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An Open *Frontier*

Open-source software has reached a tipping point. Why embracing an open community approach will enable a new generation of GEOINT.

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IF ECONOMIC ILLNESSES had physical instead of fiscal symptoms, the construction industry would have a harsh cough and aching muscles. For now, it's working through the pain. If left untreated, however, its condition could become chronic. Perhaps even terminal. >>

IMAGE COURTESY OF CESIUM

OneSky, a situational awareness app for UAVs, uses Cesium, an open-source library for 3D mapping.

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BY MATT ALDERTON

As a result of myriad factors—including declining immigration, reduced funding for high school shop classes, and the lingering effects of the 2008 housing crisis—the construction industry is in the midst of a dire labor shortage. In August 2018, construction employers in the United States had 317,000 unfilled positions—the largest number of open construction jobs since the Great Recession. In September, the U.S. Chamber of Commerce's quarterly Commercial Construction Index likewise showed that 94 percent of contractors are having a difficult or moderately difficult time finding skilled workers.

The consequences of inadequate labor are as acute as they are numerous. For one, buildings take more time and money to complete. Companies and communities, meanwhile, are unable to grow. Because they must do more with less, builders are tempted to take shortcuts, creating unnecessary risks that compromise quality and safety. But from necessity comes innovation: The construction industry is rapidly shifting to a new business model based on modular rather than conventional construction.

While conventional buildings are built entirely onsite, modular buildings consist of standardized components that are pre-fabricated in an offsite factory, then assembled in the field. Like structures made from toy LEGO bricks, modular buildings can be configured in any fashion, then customized with accessories and embellishments; the underlying components, however, are identical. With conventional buildings, contractors are limited by environmental conditions and linear construction in which each successive step must be completed before the next can begin. With modular buildings, construction takes place in a controlled environment, wherein processes that would normally unfold in succession do so in parallel. As a result, modular buildings can be completed faster, cheaper, safer, and with fewer workers.

Like the construction industry, the GEOINT Community has insufficient resources relative to demand for its services, which is growing rapidly thanks to an influx of geospatial data from small satellites, unmanned aerial vehicles (drones), and the Internet of Things.

"There's more location information coming into organizations than ever before," said Andy Dearing, CEO of geospatial software and services company Boundless. "What we see in the geospatial space is that organizations are trying to figure out how to scale their location enterprises to process all that data and make more informed decisions. Traditional proprietary technologies aren't built to do that."

Like builders, many geospatial practitioners are adding to their toolbox with a modular solution: open-source software, which is already changing the course of geospatial intelligence.

OPEN EVOLUTION

Though it's new to many organizations, open-source software isn't new at all. In fact, it's as old as computing itself. As early as the 1950s, computer hardware was distributed not only with free operating software, but also with its source code so bugs could be fixed and new functions could be added. This was thanks to early adopters, most of whom, as academics and researchers, were collaborative and open by nature. Only when computing became commercialized in the 1970s and '80s did software become commoditized and "closed."

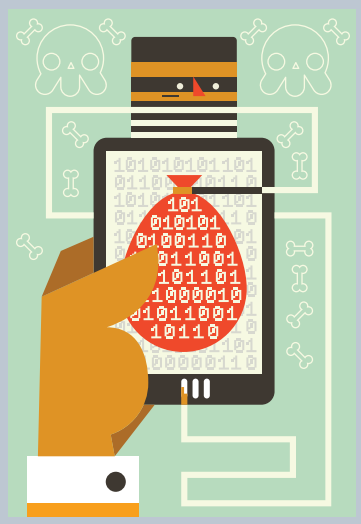
As for the modern notion of open-source software, most developers trace its roots back to 1991. That's when Finnish computer science student Linus Torvalds created Linux, a free and open-source operating system inspired by Richard Stallman, a computer programmer at the Massachusetts Institute of Technology (MIT), who, in 1983, established the GNU Project to create free and open software.

IS OPEN-SOURCE SOFTWARE SECURE?

On Sept. 7, 2017, IT professionals everywhere received a bucket of cold water to the face when news broke of the biggest data breach in U.S. history—criminals hacking into the databases of credit reporting agency Equifax had stolen the personal information of 148 million Americans.

For those affected, perhaps the worst thing about the breach was that it could have easily been prevented: The hackers' mode of attack was a vulnerability in Apache Struts, an open-source web application development framework. Though a patch was released six months before the attack, Equifax had failed to install it. The incident gave new life to an old debate about whether open-source software is secure.

"Imagine you're driving a car. If you have a Prius, you trust that Toyota has checked its supply chain; they know where all their parts come from and they have a rigorous process to make sure that when they assemble it, the final car is safe. Exactly the opposite is true in software," said Mark Curphey, vice president of strategy at CA Veracode, an application security firm that specializes in securing open-source software. "In software, you've got no clue where the steering wheel, the brakes, or the seatbelts came from."



This doesn't mean all open-source software is risky. In fact, its nature means open-source software has a superior security posture in some ways.

"With open-source software, people can see the code. That's actually a good thing because it creates a vested interest for the software provider to practice good security hygiene," said David Egts, chief technologist for the public sector organization at Red Hat. "If people can look at your code and see that it's [full] of security vulnerabilities and bugs, you're not going to last very long."

Instead of embracing or rejecting open-source software wholesale, users should establish a risk-management process for evaluating it.

"There's four questions you need to ask every time you're considering open-source software," Curphey concluded: "What am I using? Where did it come from? What does it do? And what is its quality? Going back to the car analogy, it's all about building a digital supply chain."

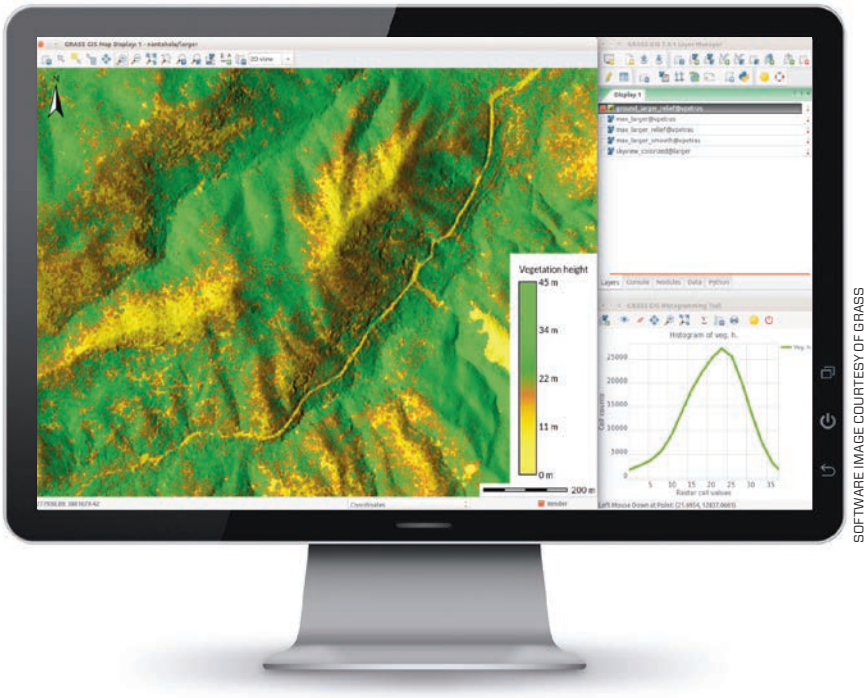
"Richard Stallman … was an early thinker and proponent of 'free' software," said Richard Grady, president of Applied Geographics (AppGeo), a GIS consulting firm that has used open-source software since 2008. "He believed software should be free to run, free to study, free to modify, and free to share."

In the GEOINT Community, open-source software has an unlikely grandfather: the federal government. In 1979, the U.S. Department of the Interior created the Map Overlay and Statistical System (MOSS) to help the U.S. Fish and Wildlife Service track and evaluate the impact of coal mine development on the environment. To maximize development speed and minimize development cost, the committee in charge mandated MOSS use as much code as possible from the public domain. The resulting product was the world's first broadly deployed, vector-based, interactive geographic information system (GIS).

In 1985, the U.S. Army's Construction Engineering Research Laboratory released the Geographic Resources Analysis Support System (GRASS), an open-source GIS software suite created to assist the military with land management and environmental planning.

"There were proprietary vendors that had GIS packages, but when the government approached them with [additional requirements] they said, 'Sorry, that's not really our thing.' So the government decided to write its own software and put it out under an open license," said open-source advocate Dr. Christopher Tucker, principal of Yale House Ventures.

GRASS—whose code continues to underlie open GIS software more than 30 years later—laid the foundation on which all subsequent open-source geospatial solutions were built. A few of the most significant were: the Geospatial Data Abstraction Library (GDAL), created in 2000 for the purpose of reading and writing raster and vector geospatial data formats; GeoServer, launched in 2001 to facilitate sharing of geospatial data; PostGIS, released in 2001 to add support for geographic objects to the PostgreSQL (Postgres) open-source relational database; QGIS, an cross-platform desktop GIS application introduced in 2002; and Cesium, a JavaScript library developed in 2011 for use with 3D mapping applications.



SOFTWARE IMAGE COURTESY OF GRASS

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"Open-source software used to be hard: A government had to decide to invest in a piece of software. A government had to decide to spin it out. And a government had to apply dollars and lawyers and developers," Tucker said. "But by the mid-2000s you started seeing more and more developer infrastructure out there that made it easier for developers around the world to coordinate."

It was a short leap from coordination to organization. In 2006, open-source developers established the Open Source Geospatial Foundation (OSGeo), whose annual Free and Open Source Software for Geospatial (FOSS4G) conference attracts more than 1,000 open-source developers and advocates every year.

Another powerful inflection point was the 2008 formation of GitHub, the web-based repository through which open-source software developers store and share their projects for consumption by the global developer community.

"GitHub made it super easy for communities of developers all around the world to collaborate," continued Tucker, who calls GitHub a revolution in code management and IT software project management. "Every cool, smart kid realized that if they didn't like their job and had a good idea, they could develop software on the side and create something amazing. That poured fuel on the fire."

The brighter the fire burned, the more attention open-source software received. Now, the flames are so hot that even the most "closed" users like the Intelligence Community are creating and executing open-source strategies.

"The federal government is interested in having open and transparent conversations. Not just with words, but with code," Dearing said. "They've realized, 'We can't do it all ourselves anymore. We need help, and there's help out there.'"

SUPER SOFTWARE

There are many reasons the GEOINT Community has embraced open-source software in both the public and private sectors.

For government users, the most attractive benefit is cost, according to Will Mortenson, lead for volunteered geographic information at the National Geospatial-Intelligence Agency (NGA), which in 2014 became the first U.S. intelligence agency to share open-source software on GitHub. "We've historically had more requirements than we could answer with our traditional budget," explained Mortenson, who said open-source software is an affordable alternative to single-use solutions; while the latter must be built from scratch—usually at considerable expense—the former often meet most of NGA's requirements out of the box, and can be customized to fill any gaps.

Achieving scale can also be cost-prohibitive.

"With open source, the incremental cost of scaling up is near zero," Grady said. "Because you're not paying for software licenses, you can add users. And when

OPEN SOURCE IN THE INTELLIGENCE COMMUNITY

Being "closed" by design, the U.S. Intelligence Community (IC) is the last place many people would expect open-source software to proliferate. Because it recognizes the inherent advantages, the IC has proven to be both an enthusiastic user of open-source solutions and a valuable contributor to the open-source community.

"The intelligence agencies are all-in on open source," said Richard Grady, president of Applied Geographics, a GIS consulting firm that builds and deploys open-source geospatial software. "They understand that being smarter, faster, and more agile is how you maintain your global advantage."

Examples abound of open-source geospatial software in the IC.

MOBILE AWARENESS GEOINT ENVIRONMENT (MAGE)

The National Geospatial-Intelligence Agency (NGA) created MAGE in 2014 to provide situational awareness to security personnel supporting events such as the 2014 Winter Olympics in Sochi, Russia.

"MAGE is a very simple application to track location information of a mobile device and make what we call observations," explained Ben Foster, NGA's product manager for mobile development and operations.

The National Guard field-tested MAGE when Pope Francis visited New York in 2015.

"Everyone on the ground could see each other's location using their mobile devices and quickly drop a point, take a picture, and make an observation," Foster said. "For example, if there was a suspicious package left on a corner, in near real time everyone on that team would be notified."

Because MAGE is open-source, NGA's partners can deploy it quickly, easily, and affordably For example, the Federal Emergency Management Agency (FEMA) used MAGE in 2017 to gain situational awareness in Puerto Rico after Hurricane Maria.

"We're contributing to solving geospatial problems, but we're enabling it to be organic to the organization that is out there operating within those problems," Foster said.

NSG OPEN MAPPING ENCLAVE (NOME)

Another NGA application of note is NOME, an open-source mapping environment that allows NGA partners to generate dynamic geospatial content in support of U.S. missions around the world. Essentially, it's the IC equivalent of OpenStreetMap, Wikimaps, and to a certain extent Google, enabling warfighters, humanitarians, and others to crowdsource collaborative living maps that provide situational awareness.

"We don't have enough resources to answer every requirement," said Will Mortenson, NGA's lead for volunteered geographic information. "[NOME] is an effort to find alternative mechanisms that give folks the opportunity to create more content."

Approximately 1,500 users from 27 nations currently use NOME during military and humanitarian assistance operations. NOME works, Mortenson said, because it leverages the wisdom of the crowd. And the reason it can leverage the wisdom of the crowd is because it's accessible to users across disparate geographies, communities, and security domains.

PHOTO BY BRIAN MURPHY/DIA

DIA's Terry Busch

MACHINE-ASSISTED ANALYSIS RAPID-REPOSITORY SYSTEM (MARS)

The Defense Intelligence Agency (DIA) is a voracious consumer of data. But its central data repository, the Modernized Intelligence Database (MIDB), hasn't been reengineered since 1996. Enter MARS, which will leverage advances in cloud computing and machine learning to make foundational intelligence gathering a dynamic endeavor.

"MARS is a program to take foundational intelligence and reinvent it to support a Department of Defense that requires an increasing level of automation and an increasing level of fidelity with data as we move into the future," explained MARS Program Lead Terry Busch.

MARS will support "millions of transactions per second" through machine-to-machine operations, according to Busch, who said the new system will "move decision-making into the cockpit" for warfighters who have a growing appetite for large amounts of granular data.

The program is still nascent, but open-source solutions are playing a significant role in its development.

"Open source initially provides us neutral ground to reset our technology, and we have done that," explained Busch. "One advantage of open source is that you have a crowd of people developing solutions, so there's a good, rich set of open-source capabilities that the world is rapidly improving. If I have a system that's designed to continuously adapt and develop to support the warfighter, that might be a good model fit for us."

With open source, DIA can onboard new capabilities immediately instead of waiting months or years for the traditional procurement cycle.

"Open source is definitely changing the way we think of technology development," Busch concluded. "Rather than procuring on long cycles and seeing improvement on a sort of release schedule, we can bring code in and constantly evaluate, adapt, and build."

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>
> —RICHARD GRADY, PRESIDENT, APPLIED GEOGRAPHICS

there is no friction to adding users, there is much greater adoption and utilization of technology, and much greater sharing of data."

Echoed former Boundless CEO Eddie Pickle, managing director of open-source programs at GEOINT services company Radiant Solutions, "In the '90s, proprietary software was [synonymous with] interoperability. The way we moved data around and tried to solve problems together was having a lot of people rallied around using similar technology. But the development of the internet blew that ecosystem wide open. ... You just couldn't deploy a solution where you knew you were going to have to make everybody down the chain invest in proprietary software. There was nothing wrong with the software, but you just couldn't predict how much of it you really needed. That led to the demand for open-source software."

And licensing isn't just expensive, it takes time. "When most people encounter free and open-source software, the tendency is to focus on the 'free' aspect: Why would you pay for software when you can get it for free?" said Peter Girard, chief technology officer at AppGeo. "Personally, I don't find the free aspect of open-source software all that compelling. If something has value, I'm willing to pay for it. Why I favor open-source over proprietary software is because it gives me freedom. I don't have to ask permission to use a piece of software. If I determine, for instance, that I need to use Postgres and PostGIS as my geospatial database, I just do it."

Open-source software also accelerates innovation by streamlining development. "There's no value in building table stakes—things that every app has to do, like user management, payment gateways, and logging," said Mark Curphey, vice president of strategy at CA Veracode, an application security firm that specializes in securing open-source software. "So over the years people have extrapolated that stuff into reusable code libraries and frameworks that everyone can use, which allows developers to focus on building differential features."

If software development were a queue, open source lets developers skip to the front of the line.

"The barrier to entry ... is very low, so you can get lots of grassroots adoption by integrators and engineers to try things out and prototype, which lets you move very quickly," explained Cesium creator Patrick Cozzi, principal graphics architect at Analytical Graphics Inc., who said another advantage of open source is customization. "In the GEOINT space, in particular, the need for customization is often very high."

Arguably the greatest benefit of open-source software, however, is the community of users behind it.

"When I'm contributing to open-source software, the maintenance and development of that software does not fall squarely on my shoulders," said Scott Clark, a program manager at Radiant Solutions, where he specializes in open-source software development. "[PostGIS creator] Paul Ramsey did a great talk a few years ago and compared open-source software to a barn raising. When you wanted to raise a barn back in the day, the community would come out and help you build it because you couldn't do it by yourself. That helped out the community, because the next time somebody else had to raise a barn they got help, too."

Open-source software often has thousands of stakeholders, according to Grady, who said quantity of users typically correlates with quality of software.

"There is a tremendous amount of knowledge development in software," Grady said. "Leveraging that knowledge is how we build on those who went before."

The open-source community believes in the group so strongly that it even has a term for its potential: Linus's Law, named for Linux creator Linus Torvalds.

"Linus's Law states, 'With sufficient eyes, all bugs look shallow,'" said David Egts, chief technologist for the public sector organization at open-source solution provider Red Hat. "What that means is: If you have a robust community of people working on your code, the level of innovation is going to be higher."

From a GEOINT perspective, having a large and diverse community with which to share code also makes it possible to evangelize and evolve the profession. NGA, for example, is using open-source solutions to increase GEOINT adoption globally.

"Geospatial technology applies to a whole set of various problems that don't just span across the IC and DoD," said Ben Foster, NGA's product manager for mobile development and operations. "By open sourcing the stuff that we're producing, we're lowering the barriers of entry [into GEOINT services] for a lot of our international partners."

Added Cozzi, "Once you make something open-source, anyone can pick it up. Cesium, for example, is used by

> "More often than not, a hybrid environment works best because you can pick and choose where it makes sense to implement open-source technologies and where it doesn't."
>
> —ANDY DEARING, CEO, BOUNDLESS

A HYBRID APPROACH

Despite the boom in open-source software adoption, proprietary software—also known as commercial off-the-shelf (COTS) software—still has many advantages. For one, the "free" in "free and open-source software" often refers to freedom, not cost. So while many open-source solutions are gratis, not all of them are. Plus, open-source software typically does not come with technical support, so organizations may have to hire experts to assist with implementation, integration, and ongoing administration. Costs can therefore be unpredictable relative to proprietary solutions.

Vendor viability is another concern. Compared to open-source providers, which are often vulnerable to acquisitions, mergers, and failures, proprietary vendors tend to have more stability and longevity, and can therefore promise greater continuity.

With open-source, the developer community controls the product roadmap. Often, this results in features and capabilities that users want. Sometimes, however, solutions veer in undesirable directions. Therefore, proprietary vendors may give individual users more control in pursuit of their unique requirements.

Given their respective strengths, the best solution for GEOINT needs lies in neither open-source nor proprietary software exclusively. Rather, it's applying the best of both using open platforms and standards.

"We don't recommend ripping out and replacing proprietary solutions. We advise people to put open-source technologies alongside proprietary technologies because there are ways to implement and integrate," said Dearing of Boundless, whose core business is providing commercial support for open-source geospatial software. "More often than not, a hybrid environment works best because you can pick and choose where it makes sense to implement open-source technologies and where it doesn't."

The upside of a hybrid approach is evident in one of open-source software's unlikely proponents: Esri. Though its GIS software is the definition of COTS, the company nonetheless has welcomed open-source philosophy in order to enhance its proprietary offerings, leveraging the best of both.

One way Esri participates in the open-source community is with open specifications, which it co-develops as a participant in the Open Geospatial Consortium (OGC). "Esri has made a strong commitment to being an open platform, meaning we are very focused on standards and making sure those standards support an open ecosystem," explained Ben Conklin, defense and intelligence industry manager at Esri.

Open standards enable interoperability between closed- and open-source systems.

"We see this a lot in the GEOINT Community today—both open-source and commercial software, working hand-in-hand through the interoperability of open formats and open standards," Cozzi said.

Esri also supports open-source projects as a user whose feedback contributes to fixes and updates that benefit the entire user community. Its software, for example, supports the Red Hat Enterprise Linux and SUSE Linux open-source operating systems, as well as the Postgres open-source database. It also incorporates numerous open-source tools, languages, and libraries. And the company regularly shares via GitHub its own open-source applications that help users customize and extend its proprietary GIS software.

Though there's no denying the potential merits of open code, the sum of Esri's efforts is something Conklin believes is more powerful: open community. "To me, the most important aspect of open source is the idea of a community built around software, where many people contribute to it and many people benefit from it," he said.

ENABLING THE FUTURE

An open community approach must be similarly embraced by the larger GEOINT Community as it builds capacity for the next generation of GEOINT services.

"Geo problems are geo problems. Those problems won't change, but the scale of the data that people can apply to those geo problems is about to go off the charts with the Internet of Things, autonomous vehicles, signals intelligence—you name it," Pickle said.

Therein lies the promise of open-source software: By leveraging the size and diversity of the global developer community, GEOINT enterprises faced with complex data management problems can develop solutions quickly, creatively, and cost-effectively.

"Think about the benefits open source provides. You've got a cost cap because there's no license for the software, you've got the ability to quickly develop systems because the source is open, and you can collaborate in an unlimited fashion," Pickle continued. "Now think about the problems of the future—data fire hoses coming into distributed systems that have many users with varying needs. You just can't solve them without open source."

Layered on top of breakthroughs in automation, artificial intelligence, and cloud computing, the potential is overwhelming.

Concluded Grady: "The global community of developers harnessing the cloud and machine learning, and applying it to new real-time data feeds? Wow. Look out."

The OpenStreetMap Foundation released a large dataset (spanning nearly eight years) of user-contributed GPS tracks. The dataset consists of nearly three billion points.

IMAGE COURTESY OF GEOWAVE