» HUMAN TRAFFICKING » FUTURE GEOINT LEADERS » OPEN GEOSPATIAL STANDARDS

2016 ISSUE 4

trajectory

THE OFFICIAL MAGAZINE OF THE UNITED STATES GEOSPATIAL INTELLIGENCE FOUNDATION

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The electromagnetic spectrum can be spliced into infinite "bands," the majority of which are invisible to the naked eye. Sensors that read approximately 10 or fewer visible and invisible bands are known as multispectral, those that read between 10 and 20 superspectral, and those that read more than 20 hyperspectral.

IMAGE COURTESY OF DIGITALGLOBE

ON THE COVER: DigitalGlobe's WorldView-3 satellite has short-wave infrared (SWIR) capabilities to detect heat and distinguish between different types of natural and manmade materials. This image shows how the Raung volcano in Indonesia appears to the naked eye. The SWIR image overlay (inside the circle) indicates where the volcano is hottest and highlights a new pool of lava that began collecting in June 2015.
Image courtesy of DigitalGlobe

TRAJECTORYMAGAZINE.COM

EXTENDED PROFILES
Learn more about the 2016 USGIF scholarship winners.

IMAGE COURTESY OF DIGITALGLOBE

SEE A BETTER WORLD
Learn how DigitalGlobe uses satellite imagery to help reveal slavery around the globe.

POWER IN NUMBERS
Crowdsourcing apps allow the general public to join the fight against human trafficking.

THE COMMON THREAD

Recent flooding in Louisiana and Texas, wildfires in California, and the impact of Hurricane Matthew are all reminders of the destructive power of natural hazards. Acts of terrorism in New Jersey, New York, Orlando, and San Bernardino are reminders of the violence we face in our homeland. Ongoing military operations and the sacrifices brought home graphically with the arrival of a fallen service member at Dover Air Force Base remind us of the price of being a world power. Through all of these challenges, geospatial intelligence is a common thread that prevents and alleviates human suffering.

In the past few months, I've had opportunities to speak at a number of events and to audiences including GIS professionals in Maryland, emergency managers in New Jersey, executives responsible for critical infrastructure protection, and national gatherings of both law enforcement professionals and public safety practitioners. GEOINT resonates significantly with these stakeholders.

They recognize the skills that have served them well for many years, and/or that they've relied upon from others, mostly limited to GIS, are necessary but insufficient. They recognize the power of remote sensing from both air and space. They recognize the need to perform data analytics and provide visualizations that are immediately intuitive to decision-makers. They are immediately receptive to my description of an integrated whole, which brings those elements together at their point of decision. When I illustrate the power of GEOINT, they are emphatic in their articulation of how badly they need it for mission success.

This idea of "GEOINT" we crafted in 2003, around which has grown a vibrant community, has transcended its original bounds. We have a tremendous opportunity at hand to share our education, training, and tradecraft with these important sectors. We have a responsibility to ensure they don't make the same mistakes we have in the past 13 years and that they benefit from what we have learned on battlefields and in disaster areas both at home and around the globe. USGIF is excited to lead the way as the idea of GEOINT spreads virally and is rapidly applied to new mission sets and adopted by new sectors.

In this issue, veteran *trajectory* writer Matt Alderton pens a cover story about diverse remote sensing phenomenology, exploring the latest in LiDAR, SWIR, NIR, thermal infrared, and multi-, hyper-, and super-spectral sensors. There are certainly applications for these technologies outside the bounds of our traditional community. Our *trajectory* managing editor Kristin Quinn writes how geospatial technology is being used to fight the atrocity of child sex trafficking—demonstrating how GEOINT technology and tradecraft extends far beyond its traditional realm.

We've also included in this issue the stories of USGIF's 2016 Scholarship Winners. I'm thrilled to say this year the Foundation eclipsed $1 million in total scholarship funds awarded since the program began in 2004. Our ability to support scholarship awards and accredit 14 college and university certificate programs, not to mention USGIF's many other programs, is sustained by our individual and organizational members as well as the participants, attendees, and sponsors of our events. If you aren't yet a member of USGIF, I encourage you to join us in supporting the GEOINT profession now and into the future. It's an incredibly exciting time to be a GEOINTer, and we'd love to have you as part of the USGIF team.

As always, I look forward to seeing you soon in our hallways and conference rooms, and at our events. Best wishes for a safe and happy holiday season, and a healthy and prosperous 2017!

KEITH J. MASBACK | CEO, USGIF
@geointer

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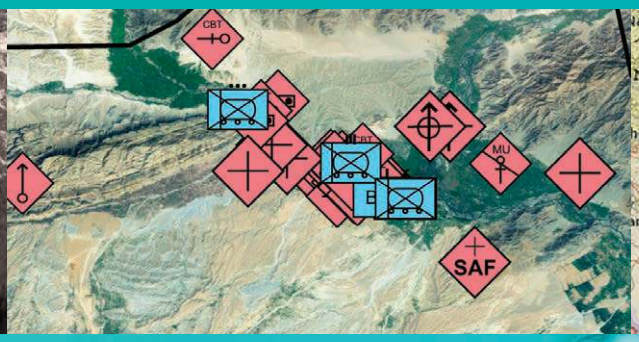
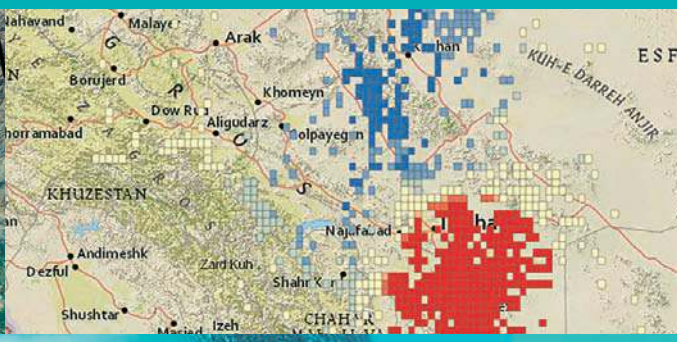
DELIVERING MISSION SUCCESS

Former army artillery officer Tyson Quink shares how he went from placing rounds on targets to placing data on a map as a solution engineer on the Esri defense team.





Q: Why is your work at Esri important to you?

A: For me, getting geospatial information into the hands of our soldiers is one of my main objectives. I really enjoy helping our military understand the value of GIS technology and educating them on how it will make their jobs easier through better decision-making in real time, thus helping them accomplish the mission and come home safely. This gives us the satisfaction that what we are doing is helping our customers—what we are doing has true meaning. That's the best part of my job.

Q: What is the most important GIS challenge for the defense industry?

A: With the rapid advancement of GIS capabilities, the military's need for a fully integrated platform to support the fusion of intelligence, operational planning, and real-time spatial data has become increasingly important. Geospatial technology is enabling stronger situational awareness by breaking down barriers to the discovery, access, and utilization of information that can directly impact a mission.

Q: How is Esri technology helping you support our military customers?

A: I wanted to continue to support soldiers, and Esri presented an impactful way to do so. ArcGIS provides our military with better tools to help conduct, plan, and execute operations. Geospatial intelligence can be leveraged by uniformed and civilian personnel to make informed decisions based on data, not assumptions.

esri

Learn more at **esri.com/trajectory**

INSIDER

NEWS UPDATES AND HIGHLIGHTS

WOMEN'S CODING INITIATIVE

NGA recently launched a new women-focused coding initiative within the Intelligence Community (IC) called Women Enriching Coding or #WECODE. NGA GEOINT Pathfinder alumnae Dr. Eliza Bradley, a spectral imagery scientist, and Sarah Vahlkamp, a workforce analyst, are credited for the idea. This grassroots project offers support to women in the IC who code at any level. Beginners can receive guidance or suggestions and more experienced individuals have the opportunity to teach new learners. Bradley and Vahlkamp hope to expand coding talent in the IC and make it second nature to share and discover coding ideas across the community.

Sarah Vahlkamp (left) and Dr. Eliza Bradley originated the idea of #WECODE.

PHOTO COURTESY OF NGA

IMAGE COURTESY OF NVIDIA

NVIDIA'S DEEP LEARNING GPU TRAINING SYSTEM demonstrates automated building detection using the SpaceNet data set.

MACHINE LEARNING FOR IMAGERY ANALYSIS

SpaceNet, an online repository of satellite imagery and labeled training data, launched in August. The platform aims to advance automated detection and extraction of features in satellite imagery via machine learning and deep learning algorithms that leverage remote sensing data. SpaceNet is a collaboration among CosmiQ Works, DigitalGlobe, the National Geospatial-Intelligence Agency, and NVIDIA, with imagery now freely available as a public data set on Amazon Web Services.

got geoint? got geoint? got geoint? got geoint? got geoint? got geoint? got geoint? got geoint? got geoint?

The total small sat market value is projected to reach $27 billion in the next 10 years.

USAID ANNOUNCES GRAND PRIZE WINNERS IN WILDLIFE CRIME TECH CHALLENGE

In September, the U.S. Agency for International Development (USAID) named four grand prize winners from its Wildlife Crime Tech Challenge. With a combined award of more than $900,000, the winners' innovations will help fight illegal trafficking of terrestrial and marine wildlife. More than 300 participants from around the world responded to USAID's initial challenge call on Earth Day 2015. The grand prize winners are the National Whistleblower Center, the New England Aquarium, New York University, and the University of Washington.

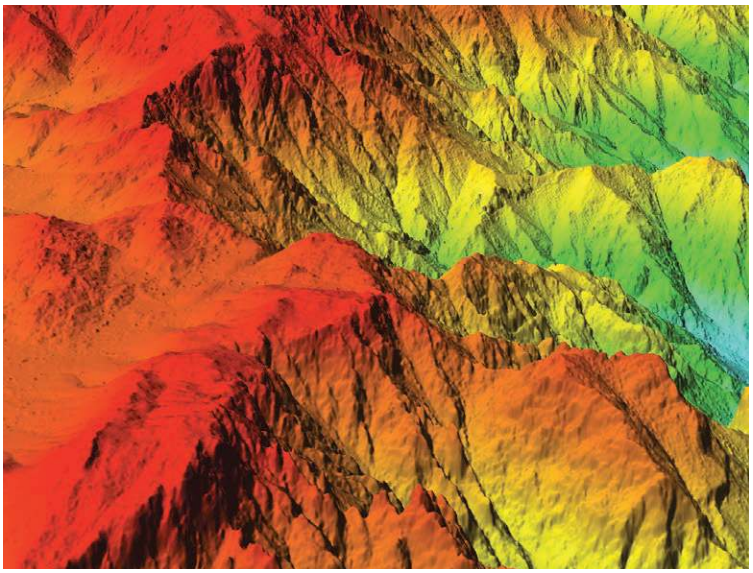


IMAGE COURTESY OF VRICON

VRICON AWARDED GSA CONTRACT

The General Services Administration (GSA) awarded Vricon a contract to support the Army Geospatial Center (AGC) with 10-meter and 0.5-meter geospatial data. Under the contract, Vricon will provide AGC with DSM-10, a digital surface model with 10-meter postings for an entire country. The company will also provide its Vricon Data Suite, a bundle of products that includes Vricon 3D Surface Model, Vricon DSM, Vricon Point Cloud, and Vricon True Ortho for specific areas of the world.

PROCRASTINATION TOOLS

HUMAN

Get moving! Human is an all-day activity tracking app that inspires urbanites to be more active. The app allows you to see other users on a map and visualizes how people in your city move.
human.co

VERNE: THE HIMALAYAS

Available on Android devices, Verne: The Himalayas allows users to explore Google Maps' 3D imagery of the Himalayas alongside a Yeti named Verne. This app is ideal for helping the little geographers in your life view the world through a different lens.
verne.withgoogle.com

LIVETREKKER

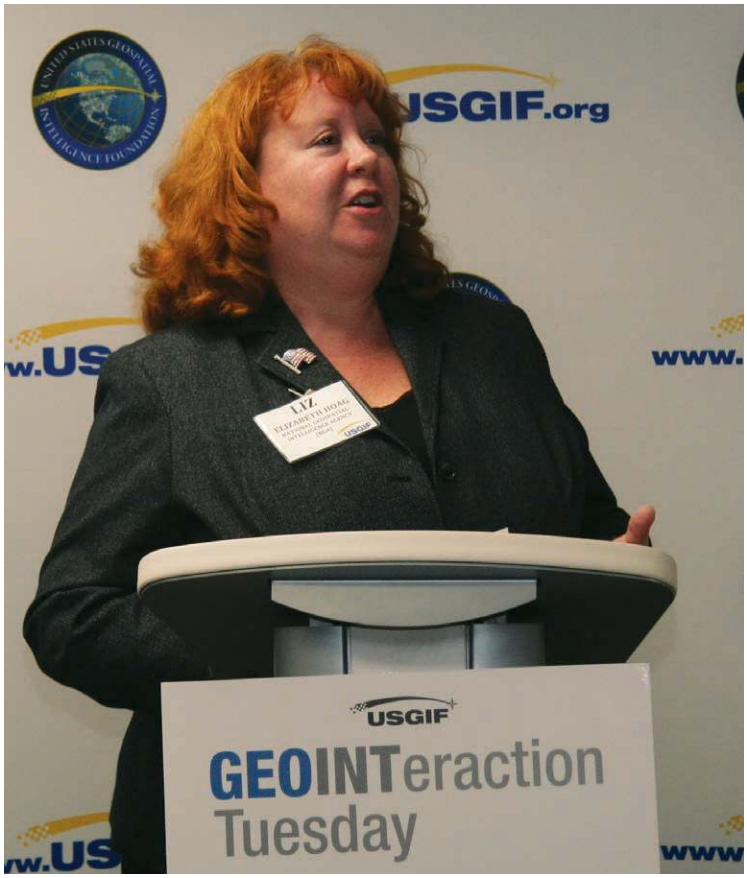
Planning your next adventure? The LiveTrekker app allows users to track and journal their travels, document them with geolocated photos and videos, and share their experiences with friends on social media.
livetrekker.com

DISPARATE DATA CHALLENGE

In September, NGA launched a $200,000 competition on **Challenge.gov** to address the agency's disparate data challenges. The challenge aims to provide unified access to data to support applications such as business metrics and information analytics. The first stage of the challenge awarded 15 $10,000 prizes and required participants to develop functional code designed to access and retrieve the supplied representative data sets from a variety of sources. Stage 1 winners were invited to participate in Stage 2 demos in Washington, D.C., October 21-22.

This is a 10% increase from the 2006-2015 time frame.

SOURCE: EUROCONSULT



USGIF FILE PHOTO

NGA'S ELIZABETH HOAG spoke about the agency's new eNGAge program at a USGIF GEOINTeraction Tuesday event.

NGA'S "PEOPLE SOLUTION"

Elizabeth Hoag, a program manager with the National Geospatial-Intelligence Agency (NGA), spoke about the agency's new eNGAge expertise exchange program in September at USGIF's GEOINTeraction Tuesday event. Hoag described eNGAge as a "people solution" that identifies areas in which NGA employees need more experience or ways in which industry could benefit from spending time at the agency.

The eNGAge website contains a list of NGA problems and challenges, and invites industry and academia to propose expertise exchange solutions. Challenges include data analytics and data science, 3D surface generation and editing, geospatial cyber research, and many more.

According to Hoag, the program is flexible and adaptable depending on need. The duration of an exchange could last from six months to multiple years—or even be intermittent. Additionally, exchanges don't have to be 1:1—meaning an NGA employee could go on assignment with a member of industry without the company sending an employee back to the agency, and vice versa. She also emphasized the program is meant to be more than an individual professional development opportunity.

"We're talking about special work and special people—people being ambassadors where they can learn and live in an immersive environment and come back and share, and multiply that sharing with the rest of the team," Hoag said.

Learn more about eNGAge by visiting **www.geoint.community** or by contacting the program office at **eNGAge@nga.mil** or **571-558-1800**.

PHOTO BY CHRISTOPHER WRIGHT, GEOTECH CENTER

USGIF'S DR. DARRYL MURDOCK accepted the 2016 GeoTech Center Distinguished Geospatial Education Partner award on behalf of the Foundation.

USGIF RECOGNIZED FOR CONTRIBUTIONS TO GEOINT EDUCATION

The National Geospatial Technology Center of Excellence (GeoTech Center) named USGIF a co-recipient of the 2016 GeoTech Center Distinguished Geospatial Education Partner award. This is the third year the annual award has been presented. The other 2016 co-recipient was the GIS Certification Institute. The awards committee selected USGIF out of several nominees for the Foundation's creation of the GEOINT Essential Body of Knowledge, which informs USGIF's burgeoning Universal GEOINT Certification Program.

As technology further enables human traffickers, more and more organizations are recognizing technology must also be a part of the solution.

See page 20: "Modern Slavery"

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USGIF FILE PHOTO

USGIF CEO KEITH MASBACK gave a keynote address at the National Geospatial Preparedness Summit.

USGIF CEO DISCUSSES GEOINT WITH PUBLIC SAFETY ORGANIZATIONS

USGIF CEO Keith Masback represented the Foundation and GEOINT Community at several speaking engagements in September. He gave a keynote address Sept. 12 at the **InfraGard National Members Alliance's 2016 Annual Congress and Conference** in Orlando, Fla. InfraGard is a partnership between the FBI and the private sector to create direct lines of communication to better protect critical infrastructure and key resources.

The National Alliance for Public Safety GIS Foundation invited Masback to give a keynote address Sept. 14 at the **National Geospatial Preparedness Summit** in Washington, D.C. The summit brought together 150 public safety leaders and GIS responders from across the country to gain new skills in applying location-enabled decision support tools, share best practices, and more.

On Sept. 15, Masback participated in a panel titled "Geospatial Impact on Policing Effectiveness" at the **Integrated Justice Information Systems Institute's (IJIS) Mid-year Briefing** in Arlington, Va. The IJIS conference focused on information sharing and safeguarding standards.

USGIF-ACCREDITED UNIVERSITIES ADVANCE THE TRADECRAFT

The National Geospatial-Intelligence Agency (NGA) awarded the **University of Missouri** (MU) College of Engineering a five-year, $12 million contract to deliver a data science education program that provides analytical training for the agency workforce and potentially other members of the Intelligence Community. The program is a collaboration between MU's Center for Geospatial Intelligence and the MU Informatics Institute's data science and analytics master's degree program. The **University of Southern California** Spatial Sciences Institute (SSI) recently introduced new degree offerings, including a master's degree in spatial informatics, which was developed in collaboration with USC's computer science department. This program is beginning its second year and attracting students from around the world. The institute also launched a Ph.D. in population, health, and place with the start of the current fall semester. Additionally, the institute now offers a minor in human security and geospatial intelligence, which benefits students seeking a career in national security.

Visit **trajectorymagazine.com/education** for more details on these academic programs.

The Global SOF Foundation selected **Fayetteville State University** (FSU) as the organization's first academic partner. Through this partnership, FSU's Center for Defense and Homeland Security will contribute to the Global SOF Foundation mission.

EVENTS FOR YOUNG PROFESSIONALS

In July, Leidos hosted approximately 30 members of USGIF's Young Professionals Group (YPG) for a **small sat talk** at its Reston, Va., office. USGIF Small Satellite Working Group Co-Chair Robert Zitz, vice president and strategic account executive at Leidos, discussed how small satellites are changing the game in the commercial remote sensing marketplace.

In August, Vricon hosted **A Night in 3D** for USGIF's YPG as well as young professionals from the American Society for Photogrammetry and Remote Sensing at its McLean, Va., office. Attendees had the opportunity to network and see a demo of Vricon's "The Globe in 3D" technology.

In September, the YPG and members of the NGA Professionals Network held a **networking event** at the International Tap House in St. Louis. Meanwhile, in Washington, D.C., YPG members caught a **Washington Nationals game**. Also in September, YPG held an **Acquisitions 101** event, at which attendees learned from ISPA Technologies CEO Brian Bleeze about cost-plus-fixed-fee contracting.

Visit **usgif.org/community/YPG** to learn more about YPG and its upcoming events.

USGIF FILE PHOTO

ROB ZITZ OF LEIDOS spoke to young GEOINT professionals about small sats in the commercial marketplace.

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The incredible detail of DigitalGlobe's images gave governments the confidence to act upon the abuses exposed by the Associated Press.

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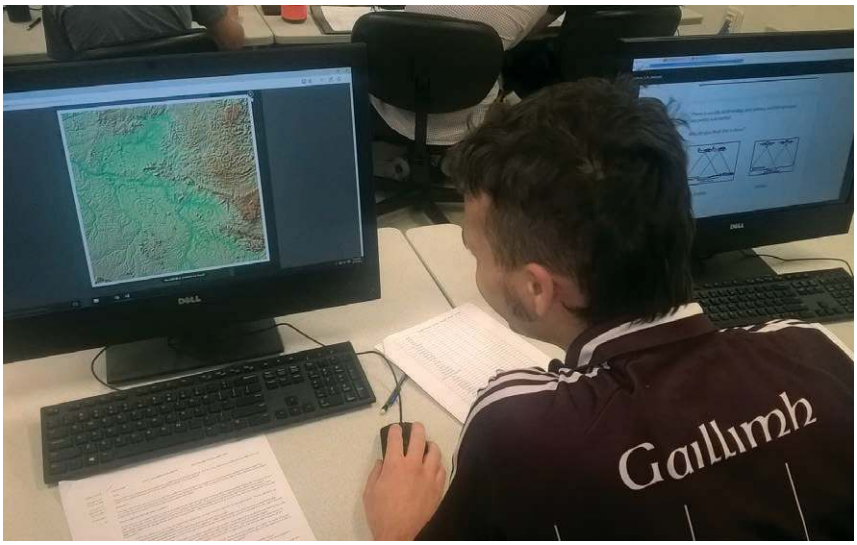
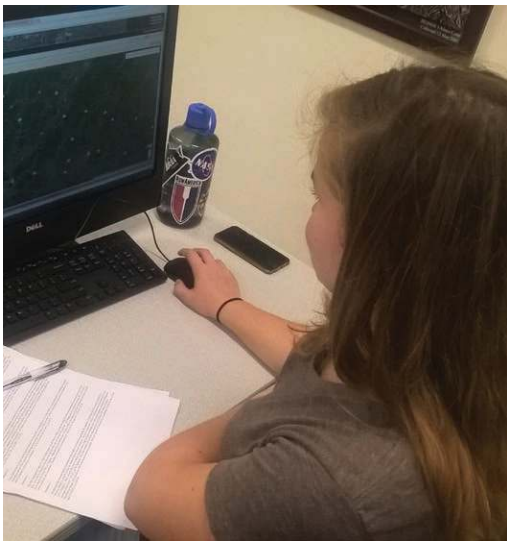
INTEGRATING DISCIPLINES

James Madison University couples geographic science with intelligence analysis

By Lindsay Tilton Mitchell





PHOTOS BY JMU

James Madison University (JMU) in Harrisonburg, Va., is less than 200 miles away from the nation's capital. JMU has had a geography program—now called geographic science (GS)—for about 80 years, and in 2007 formed its intelligence analysis (IA) curriculum to prepare students for careers in the Intelligence Community. Both bachelor's degree programs fall under JMU's department of integrated science and technology.

"Following 9/11, we asked, 'What can [JMU] do to help?'" said Dr. Tim Walton, an associate professor in JMU's intelligence analysis program. "In the years that followed, it was clear that analysts in Washington did not always have effective ways to think about problems. We talked to intelligence agencies and received grants and government backing to offer a program to develop students into more effective intelligence analysts."

Beginning with the 2016–2017 academic year, JMU's department of integrated science and technology will combine elements of its GS and IA programs to offer a USGIF GEOINT Certificate. Through USGIF's Collegiate Accreditation program, colleges and universities around the globe have the opportunity to seek accreditation for their geospatial intelligence programs and award GEOINT certificates to students who meet certain criteria. JMU is the 14th university to achieve USGIF accreditation. To date, nearly 700 students have graduated with USGIF GEOINT Certificates from accredited universities.

STUDENTS in James Madison University's geographic science and intelligence analysis programs worked together to complete an in-class remote sensing assignment. Remote sensing is one of the required courses for students to achieve a USGIF GEOINT Certificate.

"The [USGIF] certificate program ensures students are familiarized with a broad set of technical and critical thinking skills, as well as provided with knowledge relevant to entering and fostering a career in the geospatial intelligence profession," said Dr. Helmut Kraenzle, a professor of geographic science at JMU. "The interdisciplinary nature of our department and of the GS and IA programs will ensure a cutting-edge education for the students in [JMU's] USGIF GEOINT Certificate program."

Whether obtaining a GS or IA degree, students who choose to pursue a GEOINT certificate are required to take courses from both programs, including cartography, spatial thinking and problem solving, remote sensing, an introduction to national security intelligence, and more.

"We have a focus on technology and critical thinking," Walton said. "From the technology point of view, it's a big part of the intelligence business now and moving forward. Students need to have a working knowledge of technology if they want to

JMU will host a symposium on the "Future of Using Geospatial Intelligence to Anticipate Conflict" at its campus Aug. 3-4, 2017. For more information on presenting, attending, or sponsoring, contact Tim Walton at waltontr@jmu.edu.

go into that field. Also, there's a critical thinking side of it by teaching them to come up with a coherent plan to attack a problem."

Not only are students learning skills necessary for success in the GEOINT Community, they are also learning from experts. Walton spent 24 years as an analyst with the Central Intelligence Agency before becoming a professor, and Kraenzle has taught geographic information science at universities around the world since 1989.

According to Walton, approximately 70 percent of students who graduate with a GS or IA degree secure a job in industry, around 10 percent join the military, and roughly another 10 percent go to work for an intelligence agency.

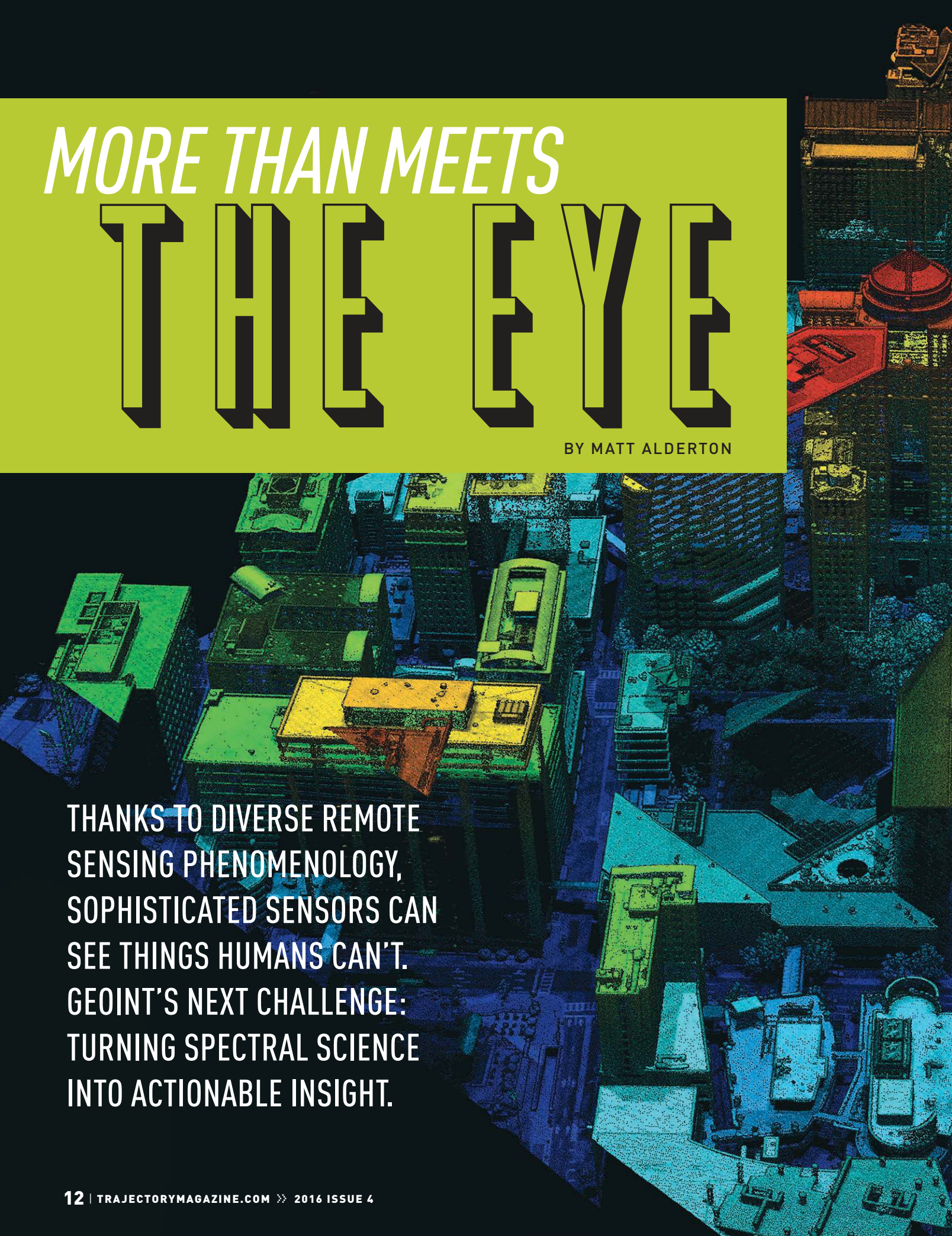
David Saunders, a JMU graduate who double-majored in GS and IA, said the programs taught him effective problem-solving as well as technical and critical thinking skills that are essential in his career. Saunders is now a geospatial analyst for Leidos working under the U.S. Army Geospatial Center's Buckeye mission.

"[JMU] taught me the vital skills that have ultimately made me feel confident in the GEOINT field upon graduation," Saunders said. "I thank my professors, who could not have been any better in providing and guiding me with such a structured, innovative, and integrated education. Without them, many students would not be where they are today in the GEOINT profession."

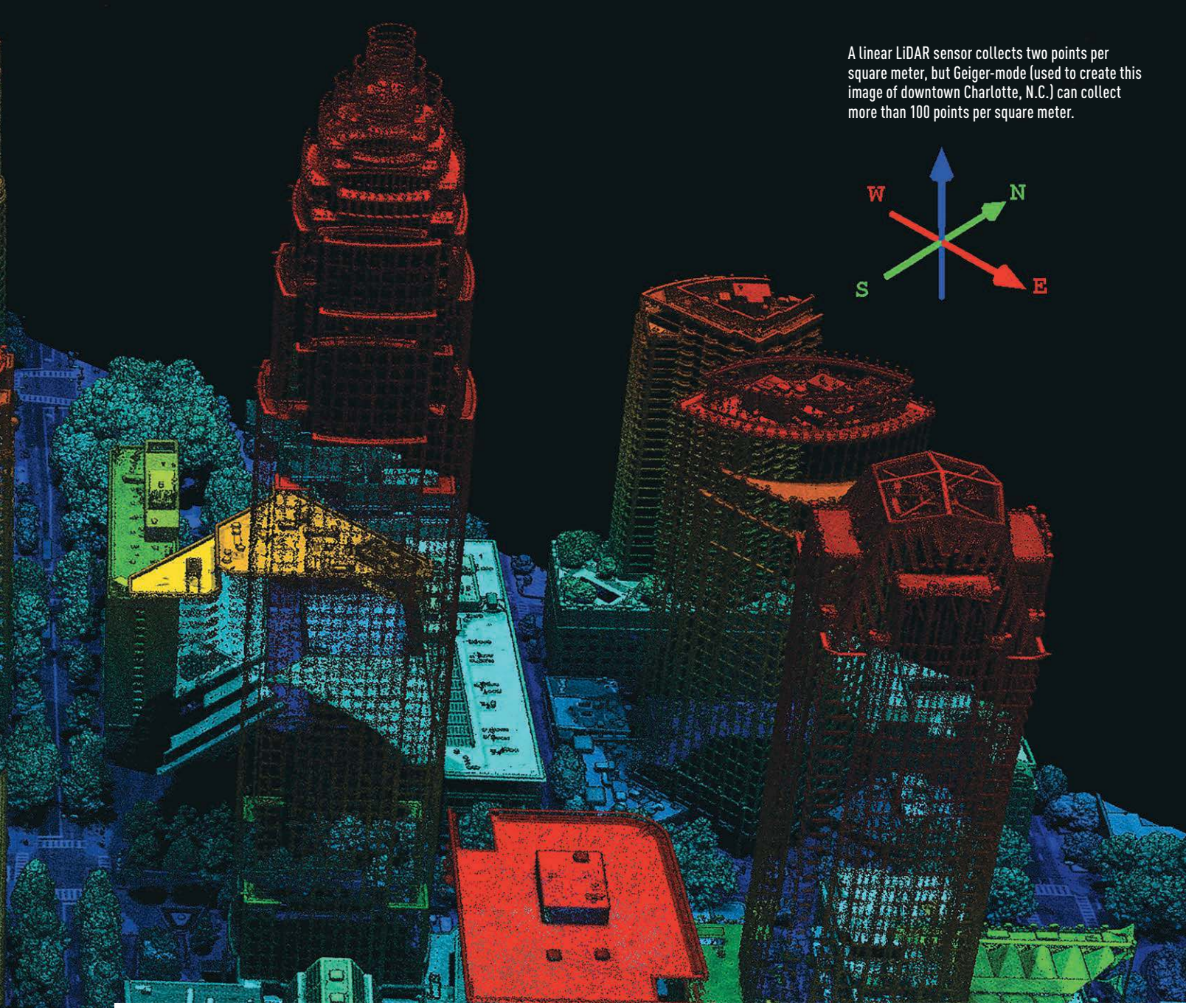
> "The [USGIF] certificate program ensures students are familiarized with a broad set of technical and critical thinking skills, as well as provided with knowledge relevant to entering and fostering a career in the geospatial intelligence profession."
>
> —Dr. Helmut Kraenzle, professor of geographic science, JMU

MORE THAN MEETS THE EYE

BY MATT ALDERTON



THANKS TO DIVERSE REMOTE SENSING PHENOMENOLOGY, SOPHISTICATED SENSORS CAN SEE THINGS HUMANS CAN'T. GEOINT'S NEXT CHALLENGE: TURNING SPECTRAL SCIENCE INTO ACTIONABLE INSIGHT.



A linear LiDAR sensor collects two points per square meter, but Geiger-mode (used to create this image of downtown Charlotte, N.C.) can collect more than 100 points per square meter.

IMAGE COURTESY OF HARRIS

The human body is a marvelous machine. Its largest organ—the skin—contains approximately 5 million touch receptors capable of telling hot from cold, wet from dry, and hard from soft. It also has a tongue with up to 10,000 taste buds discerning sweet, sour, salty, bitter, and savory; an auditory system with more than 25,000 minuscule hairs translating tiny vibrations into noise, music, and conversation; and eyes, which comprise more than 2 million working parts that together can distinguish approximately 10 million colors. Still, the human body has limitations. For every sight its eyes can see, there are exponentially more that remain indiscernible, invisible, and otherwise imperceptible. >

Remote sensing—taking images of Earth from land, sea, air, and space—is one way humans can transcend their five senses to learn more about the world. By augmenting senses with sensors, remote sensing supersedes biology in favor of physics to unlock distinguishing information about people, places, and things. The product is intelligence. The objective, however, is intervention.

For decades, the information returned by remote sensing platforms was restricted to literal images in black and white or color. The invention of synthetic aperture radar (SAR) in 1951, however, commenced a new era in sensor innovation. Along with electro-optical cameras and SAR—which can acquire imagery at night and penetrate clouds and fog—modern remote sensing platforms are bedazzled with a litany of sensors that exploit increasingly diverse phenomenology capable of seeing and sensing things never before possible.

"Just taking pictures in black and white or panchromatic provides a really limited set of information," explained Dr. Michael Egan, head of the Spectral Research Pod at the National Geospatial-Intelligence Agency (NGA). "What we really want to be able to do—and what the new and different types of sensors allow us to do—is determine what things are by seeing things in a way the naked eye can't."

SENSORS' ASCENSION

Before phenomenology, there was photography, according to remote sensing expert Daniel Ngoroi, a geospatial team leader at Woolpert. Ngoroi traces modern sensors back to NASA's 1969 Apollo 9 space mission, during which astronauts took the first multispectral terrain photographs from space. By making the case for multispectral orbital imagery, Apollo 9 influenced the 1972 launch of Landsat 1, the world's first civil Earth-observation satellite and—thanks to a sensor spanning four spectral bands—its first multispectral imaging satellite.

"[The first Landsat satellites] were designed from a multispectral point of view because people … realized there are vast expanses of the electromagnetic spectrum that we ought to be taking advantage of to see information we can't see with our own eyes," Ngoroi said.

The proliferation of diverse remote sensing phenomenology catalyzed by Landsat 1 was further stimulated by the 1992 passage of the Land Remote Sensing Policy Act and the dawn of the Information Age. The former accelerated sensor innovation through commercialization by spawning companies like DigitalGlobe, whose WorldView satellites embody the movement to develop new and more powerful sensors for commercial customers.

> "With thermal infrared you can tell whether a truck or tank engine is on, whether a building is occupied, or whether an aircraft on a runway has just landed."
>
> —Robert Zitz, vice president and strategic account executive, Leidos

"DigitalGlobe began developing … sensors with spectral bands for really unique applications," said Dr. Kumar Navulur, senior director of global strategy programs at DigitalGlobe, citing the development of DigitalGlobe's WorldView-1, -2, -3, and -4 satellites. Launched in 2007, 2009, 2014, and planned for 2016, respectively, each was outfitted with progressively more sophisticated sensors for applications in industries such as agriculture, forestry, and mining.

Equally important was the digital revolution, which enabled sensor evolution through advances in data storage, processing, and communication. The revolution brought sensors out of the laboratory and into real life.

"Twenty years ago … these national assets were so important that governments would spend billions of dollars on them. Today, that same kind of power is available in the private sector, to civilian

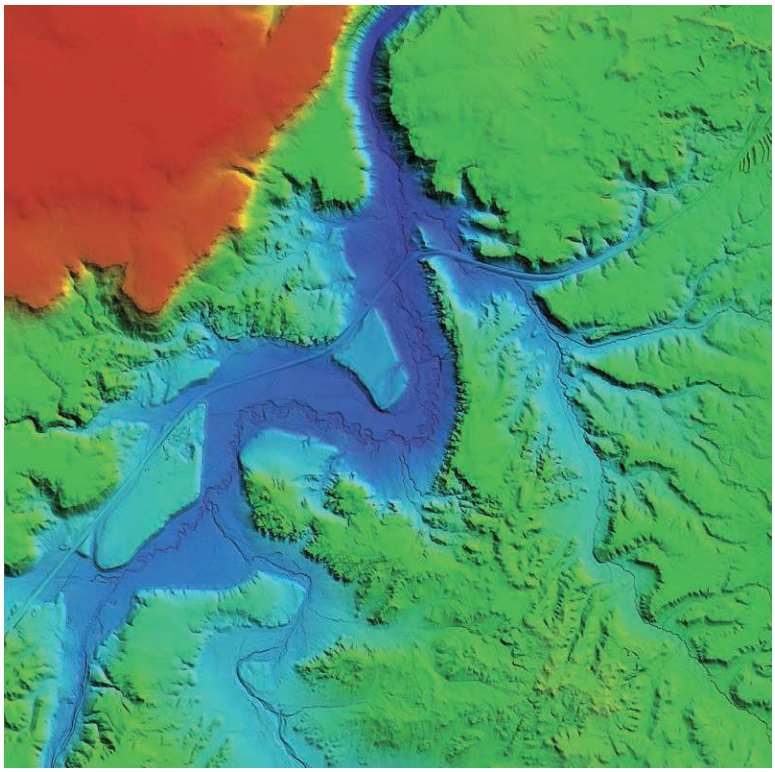


IMAGE COURTESY OF WOOLPERT

THIS PLANIMETRIC TOPOGRAPHIC MAP of Oregon's Crooked Creek is a LiDAR image Woolpert created for the U.S. Geological Survey and the Federal Emergency Management Agency.

agencies, and even to the world's poorest countries," said Dr. Michael Hauck, executive director of the American Society for Photogrammetry & Remote Sensing (ASPRS). "It's really remarkable."

SPECTRAL SOLUTIONS

History is one requisite subject for grasping diverse remote sensing phenomenology. Science is another.

"Remote sensing at its heart is really applied physics," said USGIF Vice President of Professional Development Dr. Darryl Murdock. "You have to understand physics to understand remote sensing."

Most modern sensors are designed to exploit the full range of the electromagnetic spectrum, the basic premise of which is this: Everything in the universe—the sun, the Earth, and even the human body—continuously emits energy in the form of electromagnetic radiation. This energy varies in frequency and wavelength, from radio waves with low frequencies and large wavelengths to gamma rays with high frequencies and small wavelengths. Because all objects emit, reflect, and absorb electromagnetic energy differently, capturing it allows analysts to glean information not revealed in literal images.

"Being able to observe how materials react or behave in different portions of the electromagnetic spectrum allows us to make determinations and inferences about what's happening on the ground," explained Dr. Frank Avila, a senior scientist in NGA's Office of Sciences and Methodologies. "For example, WorldView-3 gives us data across 16 [spectral bands] that we can use to look at the same portion of the ground. Each one gives us a slightly different piece of information, which together may be able to give us a complete picture."

The spectrum can be spliced into infinite "bands," the majority of which are invisible to the naked eye. Sensors that read approximately 10 or fewer visible and invisible bands are known as multispectral, those that read between 10 and 20 superspectral, and those that read more than 20 hyperspectral.

DigitalGlobe's just-launched WorldView-4 will sense across five spectral bands, while Planet's Dove satellites sense across four. UrtheCast's Iris and Theia sensors—mounted on the International Space Station—cover three and four bands, respectively, while its Deimos-1 and Deimos-2 satellites cover three and five bands, respectively. UrtheCast's future plans include UrtheDaily, a constellation of eight electro-optical satellites that will provide daily coverage across six bands.

Of all the bands multispectral sensors can capture, visible bands are the most common. Perhaps the most useful, however, are invisible bands, such as near-infrared (NIR) bands, according to Navulur, who said agriculture and forestry are two standout applications since vegetation—including trees, plants, and crops—has a particularly strong signature in NIR imagery.

"For example, when we developed our WorldView-2 satellite, one of eight bands that we derived was a band called the 'red edge' band, which allows us to identify whether vegetation is healthy or unhealthy," explained Navulur, noting photosynthesis causes NIR energy to bounce off healthy vegetation but pass through unhealthy vegetation, making it easy to identify plants affected by drought or disease. That kind of information is valuable not only to farmers and forest managers, but also to governments and militaries.

"We're using [multispectral data] to address food and water security issues by doing agricultural assessments and trend analysis to determine whether there's agricultural expansion at a country level or agricultural failure that could be an indicator for potential civil unrest down the road," Avila said.

Along with forests and farmland, the reflection of NIR energy—or lack thereof—makes it easy to distinguish manmade structures, bare earth, water, and shadows, all of which can help analysts answer questions about land composition and usage. Or in the case

LANDSAT CELEBRATES 50 YEARS

The U.S. Geological Survey's Landsat program celebrated its 50th anniversary in September—marking half a century since then Secretary of the Interior Stewart Udall announced the Department of the Interior was launching Project EROS (Earth Resources Observation Satellites). Landsat 1—originally called the Earth Resources Technology Satellite (ERTS)—launched in 1972 as the world's first civil Earth-observation satellite and first multispectral imaging satellite, paving the way for diverse remote sensing phenomenology.

Since then, seven more Landsat satellites have launched, collectively capturing millions of photos of Earth, and inspiring decades of remote sensing professionals.

"When I decided to come into this field, it was because I saw a Landsat image and was blown away that you could get a good image of the planet from space," said Daniel Ngoroi, a geospatial team leader at Woolpert.

With each iteration, the Landsat program incorporates new remote sensing technologies. Landsat 8, launched in 2013, carried two instruments: the Operational Land Imager, which included refined heritage bands and new bands such as a deep blue band for coastal/aerosol studies and a shortwave infrared band; and a Thermal Infrared Sensor with two thermal bands. Landsat 9 is expected to launch in December 2020 and carry on the program's legacy of monitoring the planet from new perspectives.

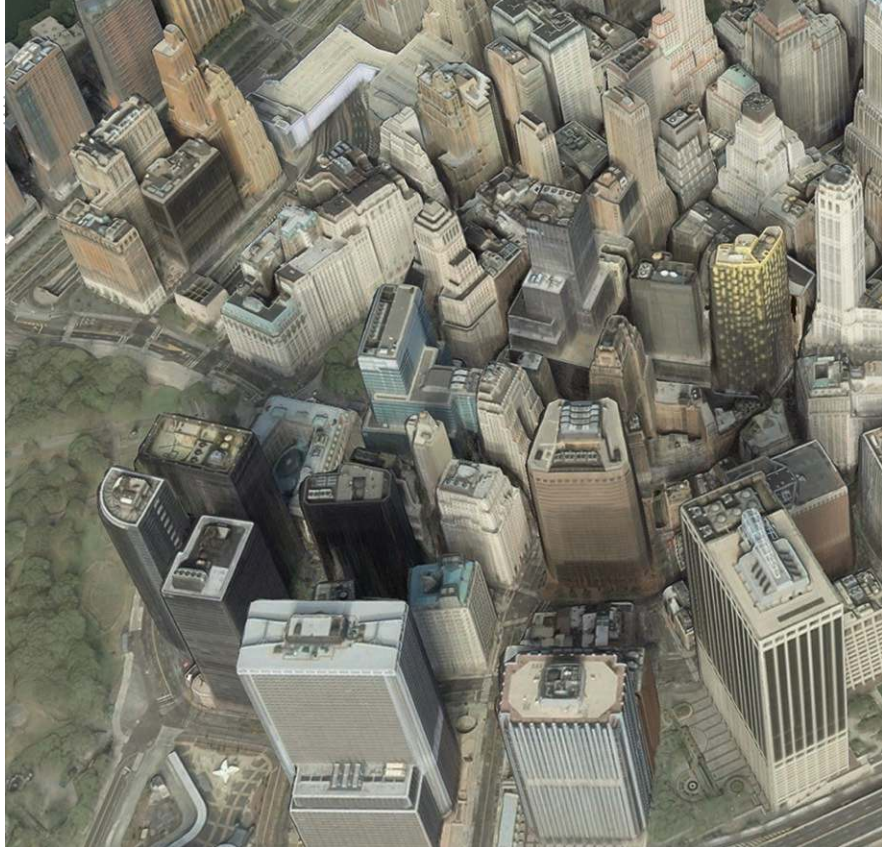


IMAGE COURTESY OF VRICON

of Vricon, build digital terrain models for applications such as hydrology, geology, defense, construction, and disaster management.

"In order to generate bare-earth terrain models as accurately and precisely as we can, we use the multispectral bands out of imagery from DigitalGlobe's satellites … to automatically classify and identify vegetation and buildings so we can remove them from the scene," said Vricon Vice President Isaac Zaworski.

While multispectral sensors are appropriate for general inquiries, superspectral and hyperspectral sensors—like those on Landsat 8, WorldView-3, and NASA's EO-1, whose sensors detect 11, 16, and 220 bands, respectively—are best for detailed inquiries.

"With superspectral and hyperspectral bands you get much finer information," remarked Navulur, who said the most valuable bands on superspectral and hyperspectral sensors are those that measure shortwave infrared (SWIR) light, which sits above NIR light on the electromagnetic spectrum. "With shortwave infrared you can move from general—'Is there agriculture?'—to be specific: 'What type of agriculture is it? Is it coffee? Is it corn? Is it soybeans?'"

SWIR bands can also distinguish among types of trees, minerals, and building materials. They can penetrate smoke, smog, fog, and dust, as can another type of band common to superspectral and hyperspectral sensors: thermal infrared, which detects electromagnetic energy from heat instead of light. Both SWIR and thermal infrared sensors can be leveraged by firefighters to find hotspots during wildfires, and thermal infrared can be used by warfighters to track the enemy.

"With thermal infrared you can tell whether a truck or tank engine is on, whether a building is occupied, or whether an aircraft on a runway has just landed," said Robert Zitz, vice president and strategic account executive at Leidos. It also can be used to detect heat signatures for missile defense. For example, Leidos' Commercially Hosted Infrared Payload sensor collected more than 300 terabytes of data on more than 200 thermal events during an Air Force-sponsored mission that concluded in December 2013.

Up and down the spectrum, the possibilities are at once overwhelming and exciting.

"Eventually, we'll get to practical-use ultraspectral sensors … with millions of discrete bands," continued Zitz, who said ultraspectral sensors will be able to distinguish seemingly identical objects manufactured at the same time by identifying their one-of-a-kind spectral fingerprint. "It is being proven in the labs right now."

LET THERE BE LIDAR

Conversations about remote sensing phenomenology may begin with space, but that's not where they end. Case in point: light detection and ranging, or LiDAR, whose chief advantages over spectral sensors are the ability to map 3D elevation and to penetrate tree cover.

Unlike passive sensors that measure electromagnetic energy emitted or reflected by external objects, LiDAR is an active sensor that emits and measures its own energy from an internal source: a laser—typically in the NIR band. Because of the power required to operate them, LiDAR sensors must be flown from aerial rather than space-based platforms. The sensors send laser pulses to the ground, where they bounce off buildings, vehicles, rocks, and earth before returning.

"What's measured is the time it takes for the pulse to travel from the sensor to the object you were shooting, and then bounce back to the sensor," explained Ngoroi, who said the resulting measurement is used in 3D terrain mapping to calculate elevation. "That time is what gives you elevation."

Each LiDAR pulse is recorded as a three-dimensional point on a map; collectively, millions of points in the same vicinity constitute a 3D point cloud that can be interpreted as an object.

According to Ngoroi, elevation data can be used for applications such as flood modeling and emergency response. For example, the State of Indiana commissioned Woolpert to conduct a statewide LiDAR survey of its buildings to improve its E911 system. Knowing a building's elevation, the state theorizes, will help emergency responders save lives.

"If someone's calling for help from a cellphone, you can't tell if they're on the ground floor of a building or the 12th floor," Ngoroi said. "If you use LiDAR to map buildings and provide that data to emergency responders, they'll know which fire truck with which kind of ladder to bring based on the height of the buildings in that area."

The same information could help law enforcement and the military determine line of sight when planning operations, architects orient buildings for maximum solar exposure, and

VRICON'S 3D SURFACE MODEL is a global representation of Earth, providing 0.5-meter resolution and 3-meter accuracy. This image of New York City, created without the use of ground control points, is based on archived commercial satellite imagery.

humanitarians target resources after a disaster.

"After the Haiti earthquake [in 2010] there was extensive LiDAR coverage to map in three dimensions the destruction and the growth of camps to help with disaster relief," Egan said. "Using 3D data [from LiDAR] for disaster response is going to be a growth area for continued development by many, including NGA."

By measuring the strength of laser pulses when they return to the sensor, LiDAR systems can also assist in material classification, as different materials—grass, for instance, versus asphalt—reflect infrared light with varying intensity.

However, if you ask Dr. David Maune, associate vice president at Dewberry, LiDAR's most important attribute is its ability to penetrate tree cover, which makes it possible to detect and map terrain that would otherwise be concealed. This capability can help seismologists discover tree-covered fault lines, surveyors classify obscured terrain, and intelligence analysts detect hidden buildings, roads, or weapons.

LiDAR can penetrate trees because every LiDAR pulse is a beam of light with a given diameter; as that beam travels through a forest, it sends multiple "returns" back to the sensor as it encounters obstructions. "While part of the light beam hits a leaf on the top of the tree, the rest of it continues on," Maune said. "It may hit other leaves and branches on the way down, but if there's an opening its last return will be the ground."

Although "single-pulse" or "linear-mode" LiDAR is the default, there are many specialized varieties of LiDAR optimized for different missions, including bathymetric LiDAR, which uses a water-piercing laser to measure water depth, and Raman LiDAR, which uses ground-based lasers to measure atmospheric water vapor. One of the most buzzed about LiDAR varieties, however, is Geiger-mode LiDAR. Instead of returning laser beams, it measures returns of the individual photons that constitute those beams. This approach produces more data points per square meter, consumes less power, and requires lower-intensity returns, allowing sensors to cover more ground, at faster speeds, from higher altitudes.

"The Harris Geiger-mode LiDAR system was designed for wide-area mapping," said Stuart Blundell, director of strategy and business development at Harris Geospatial Solutions. "Whereas a linear-mode system flies at a lower altitude—typically 2,000 feet on a single-airplane engine traveling around 90 miles per hour—we fly on a jet at 30,000 feet traveling at three times the speed of linear-mode systems. As a result, we're flying up to 850 square miles per hour, compared to 50 square miles with a linear-mode sensor."

While a linear sensor collects just two points per square meter, Geiger-mode can collect more than 100 points per square meter.

Eventually, LiDAR sensors will behave like point-and-shoot cameras, according to Hauck, who sees technologies such as Geiger-mode LiDAR, flash LiDAR, multi-band LiDAR, and photon-counting LiDAR as the future.

"Most LiDAR units don't take a complete image at one time the way a camera does—yet," he said. "Soon, they'll generate lots and lots of photons of different wavelengths (i.e., colors) all at once, and measure lots and lots of returns all at once … When that happens, we'll be able to get the shape of things and the material properties of things all in one shot, which will be very, very powerful."

MAKING SENSE OF SENSORS

In a world growing ever more crowded with diverse remote sensing phenomenology, there's an elephant in the room: Without the ability to leverage the data they collect, sensors are senseless.

"We've spent literally billions of dollars building sensors, but investment in downstream processing and analysis of data has not kept pace," Murdock said. "If you simply build sensors, and assume someone else will figure out how to use data from them, that's a broken paradigm."

> "Even if we pressed pause for a while on sensor development, there is still a ton of work to be done on advancing exploitation."
>
> **—Michael Nelson, director of intelligence and defense solutions, Riverside Research**

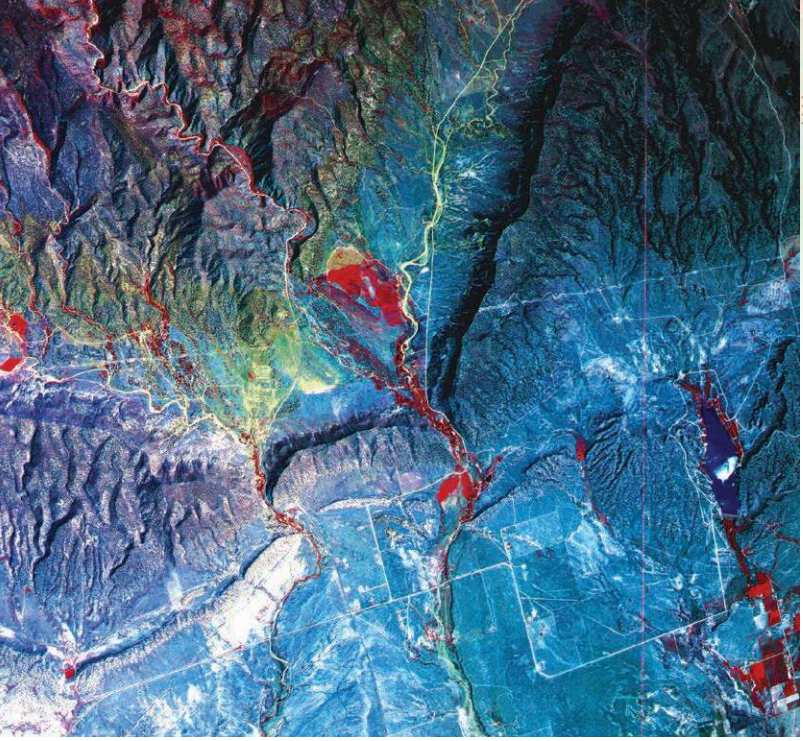


IMAGE COURTESY OF HARRIS

THIS HYPERSPECTRAL IMAGE processed with ENVI highlights geological and mineral values. ENVI can fuse multiple data modalities—radar, LiDAR, SAR, optical, hyperspectral, multispectral, stereo, thermal, and acoustic—to create geospatial products.

Turning spectral capabilities into strategic insights requires the GEOINT Community to solve several critical challenges, the first of which is data processing and exploitation.

"Even if we pressed pause for a while on sensor development, there is still a ton of work to be done on advancing exploitation," said Michael Nelson, director of intelligence and defense solutions at Riverside Research.

Added Phil Downen, vice president of government programs at UrtheCast, "It's widely recognized that the deluge of data from sensors is increasing exponentially … The tradecraft bottleneck, however, is no longer computing resources, storage resources, or downlink and backhaul. The real challenge now is the geo-analytics—the algorithms, equations, and heuristics that are brought to bear on an ever-increasing diversity of raw data to extract information from it."

To that end, UrtheCast and other hosts of remote sensing data—including NGA—are divining in-house processing solutions with algorithms that can automatically extract features from imagery and notify analysts of temporal changes and trends, allowing them to supply customers with insights derived from pixels instead of the pixels themselves.

"We don't have enough analysts to review all the imagery we're going to be getting in the very near future, so one of the things we're looking at now is how we can best use … machine learning and neural networks to make sense of all that data," Avila said.

Vricon's "The Globe in 3D" and Harris' ENVI geospatial analytics software are solutions on the forefront of machine learning. To power its large-scale 3D mapping products, the former is building a fully automated data processing engine capable of continuously ingesting and correlating data from virtually any available sensor. Based on the principles of stereo photogrammetry, Vricon's engine extracts relevant features from disparate images, then mixes and matches them to create accurate 3D models.

"As a byproduct of the fact that we're trying to generate the most accurate 3D representation of the static scene in any given location, our algorithms are essentially identifying anything that is changing in that entire scene," Zaworski said.

ENVI's image processing software automates feature extraction and change detection in much the same way. Going forward, its goal is to refine its algorithms to perform on a larger scale and at a finer resolution, according to Rebecca Lasica, enterprise sales manager for Harris Geospatial Solutions, which acquired ENVI in 2015. "Instead of analyzing an image, for example, we'll be analyzing a whole country," she said. "Likewise, we'll be able to look not just forensically back in time, but also at trends that help us predict [future change] accurately enough to take action."

Better algorithms and sophisticated machine learning will go a long way toward helping users tame an overwhelming amount of remote sensing data. The magic bullet that will help them fully exploit sensors' capabilities, however, is data fusion, or multi-source integration.

"Multi-source integration is a huge area of research and application development because each type of sensor has its own strengths or weaknesses," Nelson said. "If I have to turn off four of my five senses I am greatly restricted, but if I can use them all I'm fully functional."

Added Lasica, "Taking different modalities and putting them together can build a picture that's greater than the sum of its parts. For example, a grower may have some [multispectral] imagery that reveals information about the health of their crops. But they might also be co-collecting LiDAR that gives them information about the height of those crops. Putting those data sets together allows you to cross-reference the health of a plant with the height of a plant, giving a three-dimensional picture about when the harvest might be ready."

It sounds easier than it is.

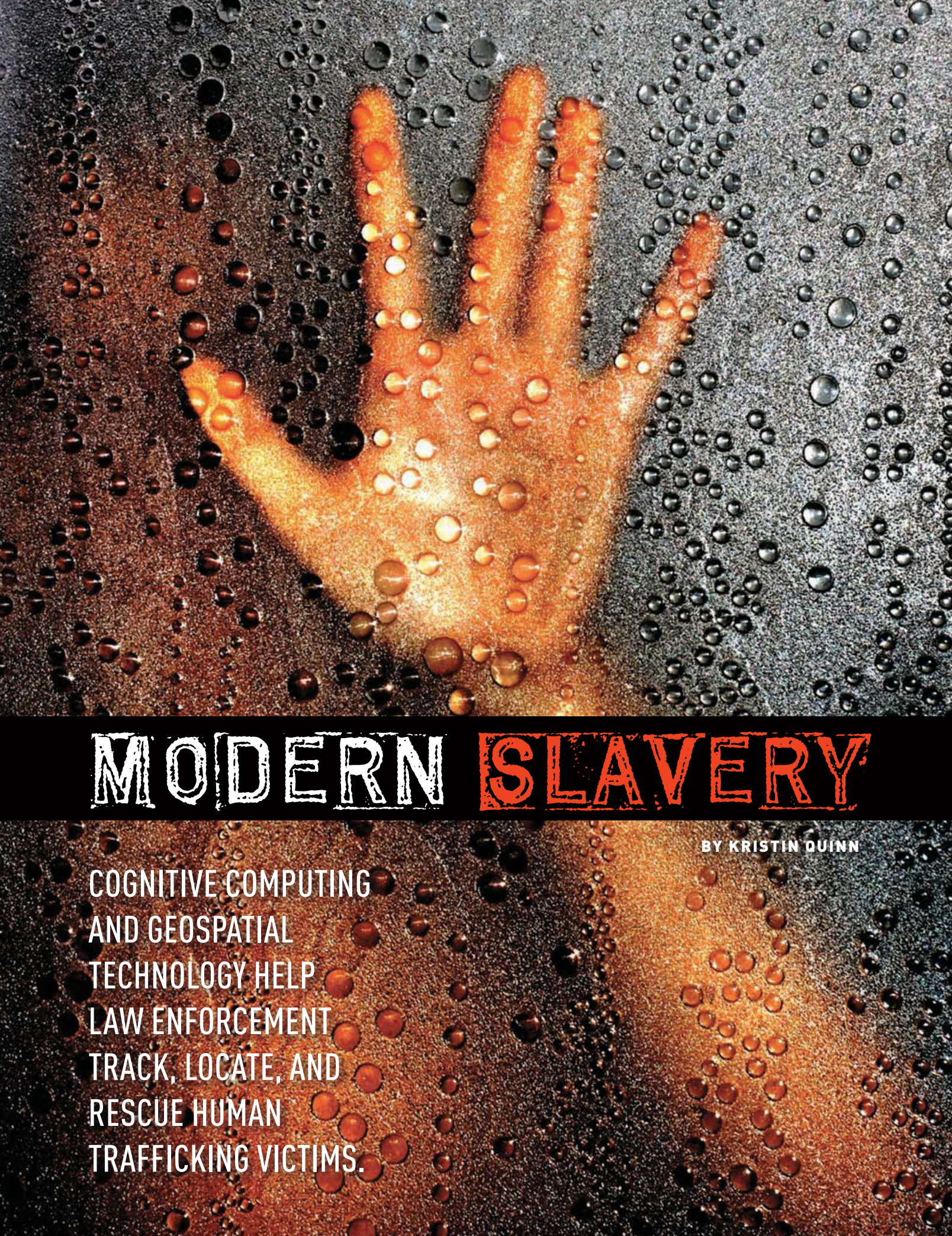
"Each phenomenology is different … at the data level; combining them in a way that's meaningful takes time and effort," continued Nelson, adding that complementary images from disparate platforms and sensors have not only different electromagnetic characteristics, but also different geographic and temporal parameters that make amalgamation difficult. "Even routine things like how to get [complementary] data sets into the same analyst's bucket at the same time are challenging. You have to have awareness, for example, that there were four sensors that collected on a given target; then you have to get all four data sets together and make sure your analyst is appropriately trained to exploit each of those modalities."

As sensors get smaller, more powerful, and more energy-efficient—shattering current size, weight, and power constraints—data fusion will be able to take place not only on the back end, à la Vricon and ENVI, but also on the front end. That will make multi-sensor integration easier, according to Blundell.

"The best way to register multi-sensor information is to collect it at the same time in a miniaturized fashion from multi-sensor pods," he said.

Exactly when and how diverse remote sensing phenomenology will be fused is anyone's guess. What's clear, however, is that sensors will continue to mine new frontiers of physics that surpass the limits of human biology.

"This is not going to slow down," Nelson concluded. "As platforms become easier and cheaper to launch, the prevalence of sensors in the commercial world is only going to accelerate. Commercial remote sensing is a growing global phenomenon."



MODERN SLAVERY

BY KRISTIN QUINN

COGNITIVE COMPUTING AND GEOSPATIAL TECHNOLOGY HELP LAW ENFORCEMENT TRACK, LOCATE, AND RESCUE HUMAN TRAFFICKING VICTIMS.

The Intelligence Community has created powerful tools for monitoring potential bad actors in the War on Terror—software that can help identify a terrorist, discern when multiple online presences are in fact the same person, visualize an individual's movement through time and space, and reveal terrorist networks. Increasingly, these same technologies are being applied against human trafficking, particularly child sex trafficking in the United States, to rescue children and put their traffickers behind bars.

Approximately 325,000 U.S. children are at risk for sex trafficking and 75 percent of these victims are advertised online, according to Thorn, an organization dedicated to driving technology innovation to fight the sexual exploitation of children. With vulnerable children not only targeted and recruited online but also sold there, the ability to ingest and analyze vast amounts of unstructured data is paramount to bring them to safety.

Thorn was founded in 2009 by actors Ashton Kutcher and Demi Moore, who began by learning as much as they could about the issue, according to Thorn CEO Julie Cordua.

"During that exploratory process, it was very apparent that technology was increasingly a part of these crimes against children, but there was no concentrated effort to make technology a part of the response," Cordua said.

As technology further enables human traffickers, more and more organizations are recognizing technology must also be a part of the solution.

"The use of forums, chats, advertisements, job postings, hidden services, etc., continues to enable a growing industry of modern slavery," said Wade Shen, a program manager with the Defense Advanced Research Projects Agency (DARPA).

DARPA, Thorn, and others have created and continue to improve platforms that mine data and make connections among nefarious material on the web. As government contractors and Silicon Valley tech companies retrain their tools on urgent and complex social issues such as human trafficking, they experience victories as well as encounter new challenges.

CRACKING THE CODE

Many law enforcement agencies lack the funding to dedicate officers to human trafficking cases, let alone to purchase trafficking-specific software. Those working in the field described the pursuit of intense cases with a lack of resources.

"If you start calling random police departments asking, 'Who works human trafficking?' you're probably going to get 50 percent of agencies that say, 'Nobody,'" said 2nd Lt. James Bacon, who oversees the Child Exploitation Squad for the Fairfax County Police Department (FCPD) in Virginia.

Yet according to Kate Reilly, a special agent with Homeland Security Investigations (HSI) New Orleans whose primary mission is to recover juveniles involved in sex trafficking, such crimes are prevalent in all major U.S. cities. Even with three or four officers at a time dedicated to human trafficking in New Orleans, resources are stretched.

"We're constantly being pulled in a million directions," Reilly said.

Both FCPD and HSI New Orleans employ software such as Thorn's Spotlight—a platform leveraging big data analytics and visualization, machine learning, and natural language processing—to automate the monitoring of ads on websites such as **backpage.com**. Thorn, in collaboration with technical partner Digital Reasoning, provides Spotlight for free to federal, state, and local law enforcement agencies around the country.

Digital Reasoning, a boutique software company in Nashville, Tenn., got its start in 2000 through In-Q-Tel funding and spent more than a decade primarily supporting the defense and intelligence communities in the War on Terror. Today, in addition to its work with the financial sector, Digital Reasoning has invested considerable resources in its Spotlight cognitive computing platform, which reimagines the company's terror fighting tactics to be applied against human trafficking.

Thorn and Digital Reasoning joined forces in 2014, after Thorn learned in its interviews with survivors that many trafficked children were forced to write their own online ads. Using both supervised and unsupervised learning, Digital Reasoning trained Spotlight to determine which ads were likely written by children and elevate the most high-risk ads to help law enforcement focus their investigations.

According to Bacon, software such as Spotlight helps police conduct link analysis to detect networks and track movement from one location or jurisdiction to another.

"It can be very exhaustive to try to manually search through these things, so to have an automated process or piece of software that can go through and do analysis and give a data dump and say,

To read about the use of commercial satellite imagery to reveal human trafficking around the globe, visit **trajectorymagazine.com**.

'Based on this search criteria, you need to be looking in this direction' is huge," Bacon said.

Spotlight's unstructured text analysis goes beyond identifying key words to mine human communication for certain concepts and behaviors.

This approach allows Spotlight to detect code words and keep up with trafficking language as it evolves. While there might be a lag between the introduction of a new word and its identification by law enforcement, Spotlight's unsupervised learning capabilities allow it to understand semantic and syntactic context to identify words used similarly to others of interest to law enforcement.

"If I'm going to bribe you, I'm never going to send you an email with the word 'bribe' in it," said Eric Hansen, vice president of federal programs for Digital Reasoning who spent 20 years in Army intelligence. "Same in the terror [or trafficking] communities. Words are used in a way that is non-obvious."

IMAGE COURTESY OF DARPA

TELLFINDER, a tool developed under Memex, enables analysts to discover new leads easily by visualizing clusters of related ads and posts.

Spotlight is now in the hands of more than 3,000 U.S. law enforcement officers at 780 agencies across all 50 states, according to Cordua. As of September 7, the platform has aided in 8,305 trafficking investigations, assisted in identifying 2,025 child sex trafficking victims and more than 4,624 adult victims, and helped bring more than 2,249 traffickers to justice. Thorn will soon introduce Spotlight in Canada and plans to expand its international capabilities in coming years.

GEOSPATIAL VISUALIZATION

Spotlight's natural language processing not only reveals the most high-risk advertisements but also the links among them.

"There may be a series of ads that mention teddy bears," Hansen said. "In one set of ads, in one locale, it may say 'my teddy.' In another series of ads in a different locale it may refer to 'bear.' A lot of times we can understand it's the same person writing the ad—one time in Arizona, another in Kansas. Now you can see geospatial movement."

Perhaps more obvious than language, visualizing the use of the same phone numbers in different locations helps reveal the full scope of a trafficking situation.

When OGSystems' Viper Labs sought a real-world use case to test the ability of its new DeLorean app to ingest, process, analyze, and display open-source data, it learned law enforcement manually searched for concerning ads and common phone numbers on sites such as **backpage.com**. The DeLorean team created a spider to crawl the website, ingest ads, process and structure their data, and then use location information to geotag them.

"The visual display would automatically draw lines that connected an ad in Washington, D.C., to an ad in Chicago using the same phone number," said Aaron Rubenstein, a consultant with OGSystems. "We took a very manual process for investigators, automated it, and provided a geospatial element to it."

This in many ways mimics how federal intelligence agencies have automated analysis—enabling law enforcement agents to read for confirmation rather than comprehension.

Similarly, Spotlight's geospatial capabilities can provide powerful historical context to a single ad, according to Cordua.

"Over time as well as across space you see geographically where [the person posting has] been and also the network that person is connected to," she said.

This automated process might, for example, allow an investigator trying to find a child advertised in Los Angeles to learn the victim is a runaway from San Francisco that has been trafficked up and down the California coast. Or an officer who has only been on the job five years to link newly posted ads to a trafficker who was jailed 10 years ago and recently released—using methodologies characteristic of activity-based intelligence.

"That's what's cracking some of these cases open," Hansen said. "Creating links that never would have been created using the manual process."

The analysis teams at the National Center for Missing and Exploited Children still conduct much of their research manually, according to Angela Aufmuth, program manager for the center's Special Analysis Unit. But the organization is working to streamline processes and is increasingly realizing the importance of location data, she added.

"[Human trafficking] is such a transient crime," Aufmuth said. "We know there's so much moving of victims—being able to track that and have those visualizations is important and certainly helpful for law enforcement."

Special Agent Reilly said she uses Thorn in two primary ways. One is to track the history of a specific ad. For example, if she recovers a 15-year-old girl from an ad with a phone number, the software can help her learn when and where else the girl has posted. The second is mobile alerts.

"If I'm home or out in the field, getting those alerts is really helpful," she said. "If I'm trying to track a specific girl, I can say 'She's posting, what can we do?,' mobilize, and go forward with a plan operationally."

DARPA takes analysis of human trafficking activity on the web a step further with its Memex program. Memex connects dots among sex trafficking information available via commercial search engines such as Google; the "Deep Web"—internet accessible to the public but not indexed by common search engines; and the "Dark Web"—the corners of the internet that obfuscate users and where illegal marketplaces thrive.

"By enabling searches across a wide range of websites, [Memex] uncovers a wealth of information that might otherwise be difficult or time-intensive for investigators to discover," Shen said. "Possible trafficking rings can be identified and cross-referenced with existing law enforcement databases, which helps police officers and public prosecutors map connections between human trafficking and other illegal activity."

Law enforcement agencies and district attorneys' offices around the country are using Memex. For example, the Manhattan district attorney's office employs the tool for all of its human trafficking investigations, and in Texas

Memex has been used in more than 200 cases leading to more than 100 arrests.

DARPA is helping others leverage Memex, including U.S. Immigrations and Customs Enforcement and the U.K. Antislavery Commission, which is piloting the tool.

BUILDING BRIDGES

Communication between developers and end users is key when leveraging technology for humanitarian causes.

Cordua said she is proud of Thorn's development process and that the idea for the platform came from understanding the victim mindset and how they move through time and space.

"But nothing else matters unless the person who is trying to go find them can use the tools," she said. "You have to understand what the user needs."

In the beginning, Cordua said, many law enforcement officers Thorn met with didn't think the organization's goal was possible.

"We got a lot of people who didn't buy in—who said, 'No, you can't. It's not going to be helpful.' But we kept working. We showed we could," she said, adding that an intuitive user interface was essential to enabling ease of adoption for law enforcement.

Although investigators aren't currently using OGSystems' DeLorean spider, the company is exploring opportunities to tailor the tool more specifically to the needs of law enforcement agencies for future operational use.

And increasingly, organizations are standing up to help bridge the cultural gap between technologists and activists. ATHack!, co-founded by Ehb Teng, is a San Francisco-based social impact venture aiming to do just that.

"We realized there were two big divides as we delved into the issue [of human trafficking]," Teng said. "On the nonprofit side we see a digital divide—technologically they aren't as up to date. And on the tech side we are finding a lack of understanding of actual, critical social issues that need to be solved."

In April 2016, ATHack! co-hosted their ATHackathon with Microsoft Reactor to bring the two sides together. Nonprofits were invited to talk about specific projects they needed help with so technologists could develop mid- to long-term solutions.

PHOTO COURTESY OF MAOMAU IMAGES

TEAM ATHACK! co-hosted their ATHackathon with Microsoft Reactor in April to develop solutions for fighting human trafficking.

Melissa Jane Kronfeld, founding co-chair of the Nexus Working Group on Human Trafficking, spends much of her day connecting tech entrepreneurs' capabilities with nonprofit organization and law enforcement needs. Nexus is an invitation-only, global organization of about 3,000 millennial philanthropists and innovators.

"Technology and data are the future of fighting human trafficking because so much of it has moved online," Kronfeld said. "Whichever way you look at it, data and technology are how we will end slavery."

While analytic software has powerful potential to enhance the efforts of human trafficking investigators, there are still gaps technology has yet to address.

The internet has democratized abuse, with many vulnerable children being recruited online—often by other children already being exploited. In addition to rescuing children faster, part of Thorn's mission is to keep them out of harm's way to begin with by making online platforms safer and stopping underage users' risky behavior.

The ability to intercept online recruiting is a need the OGSystems team noticed as well.

"[Online predators are] pervasive, and technologies that try to match these patterns and do the geotagging and really do the research on social networks at a rapid rate would have a higher probability of achieving some success in this area," Rubenstein said.

Beyond analytic software, law enforcement is particularly interested in whether geospatial technology could help locate exploited children via their smartphones. The first question Reilly asks when looking for a child is, "Do they have a phone?"

Location-based technology in smartphones makes it easy to determine a person's whereabouts should their phone connect to WiFi and therefore an IP address tied to a specific location.

"But if a kid is logging onto the internet from the phone's [data plan] and all we have is a T-Mobile IP address, we can't triangulate that data down to a location," Reilly said.

According to both Reilly and Bacon, cellphone carriers claim they do not yet have a way to triangulate that information.

"[Trafficked children] are able to conceal their activities much easier than it is for us to track them," Bacon said.

Both officers indicated this is perhaps their greatest technological challenge—one they would welcome outside solutions for.

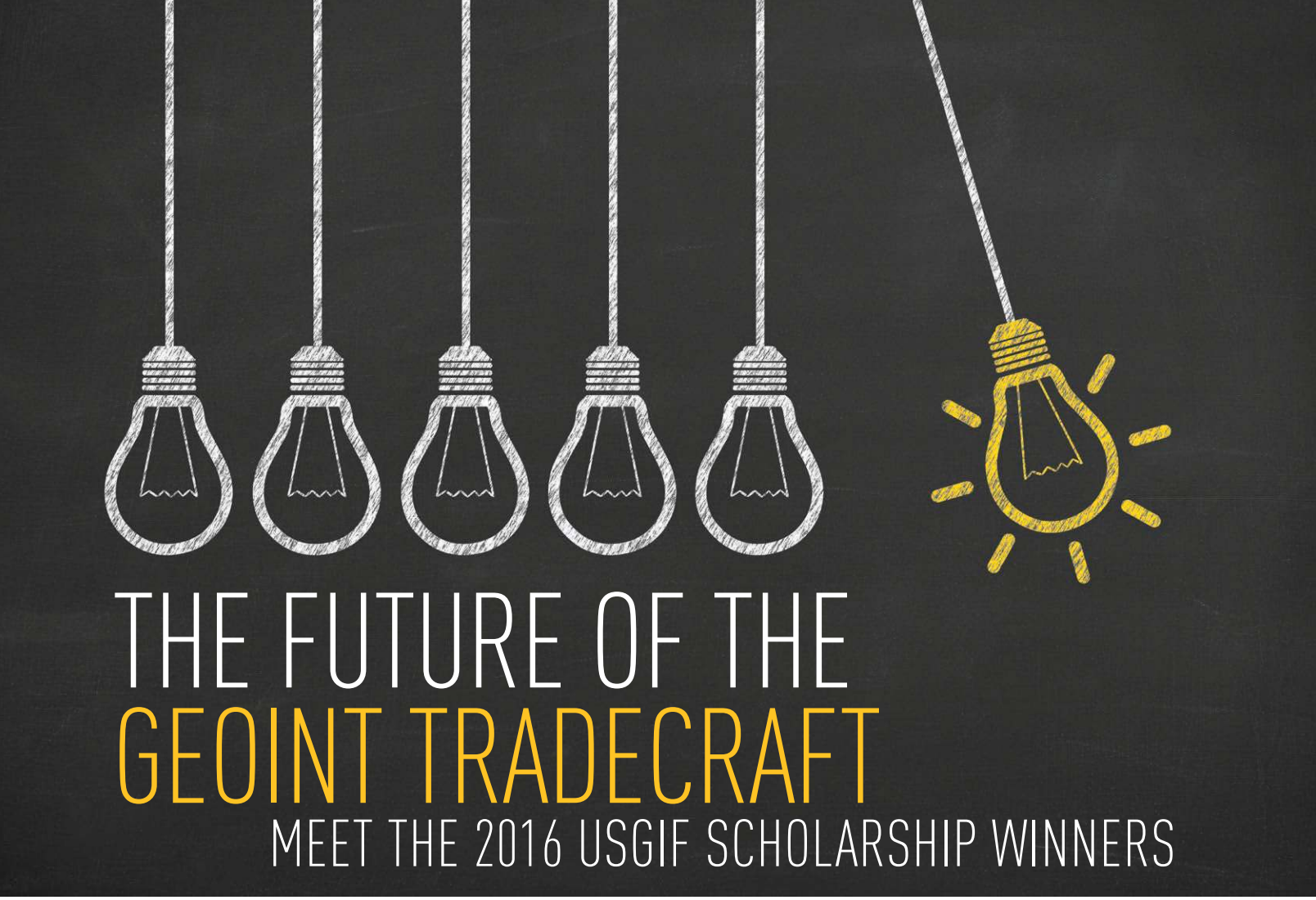
The anti-trafficking community is just at the beginning of exploring how technology can help end modern slavery, according to Hansen.

"The genie is out of the bottle," he said. "We can now read human communications and do it at a massive, massive scale … [Spotlight] is cutting edge coming out of the IC and is really the tip of the iceberg if you think about things like Twitter, Facebook, and the amount of human language being ingested every day."

Jason Beck, director of communications for Digital Reasoning, said although the company's work with the IC and the financial sector is rewarding, the staff is energized when it hears success stories from the anti-trafficking community.

Beck said, "To hear from a detective that, because of the analytics we were able to provide and the targeting we were able to assist in, a 12-year-old girl was rescued and her [victimizer] is now in jail—those are the kinds of things that are remarkable." ■

Visit **trajectorymagazine.com** to learn how crowdsourcing apps allow the general public to join the fight against human trafficking.



THE FUTURE OF THE GEOINT TRADECRAFT

MEET THE 2016 USGIF SCHOLARSHIP WINNERS

IN AUGUST, USGIF eclipsed $1 million in scholarships awarded with the presentation of $112,000 in scholarship funds to students studying the geospatial sciences or a related field. The annual USGIF Scholarship Program recognizes the achievements of graduating high school seniors, undergraduate, graduate, and doctoral students, and helps further the advancement of the geospatial intelligence tradecraft. In total, USGIF has made $1,003,000 in scholarship awards since the program began in 2004. All scholarship recipients were selected by USGIF's Scholarship Subcommittee, which evaluated applicants based on academic and professional excellence.

DOCTORATE

MICHAEL BRADY

Rutgers University

Geography

Brady, a former enlisted member of the U.S. Coast Guard, earned both his bachelor's and master's degrees in geography at Hunter College of the City University of New York under the GI Bill. In his doctoral research, Brady collaboratively maps local community risk perceptions of rapid shoreline change along Alaska's North Slope coast, driven by climatic factors such as sea ice loss. The National Science Foundation supports Brady's research.

MONICA MEDEL

Texas State University

Geographic Information Science

After more than 10 years working as a foreign correspondent in Latin America covering drug smuggling and cartel violence, Medel became interested in transnational crime patterns. Her focus is developing models to understand spatio-temporal patterns of drug trafficking while considering policy constraints. Medel hopes her research contributes to the development of workflows and algorithms to help security agencies better predict crime patterns.

BRAD G. PETER

Michigan State University

Geography

Peter is a graduate research assistant at the Center for Global Change and Earth Observations at Michigan State University. His research focuses on identifying marginal agricultural lands and development opportunities for smallholder farmers in Malawi, using remotely sensed bio-geographic and climate information. Though much of his work centers on Sub-Saharan Africa, the methodology he devised has been adapted into a global, multi-scalar model that can provide support across geographies and administrative levels.

EMANUEL ARNAL STOREY

University of California, Santa Barbara/ San Diego State University

Geography

Storey earned a master's degree in geographic information science at San Diego State University after receiving a bachelor's degree in environmental science at the University of New Mexico. Storey's general research interests are in remote sensing, image processing, and spatial statistics. He is currently developing techniques to study land cover change, monitor wildfires, and support disaster response efforts.

JENNIFER L. WHYTLAW

Rutgers University

Geography

Whytlaw is a GIS manager at Rutgers University's Environmental Analysis and Communications Group. Her work is focused on the development and use of geospatial tools and applications as components to planning projects. She is interested in hazards research including climate impacts on vulnerable populations and preparedness activities in communities to help mitigate impacts on critical infrastructure.

GRADUATE

ROXANNE AHMADI

Pennsylvania State University

Homeland Security-GEOINT

Ahmadi has held a variety of positions in the government and private sector using her training in GIS, intelligence analysis, technical writing, and Farsi. She holds a bachelor's degree from California State University, Long Beach, in geography, focusing on GIS as well as the Middle East and North Africa. Ahmadi's research interests are object-based image analysis and automation, as well as the integration of human geography and remote sensing.

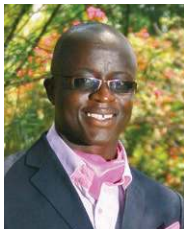
ALLISON BOHLMAN

Alabama A&M University

Plant and Soil Science

Bohlman has an environmental science background in wildlife biology, forestry, and hydrological research. While working full-time supporting geospatial research and education programs at Alabama A&M University, Bohlman trains and mentors undergraduate students in GIS and remote sensing research projects. Her thesis research examines hydrologic differences between forest management practices and building predictive models.

JAMES OSUNDWA



University of Redlands

Geographic Information Science

Osundwa has more than 10 years of experience working with the United Nations advising governments on the most suitable GIS solutions for decision-making. His thesis is on the development of a coral reef mapping tool for St. Maarten in the Caribbean. Upon completion of his studies, Osundwa plans to continue applying his expertise in the international community to solve complex sustainable development problems.

GRADUATE

ANDREW RYAN

George Mason University

Geoinformatics and Geospatial Intelligence

Ryan graduated with a bachelor's degree in geography from Virginia Tech in May 2015, after which he completed an internship with the State Department. Ryan was then accepted into George Mason University, and took on a full-time position as an all-source geospatial analyst with DigitalGlobe. Ryan's research interests include multi- and hyperspectral imaging, activity-based intelligence, data fusion, and machine learning.

CHRISTOPHER SMITH

Delta State University

Geospatial Information Technology

Smith is a program manager at the Center for Interdisciplinary Geospatial Information Technologies at Delta State University. His graduate studies focus on the application of spatial technologies to crisis and emergency preparedness and response. He spent four years as a senior consultant at Booz Allen Hamilton and was also a volunteer firefighter and medic in Mississippi and Virginia.

ZACHARY TOLL

George Mason University

Geoinformatics and Geospatial Intelligence

Toll is applying geospatial research techniques and analysis to terrorism in Colombia for his thesis, while working as a graduate teaching assistant and graduate research assistant at George Mason University. Having more than five years of experience in the GIS, remote sensing, and computer programming fields, Toll graduated from the University of California, Santa Barbara, while serving in the U.S. Marine Corps.

CLAIRE WEBER

University of Utah

Geography

Weber holds dual bachelor's degrees in geography and ecology with a minor in global terrorism studies from the University of Maryland. Weber previously worked as a GIS analyst for the University of Maryland's National Consortium for the Study of Terrorism and Responses to Terrorism. Her research interests include terrorism, GIS, Pakistan, Nigeria, data science, building spatial predictive models, homeland security, and open-source intelligence.

UNDERGRADUATE

JAMES CHRISTIANSON

Delta State University/Mississippi

Delta Community College

Geospatial Analysis and Intelligence

Christianson is an imagery analyst serving in the U.S. Marine Corps. His military experience introduced him to a wide range of geospatial applications, from humanitarian operations to geo-referencing training areas. Christianson started his undergraduate education through the Marine Corps' MOS-2-Degree Program. Christianson plans on using his education to improve intelligence sharing processes across the Intelligence Community.

HAILEE HETTRICK

Cornell University

Mechanical Engineering

Hettrick is an intern with Ursa Space Systems and is interested in the design of spacecraft, specifically satellite constellations, that provide space-based data products to improve geographic mapping and location-based information services. She is interested in continuing her education studying spacecraft controls to help create exceptionally agile Earth observation systems.

TILDEN REMERLEITCH

University of Vermont

Geography and Chinese

This year, Remerleitch is studying abroad in Shanghai, China, examining urbanization, energy, water issues, green technology initiatives, and Sino-U.S. relations. With her geography, GIS, and Spanish language skills, she is considering a career in the U.S. State Department. Remerleitch also interned with the Vermont Agency of Agriculture Food and Markets, where she edited data relating to Vermont watershed pollution and collected data for precautionary measures against Avian flu.

KRISTIN SONSTEBY

Pennsylvania State University

Political Science

As an intern with Penn State's Applied Research Laboratory and the U.S. Agency for International Development, Sonsteby supports programs to evaluate various technology solutions for humanitarian assistance and disaster relief missions. When Sonsteby graduates, she hopes to work in national security.

ELIJAH STAPLE

University of Colorado, Boulder

Computer Science

Staple is interested in deep machine learning networks that can be trained with unlabeled data to learn to recognize hidden features in complex data sets. Staple has held internships with two companies in Silicon Valley as well as the National Geospatial-Intelligence Agency, developing big data analytic techniques using deep learning to automate the extraction of business and national intelligence from large, multi-source data sets.

NEW SCHOLARSHIP AWARD

STUDYING SPACE SCIENCE

Meet the first recipient of the Ken Miller Scholarship for Advanced Remote Sensing Applications

Anne Aryadne Bennett has a passion for engineering and space. She also enjoys research and seeing her work make a difference.

Bennett is the first recipient of the Ken Miller Scholarship for Advanced Remote Sensing Applications offered by USGIF in partnership with Riverside Research. The $10,000 scholarship benefits incoming or current master's degree students who plan to enter the defense, intelligence, or national security workforce and are studying remote sensing and related topics.

While working full-time with Orbital ATK's space systems group, Bennett is pursuing an online master's degree in astronautical engineering from the University of Southern California, a USGIF-accredited school. With Orbital ATK, she is currently a senior mission systems engineer developing new satellite technology supporting national security missions. Some of her areas of focus include innovative small sat technologies and orbital debris mitigation.

"The Ken Miller scholarship has made a huge difference for me," Bennett said. "The funds will be a big help with the remaining courses I have in completing my master's degree, which will give me a head start on the doctorate degree I plan to begin next year."

Bennett graduated with bachelor's and master's degrees in mechanical engineering from California Polytechnic State University. Previously, she worked in the information technology department for solar technology provider SunPower Corporation. Bennett also held a 9-month internship with a U.S. intelligence agency, where she assisted engineering teams and participated in research and development projects. Bennett plans to achieve her second master's degree in spring 2018 and begin her Ph.D. studies to further support her work in innovative space technologies.

GRADUATING HIGH SCHOOL SENIORS

GEORGIA BASS

Monument Mountain Regional High School, Great Barrington, Mass.

Now attending University of Massachusetts, Amherst

Bass is planning to major in political science as an undergraduate student and pursue a master's degree in geospatial information sciences. Her interest in the capabilities of geospatial information sciences began when she wrote a research paper on the Atacama Large Millimeter/submillimeter Array located in Chile. Her paper placed second in the Institute of Electrical and Electronics Engineers' Berkshire section competition.

COURTNEY FASSETT

Northwood High School, Irvine, Calif.

Now attending University of Southern California

Fassett is using 3D visualization technology to map the University of Southern California's campus. Previously, Fassett interned in the finance and business analytics department for television and audio products maker VIZIO. A *National Geographic* exhibit titled "Women of Vision" inspired Fassett to study the application of geospatial solutions to economic challenges.

JOHN GOLDEN

Archer High School, Lawrenceville, Ga.

Now attending Georgia Institute of Technology

Golden is an economics major interested in the geospatial workings of the developing and developed world, such as how political geography and scarcity of resources affect communities. In the future, Golden hopes to address large-scale economic problems through greater access to real-time information from developing regions.

EMMA MCFEE

Bainbridge-Guilford High School, Bainbridge, N.Y.

Now attending University of Utah

McFee is studying geography with an emphasis in hazards, resources, and human security. Her interest in geospatial intelligence stems from her experience with floods in upstate New York, where she was evacuated from her home twice. Each time, she volunteered to help her community return to normal. She hopes knowledge of geospatial intelligence will allow her to see the wide-ranging effects of natural disasters and how they can be prevented.

GILLIAN SULLIVAN

Fairfax High School, Fairfax, Va.

Now attending University of Mary Washington

During high school, Sullivan worked as a summer hire at the American Embassy in Brussels, Belgium. She also studied geospatial analysis through a dual enrollment program offered at Fairfax High School in partnership with James Madison University. Sullivan's final project mapped and compared the terror attacks in Brussels to other terrorist attacks in the West and Middle East. Sullivan plans to study geography, political science, and geographic information systems.

GRAYSON SULLIVAN

Westlake High School, Austin, Texas

Now attending University of Utah

Sullivan is pursing a degree in geographic sciences with an emphasis in hazardous resources and human security. He also plans to achieve the GEOINT certificate offered by USGIF through the University of Utah. Sullivan hopes to learn how geospatial intelligence can be used to fight terrorism and solve other global problems.

EXTENDED PROFILES

Learn more about the 2016 USGIF Scholarship winners at trajectorymagazine.com.

DETECTING THE UNEXPECTED

MDA GEOSPATIAL SERVICES INTERNATIONAL PROVIDES INSIGHT TO A VARIETY OF CUSTOMERS

Like many companies providing products and solutions to the GEOINT Community, MacDonald, Dettwiler and Associates (MDA) is involved in more than just intelligence and surveillance. While the company is probably best known in the GEOINT world for operating the RADARSAT program, MDA is a multinational communications and information company that does business in sectors ranging from satellite imagery and remote sensing to space robotics and robotic surgery.

David Belton, vice president of MDA Geospatial Services International, said there are two core pillars to his business unit.

"One is the satellite image products and their derived services—that's clearly the overarching source of data for the majority of services we provide, including standard image products, mosaics, DEMs, and others," Belton said. "The other pillar is our overall change detection service capability, which we draw on multiple information sources and sensors to perform."

MDA was founded in Vancouver, Canada, in 1969 as an Earth observation and remote sensing company. As it grew, MDA leveraged its remote sensing capabilities for other opportunities, such as supplying satellite ground stations for government customers.

The company began to invest in geospatial intelligence services in 1993, when it helped launch RADARSAT International, the company responsible for commercializing RADARSAT-1 products and services. MDA eventually acquired RADARSAT International as a wholly owned subsidiary and rebranded it as MDA Geospatial Services International in 2006.

IMAGES COURTESY OF MDA

< RADARSAT-2 SAR satellite imagery, such as this mixed urban/rural area around Amsterdam, provides an effective way to monitor land use change over large areas. Urban areas are pink; agriculture, parkland, and forests are blue and green. At 8-meter resolution, collecting multiple images over an extended period of time is of great value to city planners, agricultural ministries, and other agencies responsible for managing land use.

Since its entry into the geospatial services industry, MDA has been the commercial distributor of products and services derived from RADARSAT-1, which ended its mission in March 2013. MDA continues to operate RADARSAT-2, which it launched in 2007. One of MDA's major collaborations with the National Geospatial-Intelligence Agency (NGA) is a multi-year supply mechanism for RADARSAT data products, which NGA and other U.S. government customers use for a variety of defense and civil applications.

"One of the primary uses of RADARSAT data is daily charting of ice in the Arctic that is performed by the National Ice Center," Belton said.

In addition to standard imagery products from RADARSAT-2, MDA also offers change detection services, providing additional surveillance information not offered by standard image products.

"Our change detection services use both optical and radar data sources that provide imagery over very broad areas at moderate resolution, as opposed to very high-resolution data sets," Belton said. "And the reason we use those types of data sets is the value we deliver looking at very broad regions. We tip and cue where [our users] should be looking."

Belton added this approach is particularly useful when locating important areas of activity that are essentially hiding in plain sight.

"One of the primary uses of RADARSAT data is daily charting of ice in the Arctic that is performed by the National Ice Center."

—David Belton, vice president, MDA Geospatial Services International

AT 5-METER RESOLUTION, RADARSAT-2 Extra-Fine Mode is useful for tracking smaller vessels or oil spills such as the one shown here off the coast of Azerbaijan in the Caspian Sea.

"We have customers who are interested in all the activity that's happening in large regions like the Middle East, for example," he said. "There are known hot spots and places where the high-value targets are understood. However, what are often missed are the unknown areas of interest. We have services and products that help to uncover and detect human activity in places where no activity is expected."

In addition to observing human activity, MDA's change detection services monitor many different types of changes with applications for a wide range of industries. Some of these include offshore oil monitoring, deforestation and crop monitoring, maritime surveillance, obstruction and airport mapping, and surface asset monitoring for mining.

Looking ahead, Belton said MDA Geospatial Services International has its eye on the current trend of satellite constellations made up of multiple small satellites, rather than a large, single satellite.

"The much reduced cost of building and launching satellites today, compared to five years ago, has enabled the constellation trend," he said. "It's a bit of a game changer in terms of the data supply … It still remains to be seen the degree to which these new providers can offer a meaningful, high-value service. We're closely monitoring the situation to see where things go, and exploring business partnerships with the new providers. We're also participating in some of the constellation initiatives through other parts of our company."

Specifically, MDA is building and will launch in 2018 the RADARSAT Constellation Mission as part of a project sponsored by the Canadian government. The constellation will consist of three satellites and extend the capabilities currently provided by RADARSAT-2, enabling faster repeat coverage and targeted revisits.

"That's the next generation," Belton said. "It's a different business model than RADARSAT-2 as it is a Canadian government-owned mission, but we're in discussions to commercialize the data. We're positioning for the future evolution of that business, so we can supply data to the international community in 2019 and beyond."

BY ANDREW CONNER

ADVANCING GEOINT AGILITY

Innovation drives open geospatial standards development

By Mark Reichardt, president & CEO, Open Geospatial Consortium

PHOTO BY U.S. ARMY SGT. JESIAH DIXON

SOLDIERS AND ANALYSTS in an Advanced Geographic Systems Analysis Using Models class studied how to streamline processes and establish NATO interoperability.

THE GEOINT REVOLUTION—the theme of USGIF's GEOINT 2016 Symposium—demonstrates strong links between the GEOINT Community and the work of the Open Geospatial Consortium (OGC). As the geospatial intelligence tradecraft leverages broader market activities and enables new technologies at record speed, this mission focus readily aligns our collective environments to advance the application of GEOINT across a growing range of domains, including emergency management, public safety, climate science, and more.

The GEOINT 2016 general session and exhibits demonstrated the correlation between cutting-edge GEOINT solutions and the OGC standards helping to empower them. In his keynote address, National Geospatial-Intelligence Agency (NGA) Director Robert Cardillo highlighted the agency's alignment with OGC's efforts to advance interoperability—work that includes complex analytics and big data processing by establishing structure in masses of disparate data. Cardillo described how NGA is working closely with OGC to "use standardized and interoperable strategies to maximize mission impact." This work supports activity-based intelligence by discovering and leveraging location and temporal "patterns in the noise."

The GEOINT Community's move to enable cloud computing—to connect analysts and leverage the Internet of Things and mobile applications—will benefit from OGC testbed initiatives and working group activities, which facilitate the development and testing of interoperable frameworks, methodologies, and ontologies that transcend disparate domains.

Open standards and associated best practices are vital for interoperability and can help rapidly integrate technologies and diverse sources of information. OGC promotes international forums to advance a comprehensive framework of open standards. Its standards are built globally into geospatial technologies that enable the rapid mobilization of tools, data feeds, and processing capabilities within the GEOINT Community. These standards significantly reduce the time, effort, and cost necessary to integrate new content sources and technologies.

INNOVATION DRIVES GEOSPATIAL STANDARDS

Interoperability challenges are often similar across communities of interest. By connecting the GEOINT Community with

representatives from diverse markets and domains, we can advance an efficient and effective interoperability framework—one that also enables effective information exchange with other communities.

At interoperability test beds, pilot initiatives, and plugfests, "running code wins"—rapidly validating new standards and accelerating delivery to market.

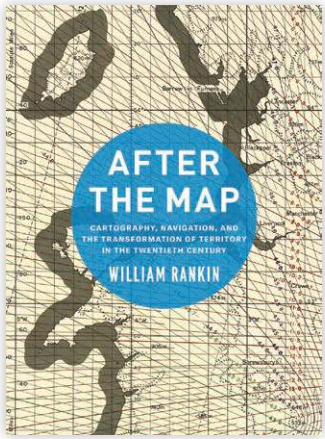
With this cross-community collaboration in mind, OGC has formed alliances with more than 30 standards and professional organizations, including USGIF. These alliances enable our organizations to collaborate on solving increasingly complex interoperability challenges, and to achieve outcomes only possible with the resources, expertise, and understanding yielded by working across mission boundaries. These alliances bolster interoperability and encourage the incorporation of open geospatial standards across the IT standards stack to ensure consistent handling of location data, avoid duplication of effort, and weave valuable domain expertise directly into the OGC standards framework.

To address the accelerating pace of technological change, OGC leverages the expertise of more than 100 university and research organizations as well as the research and development capabilities of its industry partners. Through these partnerships, OGC encourages hands-on engineering, prototyping, and applied research initiatives that enable industry, academia, research and user organizations, and individuals to develop, test, demonstrate, and validate new interoperability approaches. At interoperability test beds, pilot initiatives, and plugfests, "running code wins"—rapidly validating new standards and accelerating delivery to market. OGC's recently introduced Standards Incubator and Community Standard initiatives complement these member activities by encouraging contributions from individuals across the geospatial and broader IT communities.

The GEOINT Community's involvement in the OGC process is vital to creating an effective, globally adopted framework of open standards for use across the defense and intelligence environment.

GET INVOLVED
Help shape the future innovation of GEOINT interoperability. Visit myogc.org to learn more about OGC.

READING LIST + USGIF EVENTS CALENDAR



AFTER THE MAP: CARTOGRAPHY, NAVIGATION, AND THE TRANSFORMATION OF TERRITORY IN THE TWENTIETH CENTURY

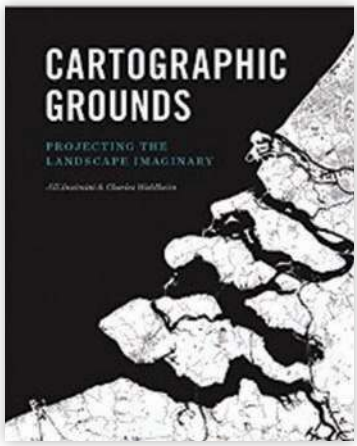
By William Rankin

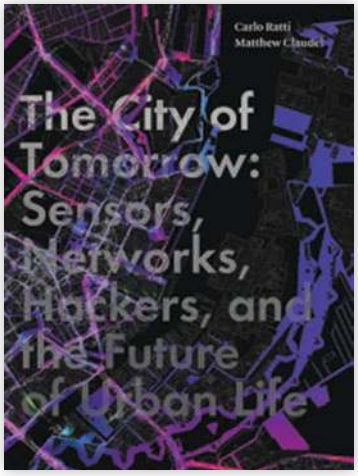
This book explores how maps were used throughout the 20th century and how they've evolved with time—positing this change in geographic perspective is a transformation of social and political territory.

CARTOGRAPHIC GROUNDS: PROJECTING THE LANDSCAPE IMAGINARY

By Jill Desimini and Charles Waldheim

The authors discuss the current use of data mapping and visualization and call for a return to traditional cartography. Each chapter focuses on a single cartographic technique and illustrates it with maps and plans from notable designers and cartographers.





THE CITY OF TOMORROW: SENSORS, NETWORKS, HACKERS, AND THE FUTURE OF URBAN LIFE

By Matthew Claudel and Carlo Ratti

Authored by an architect and an urban planner, this book studies the intersection of cities and technology and the changes taking place in urban environments. The book chronicles these urban revolutions and shares new visions for the city of tomorrow.

PEER INTEL

Andy Dougherty was named president of Continental Mapping. Dougherty has worked for a variety of companies in the GEOINT Community, including DigitalGlobe, KEYW, and Northrop Grumman.

Engility appointed **Michael Grasso** senior vice president for business development and strategic planning. Grasso joins Engility after a 35-year tenure with Lockheed Martin.

Ira "Gus" Hunt, former chief technology officer for the Central Intelligence Agency (CIA), joined Accenture Federal Services to lead its cybersecurity practice. Hunt retired from the CIA in 2013 following a 28-year career.

Letitia A. Long, USGIF board member and former National Geospatial-Intelligence Agency (NGA) director, joined Brookings Executive Education as an executive in residence. In this role, Long will work with faculty at Washington University in St. Louis to deliver research-based curriculum.

Chris Viselli of NGA was assigned to USGIF as a senior operations executive in September through the Intergovernmental Personnel Act Mobility Program. Viselli will assist the Foundation in its programming, to include professional certification. Previously, Viselli was NGA's career service manager for analysis after serving for more than 19 years in various analytic and managerial positions, including working in NGA's Office of Counterproliferation as deputy chief and then chief of the Weapons of Mass Destruction Division.

NOVEMBER

2016 GEOINT Community Week:

12
Annual GEOGala
McLean, Va.

14
Small Sats Workshop
Springfield, Va.

15
Small Sats Workshop
Springfield, Va.

YPG Panel
Springfield, Va.

GEOINTeraction Tuesday
Springfield, Va.

16
NGA Tech Showcase East
Springfield, Va.

GIS Day
Fairfax, Va.

17-18
Geography 2050
New York, N.Y.

JANUARY

9
GEOINT Career Fair
Herndon, Va.

10
Machine Learning Workshop
Herndon, Va.

JUNE

4-7
GEOINT 2017 Symposium
San Antonio, Texas

USGIF

EdGEOcation

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and for that we thank you.

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Program Management
Professional Services
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Facility Management & Modernization
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Base Operations Services
Engineering & Construction
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