U.S. state or city to see how it has changed over the years.
maps.nypl.org/warper

SMARTY PINS

Test your geography knowledge with this guessing game from Google Maps. Smarty Pins asks location-based trivia questions and users answer by dropping a pin on the map. Start playing!
smartypins.withgoogle.com

WHAT3WORDS

W3W is a grid of the world made up of 57 trillion 3x3 meter squares, each identified by three random words from the dictionary. For example, the White House is identified with "sulk.held.raves." The site claims this method is not only extremely precise, but also an effective way to globally format addresses, and make them easier to remember and share.
what3words.com

TRAVELBYDRONE

Discover the world from the perspective of a UAV. Click anywhere on this website's world map and view UAV video footage of that region. Users can also submit their own UAV videos to the site.
TravelByDrone.com

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$243 billion in revenue is expected from the manufacture and launch of satellites in the next decade.

INFO COURTESY OF EUROCONSULT

SHADROCK ROBERTS speaks about USAID's crowdsourcing project during a panel discussion at the GEOINT 2012 Symposium.

SPOTLIGHT: USGIF SCHOLARSHIP RECIPIENT

As a child, Shadrock Roberts first gained spatial skills through skateboarding. He explored parts of the urban environment that most people overlooked. These early experiences laid the foundation for an interest in international migration. Roberts knew early on working with geography and humanitarian relief was the right fit for him.

Roberts' colleagues encouraged him to apply for the USGIF Scholarship Program, and in 2010 he received a USGIF scholarship while pursuing his Ph.D. in geography with a combined focus in volunteered geographic information and remote sensing at the University of Georgia.

"Attending the GEOINT 2010 Symposium was the most important thing I did with my scholarship because it gave me great networking opportunities," Roberts said. "I broadened my field of view and met a lot of hardworking people from all branches of the government."

Roberts said attending the Symposium led to a job with the U.S. Agency for International Development (USAID), where he worked as a principal GIS analyst for more than two years.

In 2012, Roberts launched USAID's first crowdsourcing project, which pinpointed the location of USAID Development Credit Authority loan data, and made the data set publicly available. At the GEOINT 2012 Symposium, Roberts had the opportunity to speak about USAID's project and how the government applies geospatial data for humanitarian issues as a participant in the "Converged Future of Geospatial Intelligence: Young Innovators" panel discussion.

In 2013, Roberts managed USAID's Open Cities Project in the Kathmandu Valley of Nepal, and worked with the U.S. State Department's MapGive initiative.

Currently, Roberts is finishing his Ph.D. and serving as director of the Resilience Network Initiative at Ushahidi, a global nonprofit developing free and open source interactive mapping software.

USGIF STAFF CORNER

(From left to right) Justin Franz, Lindsay Tilton Mitchell, and Anna Kimmel.

USGIF recently added three new hires to its staff. **Anna Kimmel** joined USGIF as its new event operations manager, responsible for planning the many USGIF events held throughout the year, including the GEOINT Symposium. Most recently, Anna was with the American Institute for Aeronautics and Astronautics.

Justin Franz, formerly an intern, joins the Foundation as a professional development administrative coordinator. Justin will assist with USGIF's GEOINT professional certification program, among other training and education initiatives.

Lindsay Tilton Mitchell, formerly a USGIF editorial intern, joined the staff as a full-time marketing and communications assistant. Lindsay helps with *trajectory* magazine as well as Foundation and events marketing.

PHOTOS BY USGIF

GEOGALA

USGIF hosted its ninth GEOGala June 30 at the Hyatt Regency Reston in Reston, Va. More than 400 guests from government, industry, and academia enjoyed a delicious meal, a night of dancing, and the opportunity to network.

ATTENDEES at USGIF's ninth GEOGala enjoy cocktails and hors d'oeuvres before the formal dinner.

THE FAIRFAX COUNTY Police Honor Guard commences GEOGala by presenting the colors and performing the national anthem.

DATA ANALYTICS

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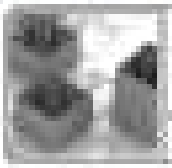

Customer Success is Our Mission

OUSD(I)'S GARY WANG SPEAKS AT GEOINTERACTION TUESDAY

GARY WANG speaks about emerging technologies at USGIF's GEOINTeraction Tuesday event July 8.

"How do I keep up with everything up-and-coming? I have a reverse mentor under the age of 30," said Gary Wang at USGIF's GEOINTeraction Tuesday event July 8.

More than 50 government and industry attendees turned out for a discussion with Gary Wang, director of the Intelligence, Surveillance, and Reconnaissance Infrastructure division with the Office of the Under Secretary of Defense (Intelligence).

Appointed to his position in 2012, Wang oversees numerous programs with intelligence capabilities across armed services and defense agencies. Wang talked about how unexpected events can take these initiatives backward.

"The most recent events with WikiLeaks, Snowden, the Washington Navy Yard [shooting], and the results of that have put a wrinkle in how you handle [resourcing the workforce]. How do we apply resources to respond to those kind of threats in the future?" Wang said.

Wang outlined some emerging technologies, saying UAVs and immersive wearables are becoming more prevalent in the commercial as opposed to the defense domain.

"Prior to the Amazon 'Prime Air' commercial, everyone thought the DoD and government were the ones who did all the sexy UAV stuff, but afterward the pendulum swung in the other direction," Wang said. "This will start to grow outside the U.S. because policies are impeding us from being more aggressive in that area."

Wang switched gears and spoke about the millennial generation and how its growing expertise will benefit cybersecurity capabilities.

"We tend to focus on the 'here and now' and we should be focusing on the next generation coming up," Wang said. "If you're going to wait for people to come out into the workforce to turn them into cyber warriors, then you're behind the power curve. Your best set of warriors are under the age of 16 right now."

He concluded with strongly advocating for seniors in the Intelligence Community to have a reverse mentor from the millennial generation to help keep them apprised of current trends and technologies.

USGIF HOSTS FIRST INTERNATIONAL WORKSHOP

U.K. OFFICIALS perform a flag ceremony before the Cotton Dinner, an annual tradition uniting the British and American intelligence communities.

The USGIF Workshop Series ventured overseas to Royal Air Force Wyton in Cambridge, U.K., to host the "Joint and Combined GEOINT Workshop" June 30-July 2. Attendees were allowed a rare glimpse into the Defence Geospatial Intelligence Fusion Centre (DGIFC) facility and had the opportunity to meet intelligence leaders from the Allied System for Geospatial Intelligence.

The three-day event kicked off with an evening welcoming reception in Cambridge, followed by an all-day, classified workshop led by the Joint Forces Intelligence Group and DGIFC. This workshop included breakout sessions discussing needs and challenges within the global GEOINT Community. The event concluded with a walking tour of Cambridge University.

EXECUTING THE MISSION IN A NEW IT ENVIRONMENT

The Intelligence Community Information Technology Enterprise (IC ITE) has mission implications beyond its community integration goals, and more than 200 people attended a June 23 USGIF workshop to hear leaders discuss the program's progress.

The morning kicked off with "The IC ITE Vision" panel, which featured senior leaders instrumental in developing the concept for IC ITE: former National Geospatial-Intelligence Agency (NGA) acquisition director Barry Barlow; former Central Intelligence Agency CTO Gus Hunt; and former NGA CIO Keith Littlefield.

"The Cloud is not the end result [of IC ITE]," Hunt said. "What we really are heading to is how to layer on top of the cloud commercial services that will enable us to operate at the same speed as the private sector."

In the "Migration to the Cloud" panel, Dave Bottom, director of NGA's IT Services Directorate, described IC ITE as "not an end but a means."

"For NGA it's a means for us to deal with persistence," Bottom said. "IC ITE is driven by the tradecraft and NGA is working hard to get the architecture in place across the Intelligence Community," said Bottom.

DIA Chief Technology Officer Gus Taveras and Chief Innovation Officer Dan Doney gave a joint presentation on the agency's DoDIIS Application Engine and NeedipeDIA, both having successfully migrated to the cloud.

The last panel discussion of the day focused on bridging IC ITE with DoD IT infrastructure such as the Defense Intelligence Information Enterprise (DI2E) framework, and the Joint Information Environment (JIE). The panel consisted of leaders representing the U.S. Marine Corps, National Reconnaissance Office, U.S. Air Force, NGA, and the Office of the Under Secretary of Defense for Intelligence.

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CORE VALUES

The Naval Postgraduate School's CORE Lab eschews theory for real-world pragmatism

PROFESSOR JOHN ARQUILLA has taught at the Naval Postgraduate School for 22 years.

A **MAP OF THE WORLD** covers a wall in John Arquilla's office at the Naval Postgraduate School (NPS). On that map, Arquilla, chair of the Defense Analysis Department, tracks the state of war around the globe.

"I know there are about 32 [wars] underway today around the world," he said, pointing to the map. "I also know that not one looks like World War II or Operation Desert Storm. Every last war is irregular, and so I ask, 'Why do we still call it irregular warfare if the only thing out there is these wars?'"

He has asked this question on the Monterey, Calif., campus for 22 years, since he and Gordon McCormick, a professor of defense analysis, migrated from the RAND Corporation to teach Guerrilla Warfare in 1992 to a class of 13 Navy SEALs.

The class spawned the Defense Analysis Department (DA) after a pioneering student helped Arquilla and McCormick write a curriculum and secure funding from the Navy. That student, who also wrote a thesis titled "Spec Ops," would eventually become the commander of USSOCOM—now retired Adm. William McRaven.

Since that initial class, DA has granted Master of Science degrees in special operations and irregular warfare to more than 1,000 graduates, including 197 international students from 50 countries. It has also seen its curriculum diversify and in 2007 added the Common Operational Research Environment (CORE) Laboratory to study social networks and develop geospatial analysis tools via capstone projects and student theses.

> "Why do we still call it irregular warfare if the only thing out there is these wars?"
>
> —John Arquilla, chair of the Defense Analysis Department, Naval Postgraduate School

PREDICTIVE ANALYSIS

Driven by the proliferation of social media and the need for human intelligence in regions where so-called "dark networks" operate, CORE Lab was established as a research arm to develop ways to apply geospatial solutions to complex data. CORE's curriculum grew out of a social media analysis course taught by Nancy Roberts, one of the lab's first co-directors alongside Doug Borer.

"One of my students had just come from [Washington] and said, 'I don't know social network analysis,'" Roberts recalled. "He said, 'I don't know geospatial analysis.' He would go on to tell stories about being in Afghanistan and said, 'We need a way to understand these networks. We need a way to geospatially locate what's going on.'"

The CORE Lab's mission was formed from such conversations. While Borer worked on logistics, Roberts developed curriculum.

"I listened to students," Roberts said. "I asked them: 'Tell me what you need in the field. Tell me what some of the problems are that you are confronting. Tell me what bugs you.' We started with the bugs list. … By the time I was finished talking, I knew it was a lot more complicated than just teaching people how to track and disrupt dark networks."

A visual analytics course was created to provide an overview of data collection and use, while Roberts' social media analysis course was split to become "Tracking and Disrupting Dark Networks" and "Geographical and Temporal Dimensions of Dark Networks." A network design course—taught by Roberts—explores how to establish and operate within such networks. And a Big Data course is planned for introduction next spring.

CORE's scope is practical, with researchers creating tools to solve real-world problems they experienced in the field before arriving at the NPS campus.

EVOLUTION THROUGH FLEXIBILITY

"Every time I teach the class, so much is changing," said Kristin Tsolis of the geographical and temporal course.

Unlike most graduate schools, the courses and students' research are less about theory and more about problem solving and critical thinking.

"When they come here, they often know what they want to research," Tsolis said of the students, who typically hold multiple combat deployments. "At first, it wasn't always clear to me why they wanted [to study] a topic, but then it became clear that it was because their friends had been killed in war. That's a lot of motivation."

New faculty members quickly learn DA and CORE Lab students have experience that trumps most theory. This requires a pragmatic approach to teaching.

"A guy can't just come in here and say 'I have this theory,'" said retired Army Special Forces Col. Greg Wilson, CORE Lab's first military co-director and a former DA USSOCOM representative appointed by Adm. McRaven to teach and oversee curriculum development. "Students [have been downrange and] can say, 'This is what the reality is.' It can't be smoke and mirrors here."

Students apply their research to the real-world operational problems they have experienced. CORE Lab developed an app called Lighthouse in 2009 to help warfighters perform geospatial and other analysis of social networks by organizing data from a variety of entry platforms. Tested in village stability operations around Kandahar, Afghanistan, "Lighthouse put us on the map," Wilson said of CORE Lab's growing reputation. "But now, we're adding other products."

Many of those products come from student projects. The Improvised Explosive Device Network Analysis (IEDNA) web application was developed from Lighthouse for Explosive Ordinance Disposal technicians to compile key information about IEDs into a streamlined and accessible database. In addition to research in Iraq and Afghanistan, CORE personnel have traveled to Thailand at the request of its government to do more IED research.

CORE's Sensitive Site Exploitation (CORE SSE) application uses geospatial elements for forensic analyses of tactical objectives, replacing a pen-and-paper approach. And then there's COREnet where students seek to influence psychological operations doctrine through social network analysis. The same dynamic Twitter network analysis applied during the Arab Spring is currently being used to monitor Twitter activity in Syria.

After serving as a fellow at the school, Army Col. Guy LeMire, the current DA USSOCOM representative, came away so impressed he later called upon an NPS graduate to help plan the transition of U.S. Special Operations initiatives to Afghani counterparts.

"I said, 'You're going to be the planner for the task force commander in transitioning the Afghan partner unit in two years to the lead of night raid operations. And, oh by the way, you're briefing a three-star about it in two weeks.'"

It was a lot to throw at an officer just out of graduate school, and the problem became more complicated when the transition timeline was reduced from two years to six months.

"I knew this guy would understand the problem set, put something together that would be flexible, and have a lot of contingencies," said LeMire. "These guys never look at problems the same way when they get out of here. Never."

BY JIM HODGES

THE NPS DEFENSE ANALYSIS DEPARTMENT HAS GRANTED MASTER OF SCIENCE DEGREES IN SPECIAL OPERATIONS AND IRREGULAR WARFARE TO MORE THAN

1,000

GRADUATES, INCLUDING

197

INTERNATIONAL STUDENTS FROM

50

COUNTRIES.

CAN INTELLIGENCE COMMUNITY TOOLS AND PRACTICES HELP STOP POACHING IN AFRICA?

WILDLI

THE VILLAIN in Walt Disney's 1990 animated film the *The Rescuers Down Under* is a money- and blood-thirsty poacher named Percival McLeach. He lives and works alone in the Australian outback, equipped with little more than his jeep and a shotgun, in search of one giant and potentially profitable golden eagle called Marahute. But this traditional notion of a singular, poverty-driven poacher in search of a get-rich-quick scheme is long gone according to the United States government and leaders at international NGOs.

FE crimes

BY KRISTIN QUINN

PHOTO ©GETTY IMAGES/CHRIS MINIHANE

In recent years, wildlife trafficking has evolved into one of the top five transnational organized crimes—alongside the drug, illegal weapons, and human trafficking trades—with emerging ties to terrorist, rebel, and militia groups elevating the problem from a conservation issue to a growing matter of global security.

"It's gone from one guy with a shotgun to many guys with automatic weapons," said Crawford Allan, director of TRAFFIC North America with the World Wildlife Fund (WWF).

Asia's growing middle class—in which elephant ivory is widely seen as a status symbol and rhino horn is thought to have unparalleled medicinal properties—is fueling demand for illegal wildlife products. One intricately carved elephant tusk or rhino horn alone can reportedly sell for hundreds of thousands of dollars in Asia, according to Jonathan Hutson, architect of the Satellite Sentinel Project and now director of communications for the Enough Project at the Center for American Progress.

Illegal wildlife products reign in up to $10 billion annually on the black market according to more conservative estimates, much of which is believed to end up in the hands of terrorist organizations. In many cases the terrorists are also poachers, or at least funding them.

In recent years, poachers have taken the African continent by storm, often better equipped with everything from vehicles and boots to weapons and technology than the authorities struggling to stop them.

WILDLIFE TRAFFICKING IS BOTH A CRITICAL CONSERVATION CONCERN AND A THREAT TO GLOBAL SECURITY WITH SIGNIFICANT EFFECTS ON THE NATIONAL INTERESTS OF THE UNITED STATES AND THE INTERESTS OF OUR PARTNERS AROUND THE WORLD.

— Excerpt from the Presidential Task Force on Wildlife Trafficking's *National Strategy for Combating Wildlife Trafficking*

RANGERS from the Tanzania National Parks Authority (TANAPA) are trained by instructors from the PAMS Foundation at the TANAPA training center in Ruaha National Park, Tanzania.

"We're not talking about the kind of traffickers we've had before," said Andrea Crosta, executive director and co-founder of the Elephant Action League, which released a 2013 report linking Somali terror group al-Shabaab to the elephant ivory trade. "We are talking about very well organized groups able to confront whatever the law enforcement agencies do in a very provocative way."

Hutson co-wrote a June 2013 report for the Enough Project, detailing how ivory trade helps finance Joseph Kony's Lord's Resistance Army in the Democratic Republic of Congo.

"If you're a terrorist, or a rebel or militia leader, an elephant or rhino is like a walking ATM and you want to cash in before your competition does," Hutson said. "Poaching is a low-risk, high-reward activity … They're in a mad frenzy, elbowing past each other to shoot Africa's last rhinos and elephants."

Allan described the current movement to stop wildlife crime, with more than 50 governments involved, as unprecedented, attributing the U.S. with taking the lead. In 2013, a Presidential Task Force on Wildlife Trafficking was implemented by White House executive order, and subsequently released a comprehensive National Strategy for Combating Wildlife Trafficking in February.

"In the past decade, wildlife trafficking … has escalated into an international crisis," the national strategy reads. "Wildlife trafficking is both a critical conservation concern and a threat to global security with significant effects on the national interests of the United States and the interests of our partners around the world."

One of the strategy's several initiatives is to "support development and use of effective technologies and analytic tools," such as those "that can assist with identifying poaching hotspots or addressing the wildlife trafficking supply chain."

Chief among such technologies being explored is GEOINT, including satellite imagery, UAV surveillance, data visualization, GPS tracking, predictive analytics, and crowdsourcing.

"The task force has really pushed this issue to the forefront and with that,

PHOTO COURTESY OF ELEPHANT ACTION LEAGUE

technology—including geospatial—does play a critical role," Allan said.

THE IMPLICATIONS

One of the first organizations to assert wildlife crime as an increasing threat to national and global security was the International Fund for Animal Welfare (IFAW), whose research on the subject dates back to 2008. In June, IFAW released "Criminal Nature: The Global Security Implications of Illegal Wildlife Trade," perhaps one of the most comprehensive looks at the ties between poaching and terrorism to date.

"The link to organized crime now is there and increasingly in places like the Horn of Africa—looking at links to terrorist groups such as al-Shabaab and others that are in fact destabilizing governments across the region," said Azzedine Downes, president and CEO of IFAW.

Downes laments there are still those who are skeptical about a strong terrorist link, but points to the scale of trafficked goods as proof.

"When you look at the size of the containers confiscated they may be five to 10 tons," he said. "That consignment isn't something just anyone can pay for. That's how we know it's organized crime. A local villager cannot pay for shipment of five tons of ivory to China."

And conservation organizations aren't the only ones making noise about this. Following the White House's lead, the U.S. State Department has also taken up the issue. In 2012, then Secretary of State Hilary Clinton hosted a wildlife trafficking call to action. M. Brooke Darby, deputy assistant secretary with the department's Bureau of International Narcotics and Law Enforcement Affairs, testified on the escalating international wildlife trafficking crisis before the Senate Foreign Relations Subcommittees on African Affairs and East Asian Pacific Affairs: "Terrorists and militia groups may seize the opportunity to benefit from the wildlife trade. We have some evidence that the Lord's Resistance Army and the Janjaweed have done so, for example, trading wildlife products for weapons or safe haven."

Darby elaborated in an email to *trajectory*: "This problem now transcends nature conservation and poses genuine security challenges." She outlined such consequences as fueling corruption, undermining good governance, exacerbating border instability, threatening civil populations, and weakening financial stability in affected regions.

In June, the International Criminal Police Organization (INTERPOL) released yet another report asserting illegal wildlife trade supports terrorist and militia groups in Congo, the Central African Republic, Sudan, Chad, and Niger.

While it's promising that governments and organizations around the world are taking notice, Samuel Wasser, director of the Center for Conservation Biology at the University of Washington warns that a precisely concentrated effort must be implemented immediately.

In 2013, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) began urging countries to send their ivory seizures to Wasser's lab, which according to him is the only in the world conducting comprehensive DNA testing on elephant ivory to determine geographic origins. Based on the total kilograms of ivory processed in his lab each year, Wasser estimates as many as 50,000 African elephants are poached annually. With approximately 400,000 wild elephants remaining in Africa—a current loss of up to 50,000 a year has staggering implications.

"It's quite possible we could lose most of Africa's elephants in the next 10 years," Wasser said.

The African rhino population is teetering on the edge as well, according to Save the Rhino International—with approximately 25,000 rhinos remaining in Africa, and more than 1,000 poached in South Africa alone in 2013.

But the illegal wildlife trade also carries a human toll. In the last few years, more than 1,000 park rangers were murdered by poachers in Africa, leaving behind vulnerable families according to Tom Snitch, executive officer of the United Nation's Wildlife Enforcement Monitoring System. But the larger economic and societal ramifications stem from the tourism industry—one of Africa's largest.

"If you look at the safari tourism business in Southern Africa, about 13 million people have jobs somehow linked to tourism," Snitch said. "It doesn't take a genius to figure out if the animals are gone, the tourists are gone … this would be a very fertile recruiting ground for terrorists and extremists already operating in Africa."

Wasser believes in addition to curbing demand from Asia in the long term, the immediate solution lies in pinpointing poaching hotspots. In the 1990s, his lab developed a method of extracting DNA from elephant dung, collected samples from across Africa, and created a genotype-specific map. Today, they extract DNA from ivory and match it with the genotype map to determine origin within a 270-kilometer range. His team has discovered there are far fewer major poaching hotspots than previously thought.

"We need to know where to concentrate our efforts so we can stop this as fast as possible, and that's what mapping really does," Wasser concluded.

A VARIETAL TOOLBOX

While visualizing poaching epicenters is a critical starting point, NGOs and government agencies are now looking toward geospatial technologies traditionally used for defense and intelligence to take efforts to the next level.

In April, the U.S. Agency for International Development (USAID) issued a request for proposals in search of an organization to help the agency manage an upcoming Wildlife Trafficking Technology Challenge.

"The poachers and traffickers have become increasingly tech savvy," said Dr. Sara Carlson, a USAID biodiversity and natural resources specialist. "We're trying to catch up and beat them at their own game."

The USAID technology challenges will comprise four major areas, each with their own sub-challenges: movement of trafficked wildlife and wildlife parts; forensics and intelligence gathering; consumer demand reduction; and corruption.

Improved intelligence gathering and management, as well as the detection, monitoring, and prediction of illegal wildlife trade routes, are the areas where the GEOINT Community's expertise could be most effectively applied.

"Geospatial technologies have a lot of potential to monitor poaching, and in particular geospatial data and analysis

APPROXIMATELY 25,000 RHINOS REMAIN IN AFRICA, AND MORE THAN 1,000 WERE POACHED IN SOUTH AFRICA ALONE IN 2013.

PHOTOS COURTESY OF JONATHAN HUTSON/ENOUGH PROJECT

A DIGITALGLOBE satellite image, taken Nov. 23, 2012, shows a former Lord's Resistance Army (LRA) campsite in eastern Congo's Garamba National Park. The top inset photo shows a park ranger discovering vinyl tarps used by the LRA to construct shelters. The bottom inset photo shows a ranger drinking from a basin the LRA created by damming up a spring in the wooded ravine.

can help target patrols more effectively," Carlson said.

She added USAID hopes to get a fresh set of eyes on the problems surrounding the illegal wildlife trade, and is particularly seeking expertise from outside the conservation world, to include social media experts, software engineers, programmers, analysts, and more.

Similarly, WWF launched its Wildlife Crime Technology Project in December 2012 with the help of a $5 million Global Impact Award from Google. The project aims to create a seamless system of four technologies: affordable tracking systems; aerial and ground-based survey systems; effective ground patrolling by rangers equipped with the Spatial Monitoring and Reporting Tool (SMART) used by many conservation organizations; and site-based data correlation with wildlife trafficking intelligence and TRAFFIC, WWF's wildlife trade monitoring network.

"It's a dangerous business for the limited number of rangers out there in the dark with no visibility," Allan said. "Poachers may lay an ambush or they may literally bump into each other in the dark. Rangers need to understand geospatially where they are, where the wildlife is that they need to protect, and where the poachers may be in a streamlined way."

For example, WWF has begun to deploy UAVs equipped with thermal imaging cameras at night in Central and Southern Africa. Allan recalled witnessing their value firsthand: "There was a giraffe 50 feet away from us and it wasn't until the UAV went over that we saw its glowing outline on the screen. The rangers are far more effective if they can find where the animals are."

Google has worked with organizations such as Save the Elephants to help track endangered wildlife since the 1980s, according to Google Earth Outreach program manager Tanya Birch.

Save the Elephants has tagged more than 100 elephants from various families with satellite collars that track their locations in Google Earth. Personnel at the Lewa Wildlife Conservancy in Kenya monitor the elephants from an operations center daily, looking for certain telltale changes in behavior. For example, if an elephant stays in one location for too long, this often indicates the animal is in danger.

Hutson points out that satellite and aerial imagery also hold utility for tracking and analyzing the movement of poachers, including why they choose certain hiding places, their common campsites, routes of travel, and water sources. For example, the Enough Project used DigitalGlobe imagery to help track the Lord's Resistance Army in Congo's Garamba National Park. Once at the abandoned site, Hutson was able to take photos of the same gardens and dammed streams discovered in the satellite imagery.

"[Changes in satellite imagery] became a leading indicator of poaching activity because there are no civilians in the park, only rangers and bad guys," Hutson said.

He added the U.S. Department of Commerce's recent decision to allow DigitalGlobe to sell its highest resolution imagery is "of tremendous importance."

"The practical effect of lifting the ban on the sale of [the highest-resolution commercial] satellite imagery is that some of the imaging for which we used to have to rely on drones and aircraft can now be done by satellites," Hutson said.

PREDICT & PREVENT

Although he describes satellite imagery as "indispensible" for the ability to cover a wider area and avoid jurisdictional obstacles, Hutson added it must be part of a larger toolbox.

UAVs are becoming increasingly popular as a part of that toolbox. Snitch, who is also a visiting professor at the University of Maryland Institute for Advanced Computer Studies, and his colleagues have developed a program to counteract wildlife crime using not only UAVs but also algorithms to determine where to fly them.

CONFISCATED elephant tusks and rhino horns.

©GETTY IMAGES/MARTIN HARVEY

"Everyone believes UAVs are the 'solution du jour,'" Snitch said. "But you have to do the analysis and the math and really think about where you're going to put a comprehensive program in place."

In Africa, his team uses the same model it formerly applied in Iraq and Afghanistan to reveal IED placement patterns and help locate the terrorists building explosives. The process starts with high-resolution satellite imagery, then adds data and runs an algorithm to determine where to fly the UAVs and position rangers.

"So if at night you're in a huge reserve, based on our model I can tell you precisely where to fly your UAV that night and where to position your rangers to intercept the poachers before they get to the animals," Snitch said.

In South Africa's Balule Reserve, this method reduced the number of poaches from nine a month to zero. But the downside is poachers have just gone "down the road" to another location, Snitch said. His next project is to create a coalition of private reserves that will share UAVs, moving them around to generate better results.

"The idea is to create an area of tens of millions of acres, making it very clear it is a no-go zone," he said.

Snitch added his team is currently in talks with IFAW exploring ways to collaborate.

The opportunity to use various technologies to map layers of data—including where rangers travel, where animals frequent, where poaching incidents occur, and movements across borders—to create a predictive model and preventative solution is the most promising application of GEOINT according to Downes.

"If we could move from a reactive model to a predictive model, I think we have a much better chance of stopping this," he said.

THE CHALLENGES

One of the most significant challenges for applying GEOINT in Africa is supplying the appropriate training catered toward users with varying dialects and degrees of education.

Snitch's criteria for the UAVs he sends to Africa are simple—they must be easy to use and simple to maintain. He's in the process of writing an instruction booklet for rangers on how to fly UAVs, describing it as an "IKEA model."

"My goal is for the UAV to be the equivalent of an Ikea coffee table, with a booklet all in pictures to avoid dialect problems and using one tool to put it together, with everything that snaps in or is color-coded," Snitch said.

He's also working to create automated UAV flight plans that can be operated via smartphone.

WWF's Allan agrees UAVs must be simple to use and also equipped with reliable connectivity in order to integrate data feeds and transfer live video. To help ensure this, WWF has installed radio frequency mesh networks at its sites. Not only do these networks serve

>> COMBATING POACHING WITH THE CROWD

Some conservationists have taken a cue from the successful use of crowdsourcing in the intelligence and GIS communities and applied similar methods to gather data on wildlife crime.

The International Fund for Animal Welfare (IFAW) is working to put handheld technology into the hands of Africans who can help identify where animals and poachers are located, according to IFAW President and CEO Azzedine Downes. However, there is great concern that involving community members could put them in danger.

"There has to be something that mitigates that," Downes said. "There are ways that using smartphones with a system put in place where people text code as opposed to some sort of message gives them some level of safety. With the GPS signal in the phone we also have the ability to transmit their location."

Downes explained this informal system of information sharing is meant to supplement formal systems, which are often classified and corrupt.

"If there's corruption inside the police force or military or rangers, that information can be easily controlled and manipulated," Downes said. "So our thinking was in addition to a formal system of data and intelligence transfer we need an informal system to mitigate for internal corruption."

IFAW hopes to roll out a pilot project testing the use of crowdsourced intelligence via handheld devices in a controlled area of Africa by the end of 2014. The next steps will be determining how to safely and efficiently store and transfer crowdsourced data, as well as who will have access.

Andrea Crosta, executive director and co-founder of the Elephant Action League (EAL), believes there is no hope to stop wildlife crime without "choking the layer of corrupt government officials, politicians, and security officers."

EAL launched the Wildleaks website in February, billed as "the first secure platform for wildlife crime whistleblowers." Since its launch, the site has already acquired three promising leaks, Crosta said.

"We've involved the media to help launch nationwide campaigns to encourage people to share information," Crosta said. "This information cannot be used inside the country because some of these people are very powerful and almost untouchable. The only way we can help those countries and the wildlife is from the outside with the collaboration of large media."

Crosta hopes the project will result in pressure from governments such as the United States or the presidents of these countries to remove corrupt officials from positions of power.

M. Brooke Darby, deputy assistant secretary with the U.S. State Department's Bureau of International Narcotics and Law Enforcement Affairs, agreed eliminating corruption is one of the most critical aspects of this fight.

"As useful as technology can be, corruption plays a major role in facilitating the illegal wildlife trade and unless or until countries address it effectively—including through deterrents and prosecution—the benefits of using new technology will be limited," Darby said via email.

SAVE THE ELEPHANTS has equipped about 100 African elephants with satellite collars to track their daily movements in Google Earth.

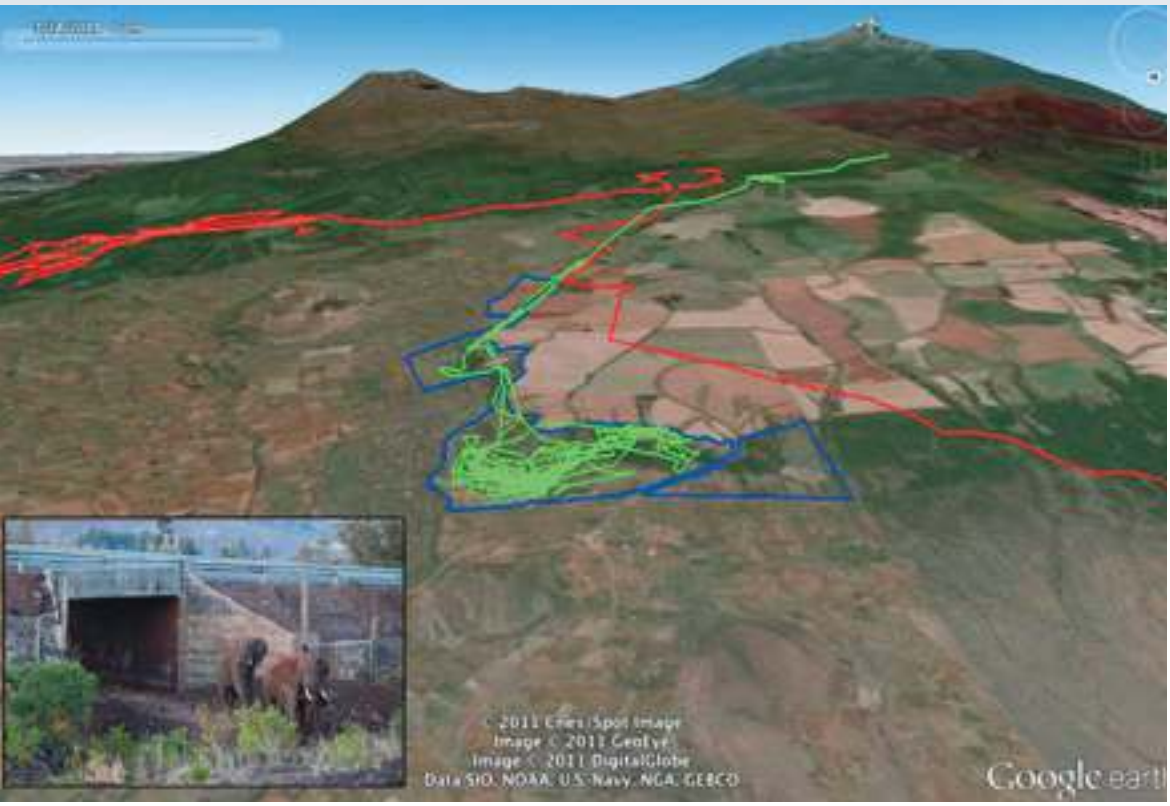

IMAGE COURTESY OF SAVE THE ELEPHANTS

IN SOUTH AFRICA'S BALULE RESERVE, THIS METHOD REDUCED THE NUMBER OF POACHES FROM NINE A MONTH TO ZERO.

as a reliable alternative in areas without Wi-Fi or cellular connectivity, but they are also encrypted.

Snitch has made security a priority as well, encrypting how data is shared from the UAVs to the rangers, in addition to how it is shared among rangers on the ground.

"Not everyone has that," Hutson said of Snitch's security initiatives. "Without that key component, you could actually accelerate the rate of poaching if eavesdroppers are able to pick up the information and use it to figure out where the rangers are."

Hutson noted other unique challenges to Africa are its persistent cloud belt and heavy tree canopy, citing infrared sensors and commercial radar satellites as solutions in these circumstances.

"Rangers could use infrared sensors on drones to detect heat from campfires and warm bodies hiding in the bush," Hutson said. "Commercial radar systems could be used to peer below the clouds and through the forest canopy to detect physical changes in the environment caused by poachers."

A CONCERTED EFFORT

Making complex geospatial data derived from remote sensing or UAVs easy to digest is the final step in the process, said Stephen Wood, CEO of AllSource Analysis, who formerly conducted analysis to assist the Satellite Sentinel Project's humanitarian work in Africa during his time at DigitalGlobe.

"For years, organizations around the world have used remote sensing to monitor large animals, but to do so systematically and to stop illegal activity is fairly new," Wood said. "It's then what you do with the data that becomes important. One of the lessons the industry is beginning to adopt is packaging and getting it into the hands of the law enforcement officials who could do something about it."

But without a rapid and well-trained response force to make decisions and execute based on such data, the technology is less effective, according to conservation experts. In order to bolster the promise of GEOINT, foundational needs for an able ranger force cannot be overlooked.

"A lot of the needs are very basic," Carlson said. "Salaries, boots, tents, vehicles … We should not underestimate how important these things are as well."

Darby echoed this statement in her email: "Geospatial technology is one useful part of the toolbox to assist law enforcement and foster sustainable conservation-management practices," she wrote. "However, many countries have a greater need for basic equipment and technologies … to assist in communications, investigations, and other law enforcement areas to target and arrest poachers."

Carlson added technology must also be nested within a more comprehensive anti-wildlife trafficking strategy that includes working with local governments, raising awareness to deplete demand, and combating corruption.

Allan adds a final reminder about adapting geospatial technology for this unique mission: "There is so much technology out there that could really help this crisis, but the cost and level of technology is high," he said. "Things have to be kept simple and low-cost for conservation applications."

GEOINT technologies and applications used for defense and intelligence hold much promise to help stop the conservation and security crises stemming from the poaching epidemic in Africa, but only if applied in concert with one another and as part of an overall global strategy.

"This is a crisis," Hutson said. "We've got to get on this. It's happening on our watch." ■

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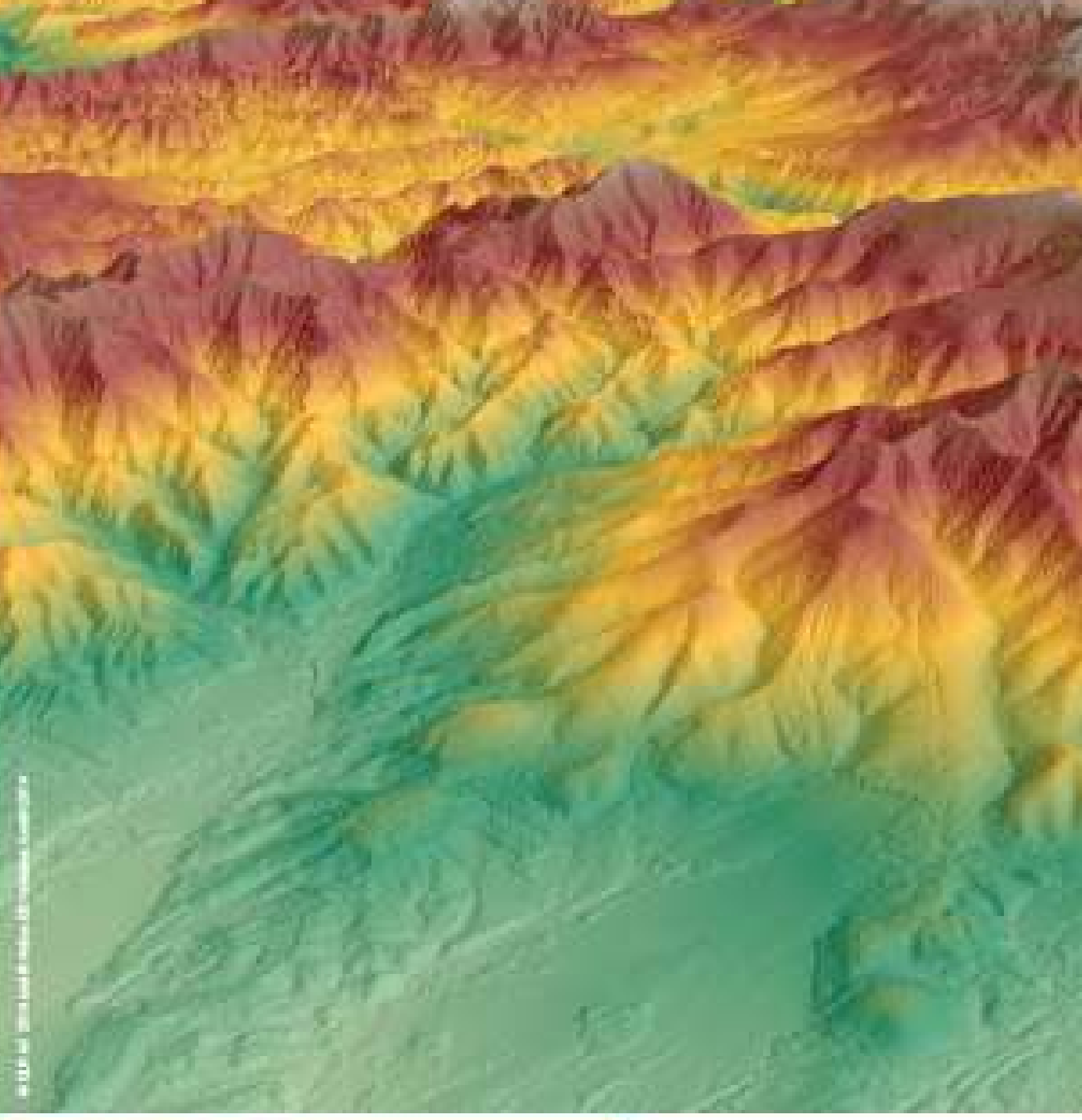

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AIRBUS DEFENCE & SPACE

AT 4:30 P.M. ON JAN. 12, 2010, the island of Hispaniola twitched and jerked, as if the earth were shivering. In Port-au-Prince, Haiti, on the island's western half, it was 82 degrees—hardly hypothermal. As the shaking persisted, it became clear—Mother Nature wasn't cold—she was having a seizure. Although the 7.0-magnitude earthquake lasted just 45 seconds, it killed more than 220,000 people, injured more than 300,000, and left upward of 1.5 million homeless. >>

DEFEATING

BY MATT ALDERTON

THE USHAHIDI Haiti Crisis Map (right) visualized more than 2,000 individual reports in the aftermath of the 2010 earthquake.

DISASTER

FUELED BY OPEN-SOURCE SOFTWARE AND CROWDSOURCING, THE CRISIS MAPPING COMMUNITY IS RAPIDLY EXPANDING. BUT THE METHOD'S STRENGTH ISN'T JUST RESPONDING TO DISASTERS—IT'S MITIGATING THEM.

The quake and its aftershocks destroyed an estimated 60 percent of the buildings in Port-au-Prince alone and caused up to $14 billion in damage. According to the Haitian government, the quake damaged or destroyed more than 313,000 homes, at least 30,000 commercial buildings, more than 1,300 schools, 13 out of 15 government buildings, and more than 50 hospitals, not to mention more than 43 miles of primary roads.

Amid so much rubble, relief efforts seemed impossible. Still, humanitarian organizations descended on Haiti with food, water, and supplies. All they needed was someone to tell them where their help was needed, and how to get it there.

Dr. Patrick Meier did exactly that. Now director of social innovation at the Qatar Computing Research Institute, he was then a graduate student at Tufts

STUNNED BY THE EARTHQUAKE, [MEIER] BEGAN MAPPING TWEETS BROADCAST BY HAITIANS IN THE AFTERMATH, HOPING TO HELP RESCUERS AND AID WORKERS LOCATE THEM. HIS CHOSEN TOOL WAS USHAHIDI—SWAHILI FOR "WITNESS"—A FREE, OPEN-SOURCE PLATFORM CREATED IN 2007.

University in Boston. Stunned by the earthquake, he began mapping tweets broadcast by Haitians in the aftermath, hoping to help rescuers and aid workers locate them. His chosen tool was Ushahidi—Swahili for "witness"—a free, open-source platform created in 2007 to map election abuses in Kenya. Within a week, Meier had recruited and trained more than 100 people to map reports from social networks, mainstream media, and a dedicated SMS hotline his group established to accept text messages from Haitians in need. In total, the Ushahidi Haiti Crisis Map visualized more than 2,000 individual reports.

Mapping these incidents wasn't easy without a reliable map on which to do so. Most of Meier's volunteers used Google Maps, but Google had only mapped a modicum of the country. To fill the gaps, OpenStreetMap (OSM)—the geospatial equivalent of Wikipedia—activated its international network of volunteer mappers. Using high-resolution commercial satellite imagery made public by providers such as DigitalGlobe, OSM crowdsourced the most detailed map to date of Haiti's infrastructure.

"Ultimately, you had about 640 mappers that made 1.4 million edits to the map of Haiti in about 25 days. That's the equivalent of a cartographic year of work for one person," explained John Crowley, a consultant with the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR), as well as a research fellow at the Harvard Humanitarian Initiative. "Not by any stretch of the imagination was the data perfect. But it was the best available map, and it was free and open to everyone, which really catalyzed the use of [crowdsourcing] for disaster response."

Since the Haiti earthquake, the crisis-mapping community has experienced exponential growth and continues to evolve with new tools, technologies, and capabilities. While questions remain about the quality and reliability of crowdsourced data, crisis mappers' ability to mobilize quickly and en masse makes them an undeniable force in the wake of a disaster.

FROM CHAOS TO COLLABORATION

A combination of forces made Haiti a seminal event for crisis mapping. One was the scale of the disaster. Another was the budding proliferation of mobile and social technology. Finally, there was the maturation of a global crisis-mapping community, which originated with the emergence of open mapping platforms such as OSM and Ushahidi—which launched in 2004 and 2007, respectively—and culminated with the first annual International Conference on Crisis Mapping (ICCM) in Cleveland in October 2009, just three months before the Haitian temblor.

"At the very first [ICCM] a whole group of people came together to form a collective understanding around the question, 'What is crisis mapping?'" recalled Crowley. "Then Haiti happened. So there was a gradual convergence of streams, a few key events, and then a major disaster … where crisis mappers had the chance to apply the lessons we'd learned from all the work we'd been doing."

In the earthquake's immediate aftermath, an OSM offshoot called the Humanitarian OpenStreetMap Team was established to facilitate collaboration between OSM and humanitarian responders. In 2012, the Digital Humanitarian Network (DHNetwork) was born, serving as a clearinghouse connecting humanitarian responders with various crisis-mapping networks as needed. These organizations and others have given formal structure to an inherently unstructured community, which in turn has helped crisis mappers demonstrate their value during numerous disasters since Haiti, including the worst floods in the history of Pakistan in 2010, the Japanese earthquake and tsunami in 2011, Hurricane Sandy in 2012, and Typhoon Haiyan in 2013.

THE CASE FOR OPEN DATA

Crisis mapping yields numerous benefits during states of emergency.

"With the volunteer geospatial community, you've got a thousand, a million, or in some cases a billion human sensors who can rapidly collect information that might otherwise be very expensive and time-consuming for a government to collect," said Dr. Alanna Simpson, a senior disaster risk management specialist at GFDRR.

For humanitarian groups and disaster victims, the more obvious benefit is situational awareness. "Especially during a big, sudden event like an earthquake or tornado, the first 72 hours is when we need the most information. But it's also when we have the least," said Dr. Jen Ziemke, associate professor of international

DISASTER MANAGERS from the Honduran Permanent Contingency Commission, as well as representatives from the Honduran Red Cross, firefighters, military, police, and other organizations, use GeoSHAPE during a demonstration in June 2014.

PHOTO COURTESY OF U.S. SOUTHERN COMMAND

DoD IN THE MIX

The Defense Department is also experimenting with crisis mapping. In June, the U.S. Army Engineer Research and Development Center (ERDC) completed its Rapid Open Geospatial User-Driven Enterprise (ROGUE) program, a two-year Joint Capability Technology Demonstration to test the utility of open-source software for humanitarian and disaster relief efforts in Latin America. ROGUE's combatant command sponsor, U.S. Southern Command (SOUTHCOM), hopes to use the program's byproduct—a data collection and sharing platform called GeoSHAPE—to facilitate crowdsourcing of geo-tagged data in disconnected environments. Using GeoSHAPE, first responders can document their route to disaster victims. For example if a road is blocked, they can record it on the GeoSHAPE map, locate an alternative route, and share the information with other responders.

"This tool allows us to put the concept of crowdsourcing in the government's hands," said Juan Hurtado, SOUTHCOM's science advisor and chief of its science, technology, and experimentation division. "We can remotely tag and track data, such as the state of roads, buildings, and bridges, and synchronize it on available maps to see on a near-real-time basis how the crisis is changing and how we can make better decisions that improve our response."

SOUTHCOM is also exploring how to transcend tools to foster open data.

"So far, nobody has been able to figure out how to achieve unity of effort when there's no unity of command—that's our biggest challenge," said Ricardo Arias, an operational manager with SOUTHCOM's science, technology, and experimentation division. "Many people look at information sharing as the way forward, but information sharing isn't a technology; it's a behavior. There will never be one solution that everybody adopts, so data needs to be able to flow freely across platforms."

relations at John Carroll University and co-founder with Meier of Crisis Mappers Net. "What neighborhoods are destroyed? What roads are flooded? Where are there shelters, and hospitals, and food distribution points? If you're trying to save lives, deliver supplies, or access services, you can leverage crowdsourced reports to give you real-time information."

Crisis mapping also holds triage benefits such as verification and tipping and queuing, which help first responders distribute resources quickly and effectively.

"You can use the crowd to sift through overwhelming amounts of data to help you find that one piece of gold information that might save a life," Ziemke added.

The key to realizing crisis mapping's benefits is open-source software, according to Simpson. "Open-source software lowers the barriers to entry for a lot of people," she said, adding that GFDRR has leveraged open-source software since 2010, when it began to support the open platform GeoNode, which serves as a content management system for geospatial applications. "As a result, small investments go a lot further; it's amazing the innovations that come out of open source."

FEDS JOIN THE CROWD

Although crisis mapping's benefits are numerous, so are its challenges. Because of its siloed nature, the federal government used to pose a hurdle for the community by hindering the data-sharing principles on which crisis mapping relies. Today, however, federal agencies are actively searching for solutions to crisis mapping's biggest challenges in a larger effort to empower and exploit crisis mappers' capabilities.

"While the two communities live in slightly different worlds, the government and crisis mappers have learned to like each other and are increasingly building bridges to figure out how to work together," said Dr. Christopher Tucker, chairman and CEO of the MapStory Foundation, whose open-source platform is used by the humanitarian community to map human geography.

Events leading up to October 2012's Hurricane Sandy illustrate perfectly how feds and crisis mappers are learning to collaborate during disasters.

ADDITIONAL RESOURCES
Visit *trajectorymagazine.com* or download the *trajectory* tablet app to watch videos and read reports on crisis mapping.

IMPORTANT EVENTS IN CRISIS-MAPPING HISTORY

2004
Steve Coast establishes OpenStreetMap to create crowdsourced maps of the United Kingdom, where the government was criticized for creating maps but not publicly sharing them. The OpenStreetMap Foundation is established two years later to expand Coast's efforts worldwide.

2007
The open-source mapping platform Ushahidi—Swahili for "witness"—is created to map eyewitness reports of violence in Kenya in the aftermath of a disputed presidential election.

2009
The Naval Postgraduate School commences its Research and Experimentation for Local & International Emergency & First Responders (RELIEF) series of crisis-mapping experiments at Camp Roberts in California.

2009
Jen Ziemke and Patrick Meier co-found the International Network of Crisis Mappers to organize a community of crisis mappers capable of developing and sharing best practices. They hold the first annual International Conference on Crisis Mapping in Cleveland in October 2009.

2010
Volunteer crisis mappers from around the globe employ Ushahidi and OpenStreetMap to create the most detailed roadmap ever of Haiti in the aftermath of the Haiti earthquake, demonstrating for the first time the contributions that crowdmapping and open-source software can make in the wake of a disaster.

2011
Following a string of 300 tornado touchdowns in the southern United States, the Federal Emergency Management Agency (FEMA) realizes the power of crowdsourcing and commissions its own crowdmapping tool, MapMill, which is deployed in October 2012 to assist with relief efforts in the wake of Hurricane Sandy.

A PRELIMINARY DAMAGE ASSESSMENT mobile app built on Spatial Network's Fulcrum platform shows color-coded collections from the main airfield of Camp Roberts during an experiment with FEMA and Tomnod (now part of DigitalGlobe) to verify crowdsourced data from imagery in real time.

In 2011, a supercell thunderstorm system ambled through the southeastern United States. Afterward, the Civil Air Patrol took thousands of photographs and ascertained there had been approximately 300 tornado touchdowns from Texas to New York.

"Unfortunately, FEMA [the Federal Emergency Management Agency] didn't know there were 300 tornado touchdowns until day five," recalled Crowley, who subsequently assisted with efforts to evolve FEMA's crisis-mapping capabilities. "FEMA's new [geographic information officer] didn't want that to ever happen again, so he asked, 'How can we process these photographs more quickly?' The answer was we had to change the way the Civil Air Patrol collected the photographs, and we had to build a crowdsourcing tool."

The tool, called MapMill, was tested after Hurricane Irene in August 2011. Lessons learned were applied when Hurricane Sandy hit, with FEMA leveraging more than 6,000 volunteers to analyze more than 35,000 geotagged aerial images.

"Very, very quickly they were able to get a damage-assessment map showing what areas Sandy impacted the worst, and what areas it impacted the least," Ziemke said.

MapMill was developed at Camp Roberts, a California National Guard post where researchers from the Naval Postgraduate School have collaborated with industry since 2009 on a series of humanitarian experiments known as the Research and Experimentation for Local & International Emergency & First Responders (RELIEF) program. Now in its fifth year, RELIEF experiments have yielded technology to help feds and crisis mappers alike overcome obstacles. One of the most recent experiments focused on mobile data collection in disconnected environments.

"We can use applications like Pushpin—which is basically like Foursquare for OSM—to collect location-based information during a crisis, but without communication on the ground there's no way to get information from the field to [the open-source community]," said Anthony Quartararo, CEO of Spatial Networks, which designed Pushpin.

To help solve this problem Spatial Networks created Fulcrum, a mobile app field-tested by FEMA at Camp Roberts for its ability to collect location data in low- or no-connectivity environments, then upload it to a central data center once Internet access becomes available.

The U.S. State Department is likewise focused on information sharing. In 2013, its Humanitarian Information Unit (HIU) launched "Imagery to the Crowd," which leverages the National Geospatial-Intelligence Agency's (NGA) NextView contract to provide high-resolution commercial satellite imagery to crisis mappers.

"Volunteers will do work if there is a compelling reason and they have access to commercial satellite imagery in an easy-to-use manner. That means you've got to figure out how to put the imagery on the web and turn it into web services that are prepared and ready to use," explained Josh Campbell, a former GIS architect and geographer with the State Department who recently became vice president of product management at Boundless. "With Imagery to the Crowd, we [process and share] imagery the U.S. government purchases … and serve it out to volunteers … In that way, we've tried to utilize imagery as a catalyst: If there's imagery, will they come map it?"

In more than 15 instances to date, this strategy has been effective, according to Campbell, who cites Typhoon Haiyan as a watershed example.

"Haiyan hit on Friday night local D.C. time," he recalled. "[NGA] worked all day Saturday and Sunday to do an initial damage assessment. They got the first clean commercial shots of [hardest hit] Tacloban on Sunday, and by Monday [HIU] had them downloaded for processing. By Tuesday night we had the first Imagery to the Crowd scenes

SCREEN IMAGE COURTESY OF SPATIAL NETWORKS

2013
The U.S. State Department's Humanitarian Information Unit (HIU) launches Imagery to the Crowd to provide high-resolution commercial satellite imagery to crisis mappers. In 2014, HIU follows Imagery to the Crowd with MapGive, a program to educate and involve the global community in mapping.

2013
Crisis mappers mobilize before and after Typhoon Haiyan in the Philippines. Their speed, collaboration, and effectiveness stand in stark contrast to Haiti, illustrating immense progress for crisis mapping in only three years.

of post-event Tacloban up and available for the crowd to map, which they did in about 36 hours, tagging in Tacloban alone approximately 30,000 buildings as damaged or destroyed. It was pretty amazing."

Equally as amazing as what happened after the storm was what happened before.

"Prior to the storm even hitting, the American Red Cross mobilized the Humanitarian OpenStreetMap Team, which activated volunteers to create baseline data," said Albert Gembara, technology integration officer for the Office of U.S. Foreign Disaster Assistance (OFDA) within the U.S. Agency for International Development (USAID). "Those volunteers rapidly mapped buildings, roads, bridges, and terrain features so practitioners on the ground could compare and contrast the before and after picture. That pre-disaster infrastructure data was essential for improving situational awareness on the ground."

A PROVERBIAL CRYSTAL BALL

Although the nature of the crises was different—one was extemporaneous, the other expected—the contrast between Haiti and Haiyan foretells the future of crisis mapping: Yesterday, crisis mappers responded to disasters; tomorrow, they'll anticipate them.

In fact, they already are, according to Simpson, whose GFDRR team specializes in disaster risk modeling and open data for resilience. "Disaster risk modeling has been around for a long time," she said. "It's like a proverbial crystal ball that tells you what could happen if Kathmandu had a large earthquake—which is generally considered overdue—or if a tsunami hit a particular community."

Adds Tucker, "A disaster may occur, but it doesn't necessarily need to turn into a crisis. Understanding what the landscape of natural hazards is, and how those overlay with the human landscape and the built environment, allows you to calculate risk and think about what investments you can make in infrastructure or capacity building to reduce the likelihood of a crisis."

Although infrastructure investments are critical for long-term risk mitigation, capacity development is an important first step.

"A lot of times, disaster-affected communities lack the capacity to understand how to work with the data that [crisis mapping] creates," Gembara said. "The technology and methodology is moving at a great pace, but helping vulnerable communities understand the information they're receiving is something we're trying to build capabilities around."

USAID's GeoCenter regularly partners with universities to host "mapathons." In November 2013, a three-hour mapathon at George Washington University attracted more than 90 geography students who used OSM to map infrastructure in earthquake-prone Kathmandu, Nepal. By the end of the evening, the areas they'd been asked to map were virtually complete, which will help humanitarian organizations plan ahead of a potential crisis.

USAID is working to expand this program internationally in places like Bangladesh, where local students will be trained to map their own cities. Doing so is a first step toward supporting OFDA's capacity building goals, according to GeoCenter senior analyst Chad Blevins. "The best practice is to have locals create their own data because they can add attributions to buildings they know, designating them as schools, hospitals, markets, and whatnot," he said.

The State Department's HIU is similarly engaged in capacity building. Following its success with Imagery to the Crowd, it unveiled a new initiative called MapGive in March. Leveraging the State Department's social media followers, MapGive aims to build an army of "digital humanitarians" by educating global citizens on the importance of mapping, teaching them to contribute to the OSM community, then deploying them during volunteer mapping projects.

"To my knowledge, this is the first time there has been a formal process to connect the government and the grassroots," Crowley said.

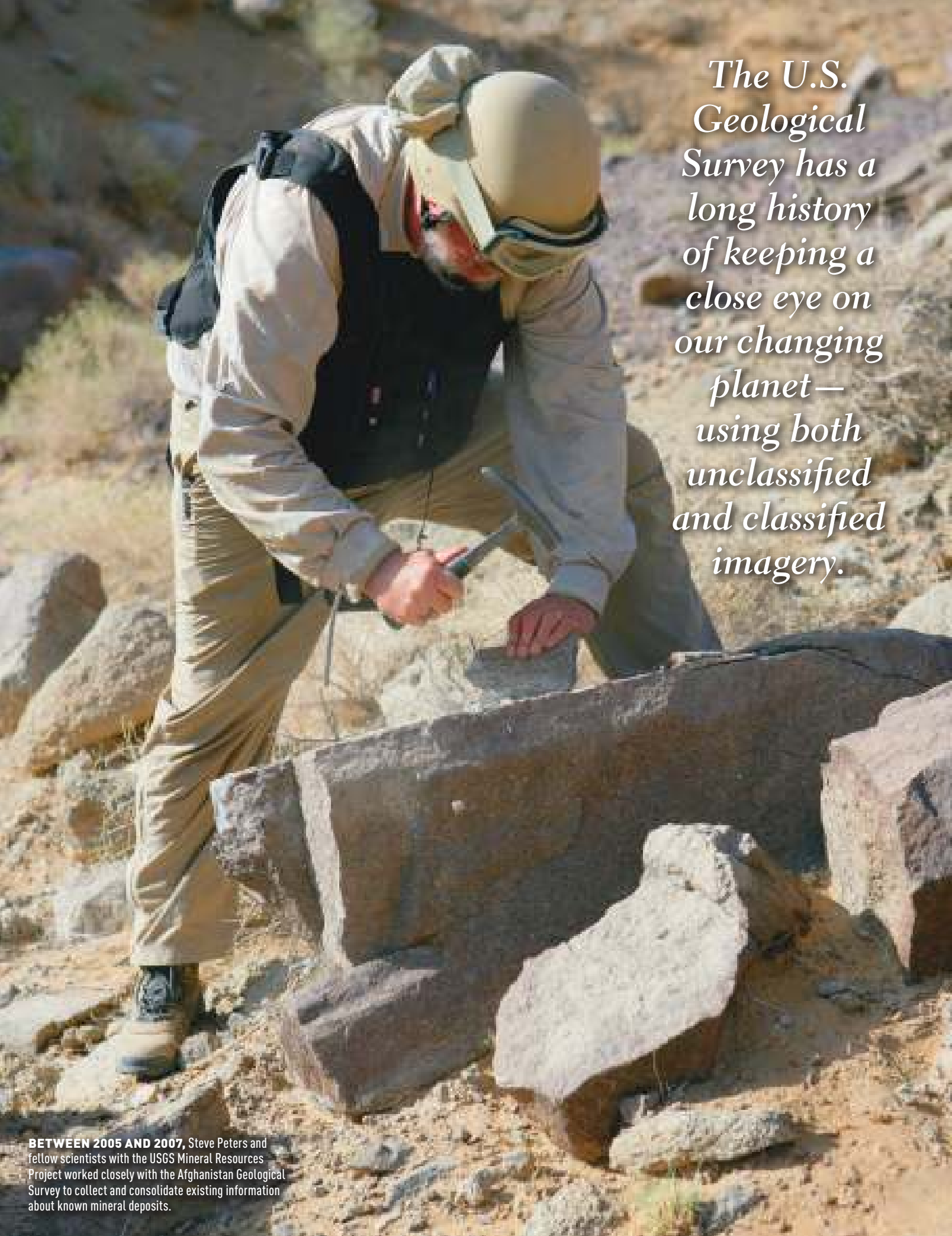
By producing not only more maps, but also more unity of effort, such connections will hopefully lead to more resilience.

It's happened before. Consider the history of urban fires, such as the massive blaze that destroyed much of Chicago in 1871. As a result of joint efforts by governments and citizens to develop smart land use plans, strong building codes, solid insurance policies, and effective fire prevention education, cities no longer burn to the ground.

"We solved this problem because our collective will was strong enough," Simpson said. "I'm fairly optimistic that one day we'll consign disasters to history much in the same way we have urban fires."

GEORGE WASHINGTON UNIVERSITY geography students in November 2013 helped USAID and the World Bank map Kathmandu by tracing satellite imagery using online tools for the Open Cities project.

PHOTO COURTESY OF CHAD BLEVINS/USAID



The U.S. Geological Survey has a long history of keeping a close eye on our changing planet—using both unclassified and classified imagery.

BETWEEN 2005 AND 2007, Steve Peters and fellow scientists with the USGS Mineral Resources Project worked closely with the Afghanistan Geological Survey to collect and consolidate existing information about known mineral deposits.

BY MELANIE D.G. KAPLAN

eyes on the earth

In August 2007, three geologists from the U.S. Geological Survey (USGS) landed at Kandahar Airfield in Southern Afghanistan to support a mission with the Afghanistan Ministry of Mines and Petroleum and the DoD Task Force for Business and Stability and Operations to rebuild the country's geological survey.

As NASA pilots flew WB-57 research jets overhead outfitted with hyperspectral imaging spectrometers, the trio of geologists helped set paths for 28 flights and reviewed data for accuracy. If the planes had been lawn mowers, they would have traversed the entire country, stripe by stripe, imaging what would later show, unequivocally, world-class mineral deposits with the potential to bring economic stability to Afghanistan.

PHOTO COURTESY OF USGS

"Logistically it was hard," said Jack Medlin, USGS regional specialist for the Asia Pacific Region, who has managed this project for the last decade. "It's not often scientists go into a war zone. But when you do, there are certain risks—you just want to make sure the risks to the people are minimized."

That includes ensuring everyone knows the scientists are engaged in, well, science. Medlin said their finished work—like all that comes out of USGS—becomes publicly available. This, in turn helps fulfill the agency's mission, which is to serve the nation by providing reliable scientific information that can be used in many different ways, ultimately to better understand the Earth and enhance and protect quality of life.

In this case, the project yielded images covering 170,000 square miles, marking the first time most of a country has been mapped via hyperspectral technology. The data set, which will be used by scientists, environmentalists, miners, policy-makers, and investors, consists of more than 800 million pixels, resulting in numerous reports and dozens of maps, the last of which was released in September.

MONITORING THE EARTH, 24/7

If USGS had a hall of fame covering its 135-year history, the Afghanistan mission may very well be a new inductee. Other all-stars could include the training of astronauts who landed on the moon in 1969; the volcano team's accurate forecast of the 1991 eruption of Mt. Pinatubo in the Philippines, which saved hundreds of thousands of lives; and the assessment of damage from the Gulf of Mexico's Deepwater Horizon oil spill in 2010.

But rather than a hall of fame, the Reston, Va.-based headquarters' hallways are filled with an extraordinary collection of maps.

Creator of The National Map—a collection of 57,000 topographic maps charting every U.S. river, valley, and railroad, and used by recreationalists, engineers and planners, scientists, and educators—USGS employs approximately 8,500 people, about half of whom are scientists. Since the agency's early years, it has used science to understand natural heritage. Even before USGS was created, President Thomas Jefferson commissioned Lewis and Clark's exploration of the American West, to map the land and collect information about soils and plants. Since then, the drive to discover and understand the Earth hasn't waned. At its core, USGS translates complex Earth science into findings and warnings that help form better policy and disaster preparation.

USGS Senior Advisor for Science Applications Jim Devine is a seismologist by training who covered his childhood bedroom walls with maps of the Pacific theater and followed the early movements of World War II. He said the agency has been moving in the same fundamental direction since its foundation in 1879—learning the geology, topography, and hydrology of the Earth.

"We are the world's earthquake and volcano monitors," he said, pointing to a large photo of Mount St. Helens behind his desk. "We send our people out at the worst possible times, and we also provide baseline information for less catastrophic situations, such as water quality and wildlife."

Devine barely touches on the overwhelming number of areas in which USGS conducts science. But among the most significant changes at USGS in recent years is the agency's increased use of technical assets to understand natural resources and respond to disasters. Access to daunting amounts of geospatial information, persistent GEOINT capabilities such as 24/7 monitoring of streams and earthquakes, and the declassification of certain images obtained by spy satellites and other sensors have changed the game at USGS.

"We have a long history as a member of the GEOINT Community," USGS Acting Director Dr. Suzette Kimball said in April during her keynote address at the GEOINT 2013* Symposium. "We have done great work together between the federal and civil communities, and the intelligence and defense communities."

She noted in her keynote that contributing to the Intelligence Community (IC) continues to be a USGS priority, especially with tools and technologies that are mutually beneficial.

DECLASSIFYING DATA

Bert Beaulieu, a National Geospatial-Intelligence Agency (NGA) senior manager on a one-year assignment to the USGS director's office, said ease of access to improving technology has caused the use of remote sensing to soar. Among his tasks is to make the availability of these images better known to scientists within and outside of USGS.

"Higher resolution imagery can improve the fidelity of anything you're trying to describe," Beaulieu said. "And by using some of the classified capabilities, you can enhance many details, down to vegetation and soil types."

He is also charged with expanding the use of classified sources among civil agencies, which goes back to the '60s, when the government realized it was prudent to use its best capabilities for dual purposes.

Beaulieu said a number of defense capabilities developed in support of warfighting over the last decade have proven beneficial on the civilian side—from the

USGS Fast Facts

- USGS was founded in 1879 and has studied the geology, topography, and hydrology of the Earth for 135 years.
- The USGS mission is to provide reliable scientific information that can be used in many different ways: to describe and understand the Earth; to minimize loss of life and property from natural disasters; to manage water, ecosystem, energy, and mineral resources; and to enhance and protect quality of life.
- The Survey is the nation's largest civilian mapping agency.
- USGS is aligned under the U.S. Department of the Interior.
- USGS has approximately 8,500 employees, about half of whom are scientists.
- USGS is headquartered in Reston, Va., and has more than 400 science centers throughout the country.
- The Survey has more than 2,000 partners from state, local and tribal governments, the academic community, other federal agencies, NGOs, and the private sector.
- The USGS maintains the National Earthquake Information Center.
- Notable USGS programs and initiatives include The National Map, the Hazard Data Distribution System, Landsat Earth observation missions in cooperation with NASA, the Global Fiducials Library, and the Civil Applications Committee.

Inside the CAC

USGS Senior Advisor for Science Applications Jim Devine loves to talk about his work. But he'll stop short if you ask one too many questions about the Civil Applications Committee, known as the CAC, which coordinates the use of data and imagery collected via U.S. National Technical Means (NTM).

The CAC developed out of the work of a World War II veteran and USGS scientist who began using classified satellite images for topographic mapping in the 1960s. The charter that created the committee in 1975 allowed civilian agencies to access classified images for non-military, non-classified purposes. USGS manages the CAC, acting as liaison between the intelligence and defense communities and civil agencies.

The CAC coordinates and filters requests from federal civil agencies, which are then approved by NGA. It then converts the images into a declassified product, disseminates the information, and protects intelligence sources and methods.

"We do this in close conjunction with the Intelligence Community," Devine said. "They know what we do—we're very, very careful to stay within those bounds, and we're not ever allowed to step over the lines. That would ruin our ability to access this information."

In addition to traditional mapping, CAC activities include remote sensing applications such as monitoring sea ice, glaciers, and volcanoes; detecting and tracking wildfires; coordinating emergency response to natural disasters; and monitoring ecosystems. In addition to USGS, the National Science Foundation, National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, U.S. Department of Agriculture, and the Army Corps of Engineers are among the most prolific users of the imagery.

In partnership with the CAC, USGS also manages the Global Fiducials Library, an archive that maintains a long-term imagery record of environmentally significant sites around the world. The program began with the CIA a couple of decades ago in an attempt to answer questions about how the Earth was changing, such as what are the national security implications of a sea level rise?

The program monitored 500 locations worldwide over time, revealing the impact of rapidly changing coastlines and invasive species. In the last six years, the program has started to make images available to the public and has received approval to release more than 6,000 images covering about 125 sites.

hyperspectral sensor technology used by USGS for the minerals map in Afghanistan, to LiDAR 3-D surface modeling.

"The civil community has benefited from some of the sensor technology," he said, adding USGS is also a proponent of using UAVs as a safe and relatively inexpensive way to monitor volcanoes. "More cartographers die in airplane crashes than from snakebites or anything else," he said. "UAVs are much less disruptive or invasive in wilderness areas than scientists."

Devine said the biggest advantage for civilian access to declassified assets is that many capabilities would be too expensive to otherwise acquire.

"As long as we don't violate the agreement not to reveal sources and methods, it's a marvelous thing to have," he said, referring to the deal with the Intelligence Community requiring USGS to protect its sources when converting images into a declassified product. "It's a prime example of good government."

PREDICTING THE FUTURE BY EXAMINING THE PAST

Among the more undervalued assets at USGS are the historical data sets that have created an effectual time machine of the Earth's recent past. For example, USGS has monitored U.S. stream flow for 125 years.

"The result is we can tell you if something's part of a normal pattern, or if it's really unusual," said Mike Foose, chief of USGS's Africa and Middle East programs. "Making observations for long periods is hugely important to identify what's out of the ordinary, whether it's a food event in the Horn of Africa or flooding in Mozambique."

Some of the most widely used and celebrated USGS images come from the 42-year-old, Apollo-inspired Landsat program, developed in partnership with NASA. Landsat images document land changes such as glacial retreat, forest fires, and urban expansion. The two Landsat satellites that remain operational, Nos. 7 and 8, collect nearly 1,000 images daily, which are sent to USGS's Earth Resources Observation and Science (EROS) Center near Sioux Falls, S.D., for processing. The two million archived images are available to the public for free and provide a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research.

EROS is also home to the Hazard Data Distribution System, which facilitates the collection of images from Landsat and other sources such as DigitalGlobe and makes them available to disaster response teams. The center responds to around 75 disasters a year.

USGS is experiencing rising demand for its data by federal agencies and the emergency response and humanitarian communities. In the Horn of Africa, USGS uses Landsat images to monitor crop development as part of the Famine Warning System funded by the U.S. Agency for International Development (USAID). Foose said USGS has also used L-band radar to look below the desert sands in Darfur, Sudan, to map sub-surface water—which improved water drilling success in the region from 45 to more than 98 percent.

Whether it's a government agency, NGO, or academic institution, USGS customers and partners say they can't get enough data, images, and information. The need for more—and faster—data is particularly acute for users that make forecasts, such as the U.S. Department of Agriculture, or those who respond to disasters, such as the Federal Emergency Management Agency.

In coming years, USGS customers are likely to find more streamlined data, available more broadly, according to Kimball. Also in store: a renewed effort to train the next generation of cartographers and remote sensing experts, and further collaboration and idea-exchange with NGA.

THE TWO LANDSAT SATELLITES THAT REMAIN OPERATIONAL, NOS. 7 AND 8, COLLECT NEARLY

1,000

IMAGES DAILY.

INTERACTIVE HISTORY

The USGS Historical Topographic Map Explorer brings to life more than 178,000 maps dating from 1884 to 2006. Visit *trajectorymagazine.com* or download the *trajectory* tablet app for links to this interactive website and a host of others created by USGS.

ANTICIPATING CHANGE

BAE SYSTEMS EXPANDS CAPABILITIES IN IMMERSION, ABI, AND CSAR

Industry is constantly pushing the boundaries of technology to not only achieve global missions quickly and more efficiently, but also to save lives.

BAE Systems is continuing to take on this challenge by channeling its diverse capabilities and innovations. The company's structure offers everything from IT and cybersecurity, to system development and integration, to imagery and geospatial analysts supporting both the intelligence and defense communities.

"It's nice to have the analytical staff along with the development staff housed in the same company—we can talk about solutions that meet the mark right out of the gate and deliver that solution as fast as possible to the customer," said Craig Brower, National Geospatial-Intelligence Agency (NGA) account manager for BAE Systems' Intelligence and Security sector.

Brower said the company has made its mark in a variety of areas—immersive GEOINT being a particular focus.

PHOTOS COURTESY OF BAE SYSTEMS

< **BAE SYSTEMS'** GXP Xplorer Snap app can be operated with Google Glass, taking users into an immersive environment.

Immersion, described by NGA Director Letitia Long during her keynote speech at the GEOINT 2013* Symposium, is "living, interacting, and experimenting with data in a multimedia, multi-sensor experience with GEOINT at its core."

"Hearing what Director Long had to say about immersive technology confirmed that we are already on the right path," Brower said. "We are focused on making sure we can connect the data to the humans. We ask ourselves how do we make that data all around you and available to you in real-time or in near real-time, so folks can make decisions going forward?"

Having explored immersion for several years, BAE Systems is now working with various government agencies looking toward an immersive future to help manage Big Data, said Brower.

"The biggest challenge facing the defense and intelligence communities is making Big Data understandable," explained Brower. "With everyone becoming a sensor, and news and information immediately accessible, we are swimming in data. The key is to make all kinds of data—structured and unstructured—useable for the decision maker."

VISUALIZING DATA

BAE Systems helps NGA and other intelligence agencies better connect their personnel with the data via the company's GXP Xplorer Snap app, a new addition to the data management application suite GXP Xplorer. Paired with Google Glass, the app allows users to take a picture, crowdsource the information, and immediately upload a report to the GXP Xplorer server for sharing. The app allows the user to automatically geo-tag and time-stamp the report, all while being hands-free.

Though the app can also be downloaded on a smartphone or tablet, combining it with Google Glass puts the user in an immersive environment, allowing them to see the data directly in front of them in order to make critical decisions quickly. The app is targeted for soldiers deployed with reconnaissance assignments and for first responders handling disaster relief operations.

According to Brower, data collected using the Snap app can also be integrated into an activity-based intelligence (ABI) workflow to enhance analyst productivity. He added the company is looking to integrate ABI solutions into its products to help analysts solve problems in new ways.

"We are building an advanced analytics platform based on the ABI tradecraft," Brower said. "In addition, we continually update our suite of GEOINT software products to support the latest tradecraft and analyst workflows."

AN UNDERRATED CSAR

Immersion and ABI are not the only emerging areas in which BAE Systems is investing. The company recently entered into a strategic partnership with Airbus Defence and Space to produce a new product line solely focused on commercial synthetic aperture radar (CSAR) products. Using Airbus satellite data collected from its TerraSAR-X and TanDEM-X radar satellites, combined with BAE System's GEOINT management and analysis, this product line aims to establish a new standard in precision change detection applications, maritime monitoring, digital elevation modeling, and topographical mapping.

"We are seeing rapid advances in the quality of commercial SAR data, similar to the TV industry's move from standard TV to HDTV, and we're making strides to advance the standard even further, comparable to advancing images from HD to 3D HD," Brower said. "You have a much more robust set of data to draw pictures of the foundation of the Earth and lay all other sources of GEOINT on top in order to provide people with a much better and more accurate view of the world."

BAE Systems hopes its partnership with Airbus will not only create outstanding products, but catapult CSAR into the mainstream, helping more potential customers realize the technology's benefits.

BAE Systems has set its sights on advances in several areas, but what does this mean for the future? Brower anticipates the way analysts solve problems is going to change, and the company strives to change with them.

"By shifting to a more immersive approach to GEOINT analysis, and integrating more advanced analytic solutions into the intelligence cycle, the very way we problem solve is going to change," predicts Brower.

"Advanced analytic solutions are helping to usher in an era of anticipatory intelligence, which is crucial to solving hard problems related to terrorism, insurgency, narcotics trafficking, and weapons proliferation," said Brower. "These tools are helping analysts interact with data in new and exciting ways and they're helping us organize and present data in such a way we will have a better understanding of the possible impact and likely outcomes of critical decisions—before they are made. This will allow leaders to test possible responses and gauge their potential global impact before committing to that option."

■ BY LINDSAY TILTON MITCHELL

THE SNAP APP allows users to automatically geo-tag and time-stamp a report within seconds, helping decision-makers act quickly.

THE COAST of Antofagasta, Chile, was photographed in 2013 during a project that collected data from more than 50 countries in one year.

PHOTO COURTESY OF COMPASSDATA INC.

AN INTRODUCTION TO GROUND CONTROL POINTS

The importance of accurate, standardized GCP collection

By W. Brant Howard, founder and CEO, CompassData Inc.

SATELLITE AND AERIAL SENSORS play leading roles in the collection of data for geospatial applications. However, the accuracy of the raw or unprocessed imagery often fails to meet end user requirements. Enhancing the raw imagery and deriving complex products with accurate geometry can be achieved by processing with ground control points (GCPs). Accurate and consistent GCPs are vital to the success of many applications of remotely sensed data.

GCPs are typically captured using GPS receivers to survey coordinates of photo-identifiable points on the ground, such as features on tennis courts or high-contrast marks on concrete or asphalt. Coordinates are reported in latitude, longitude, and elevation—or northing, easting, and heights. The accuracy of the points depends on hardware, software, the processing approach, and the experience of the production team.

For geospatial applications, the most common use of GCPs is to georeference an optical satellite or aerial image to the correct position on the Earth's surface during ortho-processing, which corrects for terrain displacement and perspective projection. The goal of an accurate image map is for every point in the processed data set to match its corresponding point on the ground with a determined level of accuracy. Other data sets such as Light Detection and Ranging (LiDAR) and Interferometric Synthetic Aperture Radar (IFSAR) surface models are also georeferenced to the terrain with GCPs.

In addition to georeferencing, GCPs are commonly used to verify geospatial data accuracy, orthorectify imagery, fuse multiple raster datasets, and calibrate new imaging sensors.

WHY ARE GCPS IMPORTANT?

Most remote sensing devices and the platforms that carry them have been calibrated to collect georeferenced data. But for many geospatial applications, the accuracy of this georeferencing is not sufficient and must be improved. This improvement is achieved after acquisition through processing with high-quality GCPs.

A raw satellite image, for example, with an advertised native horizontal accuracy of 3.5 to 5 meters may have its relative accuracy improved to 50 centimeters after being georeferenced. Processing with ground control will become even more critical as higher-resolution imaging satellites are launched.

Additionally, many UAVs and small satellite constellations entering the market do not carry inertial measurement units capable of supporting highly accurate images or videos. Post-

or near-real-time processing with GCPs will be required to improve data accuracy.

COLLECTING QUALITY GCPS

For organizations engaged in mapping operations worldwide, consistency is just as critical as accuracy when it comes to GCPs. Orthoimages created for an area in the United States, for instance, must be processed with GCPs meeting the same specifications as those used to generate similar products in Europe, Asia, South America, or the Middle East.

To ensure GCPs are uniformly accurate and consistent, the collection process should be standardized and replicable worldwide. Here are important tips:

- Point collection should be performed with professional GPS receivers by surveying professionals who follow standardized, documented procedures.
- The ideal GCP is captured on a ground feature that is identifiable in a satellite or aerial image. The feature should be permanent, on flat ground with good contrast, and with no overhead obstructions.
- Any permanent GCPs can be used multiple times in the future, compared to temporary plastic panels.
- Metadata must be collected along with the GCPs, including station diagrams and ground photographs showing the exact location of the surveyed point.
- The horizontal and vertical accuracy of the GCP coordinates must meet the requirements of the end-user application. Typical GCP accuracy ranges between two and 10 centimeters in relation to a specific coordinate system.
- Quality GCPs can be saved and used repeatedly for multiple purposes in the future. GCPs can be purchased from commercial archives.
- GCPs collected in one coordinate system, datum, and epoch can be transformed into others, including future epochs.
- Small projects typically require 10 to 20 GCPs, while large projects can easily require hundreds of GCPs depending on total area and the spatial resolution of the sensor.

For the GEOINT Community, which often uses unclassified commercial imagery and digital elevation model products, high-quality, unclassified GCPs are also available from commercial sources. Processing geospatial data with these GCPs enables coalition partners to deliver accurate products to the warfighter in the field without the burdens associated with sharing classified data sets.

The most important thing to keep in mind is to rely on experienced field surveyors to collect GCPs using procedures that are standardized and applied consistently regardless of geographic location. This ensures the GCPs will be accurate and can be used for a variety of applications. ■

A RAW SATELLITE IMAGE MAY HAVE ITS RELATIVE ACCURACY IMPROVED TO

5

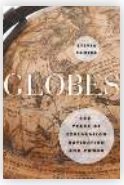
CENTIMETERS AFTER BEING GEOREFERENCED.

READING LIST

INTELLIGENCE: FROM SECRETS TO POLICY

By Dr. Mark M. Lowenthal

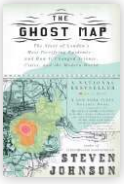
Intelligence veteran Mark Lowenthal describes the developments and challenges in the Intelligence Community in this book's sixth edition. He also writes how the community's complex history, structure, and procedures affect policy decisions.



GLOBES: 400 YEARS OF EXPLORATION, NAVIGATION, AND POWER

By Sylvia Sumira

In this book, Sumira dives into the history of globes and how they are created—some becoming true works of art. From pocket-size globes to ones that assemble like a puzzle, her book features various fascinating globes from around the world.



THE GHOST MAP: THE STORY OF LONDON'S MOST TERRIFYING EPIDEMIC—AND HOW IT CHANGED SCIENCE, CITIES, AND THE MODERN WORLD

By Steven Johnson

Johnson's writing explores the 1854 cholera outbreak in London and how the spread of the disease and rise of cities shaped the world's current geography.

USGIF EVENTS CALENDAR

OCTOBER

22-23

NGA Tech Showcase West
NGA Campus West
St. Louis, Mo.

NOVEMBER

17-21

GEOINT Community Week
Northern Virginia

18

GEOINTeraction Tuesday
Springfield, Va.

PEER INTEL

USGIF Chairman of the Board **The Honorable Jeffrey K. Harris** was elected to Riverside Research's Board of Trustees. Harris has nearly 40 years of experience in government and industry.

Rich Leshner recently joined Planet Labs as the director of government affairs. Leshner has more than a decade of experience in the civil space community, most recently as the NASA small business innovation research/ small business technology transfer program manager, and as the lead for civil space policy issues within the White House Office of Science and Technology Policy.

Booz Allen Hamilton announced **Horacio D. Rozanski** as its new CEO effective Jan. 1, 2015. Rozanski was previously the president and COO. His appointment follows the retirement of CEO **Ralph Shrader**, who has been with the company 40 years. Shrader will serve as the chairman of the firm's Board of Directors.

Northrop Grumman appointed four vice presidents within the company's information systems sector. **Bobby Lentz** was named sector vice president of strategy; **Tom Afferton** as vice president, operations, civil division; **Jay Grove** as vice president of business development, communications division; and **Michael King** as vice president, business development, civil division.

Roxanne J. Decyk has been appointed to DigitalGlobe's Board of Directors. Decyk is currently on the board of directors at Alliant Techsystems serving as the chairman of the compensation committee, and also serves as a board member of ENSCO PLC and Petrofac Ltd.

The Office of the Director of National Intelligence (ODNI) appointed **Brian P. Hale** as its new director of public affairs. Prior to joining ODNI, Hale served as the assistant director of the Office of Public Affairs with U.S. Immigration and Customs Enforcement. Hale replaces **Shawn Turner**, who recently joined the White House Press Office as deputy press secretary.

Ball Aerospace named two appointments to its strategic operations department. **Jill Pomeroy** joined as the director, legislative affairs. **Michael O'Hara** was selected as Ball's director of business development for space technology and services.

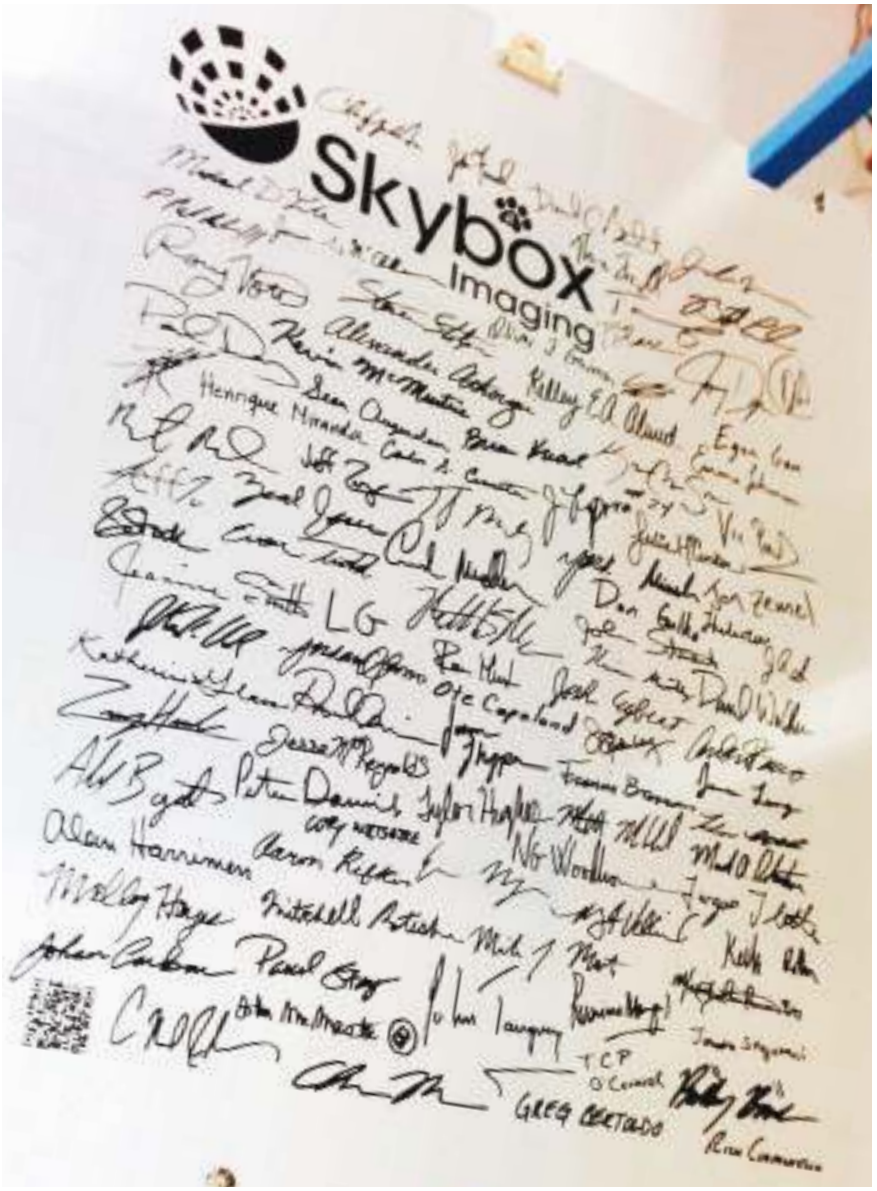


PHOTO COURTESY OF SKYBOX IMAGING

Signed, Sealed, Delivered

This image of the inside panel of SkySat-2 shows the signatures of all Skybox Imaging employees including the company dog, Ruby. The satellite, which launched in early July and is now zipping around the Earth at seven kilometers per second, is the second in the company's planned fleet of 24 high-resolution SmallSats. Skybox Imaging was founded in 2009 by four Stanford University graduate students and has since grown to more than 125 aerospace engineers and data scientists. The company was recently ranked No. 14 on the 2014 CNBC Disruptor 50 List and named *Inc.* magazine's No. 1 Most Audacious Tech Company—both with good reason. Not only does the start-up represent a paradigm shift for the GEOINT Community—which has traditionally relied upon larger, more expensive and complex satellites—but its founders hope to change the way businesses make decisions as well as the way people view the world. However, Skybox views its core business as providing information services, not building satellites. Its focus is on the valuable insight hidden in high-resolution images and videos.

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