THE RIGHT TOOLS FOR THE JOB

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Maximizing decision advantage

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Providing clarity for intelligence and humanitarian aid

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Finding answers through hackathons
Famed computer engineer Seymour Cray, widely recognized as “the father of supercomputing,” reportedly once quipped, “If you were plowing a field, which would you rather use, two strong oxen or 1,024 chickens?”

A similar question might be, “If you were eating a steak, which would you rather use, a steak knife or a butter knife?”

The point of these purely rhetorical questions, of course, is that having the right tool for the job is necessary for getting that job done – and in a timely and precise manner. A million chickens pecking away at the dirt would take forever to “plow” a field, if even they could. Cutting a steak with a butter knife could also take forever, depending on the quality of the meat, and the bites would likely be more torn than cut – and ragged.

Slow and sloppy are not words that should ever be associated with geospatial intelligence, as we well know. GEOINT must be timely and precise to effectively inform national-security and combat-support decisions – to provide the decision advantage needed to save lives and protect the well-being of citizens and soldiers alike.

Sometimes it’s hard to recognize or accept the right tools, though; especially when the best decision isn’t as obvious as it is in the ridiculous examples of chickens plowing a field and butter knives cutting steaks. Sometimes it’s just easier to stick with the tried and true.

But that won’t cut it. Yes, pun intended!

This issue of NGA Pathfinder is dedicated to the quest for tools that increase the speed and precision of GEOINT. While there are many, and most we cannot talk about in a public forum, there are three broad categories of “tools” featured in the pages of this issue: supercomputing, shared community data and a “solver” mentality to tackle hard problems and draw ideas and innovation from wherever they may originate.

Even a visionary like Cray probably didn’t anticipate the speed with which technical progress would enable the strength of his proverbial oxen to be packaged into a computer chip more than a thousand times smaller than the tiniest chicken. After less than two decades of development, however, the computers in ordinary smartphones and gaming systems are more computationally capable, accurate and faster than the Cray supercomputers of the 1980s. Meantime, as our lead feature illuminates, today’s fastest supercomputer may well have the capacity to perform calculations more than twice as fast as a human can.

The point of supercomputing is obviously to derive quality data for decision-making, and so our second feature focuses on the importance of reliable and comprehensive community data. The story highlights a new NGA damage assessment platform that is helping to clarify the situation in chaotic South Sudan for policymakers and humanitarian aid providers in the region. Similar community data platforms could aid those involved in other parts of the world.

Nestled within and around these three main features are stories that deal with cutting-edge tools such as small satellites, crowdsourcing, computer augmentation, quadcopters and more. Together, these tools are adding timeliness and precision to GEOINT that is already state of the art. Even though the analogy is a silly one, at NGA we are always looking for stronger oxen and sharper steak knives. Chickens need not apply.
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Simply giving analysts more satellite imagery to look through every day is not helping them in their day-to-day analysis, however, said Scot Currie, director of the Source mission integration office. “The trick is, how do I take that [data] and automate things to extract the value hidden in the image and give it to an analyst to make them that much more efficient,” he said.

The GEOINT Assessment Framework is one tool NGA is using to evaluate new technology and automation capabilities against current and future mission areas. “Through our Commercial GEOINT Assessment Community of Practice, over 40 NGA and NSG [National Systems for Geospatial-Intelligence] stakeholders have come together to create, mature and use this framework to assess commercial pixel providers and analytic services providers,” said Charles. “The framework can take commercial GEOINT products and services and walk them through a standard, repeatable assessment process, resulting in an objective, structured and comprehensive understanding of the mission utility of the product for the NSG.”

**When ‘Small’ Means ‘More’**

*By Sam Wilson, Office of Corporate Communications*

In a world increasingly driven by big data, it may seem ironic that some of the most reliable information providers are relatively tiny.

The Planet Feed, Planet’s imagery and data-hosting mechanism, collects terabytes of data about Earth every day, which creates an exciting conundrum for the National Geospatial-Intelligence Agency. Now that the agency has purchased a $14 million subscription for imagery provided by the commercial provider, the challenge becomes identifying the data most directly supporting NGA’s mission. Agency analysts must determine the best way to sift through the massive amount of data now available from the small satellites without expending an equally massive amount of man-hours. “The many emerging commercial imagery providers are not simply bringing less expensive versions of capabilities we’ve seen from traditional providers,” said John Charles, NGA commercial GEOINT lead. “We are working to leverage the global coverage and higher revisit rates made possible by these constellations.”

Learning to automate processes to detect change within the huge amount of data is key, according to Charles. He also said that the agency is exploring how to use the same change-detection software to assist in tasking its more exquisite imagery satellites. “This is still a work in progress,” Charles said.

**Extracting Value**

NGA and Planet began a contractual partnership in August 2015 with a research and development contract to learn where satellite persistence and high revisit rates could potentially help a variety of NGA mission areas. The lessons learned in this effort led to a seven-month operational prototype contract, spanning September 2016 to April 2017, which allowed NGA internal and external customers to dig deeper into capabilities, automation and specific regional areas of emphasis applied against operational problem sets.

“We are embracing small sats as a major mover in the ‘GEOINT broker’ concept.”
In fact, NGA used the GEOINT Assessment Framework to assess Planet’s potential to assist the agency and its NSG mission partners. NGA surveyed its internal analysts and NSG partners about mission needs, and then put the survey results through the framework. The process helped guide decision-makers moving forward with our second Planet contract, said Michael Applegate, NGA’s Planet program manager.

Applegate also said that having the software capabilities and processing environment in place is key to successful automation. This presents a challenge for NGA, he said, in determining how to most effectively utilize the commercial capabilities alongside what is created inside NGA.

“Just because a vendor has a capability doesn’t mean we can plug-and-play easily,” said Applegate. “We have to think through questions – whether it makes more sense to leave the capability on the vendor side for them to do the processing and/or analysis and provide NGA the results – or alternatively, maybe it makes more sense to bring a specific tool, process, algorithm, etc. inside our firewalls.”

Also important to consider are integration challenges, security, multiple domains, processing and storage costs, he said.

“To do this analysis with every vendor and every widget can be hard to manage,” said Applegate. “This is a tough problem we are still working through, which is why tools like the GEOINT Assessment Framework are so important.”

NGA has already experienced an automation success with the new data, according to Applegate. Analysts in the NGA Maritime Safety Office combined Planet imagery of Madagascar with an open-source software called “Beachfront” as part of an effort to build a global coastline dataset. The effort indicated a potential time savings of more than 70 percent from the standard, manual processes used for extracting coastlines from imagery.

Planet data has also proven valuable in understanding activity trends in ports and military garrisons, as well as urban development, road network extraction, energy infrastructure changes, and food and natural resource security monitoring and forecasting, said Applegate.

“I’m excited to see what we’re able to do when we marry up deep imagery sources with processing tools,” said Applegate. “That’s when we’ll start to get big returns and realize the potential that new data sources, like Planet, have in store.”

A BIGGER PICTURE

Planet is the only small-sat company NGA currently has under contract, but the partnership is just one piece of NGA’s overall commercial GEOINT strategy.

“We are embracing small sats as a major mover in the GEOINT Broker concept,” said Charles. GEOINT Broker is an operating model that prepares the community to benefit from the increasing availability and diversity of national, defense, civil, commercial and international GEOINT suppliers. As a GEOINT Broker, NGA works with partners to identify and assess the rapidly expanding set of suppliers to find the best capabilities and services to apply toward those partners’ needs. NGA is working to understand many commercial capabilities that are emerging or available, assessing their utility, getting useful capabilities on contract and flowing them into the agency’s analytical process, according to Charles. The agency analyzes each vendor individually to determine whether they fit well into the collective.

“We currently contract with dozens of imagery and data providers, but Planet is the only real small-sat provider so far,” said Currie. “We have to leverage what we’re learning with Planet and scale that going forward with other sources of data.”

The end sum is that NGA is finding new and different ways to combine data and imagery from both traditional and unprecedented sources to create the most comprehensive view of the world ever possible. ✨
NGA SALUTE:
ARMY CAPT. HANNAH CULBERG

By Nancy M. Rapavi,
Office of Corporate Communications

Photo courtesy of Ken Walker Jr., adapted by NGA Office of Corporate Communications
In a world where getting from point A to point B can be as easy as steering a car in the direction of your destination and listening to the GPS tell you where to go, Army Capt. Hannah Culberg has found a way to disconnect from ever-pervasive technology and connect with nature through the sport of orienteering.

A combination of land navigation and running, orienteering is a timed race during which participants must clock-in at certain checkpoints in a specific order. A map and a compass are the only permitted aids to navigation.

“There is a very big physical component, in that you have to run fast, but you also have to be very focused the whole time,” said Culberg, who at press time is just wrapping up a two-year post at the National Geospatial-Intelligence Agency, where she has served as the operations officer for the Army NGA Support Team, or NST. “You are never going to get bored.”

The sport has kept her engaged since she first discovered it by chance during her first year at the U.S. Military Academy, where she studied computer science and geographic information systems.

“It turns out that at West Point you need to very quickly find yourself a sport, or you will be stuck practicing for parades every afternoon,” she said.

And so when she saw a flyer advertising orienteering as a way to combine a love for the great outdoors and running, she signed up and has been navigating ever since — both for fun and for competition.

Since moving to the Washington, D.C. area, Culberg said there are numerous opportunities for club-level involvement, including the Quantico orienteering club, of which she is a member.

“Living here has been fantastic for training, because there is such an active club, and there are so many opportunities to get out and train,” she said.

Culberg also competes in orienteering on the national and international levels. In March she competed in the Armed Forces Orienteering Championship where she won three medals, including a gold medal in the ultra-long championship. These wins qualified her for the World Military Orienteering Championship in Hamina, Finland, in June, where she joined other military members representing the United States. About 260 military athletes from 30 countries participated this year.

While the competition is rewarding, Culberg said the sport itself provides a peaceful outlet.

“When you are running hard and all the right things are showing up and you are hitting those checkpoints perfectly, everything clicks, and it becomes a little Zen-like state — everything is perfect,” she said.

Culberg grew up in Pittsburgh, Pennsylvania, where she became interested in applying to West Point after her junior year in high school.

“I was interested in the personal challenge, being part of the Army and having an opportunity to give back,” she said. “In her NGA position she ran administrative operations that helped the NST operate on a day-to-day basis, including working queries between NGA and Army headquarters.

U.S. Army Lt. Col. Cary Stoffels, who is the chief of the Army NST, said Culberg’s exceptional skills at simplifying problems kept the NST on track.

“She has the unique ability to look at problems and reduce them to the root cause,” he said. “This helps save a lot of time.”

Commissioned into the Army as an engineering officer, Culberg said NGA has given her a perspective-broadening experience. While her previous assignment at Fort Lewis in Tacoma, Washington, offered a tactical viewpoint — with her unit frequently conducting operations in the field — at NGA, Culberg said she had the opportunity to see the Army from a strategic point of view.

“This has been fantastic exposure to the way the Army utilizes GEOINT and what the tie-points are back to the national intelligence construct,” she said.

**‘SHE HAS THE UNIQUE ABILITY TO LOOK AT PROBLEMS AND REDUCE THEM TO THE ROOT CAUSE,’ HE SAID. ‘THIS HELPS SAVE A LOT OF TIME.’**

Stoffels said NGA benefitted greatly from Culberg’s tactical perspective, which enabled the NST to see problems from a soldier’s standpoint.

“At the strategic level, it’s possible to lose touch with the warfighter,” he said. “Just having that perspective from someone who comes from a tactical unit gets us to understand exactly what the soldier needs.”

After serving in the Army for five years, Culberg will fulfill the rest of her military commitment in the inactive readiness reserves while she heads to Stanford University to study electrical engineering with a focus on radar and remote sensing systems.

Noting that she plans to return to government service in some capacity, Culberg said her dream job would be to join the NASA Jet Propulsion Laboratory, working in the radar engineering section.

“I’m definitely trying to stay in the GEOINT world,” she said. ♦

Know a service member worthy of an NGA Salute? Send your suggestion to Pathfinder@nga.mil.
I AM NGA: CHARLIE CHAPIN
By Jacquelyn Karpovich, Office of Corporate Communications

It takes a comfortable pair of shoes, a good alarm clock and a passing familiarity with East Coast public transit to keep up with Charlie Chapin. As the lead for National Geospatial-Intelligence Agency’s public-private partnership interface, Chapin looks for opportunities for technology partnerships with companies that have the potential to co-create intellectual property using the agency’s data – and that means he’s often on the road.

“I’m telling them about our agency and spreading awareness of the public service we provide and giving it context,” said Chapin. “Because a lot of people just do not understand what we do, don’t understand the IC [intelligence community], have never worked with the Defense Department.”

For Chapin a typical travel day starts by catching the 5:30 a.m. train to New York. Once he gets to Penn Station around 9 a.m., the wireless earbuds go in, and he’s fielding conference calls, dodging pedestrians and making the 10 blocks to Civic Hall, a collaboration center for civic innovation, where NGA holds a membership.

At Civic Hall, it’s co-working and conference calls until midday, then a trip downtown on the subway for demos, meet-and-greets and meetups until around 9 p.m.
“Grassroots involvement is the best way to understand, what are the tech and business trends driving innovation in our economy?” said U.S. Army Lt. Col. Erwin Godoy, special advisor for innovation to NGA’s director of plans and programs. “By working out of incubators and tech hubs, NGA’s outposts personnel get exposed to these trends early. We also want to see how different industries are changing the way they do work, changing their business models, in response to technological change.”

Personnel at NGA’s outposts do a lot more than scout new technology, according to Chapin. They also focus on people and processes, incorporating best practices from industry, academia and other government partners.

New York, along with Silicon Valley and San Antonio, is part of the agency’s broader outposts strategy. New York is noted for its technology ecosystem around advertising, finance and media, which at first glance might not seem to have a direct connection to the NGA mission. But the underlying technologies rely on data analytics, artificial intelligence, computer vision and machine learning, according to Chapin.

“And that’s why New York is one of the areas the agency should look for partners in co-creation through this data exchange,” Chapin said.

New York, according to Chapin, also provides a very real perspective on the value of products to people. He believes adapting to honest feedback is the only way to survive in the open environment, and the public-private partnership interface enables that process.

“I love the perspective the city gives me,” he said. “The first time I went to New York I thought, ‘Even if this is the last time I go for the agency, this is such an incredible privilege, I am so thankful.’”

Chapin’s journey to his NGA role started in his final semester at Middlebury College, when he got interested in geographic information systems. He followed that interest after graduating, returning home to San Jose and beginning an internship with Google Earth. He also enrolled in geography classes at San Jose State University.

At Google, Chapin said he saw people who were passionate about creating applications, but it was an opportunity to work with Red Cross data during Hurricane Katrina that made him realize that he wanted more.

“I was connected to state and local governments, and I was seeing people really use the data,” said Chapin. “At the end of the day, it really came down to having a sense of purpose and having a sense that what you do really matters to people that aren’t necessarily technology users.”

It was perfect timing for a job offer from NGA.

Chapin joined the agency in 2006 as an analyst. He has spent the last 11 years connecting with the mission in a variety of roles. Among them have been supporting counterterrorism capacity-building between U.S. Pacific Command and the Armed Forces of the Philippines, facilitating shared awareness of GEOINT analysis across the “five eyes” allied nations, and serving as a liaison with the Central Intelligence Agency.

All of those roles shared two things in common: travel and partnerships.

“I learned the technical side of what we do, I learned what the customers are looking for – both in the field and within the [D.C.] Beltway in the policymaker circles,” said Chapin. “And I also learned what it takes to establish, develop and maintain partnerships — both internationally and within the IC [intelligence community].”

Those experiences led to a situation where he was in the right place at the right time. But it was more than just a lucky opportunity, Chapin said. When it came to selecting NGA tech partnership scouts, Godoy had a laundry list of requirements.

“You have to be outgoing, willing to lean forward to build relationships, adapt swiftly to new environments, learn new tech subjects and ask good questions,” said Godoy. “You need to be comfortable with ambiguity and be able to relate with the startup and tech culture. Charlie fits all these and executes with enthusiasm and optimism.”

Chapin views himself as a connector, working with NGA’s different innovators to ensure that the products they are building have a place within the agency. He works closely with the agency’s analytic capabilities portfolio, automation and anticipatory analytics research pods, and the computer vision working group to connect the people who really understand the needs of the customers with the people doing the technical work. And with the tide of new tech companies rising each quarter, he strategizes with colleagues exploring business development through other innovation-seeking channels, namely those at the Outpost Valley, NGA In-Q-Tel Center and GEOINT Solutions Marketplace.

While the opportunity to travel seems like an obvious choice for Chapin’s favorite part of the job, he’s been most surprised by the tech community response to the agency’s mission.

“You talk to one person in New York, and they know 10 people they want to introduce you to,” said Chapin. “And so talking to one person about what NGA does creates 10 new opportunities to tell other people. What we do — we do it for the country, we do it for everybody around us.”
SUPERCOMPUTING:
MAXIMIZING DECISION ADVANTAGE

By Anne Arians, Cir., NGA Research

Human problem-solving may be nearing superhuman speed. While estimates vary wildly about how many calculations per second the human brain can perform, it may be that the world’s fastest supercomputer can do more. And it can do those calculations 24 hours a day, 365 days a year, with larger memory capacity. Computers are still far from replicating human brain capabilities, but human thought has never before been supported by so much supplemental power, and the technological wonder of high-performance computing is changing everything from social media to business services to national security intelligence. At the National Geospatial-Intelligence Agency, spatiotemporal computation at the massive scale made possible by supercomputing will drive unprecedented analytic transformation that will accelerate the decision advantage of the agency’s customers.
BRAIN POWER

Even with extensive research, the depth and breadth of human brain performance is still largely unknown and widely varies depending on which attributes are measured and how. Many researchers believe the human brain performs around 38,000 trillion calculations per second, however; and until 2016 supercomputers could calculate only half as fast. Now, the world’s fastest computer – the Sunway Taihu Light in China – can perform more than 93,000 trillion calculations per second, or potentially more than double what the human brain can do.

Sources: Human Brain Project, http://top500.org

UNDERSTANDING HPC

In the simplest terms, supercomputers perform at extremely fast rates with greater processing capacity than other computers. The supercomputing revolution began in the early 1960s with the introduction of Seymour Cray’s CDC 6600 high-performance computer that processed over three million instructions per second. The fundamental distinction in Cray’s approach included a circular design that decreased signal delays and parallel processing that accomplished multiple tasks simultaneously.

The supercomputing performance of earlier decades is now equivalent to that available in today’s smartphones. Tasks that used to require rooms of hardware to accomplish can now be performed on devices that easily fit inside a shirt pocket. Cray’s parallel processing approach is still key, however; as high-performance computing is often achieved by linking multiple computers in parallel architecture that can simultaneously process huge volumes of data for scientific or engineering tasks – back to huge rooms of hardware, but now with exponentially greater computing capabilities.

The leading-edge HPC systems are continuously displaced by newcomers with new technologies. ISC Group, one of the world’s most prominent providers of services that drive leading-edge technologies, has tracked this international race and published a “Top 500” list since 1986. Just a few years ago, government and industry supercomputers in the United States held most of the higher positions. As of June 2017, U.S. systems still account for more than a third – 37 – of the top 100 on the list and five of the top 10. Of note, U.S. private-sector giant Facebook ranks at 31. The two top-ranked HPC systems on the list are both in China. All five U.S. systems in the top 10 are in Department of Energy national laboratories. (See box.)

In some ways, the Top 500 list is increasingly an anachronism. The systems are ranked using a well-known floating-point benchmark that reflects the original dominant use of supercomputers for the modeling and analysis of physical systems. While such benchmarks have been invaluable in providing metrics that have driven HPC research and development, they also constrained the architecture and technology options for HPC system designers. The HPC benchmarking community is moving beyond the traditional raw-speed benchmarks with new ones focused on data-intensive analysis of large graphs and on electrical power efficiency. The massive computing capabilities of major nontraditional HPC companies such as Google and Microsoft – absent from the Top 500 tally – and the increasingly prevalent computational demands of artificial intelligence and machine learning will change how these lists are assembled in the future.

RESHAPING WHAT’S POSSIBLE

Computational challenges have always demanded more computing power than was readily available. Challenging scenarios included designing GPS systems, weather
The volume of relevant data is growing at breakneck speed, according to NGA Director Robert Cardillo.

‘...[W]hether our new persistent view of the world comes from space, air, sea or ground, in five years, there may be a million times the amount of geospatial data that we have today. Yes, a million times more,’ Cardillo said in his keynote address at the 2017 GEOINT Symposium...

He declared that NGA does not fear “the data deluge.”

“Managed smartly and efficiently, it’s the solution [to understanding the world],” Cardillo said, “but it’s going to require us to change.”

The agency will process that vast amount of data with HPC tools, ready access to HPC-class resources and an HPC mindset, Highnam said.

There is already a variety of HPC experiences within NGA, according to Highnam, albeit none at the scale of traditional supercomputing applications or at the scale of the social media companies. He said NGA has explored the use of HPC for space and airborne sensor data processing, machine learning, physical sciences modeling and data science. By partnering with several DOE national laboratories, NGA has also executed HPC experiments.

“We have substantial opportunities to put HPC to good use, positive experiences with specific applications, and a vibrant external HPC ecosystem to tap and build upon,” Highnam said.

HPC assets can be remote, such as Facebook’s data center in northern Sweden that takes advantage of environmental cooling and electrical power. HPC work can also be “farmed out” over multiple HPC systems for responsiveness and resilience - e.g., Amazon Web Services, Google. Traditional HPC computations often require large single-site work. Systems that support approaches such as computational steering place data analytics and visualization close to the end user, in addition to potentially remote capabilities.

“In short, NGA’s distributed architectures and cloud-based approach can be tailored to fully exploit HPC systems as tools,” Highnam said.

PARTNERING WITH HPC EXPERTS

NGA’s commitment to enhance its tradecraft with HPC capabilities led the agency to host a geocomputation summit, “Transforming National Security with High Performance Computing,” in February 2017. The DOE Oak Ridge National Laboratory was a close partner in the organization of the event. Technical experts from successful external organizations described why and how they use HPC to move the boundaries of the possible. Industry pioneers speaking in the summit included Vint Cerf of Google; Shaun Gleason and Jeff Nichols, both of ORNL; Doug Cutting of Cloudera; Bill Gropp of the National Center for Supercomputing Applications at the University of Illinois; Ryan Quick of PayPal; and Mark Dumas of PlanetRisk.

The event confirmed that both the private and public sectors are in an HPC revolution. Speakers emphasized the importance of learning mission problems, workflows, close partnerships with end users on specific targeted problems, and understanding...
how to achieve the greatest impact with the power of HPC tools. They advised that HPC success requires organizational commitment, cultural adaptation, risk tolerance and rigorous evaluation. Major companies that are significant users of HPC have invested years in building their teams and systems.

PREPARING TO MOVE OUT
NGA is preparing for its own high-speed future with an increasing emphasis on computational thinking and data science. Both are needed to fully exploit the power of HPC systems. The agency currently has limited internal expertise in the development, use and maintenance of HPC, according to Highnam, but he said that there is a substantial base of experience within the government, including the DOE laboratories, that NGA can tap as it continues to develop its own expert computing cadre.

NGA Research is applying the same approach to implementing HPC tools as it does to planning and executing other agency projects, according to Highnam, including “starting with the Heilmeier questions.” The questions, developed by George H. Heilmeier when he served as director of the Advanced Research Projects Agency in the 1970s, must be answered before pursuing any proposed research. Among them are “What are you trying to do?” and “If you’re successful, what difference will it make?” (See box.)

The National Strategic Computing Initiative, an executive order signed July 2015, is also guiding NGA’s development of high-performance computing capabilities. The NSCI explicitly seeks to enhance U.S. leadership in HPC through collaboration of government, industry and academia. The order directs broad deployment of HPC capabilities that leverage public-private collaborations and transition results from research to operations.

NSCI is aggressive in seeking exascale computing (see “A new vocabulary” sidebar). It intends to ensure application to both data analytics as well as modeling and simulation, and a robust and enduring national HPC ecosystem of expertise, organizations and tools. DOE is leading the charge in terms of exascale computing investments.

The expected computational load from significant analytical investments in structured observation management, full-motion video and foundation GEOINT is a major driver for accelerating NGA’s higher computing capabilities, according to Highnam. He said substantial HPC capability is available for the agency to exploit as it meets the challenges of massive – and growing – data volume.

NGA and its mission partners in the National System for Geospatial Intelligence, as well as its international partners in the Allied System for Geospatial Intelligence, have deep mission knowledge that will serve to ensure that HPC is applied to critical current and emerging GEOINT challenges.

“With our partners we are investing in HPC resources, tools and expertise,” Highnam said. “Just as HPC transformed major industries, we expect that HPC will be a fundamental enabler for NGA.”

The new capabilities will help NGA’s partners and allies to achieve more and know more about the nation’s adversaries. They will be able to better anticipate activities and threats, and above all, to maintain the ever-crucial decision advantage.

‘HEILMEIER CATECHISM’
Former ARPA Director George Heilmeier created a list of questions in the 1970s to serve as high-level guidance for research proposals. He called the list the “Heilmeier catechism.” The questions are still used by government research facilities nearly a half-century later.

HEILMEIER QUESTIONS
H1. What are you trying to do?
H2. How is it done at present? Who does it? What are the limitations of present approaches?
H3. What is new about your approach? Why do you think that you can be successful at this time?
H4. If you succeed, what difference will it make?
H5. How long will it take? How much will it cost? What are your mid-term and final “exams”?

A NEW VOCABULARY
In the last decade or so, supercomputing performance has been measured in benchmark tests by how many floating-point operations – e.g., addition, subtraction, multiplication and division of real (vs. integer) numbers – the systems execute per second. Today’s leading high-performance computing systems use the metric system peta prefix, e.g., 1 PFLOP/second, or 1 PFLOP/s, meaning 10,000,000,000,000,000 (or, 10^15) floating-point operations per second. Similarly, tera (10^12) is written TFLOPS/s, and exa (10^18) is written EFLOP/s.

Metric system prefixes are also used for storage and communication, thus exabyte data stores – as used by social media companies, and gigabit/s as a unit for communications. Based on predicted increases in future performance, the 10^21 (zetta) and 10^24 (yotta) are already approved prefixes.
The Global Positioning System is both staggeringly complex and disarmingly simple. Technological advances are rife with such dichotomies. One that’s certain is that every major breakthrough brings unintended consequences along with its benefits.

But that should never slow us down. Just as GPS directs us, the good wrought of technological innovation should be our trusted beacon.

A vast global infrastructure keeps GPS running smoothly, owned and operated by the U.S. Department of Defense, administered by the U.S. Air Force, with map data provided by NGA, and involving the input of many facets of the federal government. Ann Ciganer, executive director of the GPS Innovation Alliance, a group that promotes innovative uses for GPS, likes to refer to this support network as an “ecosystem,” an apt metaphor. A network of 24 active satellites, arrayed so that every spot on Earth has a line of sight to at least four, along with monitoring stations around the world — most controlled by NGA — obsessively tracking their ephemera to the millimeter, requires a system working in complete lockstep. And that is to say nothing of the scientists and research facilities around the world whose constant observation of the system ensures that GPS is accurate enough to measure the movement of the Earth’s tectonic plates, and even the subtle dance of neutrinos.

PRECISION WITHIN NANOSECONDS

At root, however, GPS is just a clock — or rather, the world’s greatest stopwatch. Every satellite carries an array of atomic clocks, all synchronized to within nanoseconds, obeying a time signal ultimately linked to the clock at the Naval Observatory in Washington, D.C. Whenever any GPS receiver computes a position fix, from the GPS chip in your phone to one on a guided missile, it utilizes this clock. Every satellite emits a constant radio signal that provides information about the position of the satellite and the exact moment the signal emerged from the satellite. By noting the travel time required for the signal to reach the receiver, and doing this simultaneously with three other GPS satellites,
GPS is probably the only system created by humans — with the exception of particle accelerators — that must account for Einstein’s laws. The satellites are far enough away, and traveling at a sufficiently fast speed, that time for them is moving at a slightly different rate than it is for us on the ground.

Taking a broader view, GPS was a crucial updating of an innovation first realized in the 18th century. European ships were hampered by their inability to calculate their longitude, a process that required knowing the time at sea and comparing it with the time at a prime meridian. There were no clocks robust enough to withstand the rigors of sea travel without losing their accuracy. The chronometer was merely a clock that could keep time on the open ocean, but its development was transformative. In the Western world, the calculation of location would forevermore be inseparable from a knowledge of perfect time. GPS works in the tradition of the chronometer, a system of timing strong enough for the modern frontier of outer space.

**IMPACT ON THE WORLD**

The innovation of the chronometer, in world-historical terms, had an effect that was linear. It opened up the world for European exploration on a scale previously unthinkable. With GPS, the impact on the world has been more diffuse and multifaceted. In a short amount of time — the first GPS satellites were launched in the early 1970s, and the constellation itself did not reach maturity until the early ‘90s — GPS has become an indispensable part of how our world operates. And it is important to understand that this transformation flows from the original innovation. The basic technology of GPS has remained unchanged since the program began in 1973. Unlike almost every other technology on the planet, this stasis is definitely a feature, not a bug, providing a foundation for the technology that has remained stable as its applications have developed.

Because of GPS, our ability to locate ourselves in physical space has reached a level unthinkable to our ancestors. Even the original GPS architects, though brilliant and forward thinking, could not have foreseen a world where GPS navigation is used to grow the world’s food and track employees in company cars, two GPS cottage industries — “precision agriculture” and “fleet management” — growing at an explosive rate. But the larger unexpected outcome of the innovation of GPS has been that its timekeeping aspect, far from just enabling our sense of where, has increased our dependence on our knowledge of when.

The biggest open secret of GPS is that, by some metrics, time-keeping is now its most important function. Because the GPS signal is so accurate, and provided gratis to everyone everywhere, it has become the tool of choice for linking complex systems, spread over large geographic areas, that require precise timing. GPS controls the smooth hand-off of mobile phone communication between cell towers. GPS timing regulates our electrical grid. In an era when billions of dollars change hands through automatic high-speed trading, GPS time-stamps organized transactions on the major exchanges. Most facets of our critical infrastructure now contain a GPS-dependent component.

**UNPREDICTABILITY OF INNOVATION**

This transformation has occurred so quickly that we are just now coming to terms with the effects of GPS. Governments around the world, including ours, have become alarmed with the porous nature of the GPS system, especially its susceptibility to “spoofing” attacks, in which a bogus GPS signal confuses GPS receivers, disrupting their timing and sowing chaos in these large systems. This vulnerability presents a real challenge but not an insurmountable one.

GPS may offer a case study in the unpredictability of innovation, but it is also a story of how innovation can be so catalytic that even the innovators cannot envision the gift they have given the world. As much as any natural ecosystem, this gift makes GPS — and the fearless pursuit of innovation — worth protecting.

**Greg Milner** is the author of “Pinpoint: How GPS Is Changing Technology, Culture and Our Minds” and “Perfecting Sound Forever,” and a finalist for the National Book Critics Circle Award. His work has appeared in Rolling Stone, Slate, Wired, Salon, Spin, New York and Village Voice. He can be reached for comment or discussion at gmilnermail@gmail.com

Have an idea for a GEOINT or national security Viewpoint contribution? Send your query to Pathfinder@nga.mil.
When Sir John Franklin and his crew navigated their two ships into Alaska’s ice-choked Baffin Bay in July 1845, they relied on unverified maps, anecdotal accounts from other ship’s logs and a few facts gleaned from the oral traditions of the area’s Inuit tribes. While primitive to modern standards, this traditional method of maritime navigation could be considered an early form of crowdsourcing – the practice of piecing together information supplied by the community.

Today, the National Geospatial-Intelligence Agency is leveraging new and innovative ways to ensure safe navigation, including mapping the highest peaks in the Arctic to the depths of the oceans. Key to the efforts are the time-tested and ever-more valuable practice of sharing knowledge among the communities who need it most.

The agency has never before had such a robust set of tools and dynamic data repositories to accomplish this – partnerships with other agencies and commercial entities, big data, crowdsourcing, supercomputers and web-based delivery services and apps. These tools are allowing NGA to cut mapping efforts in half and instead to collect data from an increasing diversity of sources and disseminate it to the widest possible audience – resulting in an unprecedented, near real-time understanding of the Earth.

SEEKING SAFE PASSAGE

Sir John Franklin and his men knew their quest for the Northwest Passage would be challenging. The captain and crew of this lost expedition could not predict what lay ahead, as there was no GPS, no radar, no topo maps, no sonar in those days. The absence of these tools and technologies, along with tainted food and bad luck, doomed the expedition almost from the start.

“Lord Franklin’s Lament” first appeared as a broadside ballad around 1850. It recounts the loss of Franklin and his crew, who disappeared in Baffin Bay during an 1845 expedition through the Arctic Ocean.

Times have changed since the early expeditions to locate the Northwest Passage and map the Arctic. Travel by air rather than ship is now the preferred method for getting around the area, making precise elevation data highly desirable. The topography of the Arctic is still poorly mapped compared with most other regions of Earth due to logistical costs and the limits of satellite missions with low-latitude inclinations.

A partnership between the National Geospatial-Intelligence Agency and a team led by the National Science Foundation...

Excerpt, “Lord Franklin’s Lament”

“With a hundred seamen he sailed away
To the frozen ocean in the month of May
To seek a passage around the pole
Where we poor sailors do sometimes roll
Through cruel misfortune they vainly strove
Their ships on mountains of ice was drove
Where the Eskimo in his skin canoe
Was the only one who could make it through.”

“Lord Franklin’s Lament” first appeared as a broadside ballad around 1850. It recounts the loss of Franklin and his crew, who disappeared in Baffin Bay during an 1845 expedition through the Arctic Ocean.
funded Polar Geospatial Center is changing that with an initiative called ArcticDEM [digital elevation models]. The public-private project is a response to the need for high-quality elevation data in remote locations, the availability of technology to process big data, and the need for accurate measurement of topographic change. The producers did not intend for the final product as a single eyes-on or edited product, but rather a collection of time-dependent elevation models and the infrastructure to process the flow of imagery from an ever-expanding constellation of satellites producing an ever-increasing volume of high-quality data.

PRODUCING DIGITAL MODELS

ArcticDEM, being unveiled through a series of releases, will deliver a seamless, two-meter posting mosaic of the entire Arctic above 60 degrees north, including all of Alaska, Greenland and Kamchatka. The initiative will produce a high-resolution, high-quality, digital surface model of the area, using optical stereo imagery, high-performance computing and open-source photogrammetry software. ArcticDEM data is constructed from in-track, high-resolution (~0.5 meter) imagery acquired by the DigitalGlobe constellation of optical imaging satellites and licensed through the NGA NextView contract.

A convergence of civilian, high-quality sub-meter stereo imagery; petascale computing; and open-source photogrammetry software has made it possible to produce a complete, very high-resolution (two- to eight-meter posting) elevation model of the Arctic.

“The models are created using multiple photos of the same location, which will allow users to track changes over time,” said Paul Morin, University of Minnesota, who is collaborating with NGA on the project. “Tracking these changes can help communities monitor the coastal erosion that can affect maritime navigational charts that rely on location data.”
Current DEM coverage of the Arctic. Alaska has been processed to a 2m posting. The rest is at an 8m posting. Graphic from the Polar Geospatial Center.

ArcticDEM uses stereo imagery from DigitalGlobe’s Worldview-1, 2 and 3 satellites and the Ohio State University’s “Surface Extraction with TIN-based Search” space-minimization software, referred to as SETSM, running on the University of Illinois’s Blue Water supercomputer.

“The satellites are collecting huge amounts of data. Researchers are getting data from areas the size of California every day. The combination of the large areas and high-resolution images creates up to 30 terabytes of data a week,” according to project literature released by the University of Illinois, which houses the supercomputer that processes the data.

The ArcticDEM output raster files are made available as both strip files – as they are output directly from SETSM and preserve the original source material temporal resolution – and as mosaic files compiled from multiple strips that have been co-registered, blended and feathered to reduce edge-matching artifacts.

**TRACKING CHANGE**

The time-dependent nature of the strip DEM files allows users to perform change-detection analysis and compare observations of topography data acquired in different seasons or years. The mosaic DEM tiles are assembled from multiple strip DEMs to provide a more consistent and comprehensive product over larger areas.

GIS-expert Esri has developed an online web-mapping application to explore ArcticDEM data. With this web map, users can visualize the data, preview the spatial coverage and download simple exports. Raster elevation data – strip and tiles – is served via an Esri image service. Esri also provides an ArcGIS online feature service for the ArcticDEM mosaic tile scheme [no raster elevation included]. The GIS layers can be used directly in desktop GIS software.

The ArcticDEM project will also make available more than 300,000 individual time-stamped DSM strip pairs that were used to assemble the mosaic. These will be available for download, but also as dynamic image services usable in a wide range of interactive applications to explore this changing environment. The data set can also be used to highlight changing geomorphology due to mass transport processes of Earth’s surface occurring in active volcanic and glacial environments.

When complete, the ArcticDEM will catapult the Arctic from the worst-mapped region of the planet to one of the best. Lord Franklin, if he were alive today, would no doubt marvel over this great accomplishment.
MONITORING INCREASINGLY NAVIGABLE SHIPPING CORRIDORS

The Northwest Passage, Northern Sea Route, and Transpolar Route all offer the potential for significant time and fuel savings for commercial ships seeking shorter alternatives to routes passing through the Suez Canal or Panama Canal. For example, a voyage from the Port of Rotterdam – the largest port in Europe – to Yokohama, Japan, is over 12,000 miles via the Suez Canal. It is less than three-fourths as long, or just over 8,400 miles, via the Northern Sea Route.

Shrinking ice in the Arctic is increasing the navigability of the northern shipping corridors, but safety of navigation is both a concern and a challenge constantly monitored by the National Geospatial-Intelligence Agency. While the Bering Strait sees less than 10 percent sea ice in its open water for nearly half the year – approximately 21 weeks – the Northern Sea Route has less than 10 percent sea ice in its open waters for only about two weeks out of the year. The Transpolar Route and Northwest Passage currently never have less than 10 percent sea ice.

Satellite imagery enables NGA and its partners at the National Snow and Ice Data Center, National Oceanic and Atmospheric Administration, the U.S. Navy and others to monitor, map and predict changes in ice coverage over time.

Arctic sea ice reached its minimum extent in September 2015, the fourth-lowest extent recorded since monitoring began in 1979. This record is consistent with a long-term downward trend in ice extent and thickness since satellite monitoring began. The 2015 minimum extent ranked behind the lowest extent in 2012, second-lowest in 2007 and third-lowest in 2011. The nine lowest sea ice extents in the satellite era have all occurred in the past nine years.

Ensuring safety of navigation in the Arctic region will become increasingly important according to trend models created by NGA and its partners studying the region. The models indicate that by 2030, the Bering Strait will have less than 10 percent sea ice in its open waters for 27 weeks each year; the same will be true for nine weeks in Northern Sea Route, six weeks in the Transpolar Route and five weeks in the Northwest Passage. Satellite imagery of the region will assist NGA in providing accurate charts and maps to ensure safe passage through these icy corridors.

Sources: National Snow and Ice Data Center, NOAA, US Navy Task Force Climate Change.
From the days before electricity, when sailors navigated the seas with magnetic compasses and crude charts, to the modern era of advanced scientific instruments such as GPS to guide mariners’ routes, one thing has been paramount – the need to safely navigate the Earth’s waterways.

“The American Practical Navigator,” more commonly referred to as “Bowditch” after its author, Nathaniel Bowditch, has been the go-to nautical handbook since its premier publication in 1802. There’s likely a copy on the bridge of every U.S. watercraft, according to Jerry Clifford, Ph.D.

Two years ago Clifford received a phone call while on assignment at the Office of Naval Intelligence. It was from the National Geospatial-Intelligence Agency, asking if he would be interested in serving as editor of the 2017 edition of Bowditch. Clifford accepted, then embarked on a journey to “make Bowditch continue to be a great book – the epitome of marine navigation.”

Clifford refers to the book as the “‘Gray’s Anatomy’ for navigation.” Like Henry Gray’s revered tome on human anatomy, Bowditch is considered the gold standard for its field. NGA and its predecessor organizations have reviewed and updated Bowditch since the 19th century. This year marks the 150th anniversary of the U.S. government’s $25,000 purchase of the rights to the book.

PERSONAL COMMITMENT

Clifford’s relationship with Bowditch began long before NGA asked him to update the nearly 900-page book, he said. His fondness for the book started with an admiration for the man behind it and carried through to his time as a midshipman at the U.S. Merchant Marine Academy.

“Here’s a young man, a teenager, finding errors in [Isaac] Newton’s published work, and later, dedicating his life to trying to make the sea, a very dynamic environment, as safe as possible,” Clifford said of the young Bowditch. “Him as a human being, a real person, and all that he accomplished and his legacy – it’s something that will endure for a very long time.”
The Bowditch 'bible' is the **SCIENCE** and the **THEORY** behind the **ART OF NAVIGATION,**” he said. “Every advance in that art has to be accounted for, explained and disseminated so that other people hear about it.”

As a young man standing in line at the Merchant Marine Academy bookstore, Clifford said he and his classmates were handed one book that was larger and heavier than the rest. Inside “The American Practical Navigator” the students found chapters on the fundamentals of maritime navigation, piloting or navigating along the coastline, electronic navigation, electronic charts and radar navigation, celestial navigation, mathematics, safety and regulations, oceanography and meteorology.

“You’re just a young kid when you learn marine navigation,” said Clifford. “You really are told that Bowditch is the maritime bible. It’s such an honor [to edit the newest edition] because it’s such a rich tradition that’s dear to so many people’s hearts.”

**WORLD REACH**

U.S. Naval Academy midshipmen are encouraged to get Bowditch in their first days on campus, according to Clifford, who has a photo on his desk of a U.S. naval officer swearing his oath with his hand on a copy of Bowditch.

While NGA is responsible for overseeing the updates, the U.S. Coast Guard and the U.S. Navy, among others, provide updated content. Bowditch – or similar content – is mandated to be onboard every ship that flies the U.S. flag, said Clifford, and many other countries also use it. For example, the Philippine Merchant Marine Academy uses Bowditch to instruct its cadets on marine navigation and other topics.

“That’s not insignificant, as Filipinos represent one of the largest groups of professional mariners around the world,” said Clifford. “Many shipping companies hire Filipino crews for their ships.”

Clifford shared the story of a colleague who captained a German-flagged vessel, recalling that the German shipping company required Bowditch to be carried on the bridge of all ships in its fleet.

“Because 95 percent of all commerce travels around the sea, the safety of navigation is critical to the economic security of all countries,” said Clifford.
For that reason, NGA released the 2017 Bowditch at an international forum. The agency provided a copy of the new edition to every attendee of the International Hydrographic Organization conference in Monaco April 24. NGA released a digital version to the public in June.

**FOCUSED UPDATE**

Clifford said he had three main focus areas when he started updating the 2017 edition of Bowditch: ensuring the accuracy of the information in the publication; reconstituting unique content deleted from previous editions, in response to received feedback from marine navigation professors across the United States; and capturing the present practice of marine navigation, including an emphasis on electronic navigation and digital charts.

Readers will see updated content and graphics throughout the 2017 edition, said Clifford. New to this edition are more than 200 links to additional information and websites, and matrix barcodes or QR codes.

The digital-only Bowditch release is new for NGA, and that’s a good thing, said Clifford.

“A digital copy makes it easier to access in our digital age and easier for students to reference on their devices, not having to lug around a heavy book to class,” he said.

Clifford also notes that navigational practices themselves have changed significantly since the first Bowditch.

“They used to throw a rock over the ship, on a string with a bunch of knots in it, to measure the depth of the water,” he said. “So much of what [early mariners] learned was just through experience – trial and error.”

That seafaring tradition, or art, of accumulating knowledge about the ocean and how to navigate it formed the basis of the first edition of Bowditch, according to Clifford.

“The Bowditch ‘bible’ is the science and the theory behind the art of navigation,” he said. “Every advance in that art has to be accounted for, explained and disseminated so that other people hear about it.”


‘They used to throw a rock over the ship, on a string with a bunch of knots in it, to measure the depth of the water,’ he said. So much of what [early mariners] learned was just through experience – trial and error.”
**MODERN MESSAGING: COULD THIS APP HAVE SAVED THE TITANIC?**

By James Brown, Ctr., Source Foundation Group

We all know the fate of the Titanic and its more than 1,500 passengers on the night of April 14, 1912, after it struck an iceberg in the North Atlantic, then sank. Since then, navigation and communications technology have made exponential advances along with procedures to ensure an event as epic as the Titanic’s never happens again.

Soon after the disaster and continuing to this day, NGA and its predecessor organizations have been integral to stepped-up efforts to make navigating the seas and coastlines safer through accurate and timely safety messages issued by the NGA Maritime Safety Watch. NGA is about to up the game again, with an app that will open up a new dimension in how safety messages are created and disseminated.

An old adage says “timing is everything,” and it’s especially true in navigational safety. Timing and accuracy are what sets the new NGA Maritime Guardian Pro app apart from the way safety warnings have been disseminated since the days of the Titanic – via textual notifications.

This new app could easily be called the “WAZE of the seas,” as it will offer similar capabilities and visualizations available on the popular traffic crowdsourcing app used by thousands of motorists for traffic monitoring and navigation. But what makes the new app a game-changer from the textual messages approach is that it taps into a global web service that delivers the latest geospatially enabled navigational warnings to mariners on a variety of devices in near real-time.

The Titanic tragedy underscores the importance of timing to navigational safety. Although an iceberg warning message was sent from the nearby ship Amerika to the Titanic, the captain never received it. Due to operation schedules and procedures, the Navy Hydrographic Office, an NGA predecessor, didn’t receive that same warning until the following day – too late to issue a safety warning to save the Titanic or any other ships in the area.

But the structure of the navigation warnings the Titanic received has changed very little up until now. Mariners relied, and continue to rely, on textual notifications that were not geospatially enabled on charts and had to be plotted by hand to determine their relevance — a time-consuming endeavor. Technological advances, including the incorporation of a satellite broadcast capability in the 1990s, made access to such information available on a 12-hour cycle.

Now, the new maritime app delivers geospatially and service-enabled warnings in near real-time, at the rate of about 25-30 warnings per day.

“Maritime Guardian Pro provides a global geospatial representation of hundreds of immediate hazards to navigation and allows the user, within seconds, to focus on what’s important,” said Chris Janus, chief of the NGA notice to mariners branch.

The new app can be used to populate an online web map, a mobile app or any other third-party application that can use the service. It has a capability for users to report immediate hazards they observe, making it by default a safety warning crowdsourcing service. No longer a mere messaging product, it is a significant enhancement to the international requirement for ships to receive textual maritime safety information via the Worldwide Navigational Warning Service, or WWNWS.

The Maritime Guardian Pro app is available from NGA’s maritime safety information web portal, accessed via NGA’s public website.

**APP DELIVERS HOST OF MESSAGES**

- Failure or changes to navigational aids (buoys)
- Newly discovered wrecks or natural hazards (sand bars, ice below 52 degrees’ latitude)
- Military operations
- Search and rescue
- Cable laying
- Scientific research
- Overdue and missing ships and aircraft
- Man overboard
- Maritime advisories and alerts (political conditions)
Surrounded by hostile or unstable neighbors on nearly all sides, the newest country in the world is struggling to survive. The Republic of South Sudan separated from Sudan in July 2011 and plummeted from hopeful independence to brutal civil war in just over two years. Now wracked by corruption and ethnic violence, the fledgling nation has lost tens of thousands of its citizens to famine and targeted killings of civilians. More than 3.8 million South Sudanese, or approximately one-third of the nation’s current population, have fled their homes.
To understand the implications of that kind of disruption for a country’s national security, consider if one-third of the U.S. population was dislocated and homeless. It would be roughly equivalent to every person who lives in the east-coast states, from the tip of New York to the tip of Florida, and Washington, D.C. Massive economic, political and social unrest would ensue for no other reason than the percentage of citizens involved.

Myriad issues arise from any significant population dislocation, but conditions worsen when civil war is involved, as is the case in South Sudan. While intelligence officers routinely track migration and other trends related to movement, such as where conflict occurs, those who focus on Africa very often operate at the nexus between traditional intelligence and humanitarian response.

National Geospatial-Intelligence Agency analysts are finalizing an innovative approach to make it easier for agency customers and partners to monitor ongoing conflicts and humanitarian issues in South Sudan and neighboring Sudan. The NGA South Sudan Unclassified Damage Assessment Environment is a password-protected unclassified website for official use by analysts and U.S. government aid providers operating in that area. The project was inspired by NGA Analysis Director Susan Kalweit.

“She learned we were creating unclassified data as part of our classified mission, and she challenged us to develop an automated process for safely getting that unclassified data down to the unclassified network, where many of our customers work,” said Terry Wilcox, head of the NGA Africa division, which is designing the new geoportal.

By providing data at the unclassified/official use only level, the geoportal will enable customers, whether they are on the policy side or the humanitarian assistance side, to perform their missions faster and more effectively. It will also allow them to access the data in a forum and on a system they are already familiar with, according to Wilcox.

**A CASE STUDY IN POTENTIAL**

NGA developed the South Sudan geoportal with the U.S. Department of State and U.S. Agency for International Development in mind. USAID has provided humanitarian assistance and conflict mitigation assistance in the South Sudan region for decades.

“We believe the product we are creating will be of interest and of use to any [of our mission partners] interested in Sudan and South Sudan, though,” Wilcox said. “Several foreign partners and other elements of the Defense Department have also expressed interest.”

The new geoportal is expected to be ready for use by the end of summer 2017. Once fully launched, the portal will enable customers to log on whenever they need to see the latest information on conflict and humanitarian issues in the Sudans and to use that information to inform their analysis and decision-making.

Customers will be able to interact with the data, download it and combine it with their own data to suit their unique mission needs, according to Kalweit. In its current demonstration phase, NGA is hosting more than 30,000 data points on the platform, accessible to any NGA customer with an internet connection and a web browser.

“Not every person monitoring the Sudans has access to our classified networks or even the data we create,” said Kalweit. “Before we created this new platform, they either would not be able to get this data at all or would only be seeing it only in finished reporting.”

Sudan and South Sudan were chosen for the project because many of the issues facing the regions provide a living case study for looking at avenues to provide intelligence at the unclassified/FOUO level, according to Wilcox.

“Our agency is not unfamiliar with operating at the unclassified level; it is just that traditionally this kind of data would have been provided on an ad hoc, request basis,” Wilcox said. “Now, because of this project, we will be able to provide support on a consistent weekly basis, and even on demand, should the need arise.”

NGA is focusing on supporting its customers who help formulate U.S. policy for the Sudans every day, said Wilcox. The new platform and the data being provided through it will help not only with conflict monitoring for foreign policy reasons but can also be useful for humanitarian missions. For instance, it will help customers such as USAID identify areas with increased need for assistance.

NGA personnel have long recognized that data created for intelligence purposes and hosted on classified networks also has high value and impact for humanitarian purposes that rely on unclassified data. For instance, the agency’s office of the Americas and disaster preparedness provides geospatial-intelligence support to humanitarian assistance and disaster-relief activities when requested by other federal agency partners, such as the Federal Emergency Management Agency, the Department of State and even the Department of Homeland Security. By carefully protecting classified elements but making unclassified elements available to partners who need it for their missions, geoportals such as the one for South Sudan hold tremendous potential for NGA to contribute more easily to federal humanitarian efforts when requested to do so.

Other parts of NGA with a mission focus in Africa are also looking at how they can integrate this customer-service model and adapt some of the processes being worked on.

“We think the greatest benefit this project can provide to others in the agency will not necessarily come
from copying exactly what we did, but instead from being inspired and empowered through our pathfinding, our process development and our lessons learned,” Wilcox said.

COLLABORATIVE PLATFORM

Wilcox said his group decided to use the Protected Internet Exchange for the South Sudan geoportal for a number of reasons. PiX is a DoD/State Department collaboration platform using the familiar Wikipedia format.

“First, the process of getting and managing accounts is relatively straightforward for those in the government or with the right accesses,” Wilcox said. “Second, PiX already came with technical and geographic information system support; they have a team who understands our vision and actively works with us to evolve our page in order to fit those needs.”

The third reason is that the platform is already used by many customers NGA wants to support with the data. A long-time agency goal has been to put GEOINT into the hands of users at whichever classification level they operate.

Kalweit said she hopes personnel working in other NGA mission areas ask themselves whether they are really making the agency’s GEOINT accessible to customers in the ways they need it. If not, she encourages them to follow the new geoportal example.

“We hope this project encourages other analysts and mission managers to break down some of the long-standing barriers the agency has built up around itself when it comes to producing GEOINT,” Kalweit said.

As with any agile process, the NGA South Sudan Unclassified Damage Assessment Environment will continue to evolve after it is launched.

“We are still working on what is probably the most difficult part of the project and will have the largest agency impact – helping to push for a cross-domain, enterprise solution for seamlessly getting the data we create to the lowest level possible,” Wilcox said. “If you create secret data, for example, we are working and advocating for creating an enterprise process that will automatically host that data on our secret-level systems and not just our top-secret systems.… It would be a big step for NGA and a massive boon for our customers.”

The overarching goal, said Wilcox, is to put community data straight into the tool most useful to that community.
Within war-torn South Sudan, the city of Yei is one of the most desperate. A once-thriving trading hub approximately 100 miles from the capital of Juba, Yei has seen 60-70 percent of its population flee since July 2016, according to Reuters. Because the volatility in Yei affects the overall stability of South Sudan, it is imperative that analysts and U.S. government aid providers maintain awareness of conditions within the region. National Geospatial-Intelligence Agency personnel and several mission partners are making that easier through the use of the NSG Open Mapping Enclave, or NOME.

NOME is an online capability that enables National System for Geospatial Intelligence members – including NGA – and partners to add, edit and update foundational GEOINT content at any time. It is being developed as a means to use crowdsourcing techniques to produce timely and relevant foundation data within a resource-constrained environment.

“NOME’s suite of tools extends far beyond basic feature-extraction capabilities and provides enhanced utility allowing users to compare, conflate, query, export, import and store data,” said Brandon Shore, a GEOINT analyst on the NGA volunteered geographic information team.

“Providing VGI helps improve NGA’s foundation GEOINT through direct feedback from the community,” said Christopher Ocasio, another member of the NGA team. “Sharing content and edits among your peers in the community through this application ensures that everyone has immediate access to the content and tools within NOME.”

The VGI CORE team has been developing and improving the system and its capabilities since January 2016. As part of the process, NGA personnel teamed with partners from Australia, Canada and the United Kingdom, plus other U.S. government partners, to determine the feasibility of crowdsourcing with non-collocated partners. The team chose Yei for its case study because of its significance to overall awareness of the situation in South Sudan.

During the two-week campaign, the team acquired data covering an area of 38 square kilometers. The exercise resulted in the addition of 74,000 buildings, 760 kilometers of roads, 320 kilometers of walls and 76 map points to the cache of foundation data for Yei. That translated to a 500 percent increase in line features and a 229 percent increase in map features, according to William Mortenson, NGA VGI team lead.

The foundation data over Yei will provide situational awareness of geospatial data at a more current and greater granularity than any other known area source, he added, including OpenStreetMap, a collaborative project to create a free, editable map of the world.

“The responsive nature of NOME data to this dynamic crisis multiplies the value of GEOINT to partners and decision-makers,” Mortenson said.

The Yei campaign proved NOME to be very effective, according to Mortenson, allowing warfighters, government agencies and international partners to contribute expert knowledge to map overlays of the area.

“It opens up geospatial data to GEOINT producers and consumers who in the past relied on their own limited collection resources and proprietary technologies,” said Mortenson.

NOME is a tool for all members and partners of the NSG, Allied System for Geospatial Intelligence, Multinational Geospatial Co-production Program partners, as well as additional countries not contained within the aforementioned groups who are approved and vetted by NGA. It is being developed for use in any part of the world where timely unclassified GEOINT is needed.
A ‘SOLVER’ MENTALITY: FINDING ANSWERS THROUGH HACKATHONS

By Jonas Skinner, Enterprise Innovation Office
For the 55 strangers huddled in a repurposed textile manufacturing warehouse in Alabama, it didn’t matter that the crisis wasn’t real; their task was. They had just 36 hours to develop a new application to help federal, state and local agencies better respond to natural disasters.

The event, held in February 2017 at The Mill — a burgeoning tech hub — just outside downtown Huntsville, kicked off a year-long series of public hackathons sponsored by the National Geospatial-Intelligence Agency to crowdsource innovative solutions to geospatial intelligence challenges. While NGA does not directly provide disaster response, it assists the federal agencies that do with relevant GEOINT when requested, such as identifying infrastructure damage, mapping potential rescue routes and providing anticipatory analysis of areas most in danger of severe weather damage. This public work often generates valuable lessons that are also applicable to the national security tasks within NGA’s classified purview.

The challenge for the Huntsville hackathon participants was to find a way to make NGA’s data more accessible and useful to first responders. The opposite was true for NGA; its goal was to bring outside ideas back into the agency.

“In order to be relevant, you have always got to be reinventing, reimagining,” former NGA Deputy Director Sue Gordon said in an interview with NGA Pathfinder shortly after joining the agency in 2015. “There are so many great ideas popping — particularly because the world has figured out the incredible reach and power of connecting time and space to events. That [realization] has created this great churning cauldron of ideas that we want to take advantage of.”

The goal of expanding the agency’s pool of innovators to include those outside of the traditional defense and intelligence communities has been an agency hallmark since Robert Cardillo’s earliest days as director. During his first week, he sent an open letter to NGA’s industry partners stating, “In my experience, the best outcomes result from focusing on delivering what the customer needs. I am committed to working with you...[using] innovative solutions that will drive the right consequences for our customers.”

The hackathon program evolves that thinking by moving beyond industry to the public marketplace of innovation. NGA initiated hackathons in Sunnyvale, California, Chicago and New York in 2016. Incorporating lessons learned, the agency stepped up a level with a formal program of more than double the number of events scheduled during 2017. After Huntsville, NGA’s hackathon organizers have held events in Los Angeles and Seattle, and others are planned for Austin, San Francisco, Boston, New York and Denver.

DELIVERING PROTOTYPES IN MONTHS
An innovation is the implementation of a new or significantly improved product or service, process, marketing method, business practice, workplace organization or external relationship. Hackathons lead to innovation by presenting a mission gap to a “solver community,” which is then tasked with developing a minimum viable product to solve said mission gap — often a tough question the “problem owner” has not answered to the degree of success they seek.

Hackathons are opportunities to publicly innovate solutions to an NGA geospatial hypothesis that discovers, captures, analyzes and disseminates information to or for GEOINT customers — including NGA’s partners within the National System for Geospatial Intelligence, or NSG — within a 24- to 48-hour monetarily competitive environment.

The hackathon series is significant to speeding the pace of innovation at NGA, in large part because it breaks some of the traditional constraints that can hamper progress. Small technical development hurdles or analytic issues often stymie IC innovation, because contracting solutions may cost millions of dollars and precious time. Crowdsourced open innovation, on the other hand, allows NGA to use the medium of open competition to source out-of-the-box solutions. Using creative solutions for technical questions and other alternative contracting vehicles drives delivery of new prototypes in months rather than years, and at a fraction of the normal cost.

The Huntsville event typified the fast pace of innovation made possible by crowdsourcing. In just 36 hours, event participants developed 12 minimum viable solutions and presented them to a panel of first responders and public managers for judging. The top honor went to an augmented-reality app designed to assist first responders in triaging and prioritizing resources with predictive and real-time analysis.

The local head of emergency services and training for Madison County, Alabama, thought so highly of the winning app that he encouraged his county to pursue further development with the winning team. In fact, the teams that developed the two top ideas during the hackathon are pursuing tech and education grants to fully develop their apps for use by state and local first responders.

OPENING ENDLESS POSSIBILITIES
Though hackathons include the word “hack,” they should be viewed more as “life hacks” rather than coding-
or program-breaking events, according to U.S. Air Force Capt. Adam Satterfield, NGA’s program manager for crowdsourced open innovation. Essentially, participants take open-source and commercially available information and find new and innovative ways of using the data; end uses are not preconceived and may range widely.

Timelines for developing a hackathon depend on the problem owner’s schedule, motivation and urgency to execute a mission priority, said Satterfield. His team typically schedules hackathons three to six months in advance and executes them within a 48-hour time period. As a result, NGA is discovering innovative solutions for mission-oriented problems normally unachievable due to limitations on time, resources and expertise.

NGA conducts its hackathon events inside industry tech hubs or academic centers of excellence to expose the agency’s mission challenges to a wide but targeted community of industry, academia and individual problem-solvers. The benefits, according to Satterfield, are twofold: In addition to creating fresh new solutions, the events also expose NGA analysts and geospatial specialists to nontraditional problem solving.

“Crowdsourcing NGA’s mission-centric problems provides valuable technical solutions and allows NGA to recruit top talent,” said Satterfield.

As an example, the Huntsville event was attended by 55 innovators, including a record number of women – 30 percent of the participants. The event garnered more than 100,000 views on social media, and NGA recruiters received eight résumés and another 48 inquiries from developers regarding potential careers at the agency.

**FOCUSING ON SPECIFIC TASKS**

Much like a hackathon, a second tool for open crowdsourced innovation is a “challenge,” which organizations typically conduct for their internal workforce and more traditional mission partners. Challenges provide an incentivized — e.g., prize money, time off or high-level recognition — and competitive setting to apply crowdsourced technical, scientific and ideation solutions to specific mission-centric problems by increasing the number of internal and external teams and individuals working to resolve the problem, regardless of geographic region. NGA conducts challenges internally, externally through IC communications or publicly via websites such as challenge.gov and InnoCentive.com. While focused on specific end-goals, problem sets for challenges are not limited by classification and can range from seeking simple coding solutions to developing complex, Ph.D.-level theory. While a challenge can be planned in less than 30 days, its period of execution — 10–60 days — is significantly longer than that of a hackathon.

Much like looking for a set of very specific needles in a worldwide haystack, NGA’s first major challenge, held in September 2016, focused on finding advanced software solutions with intuitive capabilities to search, retrieve and analyze large and wildly disparate data formats, schemas, interfaces and locations. During the first stage of the challenge, solvers were asked to implement functioning and demonstrable capabilities to access, retrieve and analyze datasets representative of the chosen challenge site.

Digital marketing of this challenge reached a solver community numbering more than six million people, and the event was highlighted on Yahoo Finance, which drove more than 15,000 visitors to challenge.gov. Ultimately the challenge drew 32 teams — including two universities and four private individuals — from diverse communities new to NGA. Of the 32 teams, 25 represented capabilities not previously known to the agency.

Judges evaluated the submissions and awarded 15 cash prizes to U.S. companies or individuals and one non-cash prize to a Canadian company. Each U.S. winner received $10,000. All winners were invited to a follow-on “Demo-thon” in the Washington, D.C. metropolitan area in October 2016.

The solutions submitted during stage one of this challenge allowed NGA to validate the capability most likely to advance search, discovery and access relative to disparate data sets; stage two involved participants demonstrating their solutions and the special features they believed addressed the challenge. Out of this challenge, three commercially available programs were identified as candidates for solutions to the problem of analyzing disparate data, and two of the three are currently in the acquisition and programmatic process for deployment and use by NGA.

**FINDING THE STATUE IN THE STONE**

Whether focused on solving a specific problem or finding new and different ways to use existing data and tools, the goal of both challenges and hackathons is to find processes, techniques and answers previously unknown. Michelangelo is quoted as having said, “Every block of stone has a statue inside it, and it is the task of the sculptor to discover it.”

Through its use of hackathons and challenges, NGA is inviting developers, entrepreneurs and big thinkers to chip away at NGA’s problem “stones” to reveal the most attractive solutions possible. These open crowdsourcing events enable the agency to reach beyond its workforce and traditional contractors to increase the number of entities working to tackle tough mission problems and fulfill NGA’s strategic objectives. By extending a welcoming hand to solvers in industry, academia and the private sector at large, NGA is learning to harness the collective genius of an increasingly open, connected and creative world.
PREPPING BEHIND THE SCENES

The Chief Information Officer and IT Services directorate’s enterprise innovation office, along with partners from the intelligence community and National System for Geospatial Intelligence, seek and embrace new and diverse sources of information, techniques and tools to increase the agency’s innovative approaches to solving operational and technological problems. The office sponsors hackathons and challenges to accomplish the following goals:

- Increase innovative approaches to NGA problem sets
- Align with NGA’s core goal of finding and exploiting the innovation of others, including industry, partner and customer communities
- Recruit talented individuals and companies otherwise unknown to NGA
- Elevate NGA’s brand through increased partnership in the IC, industry and academia

CIO-T’s enterprise innovation office provides a small dedicated team to plan, run and operate hackathon and challenge events while working closely with NGA customers and non-NGA partners. Updates can be found on expeditionhacks.com.
QUADCOPHERS: NGA'S LATEST TOOLS FOR FMV, LIDAR?
By Laura Brown, Ctr., NGA Research

Vehicles to capture aerial imagery have spanned many years, from Civil War-era hot-air balloons to school bus-sized satellites traveling thousands of miles above Earth. The latest candidates are small unmanned platforms that can fly for about 12 minutes on one battery pack.

National Geospatial-Intelligence Agency researchers in St. Louis are experimenting with autonomous quad-, hexa- and octocopter vehicles to collect and disseminate full-motion video, electro-optical, infrared and LiDAR data. The work was started under an IDEA grant for the purpose of developing the next generation of 3-D modeling using airborne sensors and virtual reality. IDEA grants are competitive awards of $100,000 or less to explore new technologies, novel techniques and innovative approaches for game-changing geospatial intelligence capabilities. These grants leverage unclassified data and problem sets to be applied within an intelligence context.

Matt Trani, one of the NGA researchers working on the project at the agency’s western campus, has plenty of relevant experience. A former U.S. Marine, Trani served 20 years on active duty as an operator and instructor with a specialty in unmanned aerial and underwater systems. NGA recruited Trani though the Wounded Warrior Program.

Trani is joined in the research by Kathleen Venhaus, whose focus is technical. With expertise in software and embedded systems development, Venhaus is working the transition of technology and visualization tools to new ways of solving GEOINT challenges. Together, Trani and Venhaus are using 3-D printed technology to custom design and test various small unmanned aerial systems – known as sUAS – and payloads based on specific mission needs of the agency’s customers.

The team is researching the use of sUAS to provide an inexpensive tool for remote sensing that is user-friendly, safe and repeatable. A quadcopter, for instance, can carry up to a half-pound of electro-optical sensors and/or cameras, capable of capturing still images or FMV that can be live-streamed to a ground station. The team is also developing methods for processing and fusing the collected data into actionable GEOINT.

Highly accurate, geo-referenced 3-D models can be quickly created from collected sUAS imagery, allowing users to rapidly analyze real-world data, according to Trani and Venhaus. In some cases the researchers are developing prototype software to view 3-D models on commercially developed virtual reality headsets – for example, HTC Vive and Oculus Rift – using 3-D point clouds, 3-D mesh models, orthomosaic models and processed FMV or still imagery.

Using imagery collected from sUAS, headset technology allows users to be completely immersed in an interactive 3-D environment.

The ability to virtually walk around or fly through a scene provides an unprecedented sophistication for visualizing 3-D models, say the researchers. The capability helps users visualize cities, terrain and other objects. This visualization can be applied to a number of customer needs, including mission planning and rehearsal, security and disaster-relief operations.

TRANSFORMING IMAGES INTO 3-D MODELS
The image on the left was collected using a GoPro camera onboard a small unmanned aerial system. On the right, the image is transformed into a 3-D model for visualization, using a virtual reality headset.
THE ABILITY TO VIRTUALLY WALK AROUND OR FLY THROUGH A SCENE PROVIDES AN UNPRECEDENTED SOPHISTICATION FOR VISUALIZING 3-D MODELS, SAY THE RESEARCHERS.

While the sUAS work began under an IDEA grant, it has expanded within NGA and to nongovernment customers under several cooperative research and development agreements. CRADAs are written agreements that allow federal agencies and nonfederal partners to optimize their resources, share technical expertise and intellectual property in a protected environment, and speed the commercialization of federally developed technology to apply to GEOINT problems and mission sets. NGA uses IDEA grants and CRADAs to connect with technical talent, ingenuity and expertise from national labs, universities and businesses to identify fresh ideas, novel research techniques and path-breaking scientific opportunities.

The sUAS research has the potential to strengthen everything from the deployment of military forces to support of first responders and power-line inspectors. The NGA team is working with a range of customers to devise innovative and flexible approaches to their unique mission needs. The researchers are collaborating with personnel from the U.S. Department of the Interior, U.S. Geological Survey, Federal Bureau of Investigation and the U.S. Coast Guard. Within NGA, team members have worked with the Source directorate’s geodetic surveys division and have trained NGA Police and personnel involved in disaster response.
The first time one of Elon Musk’s SpaceX rockets safely landed after traveling into space in 2015, only a handful of specialists really understood the tiny details that made the historic first possible. Those experts didn’t work for SpaceX or even NASA; they worked for the National Geospatial-Intelligence Agency. NGA’s eastern range geodetic survey branch, located at Patrick Air Force Base, guided the historic landing by establishing geodetic control on the launch pad. In layman’s terms that means the team provided accurate three-dimensional location data for the landing and recovery of the first-stage rocket that powered the mission.

Sometimes the most important details, like those enabling the SpaceX landing, are the least exciting to talk about. Even the sum total of those details – precision – isn’t something that normally captures headlines. But the SpaceX landing, and countless other missions, could not have succeeded without the precision that NGA’s geodetic surveys brought to the effort. It’s by providing accurate and precise information about specific areas on Earth – the launch pad in the SpaceX example – that NGA enables mission success, helps save lives, ensures safety of navigation and contributes to the Global Positioning System, or GPS.

Just because precision, accuracy and the disciplines that enable them – math, geography and mapping, geodesy and surveying, among others – aren’t often highlighted in success stories, doesn’t mean they can be taken for granted; far from it. They are in fact integral to all six of NGA’s primary mission responsibilities. (See box.)

**THE STARTING POINT**

All geospatial intelligence, or GEOINT, starts with “foundation” data and content – details describing the earth’s physical and cultural characteristics. These fundamental details form the context for all intelligence; they describe the setting and conditions where threats occur or are most likely to occur. As such, accuracy and precision must be built in at the very beginning of the analytic process, in the foundation data, in order for conclusions to be actionable.

Accuracy is also the bedrock of two of NGA’s signature services: safety of navigation and targeting. Maps and charts that guide warfighters, mariners, aviators and first responders during times of crisis must be correct and up-to-date at all times. In fact, Congress mandates that NGA update all aeronautical and maritime charts every 28 days.

**KEEPING IT REAL**

Ensuring accuracy and precision in a rapidly changing threat environment, especially at the point of warfighter and analyst need, necessitates that NGA constantly find new ways to modernize and develop its foundation data.

“Evolving in the areas of business innovation, IT modernization and automation, and new acquisition methods, will move our group into the future and increase the ability to deliver more and better foundation GEOINT to users,” said Kevin Hope, director of the NGA foundation GEOINT group.

**Business innovation**

NGA, through its foundation GEOINT group, constantly evaluates methods to more dynamically deliver content to users, and a promising answer to this challenge is the NSG Open Mapping Enclave. NOME is an online capability employing crowdsourcing principles to create and edit foundation data faster. (See related story, page 27.)

Anyone within the National System for Geospatial Intelligence, of which NGA is a leading member, can update data instantly as situations on the ground change. NSG partners, as well as America’s international allies, can also use and contribute to NOME through a simple suite of tools that require little bandwidth.

“As part of the NOME crowd, users at all levels – from forward-deployed units to geospatial and intelligence analysts at home – will be able to participate in building that content,” Hope said.

NGA is engaged in active training and community-engagement efforts to help users understand the benefits of NOME, according to Hope, and the agency will continue to develop and refine the capability.

**IT modernization and automation**

Keeping pace with today’s rapid information exchange, NGA has also instituted a modernization project known as FGMod to upgrade the information technology used to deliver and use foundation GEOINT.

“FGMod employs agile development with maximum analyst participation to rapidly develop and deliver
NGA’S MISSION
NGA’s annual financial report articulates the agency’s mission as follows.

We provide GEOINT for our nation’s security.

NGA supports the president’s national security priorities and receives oversight from DoD, ODNI and Congress as both an intelligence agency and a combat support agency. As the lead federal agency responsible for GEOINT, NGA is the primary provider of GEOINT to the defense, intelligence and civilian communities, including:

• Supporting the U.S. military with real-time data, to include target identification, damage assessments, troop movement monitoring, foreign military capability assessments and other critical, time-sensitive needs.
• Ensuring the precision of the Global Positioning System to maintain effective target engagement for U.S. weapons systems.
• Supporting mariners and pilots who depend on our analysis for safety of navigation at sea and in the air.
• Delivering strategic intelligence that enables national policymakers to make decisions on emerging global issues, counterterrorism, counterproliferation, cyber warfare and other national security issues.
• Supporting first responders during humanitarian and disaster-relief recovery operations.
• Collecting, verifying and maintaining foundation data such as physical geography, land cover and cultural data used to support the GEOINT mission.

capabilities to our analysts,” Hope said. “It leverages NGA investments in cloud technologies, the agency’s robust online services, and existing and emerging technology baselines.”

NGA is also investing in additional technologies to enhance safety of navigation specifically. According to Hope the development of the agency’s Enterprise Engine – E2 – system updates legacy methodology to maximize maritime analysts’ decision-making process efficiencies. The new system will enable compliance with a congressional mandate directing the backlog of Notice to Mariners messages, which NGA manages, be eliminated by October 2017. Additionally, the agency’s aeronautical and maritime mobile applications are delivering content to users on handheld devices, providing access to content faster and eliminating the need for paper products.

Automation is a key factor to modernization, said Hope, especially for speeding the agency’s ability to examine commercial imagery to detect changes in situational conditions. Examining opportunities to automate key processes such as mass data conflation and automated feature extraction also promise to increase efficiency and promote business innovation. (See related story, page 36.)

GETTING NEEDED DATA
Embracing technological advancements builds the infrastructure to operate more efficiently. NGA is also improving how it can obtain needed data more rapidly. Employment of a new contracting method known as JANUS is helping NGA’s foundation GEOINT group to enable dynamic versus static content management. Thanks to JANUS, NGA’s suppliers and customers access the same network, so that data delivered by suppliers can be published and exposed immediately to the agency’s customers. Pilot deliveries are currently used to validate production methodology, requirements and expected outcomes.

As customer missions grow more complex and decisions must be made more quickly, NGA’s continual adoption of innovative processes and technologies will ensure that the agency’s customers have access to and confidence in its complete suite of foundation data, products and services.
When HAL 9000 debuted on the silver screen in “2001: A Space Odyssey,” the personified computer was anything but a hero.

A half-century later, when IBM’s Watson supercomputer faced off with Brad Rutter and Ken Jennings on the TV show “Jeopardy,” it was clear that the humans couldn’t keep up. This time the computer wasn’t cast as a villain, however; Jennings acknowledged the besting with humor and a nod to a popular adult TV cartoon. Below his answer, he wrote, “I, for one, welcome our new computer overlords.” (See editor’s note.)

AUGMENTATION VS. AUTOMATION

In the six years since the “Jeopardy” tournament, Watson has achieved many notable goals. One of its more recent achievements is helping Californians conserve water, according to IBM. Though the supercomputer’s contributions to water conservation may not seem like they would share similarities with analytic processes at the National Geospatial-Intelligence Agency, they do. Working in conjunction with OmniEarth, an environmental analytics company, Watson reviews aerial and satellite imagery and cross-references it with open-source information to ascertain where the most water is being used in a given community and by whom. That kind of automation is one of NGA’s primary goals for future operations, as stated in the agency’s GEOINT CONOPS 2022.

Watson can scan imagery at a rate of more than 100,000 parcels in a matter of minutes. Where does that leave the average human analyst, who can’t feasibly do half that work in twice the time? Is it time for us to welcome our new computer overlords?

Actually, no. What NGA visionaries mean when they talk about automation is far closer to a concept called augmentation. “Automation” refers to machine replacement of human workers in performing hazardous or repetitive tasks, such as when manufacturers use machines for welding or when retail establishments install self-checkouts. In contrast, “augmentation” is the use of machine learning and artificial intelligence to assist humans in their day-to-day tasks, using the relative strengths of both to achieve optimal overall performance.

As CIO-IT Services Deputy Director Mark Munsell notes, “We are dealing with a vast amount of data from more sources than ever before, and our analysts have to have a way to effectively parse that data.” Accordingly, augmentation at NGA is focused on the adoption and development of a variety of data-management processes, algorithms, platforms and tools intended to serve analysts, not replace them.

SOM AND ABI

One of NGA’s foundational approaches to augmentation is employing data-management processes such as structured observation management, or SOM. The agency’s approach to capturing, standardizing and storing GEOINT observations, SOM collects observations using a prescribed set of parameters and stored in a structured, uniform way. This structure enables analysts to easily access the specific data they need, every time they need it, without having to rely on memory or extensive, repetitive text or imagery reviews.

Activity-based intelligence, or ABI – a strategy for solving intelligence problems by viewing events, transactions and other activity in both spatial and temporal contexts – relies, in part, on SOM’s structured processing of vast amounts of data. Analysts record SOM data in both of these contexts and can easily retrieve that data to make relevant correlations based on times, dates or locales.

As an example of real-world mirroring of agency processes, consider Watson’s approach to determining water conservation. Watson, arguably, makes its judgments through SOM and ABI. First, Watson ingests an image and makes relevant observations, such as which properties have water-consuming features such as swimming pools or decorative ponds and fountains. Watson then stores and organizes these observations in order to make more complicated associations. By comparing relative activity and water levels over time, Watson can determine how much water these features use in a given time period and can further extrapolate...
Improved accuracy
Global service provider KPMG regularly reviews technologies and their capabilities as either risks or opportunities for its clients. CNN Money summarized the message of a recent KPMG U.S. online scenario involving computer intelligence with the statement, “It is a combination of man and machine that will herald changes that lead to improved accuracy, relevancy and trust.”

from there. If a parcel of grass is unexpectedly far greener than those around it, Watson will attempt to use past observations to determine whether the greener areas are attributable to activity like deliberate oversaturation from automatic sprinkler systems or unresolved leaks in water feature or pipes. Watson then uses open-source spatial intelligence integration to define property boundaries and determine property ownership.

Though humans may seem superfluous to Watson’s process, they remain integral. Because Watson performs algorithmically defined observation and correlation, the supercomputer needs humans to define, develop and implement the algorithms that inform those tasks.

NGA’s HUMANS
At NGA, our humans are also developing algorithms, tools and capabilities that help analysts solve a variety of intelligence problems.

One algorithm scans through sparsely populated imagery in search of probable manmade objects, “creating optimized graphics and vector files, and automatically alerting analysts to occupied areas of interest,” according to imagery scientist Daniel DeGennaro.

Algorithms like this search larger areas and greater amounts of imagery, and provide relevant detections far more quickly than an analyst is capable of. This frees the analyst to spend less time finding these objects and more time determining what they mean in a larger context.

Keith Jerdan, deputy director of the NGA support team at the Office of Naval Intelligence and Naval Oceanographic Office, first conceived of The Overhead Coastal Environment Analysis from Tide Integrated Data Elements, or OCEAN-TIDES, software tool “while vacationing on Harbor Island, South Carolina, and observing the extreme tidal range.” OCEAN-TIDES gives analysts the ability to predict a high or low tidal state, based on correlations in imagery or data points in a given location, a specific time and the associated tidal station contained within the tool. OCEAN-TIDES data can help ensure safety of navigation, establish maritime vessel traffic baselines to detect change, and monitor tidal conditions for military planners and operations.

Visualization and Analytics Data Lake – VANDL – is a capability that facilitates “open-ended exploratory data analysis on big corporate data” like financials and aggregated human capital, as characterized by Data Science Division Chief Marc Boysworth. He further explained that – though currently in use – VANDL is still in development. It will provide an expanded future set of capabilities that include time-series analysis, classification, regression, natural language processing and machine learning.

ENHANCED ANALYSIS
Our electronic partners need us for more than just initial programming. Machines, like humans, can also make mistakes – and those errors have to be caught and corrected by human counterparts. Regarding Watson, Popular Science noted that – when reviewing satellite imagery of a cemetery – the supercomputer had to be corrected after initially identifying headstones as buildings or skyscrapers.

Likewise, when using any of NGA’s tools, analysts must report incorrect data returns to the data scientists and developers who can correct these mistakes. Simply put, it’s a user-driven cycle of continual electronic adjustment, improvement and refinement that will only grow more complicated as GEINT data sources continue to expand.

Humans are also an integral part of augmentation through actualization of the data that the computers produce. For instance, when Watson detects anomalies, it notifies its human partners at OmniEarth, so they can send appropriate, targeted conservation recommendations to those whose water consumption exceeds the average. The computer notes the discrepancy, but it is the humans who must follow through.

At NGA, augmentation allows analysts to spend less time combing data and imagery to identify and document observations, but the humans are likewise necessary for the final analysis. Analysts are imperative for making distinctions between what the computer deems algorithmically significant and what is analytically significant – and for determining the meaning of the observations, data and patterns the machine produces. The analysts are not replaced or supplanted; instead, they are enabled to spend more time on higher-level analysis.

In this manner, augmentation gives NGA greater opportunities to deepen and complicate its analysis to produce the most timely, targeted and effective GEINT possible for mission partners, warfighters and U.S. allies around the globe. ♦
In late 2016 the National Geospatial-Intelligence Agency acquired key human geography data from its mapping partner in Ethiopia. Analysts in the NGA office of geography reviewed the data and authenticated as much of it as possible with existing agency data sources.

“We found [the data] to be really valuable and new data that we didn’t have before,” said Tiffany Huff, an analyst in the office’s Africa division. “It is not something we can really get by any other means, because we can’t send our own people into the field. This information is very difficult to accurately gather through open source research or academic methods.”

The Ethiopian data was shared through one of NGA’s many agreements with international collaborators managed through the agency’s office of geography.

NGA’s most defined multilateral framework is the multinational geospatial coproduction program. The MGCP coproduces high-resolution vector data over regions of the world where large-scale data does not exist or existing data needs improvement.

“Working with our international affairs team, we engage with our international partners at the bilateral and the multilateral level to receive meaningful content back from them – the relevance of our work is always at the forefront of our mind,” said Scott Stauffer, Asia-Pacific program manager.

The last issue of NGA Pathfinder explored the agency’s partnerships with America’s closest allies – Great Britain, Australia, New Zealand and Canada – through the Allied System for Geospatial Intelligence. NGA’s partnerships expand well beyond this tight-knit community, however; the agency’s office of geography manages a variety of exchange and coproduction relationships with counterpart agencies in 31 nations through the MGCP. The content gathered through these partnerships helps NGA support its customers’ understanding of the world by clarifying place names, locating mountain ranges, highlighting elevation changes, recognizing technology trends, identifying markets, water wells and much more.

A DECADE AND COUNTING

Approximately 10 years ago, office of geography analysts needed additional resources for creating vector data and corresponding maps. They quickly realized that other nations strive to accomplish the same mission. This led to the creation of the MGCP, which increased data sharing among international partners and the resources needed to produce quality maps for customers.

“Via the NSG Operations Executive, [NGA] takes foundational geospatial requirements that come in from customers around the world for foundation vector data and coordinates data and map production with the rest of the MGCP partners, ensuring we do not duplicate efforts with our own agency work,” said Stauffer.

As a combat-support agency, NGA uses MGCP data to augment its support to military personnel. Of all of the agency’s customers, soldiers on the ground are most in need of accurate maps to safely navigate unfamiliar conflict zones. Those maps are created in many formats.
“In this modern, highly digital, ‘Google Maps’ world that we live in, it sounds kind of quaint to have an old-fashioned paper map, but it is still what the military likes to have in hand,” said Stauffer.

“In Iraq for example... during the heaviest of combat situations, you didn’t have cell phone towers, you couldn’t just find your location by Google,” said Stauffer. “Soldiers preferred paper maps to successfully navigate the terrain.”

The details shown in the products created by the MGCP are also unique among military-support maps. The group creates topographic maps that depict the terrain – e.g., steepness of a mountain, rise of elevation – and topographic features such as waterways, groundcover and potential obstructions.

COUNTRY DYNAMICS

Human geography looks at the relationship between people and their environment, and correlates what humans do with where they do it. Analysts use foundational human geography data to understand the dynamics of a country based on attributes such as the location of water sources and markets. One of the most accurate ways to obtain this type of data is through conducting surveys on the ground. Working with bilateral partners allows NGA to gain specific information and data about places that analysts are not able to visit.

“International coproduction is all about leveraging international partners, using existing agreements, managed by NGA’s International Affairs [Office], to bring in foundation GEOINT content that meets our customer needs,” said Stauffer.

Each partner brings in data over certain areas, often resulting in the development of a coalition. Only countries that contribute information are allowed to use the community data. These partnerships yield a tremendous amount of data at very little cost to NGA and provide access to information in areas Important to NGA, such as in the Middle East and North Africa.

MGCP does have limitations, however, and gaining access to information is not always feasible via that program. This is where bilateral coproduction programs, such as the human geography program with Ethiopia, make it possible for NGA to obtain unique datasets.

FUTURE FORECAST

On the horizon, the office of geography is working on a new multinational effort involving human geography. This new initiative will be known as the International Program for Human Geography, or IPHG.

“The purpose of the IPHG is to generate high-quality human geography data that informs a global understanding of the human environment through multinational production coordination,” said David Fontenot, chairman of the MGCP plenary group and lead for the IPHG.

Of significance, the IPHG will standardize the way human geography information is obtained and disseminated. According to Fontenot, standardization will make it easier for NGA’s customers to share, use and customize this world-class data.
Assessing regional stability is an important part of the National Geospatial-Intelligence Agency’s mission. Monitoring activity trends on roads and in ports, airfields and military garrisons can help analysts predict possible military threats. On the humanitarian side, situational awareness of migration patterns, draught and food scarcity, and other events that threaten civilian well-being can help analysts pinpoint areas where unrest is most likely and relief efforts may be needed.

Satellite imagery enables NGA and its defense and intelligence community partners to easily assess and monitor regional conditions; use of commercial satellite imagery facilitates the timely sharing of information among NGA partners, including U.S. government agencies that provide humanitarian aid and international allies. Commercial satellite imagery can be most useful for monitoring remote areas of known unrest where rescue and aid workers may need to respond quickly to save human life.

Imagery captured by commercial provider DigitalGlobe has revealed destruction in various civilian communities in recent years. For instance, color infrared imagery collected in 2014 over South Sudan revealed the destruction of civilian huts in Duk Payuel, Jonglei State. The imagery showed at least 10 huts were burned between February 9 and March 5 that year. Knowledge gained by analyzing the imagery helped inform the efforts of relief agencies working in the region.

Commercial satellite imagery is an important element in several NGA customer offerings, including the agency’s new South Sudan Unclassified Damage Assessment Environment, a password-protected website for official use by analysts and U.S. government aid providers operating in that area.

To learn about NGA’s commercial partner relationships, visit http://www.nga.mil