APOGEO SPATIAL

ELEVATING GLOBAL AWARENESS

SERIES: Filling the Gap

Mapping & Analysis News: Mapbox, DigitalGlobe, and AGI's Cesium p. 16

"Mapbox offers everything from heavily curated basemaps to map and data design tools to directions matching to geocoding, via a set of cloud APIs and open source libraries and tools."

– Matt Irwin, Mapbox p. 16

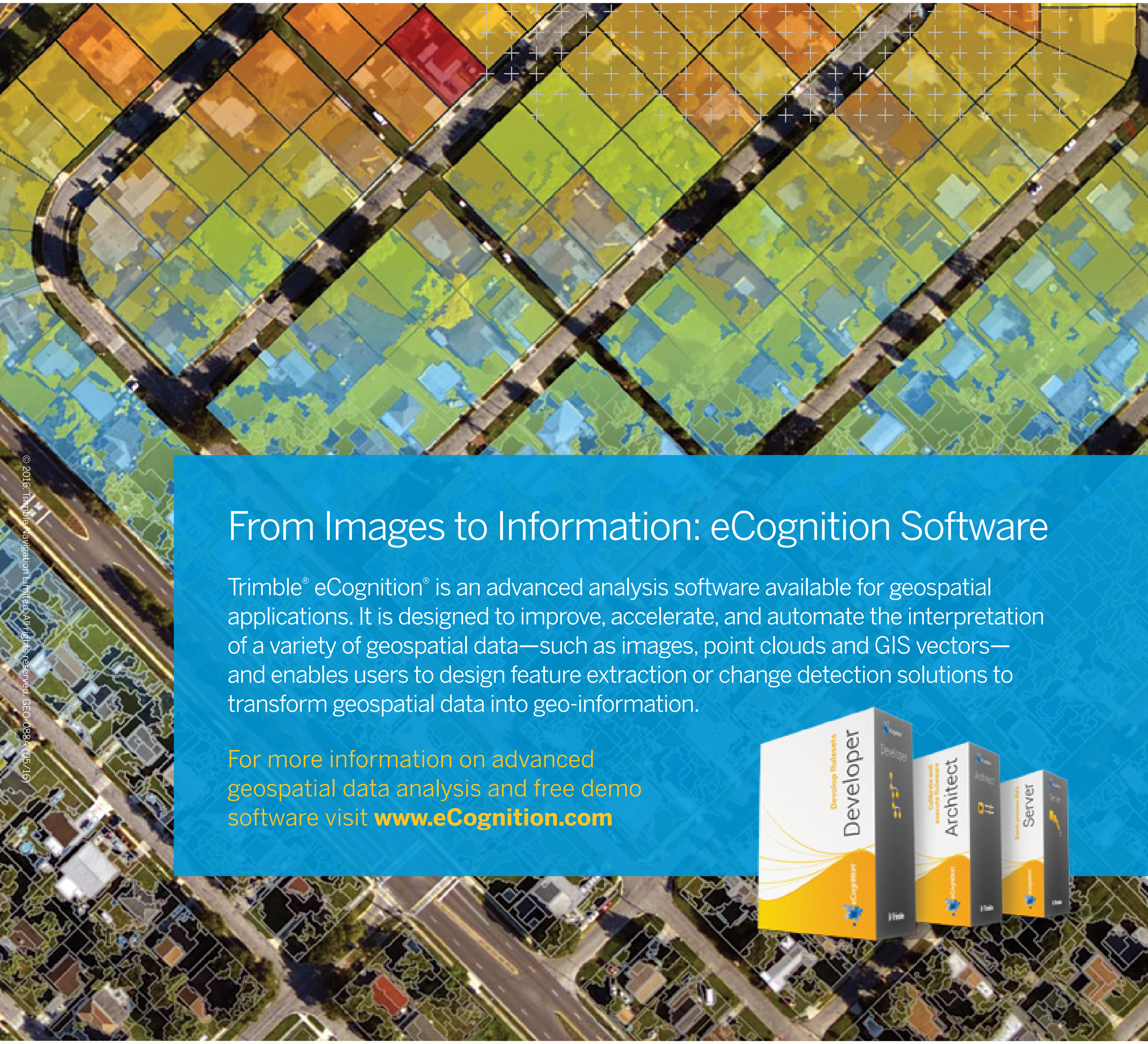
"While this practice (illegal fishing and forced labor) had persisted for generations and was well known, the image provoked a visceral response, and gave the Indonesian authorities the confidence to decide to intervene."

– Nancy Coleman, DigitalGlobe p. 11

FORMERLY Imaging NOTES

Image of an illegal fishing vessel with slaves aboard in the ocean south of Papua New Guinea, courtesy of DigitalGlobe. See story on page 11.

[Summer 2016 / Vol. 31 / No. 3]



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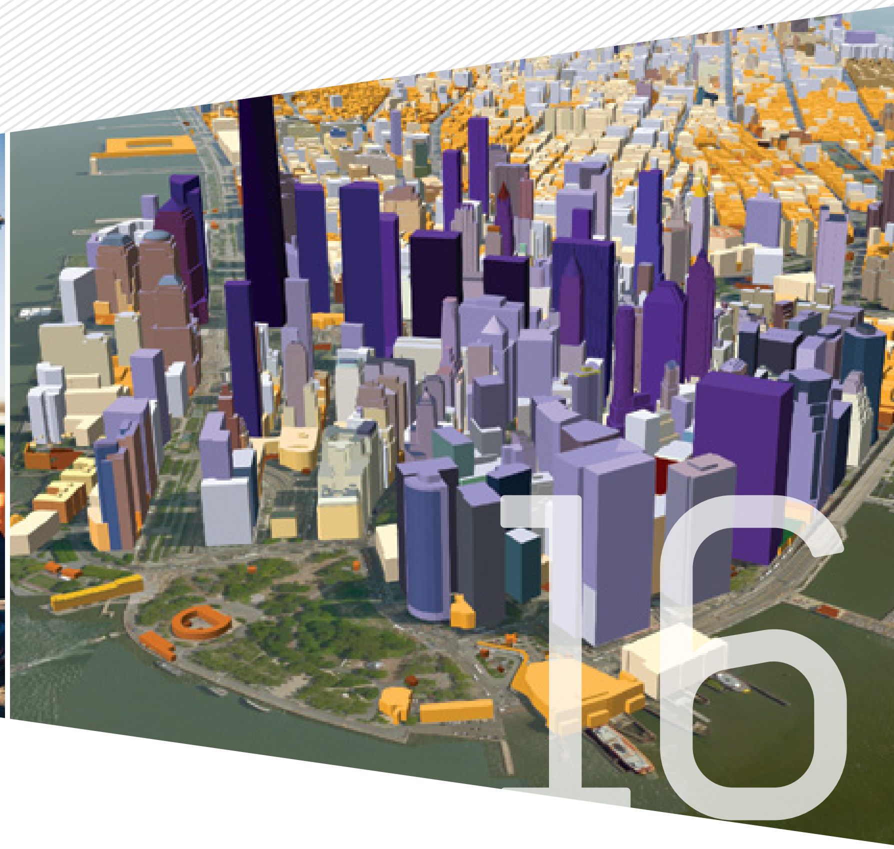

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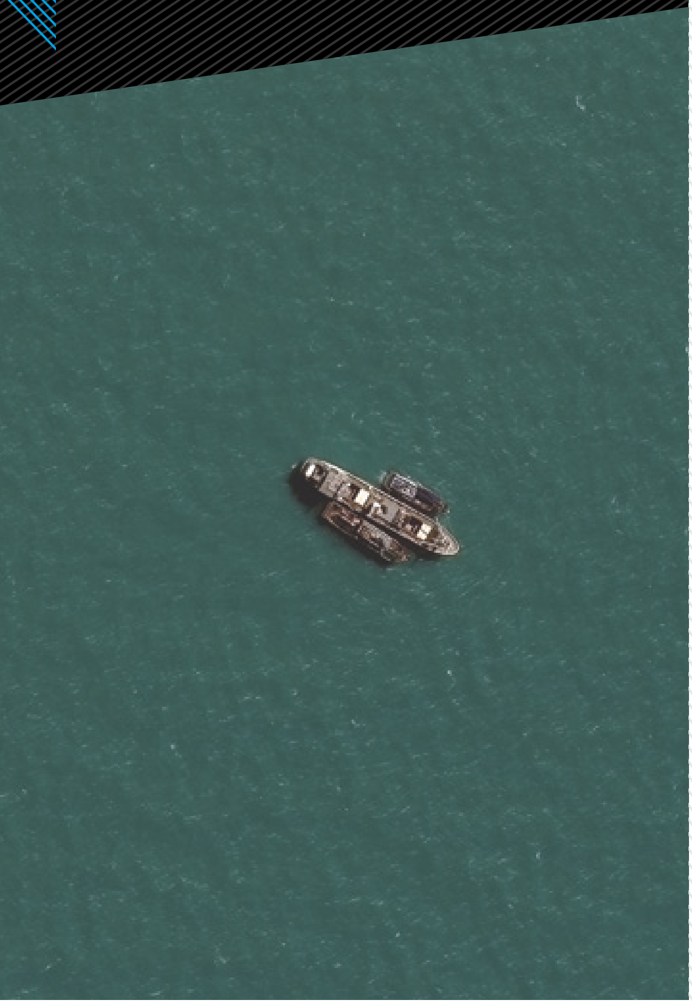
COVER IMAGE



Illegal Fishing Boats Found in the Arafura Sea

IN A MAJOR INVESTIGATION BY THE ASSOCIATED PRESS (AP), illegal fishing boats were found in the Arafura Sea, south of Papua New Guinea. Upon request by the AP, DigitalGlobe was able to capture this image of the boats and image analysts confirmed that the smaller boats were illegal trawlers, loading their catch onto commercial fishing boats. Because of this proof, the perpetrators were prosecuted, and people who were enslaved were freed.

This series won the Pulitzer Prize for the AP. Read more about this compelling humanitarian story on page 11. ΛσΊ

APOGEO SPATIAL

Formerly Imaging NOTES

[Summer 2016 / Vol. 31 / No. 3]

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Advocating for the Power of Global Earth Observations

The Rakaia River carries glacial run-off
through pastureland and into the Pacific Ocean, at Canterbury,
New Zealand. Image captured March 26, 2016, courtesy of Planet Labs.

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APOGEO SPATIAL

ELEVATING GLOBAL AWARENESS

Saving Lives and Illegal Fishing

DATA PLATFORMS AND DIGITAL MAPPING

Myrna James Yoo
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DEAR READER,

The value of geospatial tools and data continues to grow, and now, accessing that data is easier and is possible in more ways than ever before. Our ongoing series on "Filling the Gap…" (left by Google Earth Enterprise), is evolving to be about all kinds of geospatial software, digital mapping, and solutions, offered by all kinds of companies. What most of them have in common is that they are creating data platforms. These platforms are making each company's data, as well as other companies' data (sometimes including their competitors' data) more easily accessible by all users, experts and non-experts alike. This is what these companies have been working towards for several years.

The more we research and cover companies in this space, the more we realize that perhaps there is no gap. Or perhaps that gap is being filled quite quickly and expertly by innovative companies that are seeing the opportunity, which is what Esri did with ArcGIS Earth (which we covered in the Fall 2015 issue).

In the Spring issue, we published a teaser about what DigitalGlobe is up to, and in this issue, beginning on page 16, we go further in depth, sharing information about their GBDX (Geospatial Big Data Platform), Maps API, and other offerings. So much more than an imagery company, DigitalGlobe is providing solutions that incorporate many data sources within GBDX, and their new offering, AnswerFactory, calculates answers to geospatial questions primarily for business users. The company has different levels of users, including Developers (APIs and SDKs), GIS Users and Remote Sensing Experts (the traditional users of their imagery), and, increasingly, Business Users (for Web, mobile and desktop applications and for AnswerFactory, as well as for full information products and analytics reports).

Included is AGI's Cesium, which began in 2012 to take time-dynamic aerospace models and put them on the Web without a plugin. AGI decided to open source Cesium, and adoption has been viral in many industries. Cesium is an SDK with which users can build implementations.

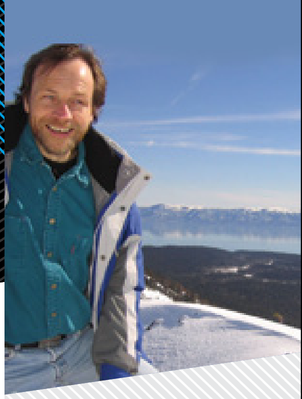
Mapbox is unique. Mapbox is included in this series because you need to know about them and their work. They are competing with Google Maps and Esri and many others, making mapping easy for non-experts, and they are stirring up some controversy. They use both OpenStreetMap (free open source data) and DigitalGlobe (not free data) for foundation data, and their clients build on that. They launched Mapbox Drive in early June, which ambitiously competes with TomTom and HERE for navigation and routing.

I think that most of us in this field believe that geospatial tools are truly doing some good in the world, but rarely do we have examples as poignant as the story from DigitalGlobe and The Associated Press in this issue, on page 11. The story started when the AP approached DigitalGlobe for an ongoing investigation about getting images of ships deep in the ocean to prove that they were doing illegal fishing. The AP was able to confirm with the image taken of the boats in the sea south of Papua New Guinea not only illegal fishing, but also that many people were forced to live on these illegal boats for years at a time. The result of the "smoking gun" image, which proved the illegal activity, was prosecution, and the freedom of about 2000 slaves.

Another inspiring story is about Resilient Cities, which are committing to managing their Urban Tree Canopy for managing carbon. It features Boulder, Colorado, and mentions what is being done in New York City, Pittsburgh, and Washington, D.C. The story begins on page 22.

Thanks for reading.

ON THE EDGE



The Laboratory for "Patient Earth"

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Norfolk, Va.
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THE LEADERS OF THE WORLD ARE IN need of knowing what is happening to the Earth's life-support system and this knowledge can only come from observations that tell us how this system is changing. Not unlike a doctor, who is in need of laboratory results to come to a diagnosis, our leaders need lab results for "Patient Earth." Not unlike a pilot in an airplane, our leaders need a cockpit for "Spaceship Earth"[1] with all the panels that capture the essential variables defining the state and trajectory of this planet that we call home.

Already in 2000, I used this analogy[2] and concluded that the dashboard available to our leaders was insufficient with many of the essential variables of the Earth system not captured, including those describing the increasingly dominant anthroposphere with a global complex economy and social structure. Unlike the pilots in a modern airplane, who have a very comprehensive dashboard (***Figure 1***) informing them in detail about the state and trajectory of the plane, decisions that impact the state and trends of the Earth's life-support system are informed by rather incomplete and often inaccessible or unusable observations.

Since 1984, the Integrated Global Observing Strategy (IGOS) initiated by the G7 as a framework for Earth Observations was developed with the goal to identify the essential variables that need to be observed in order to document the changes that are happening on the planet. In 1998, the IGOS Partnership (IGOS-P) was established, bringing together major organizations in the scientific and Earth observation fields in an effort to first identify what needs to be monitored and then to implement the corresponding observing systems.

IGOS-P used a well-defined theme approach to define the overall strategy, which "recognises that in reality it is impossible, in one step and for all eventualities, to complete the exercise of defining all the necessary observational requirements and hence the observational systems, data handling, processing and analysis infrastructure for a comprehensive global system. The theme approach allows the coherent definition and development of an overall global strategy whilst recognising the different state and stage of development in different areas. Themes have not *a priori* been defined; rather it is anticipated that the user communities will identify areas that require action and bring forward themes for agreement and action."[3] The resulting IGOS-P theme reports were excellent outcomes of the first step defining observational needs for societally relevant themes, but the implementation of the findings by the space agencies and other providers did not follow suit.

When the Group on Earth Observations (GEO) was initiated in 2003 (again by the then G8) and fully established in 2005 with a ten-year mandate to build the Global Earth Observation System of Systems (GEOSS)[4], I had the hope that now matters would progress towards implementation of the urgently needed cockpit for "Spaceship Earth." Or, to use the medical analogy, I saw a beginning of building the laboratory needed to assess the health of the Earth's life-support system, to diagnose the sickness, identify its causes, and develop a therapy.

Unlike IGOS-P, where themes emerged from a community and expert-based approach, the activities of GEO were structured according to nine pre-defined Societal Benefit Areas (SBAs) (***Figure 2***). This was not unlike the medical lab sheets that are structured according to different medical benefit areas of the data obtained in the laboratory. Although not perfect, the nine SBAs provided a basis for identifying the essential variables in each of these SBAs as guidance for what should be observed.

During the first 10 years of GEO, the GEO Work Plans were structured according to the SBAs. In more recent years, additional Societal Benefit Tasks were added to emphasize large areas that the nine SBAs did not sufficiently cover, including those focusing on Oceans and Society: Blue Planet, Global Land Cover, Global Forest Observation, Global Urban Observation and Information, and Impact Assessment of Human Activities.

1

◀ FIGURE 1. Cockpit of the A380 airplane.

However, my initially very high expectation that GEO finally would make significant progress towards designing and implementing the dashboard for our leaders was not met: After the first 10 years, only a few of the SBAs and SB tasks, such as Climate, Weather and Oceans, have developed a more or less complete set of essential variables, while others are still far away from even having agreed on what is essential to observe.

In the transition from the first to the second 10-year plan, new people came in and facilitated changes in many aspects of GEO. New SBAs were defined (***Figure 3***), and they look more like the structuring of medicine than the structuring of the medical lab sheets. It appears that the new structure puts GEO in the position of the doctor, not the technician providing the lab results for all essential variables.

Moreover, the GEO Work Programme for 2016[5] has very little connection to the new set of SBAs. In fact, a reader would not be able to extract these SBAs from the list of Community Activities, GEO Initiatives, and Foundational Tasks collected in the GEO Work Programme. This disconnect between the declared SBAs and the planned activities in the Work Programme indicates a flaw in the strategy developed by the Implementation Plan Working Group (IPWG), the group that orchestrated the transition into the second 10 years: the new SBAs are neither connected to any societal framework nor to the way the GEO community would structure the observation landscape. One reason for this is that the broad GEO community proposing the Work Programme activities was not well connected to the process of developing the GEO strategy for the post 2015-period. This was different during the ad-hoc GEO period (2003-2004), when the first 10-year implementation plan was developed in a broad community-based process.

It amazes me how a great idea and concept that was discussed in the 1980s and 1990s was watered down and is now no longer recognizable. I first heard of IGOS and IGOS-P in 1998 at the 27th International Symposium on Remote Sensing of the Environment in Tromso, Norway, where those involved in IGOS-P enthusiastically talked about the progress the world could expect because now the IGOS would provide a solid basis for planning the observation systems so urgently needed to inform humanity about the changes in the planet and because IGOS-P would ensure the implementation of the IGOS. Today, more than 30 years after the discussion started, nearly 20 years after IGOS-P was established, and more than 10 years after GEO was initiated, we are still far away from the exciting vision of the 1990s. The new strategy for the next 10 GEO years does not promise to change this very much.

We urgently need a global effort to design and implement the laboratory for "Patient Earth." The concept of essential variables is a valuable path towards a comprehensive laboratory. Characterizing the main subsystems of the Earth's life-support system, understanding the physiological processes in this system, including those that link the anthroposphere to the life-support system, and identifying the essential variables for these subsystems and processes would provide guidance for designing the lab.

▼ **FIGURE 2.** The original Societal Benefit Areas (SBAs) of Earth observations defined during the Ministerial Earth Observation Summit in 2004 in Tokyo, Japan.

▼ **FIGURE 3.** The new SBAs defined by the IPWG.

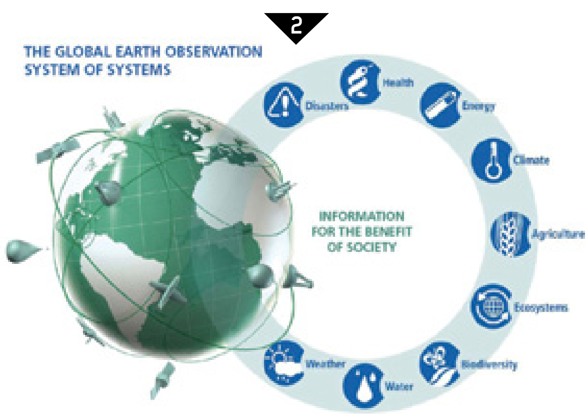
▶ **FIGURE 4.** The Sustainable Development Goals of the Agenda 2030 agreed upon by the United Nations in 2015. From https://sustainabledevelopment.un.org/sdgs.

Today, one of the most important processes in the Earth system is our economy,[6] which links humanity to the Earth's life-support system and has led to significant degradations in the life-support system. Neither the impact on the life-support system nor the process itself is comprehensively documented so that our leaders could reduce the degradation and even start to work on restoring its health.

Humanity's economy is comparable to the lifestyle of an individual impacting the health of the individual. For such an individual, only a change in lifestyle can lead to significant improvements of health, but in order to see the improvements, frequent lab results need to be available. There is a crucial difference between the lab results a doctor may request to see the subtle improvements or degradation in a patient's health and the emergency room monitoring that has the task to discover any threatening development as early as possible.

With the current rapid degradation of the Earth's life-support system, we need both, the lab results on request, and the constant monitoring to discover new—and potentially threatening—developments. In both cases, we need to know what is outside the baseline, outside the normal variability warranting an alert. In my opinion, GEO would serve humanity best if it would design the planetary laboratory providing comprehensive observations enabling both the "emergency room monitoring" and the assessment of life-style changes on the health of the Earth's life support system.

One major global effort to improve sustainability is the Agenda 2030 for Sustainable Development, which aims to reach 17 Sustainable Development Goals (SDGs, ***Figure 4***). Wouldn't is be great if the planetary lab was designed to provide what is needed to inform the planning of actions that would bring us closer to these goals and would help us to monitor the progress? Using the 17 SDGs to organize the Earth observation activities into societal benefit areas would connect GEO strongly to established societal frameworks.



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1 "Spaceship Earth" is a term coined by Buckminster Fuller in his 1968 book, *Operating Manual for Spaceship Earth.*

2 Plag, H.-P., 2000. *Towards an Integrated Global Geodetic Observing System,* Integration of geodetic techniques into a global Earth monitoring system and its implication for Earth system sciences, edited by R. Rummel, H. Drewes, W. Bosch, & H. Hornik, vol. 120 of International Association of Geodesy Symposia, pp. 73-83, Springer, Berlin.

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Freeing Slaves from the High Seas

Imagery from DigitalGlobe Provided Proof for an Associated Press Investigation

BY MATTEO LUCCIO / CONTRIBUTOR
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In May 2015, former slave fisherman Myint Naing, 40, was reunited with his family after 22 years. He was among hundreds of former slave fishermen who returned to Myanmar following an Associated Press (AP) investigation into the use of forced labor in Southeast Asia's seafood industry. The persistent, meticulous, and sophisticated investigation by a team led by Martha Mendoza traced slave-produced seafood from Asia to major U.S. supermarkets, restaurants, and food suppliers, and resulted in the freeing of 2,000 slaves. This spring, the project earned the 170-year-old news agency its first Pulitzer Prize for Public Service, Mendoza's second Pulitzer Prize.

A key piece of the reporting was a stunning image captured by DigitalGlobe's WorldView-3 satellite of a slave boat transferring its catch to a commercial fishing vessel in the middle of the ocean. An escaped slave corroborated that the boat was the one on which he had been forced to work.

THE COLLABORATION

DigitalGlobe often helps media organizations tell important stories about global events by providing them satellite imagery. "This AP story was the most shining recent example of the power of satellite imagery and geospatial information at work," says Turner Brinton, DigitalGlobe's Public Relations Senior Manager. The catalyst for this collaboration between DigitalGlobe and the AP was a phone call last spring from Mendoza about this project, on which her team had been working for more than a year. "The more we learned about what they were trying to do, the more we knew that we wanted to help and that there was a good chance that we would be able to do so," says Brinton.

Mendoza was looking for large commercial fishing vessels that had been meeting up with slave boats where no one could see them and they could not be found. They would turn off their Automatic Identification System (AIS) tracking devices while they were doing this to prevent their locations from being known. This allowed the slave boats to transfer their catch to the commercial fishing ships.


All photos courtesy of The Associated Press and DigitalGlobe.

The ships, in turn, would give the boats just enough food and water to keep the slaves strong enough to do their grueling work for 20 to 22 hours a day and stay out at sea for years at a time. “We’ve heard reports of these slave boats being at sea for five to ten years,” says Brinton. “These people were often captured from their homes and families or tricked into working on these boats. This is a textbook definition of modern-day slavery.”

Everyone at DigitalGlobe relies on its motto, “seeing a better world,” in making day-to-day decisions, says Nancy Coleman, the company’s Senior Director of Communications. Therefore, she recalls, when Mendoza called, she and Brinton felt empowered to decide to support the AP as part of their role as storytellers and in order to demonstrate what the geospatial industry can do. “Because we knew that this was in alignment with our purpose, we did not have to reflect on whether or not this had potential as a commercial opportunity,” says Coleman. “It was just the right thing to do.” She and Brinton have been fielding more investigative types of requests since and are exploring some currently. “We are extremely proud of our small contribution to this tremendous work that the AP has done,” says Brinton.

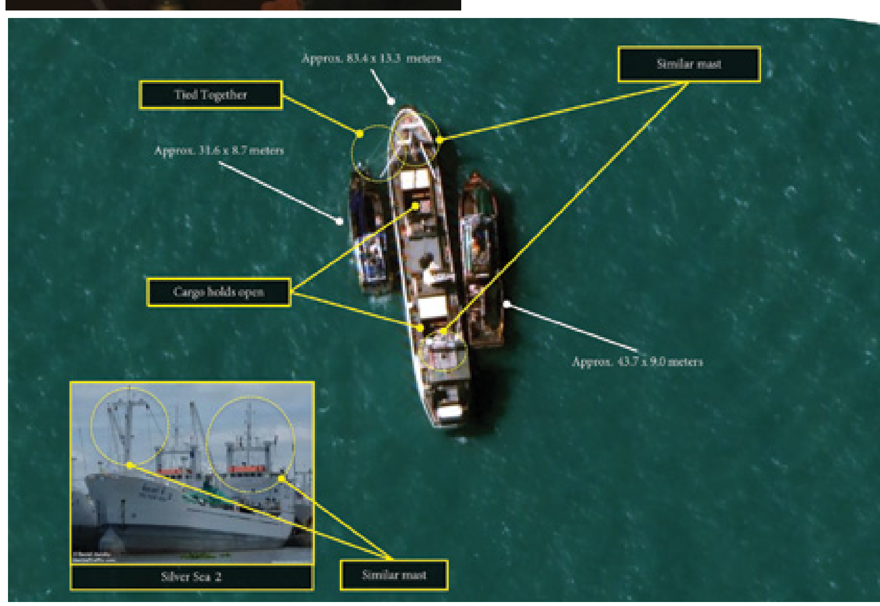
CAPTURING THE IMAGE

The AP team’s reporting led to the suspected location of the transfer of catch on the high seas. “A couple of months after our initial conversations,” Brinton recalls, “we received a call out of the blue one day.” The team suspected where a commercial fishing vessel was and needed to know whether DigitalGlobe could take an image of it. As it turned out, DigitalGlobe’s most capable satellite, WorldView-3, was within viewing distance of the area when the AP provided the coordinates. “We were able to take an image that same day and provide it to the AP with some analysis of what that image was showing, less than 24 hours after we received those coordinates,” says Brinton.

The AP team knew specifically which ship they were trying to catch in the act because they had

While this practice had persisted for generations and was well known, the image provoked a visceral response, and gave the Indonesian authorities the confidence to decide to intervene.

THE “SMOKING GUN” IMAGE: This image of smaller illegal fishing vessels and a larger commercial vessel, the Silver Sea 2, a Thailand-owned refrigerated cargo ship, in the Arafura Sea south of Papua New Guinea, led to the eventual release of about 2000 forced-labor slaves. DigitalGlobe imagery analyst Micah Farfour is shown here. Images courtesy of DigitalGlobe.



> The series of AP stories was the catalyst for a lot of action, (including) freeing more than 2,000 men from fishing boats.

people on the ground, Coleman explains. "They had ground truth and photographs of the ship they were looking for. Their reporting ultimately led them to observe the suspected fishing ship at port and correlate its tracking signal. When it left port for one of the suspected slave boat rendezvous, AP provided the approximate latitude and longitude for where the ship was headed just before it turned off its tracking signal. Despite this, it was still a needle in a haystack problem, as the ship could have been anywhere within a 500-square-mile area. Ultimately, one of the first people who saw the satellite image we provided was an escaped slave who was able to confirm that it was indeed the ship from which he had escaped."

"Only a satellite like WorldView-3, with its large aperture and sophisticated pointing agility, could have captured the right image at the right time," says Brinton. "The 30-cm satellite image enabled a positive identification of the commercial fishing ship, showing its cargo holds open to accept the slave-caught fish."

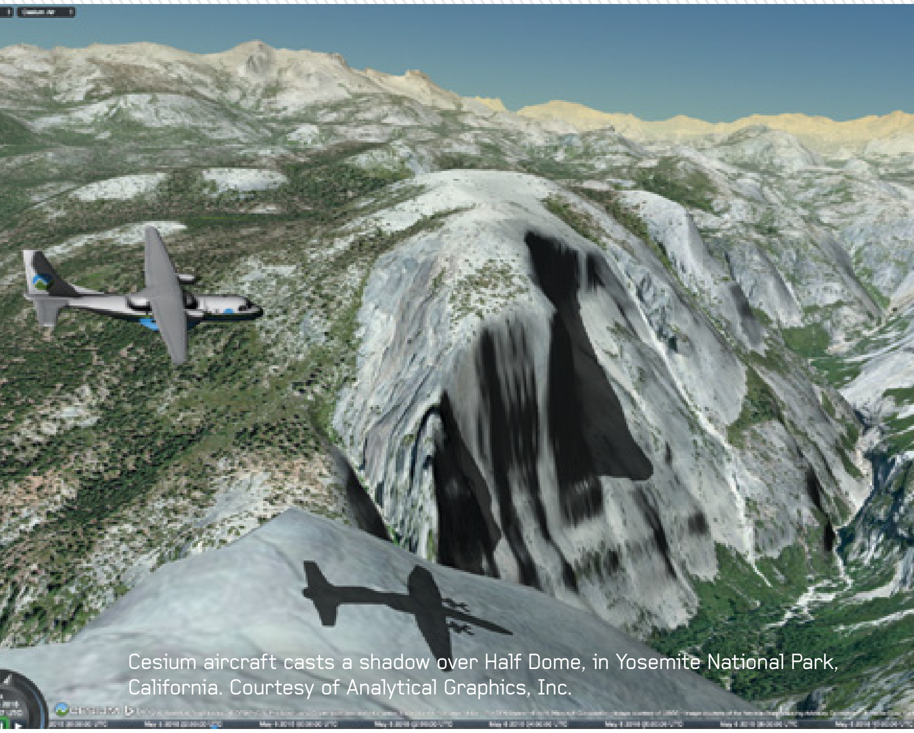
> This spring, the project earned the 170-year-old news agency (AP) its first Pulitzer Prize for Public Service.

THE CONSEQUENCES

DigitalGlobe provided the image to the AP, who, in turn, provided it to the Indonesian authorities. "They did so much ground work that they already had contacts in the government who were aware of this issue and the AP's investigation," says Coleman. "The imagery that we provided was the smoking gun that allowed the authorities to intercept the vessel, arrest the captain, and free the men onboard." While this practice had persisted for generations and was well known, the image provoked "a visceral response," says Coleman, and gave the Indonesian authorities the confidence to decide to intervene.

The series of AP stories on this subject, collectively titled "Seafood from Slaves," came out last summer and fall and was the catalyst for a lot of action that has happened since, in addition to leading to the freeing of more than 2,000 men from fishing boats. It led to legislation signed by President Obama that closed a loophole in U.S. law that allowed for goods produced by slaves to be sold in the United States, and demands for change by U.S. importers have resulted in three class-action lawsuits.

From Selling Pixels to Selling Answers



Cesium aircraft casts a shadow over Half Dome, in Yosemite National Park, California. Courtesy of Analytical Graphics, Inc.

1.1 million New York City buildings dynamically styled with Cesium 3D Tiles. Image courtesy of Analytical Graphics, Inc.

DigitalGlobe: Expanding Access to Insights from Satellite Imagery

AGI: Cesium Disseminates 3D Models

Mapbox: Enabling Developers to Build Custom Maps

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This series of articles began in our Fall 2015 issue by focusing on the impact on vendors and users of geospatial technologies of Google's decision to end support for Google Earth Enterprise (GEE). It has widened to present an array of new offerings that expand access to Earth observation data and give users new tools to analyze them. For this installment, I talked to John-Isaac Clark, Director of Product Management for Geospatial Big Data at DigitalGlobe; Todd Smith, Cesium Product Manager at AGI; and Matt Irwin, who handles business and government at Mapbox.

DIGITALGLOBE:

LOWERING THE BAR TO ENTRY

DigitalGlobe is launching a new platform, and new offerings: GBDX (Geospatial Big Data Platform), Maps API, crowdsourcing, and Spatial on Demand—plus AnswerFactory and the ArcMap Plugin as additional ways to consume these capabilities.

Until recently, Clark explains, non-remote sensing users predominantly used pixels as reference onto which to overlay vector data, such as areas of interest, state boundaries, or roads. For this reason, Google, Apple, Bing, and Esri became some of the major commercial purchasers of satellite imagery as users began leveraging their respective mapping products to marry vector and satellite data within Web, mobile, and desktop applications. Users then realized that they could buy these pixels, too. However, the cost—$10-$30 a square kilometer—and the size of the Earth's landmass made this very expensive to do. Therefore, only the likes of Google, Apple, and national governments buy vast amounts of imagery and generally use it only as a basemap.

In particular, answering questions about change over time—such as finding every new road in a country—would have been extremely expensive, Clark points out. In addition to buying imagery from DigitalGlobe or others, it would have required downloading terabytes of this data, storing and processing it, and then hiring Ph.D.-level remote sensing experts who would have had to employ high-end and expensive tools, such as ENVI or ERDAS, to perform multi-band analysis on the pixels. "Then, hopefully, at the end, after you'd spent quite a bit of money on software, people, storage, and processing, you might have been able to answer your question."

However, Clark explains, recently the cost of storing and processing data have dropped dramatically—thanks in large part to cloud offerings by Amazon and Google—and the Internet infrastructure to transfer data has improved. Now, DigitalGlobe can allow users to query its 90 petabytes of imagery data of the surface of the planet, collected over 15 years, and extract answers and insights. On the back end, machine learning techniques can analyze the data at scale, inside a cloud infrastructure. "Let's let people rent the pixels to get these answers, instead of having to pay to download them and build their own infrastructure," says Clark.

NEW PLATFORM: GBDX

To this end, DigitalGlobe is launching GBDX, a Web-based platform that allows users to access its entire archive of data for the purpose of running analytics on the data in the cloud. "With this approach," says Clark, "we can drastically reduce the costs. Through Web services and with storage and processing hosting on Amazon, anybody who wants to use it in their applications does not need to build their own infrastructure. They don't even, in some cases, need to know what remote sensing is." See ***Figure 1***.

GIS users can now do this directly from ESRI ArcMap via a GBDX plugin. For example, they can request to be notified whenever a satellite image of their area of interest is captured and then perform automated feature extraction at scale. "Tell me if there is a new building, a car, a new road," Clark explains. "That is what is incredibly exciting and very powerful about doing remote sensing on planetary-size data and making it accessible to everyone."

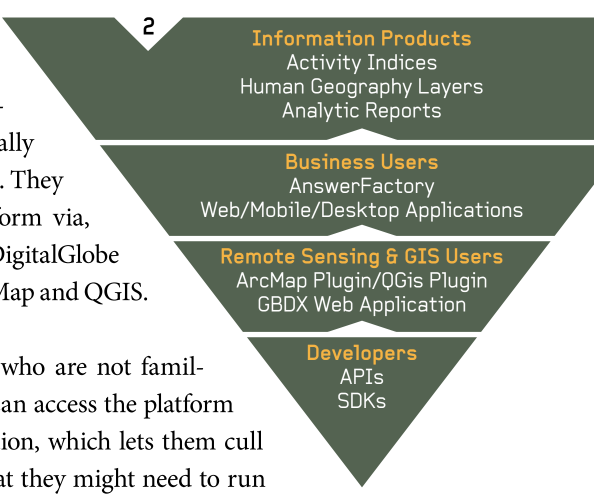
THE INVERTED PYRAMID

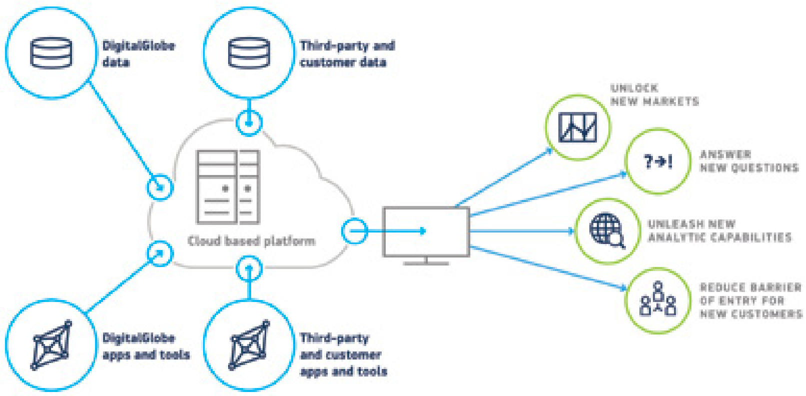
What knowledge, skills, and tools users need to ask those questions depends on who they are. Clark uses an inverted pyramid to explain this. At the base are developers, who access the DigitalGlobe platform via APIs and SDKs. "Organizations like SpaceKnow or Orbital Insight, which know remote sensing very well and are also very conversant in software development and Web programming languages, are at the base. They have core access to the platform and can make it do whatever they want." Such users can find data in DigitalGlobe's archive catalog, order it, create new workflows and algorithms, download the data to Amazon, etc.

A step up from the developer tier is that of remote sensing and GIS professionals, who traditionally have been in separate camps. They can access the GBDX platform via, for example, plugins that DigitalGlobe has developed for ESRI ArcMap and QGIS. See ***Figure 2***.

Remote sensing experts who are not familiar with those applications can access the platform via the GBDX Web application, which lets them cull through the type of data that they might need to run

▼ FIGURE 2. The Inverted Pyramid Market Funnel from DigitalGlobe.





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▲ FIGURE 1. DigitalGlobe's GBDX Platform Overview

▶ FIGURE 3. Time-dynamic, highly accurate 3D visualizations depicted in AGI's Spacebook, showing space situational awareness for ComSpOC. Images courtesy of Analytical Graphics, Inc.

▶ FIGURE 4. 15,000 objects being fed real-time into Cesium for time-dynamic and 3D visualizations. Courtesy AGI.

▶ FIGURE 5. Image showing roofs by roof type, courtesy DigitalGlobe.

▶ FIGURE 6. DigitalGlobe's GBDX provides answers to queries such as shown here in AnswerFactory.

their algorithms and leverage pre-built ones—including those in the Harris ENVI remote sensing algorithm suite. For example, if a user searches for Eureka, California, the GBDX catalog service returns 3,000 images. They can sort them by such things as the type of content, resolution, off-nadir angle, and cloud cover.

While remote sensing experts often output from raster data to raster data, for GIS experts it is typically more useful to output vectors. This allows them to ask such questions as, "How many cars were in San Francisco today within 500 meters of Kezar Stadium? We can answer that."

EXPANDING THE USER BASE

Clark is especially interested in bringing these capabilities "to the people who have never even heard of DigitalGlobe, who don't know what raster is." This brings us to the next level of the pyramid: business users who access the platform through applications such as AnswerFactory, which is powered by GBDX. These users simply define areas of interest and then ask the platform what it can tell them about these areas. "If I selected the Dallas airport and for every satellite image of it asked it to count airliners, that would be really interesting," says Clark.

Many of the back-end processes that these tools leverage run "extremely advanced, machine learning, based on AI (artificial intelligence) convolutional neural network approaches," Clark explains. One of the object detection methods available in AnswerFactory has been trained on millions of different views of airplanes. However, a business user does not need to know what a convolutional neural network is or how to manage the complexity of training it, in order to take advantage of its capability.

By selecting "suburban roads," a user can extract roads from the latest version of the satellite imagery from DigitalGlobe's catalog with the least cloud coverage. "Users don't have to understand material selection or know what off-nadir is. They ask their question and we get the best and most current shot to generate the answer," Clark says.

DIFFERENT FRONT ENDS

The question has long been how to inexpensively access the data that Earth observation satellites constantly rain down from the sky. GBDX has different front ends, depending on the user. Developers will build on the GBDX capability using the API, which Clark calls "the basement of the platform." Above this level, integrations with existing desktop tools, such as ESRI's ArcMap, will allow users to query or operate GBDX algorithms and bring the resulting data into their desktop tools and environment. Business users who do not understand the underlying science or technology will use AnswerFactory.

What are the cost and learning curve for the occasional, non-specialist user? While DigitalGlobe began with predominantly developers using its platform, now it is focusing on enabling other users as well. "We want more companies to be able to build and feed these exciting new use cases to other users as well," says Clark. "But it is equally important that we begin to explore how we can monetize these new capabilities in such a way that what we are charging businesses and organizations is commensurate to the value that we are creating for them."

THE MAPS API

"DigitalGlobe is not looking to bring to market a replacement for GEE or a 3D visualization product," says Clark. "However, we are supporting some very interesting development of people who are creating 3D content or extracting 3D datasets from our 2D satellite images." For example, he points out, VRICON, a joint venture between SAAB and DigitalGlobe, is processing DigitalGlobe data and creating 3D products, which can be displayed using the VRICON Explorer products, or potentially within other 3D visualization environments. (Editor's note: VRICON was featured in Part 1 of this series, Fall 2015.)

Not every potential user can afford to pay $30,000-$500,000 a year to take advantage of the full range of GBDX data and services at the developer tier designed for organizations to build their own products. Therefore, Clark explains, his company is exploring market-specific solutions pre-packaged to leverage the platform's capabilities. "What would you pay if you could monitor your assets and receive an alert any time DigitalGlobe takes a satellite image and it reveals signs of human activity anywhere near your infrastructure?”

DigitalGlobe is also talking to other providers of Earth observation data about bringing them into GBDX. It recently acquired Spatial Energy, whose Spatial OnDemand product gives energy business users access to both raster and vector data. Going a step further, Clark sees new DigitalGlobe product offerings to support multiple industries.

Unlike Google’s, Bing’s, and Apple’s mapping APIs, DigitalGlobe’s new Maps API provides rights in its licensing terms to make derivative products. It also provides a license option that allows users to download some of that data for offline use. Maps API launched in August 2015, with the self-service marketplace launching in April 2016.

While Mapbox purchases DigitalGlobe imagery and provides it to their users through the Mapbox API, they are also a business partner. “We partnered with Mapbox to launch our Maps API and make it available via their infrastructure, so that we can offer our users an SLA with a 99.999% uptime that Mapbox’ infrastructure supports.”

The point, Clark says, is not to compete with Mapbox, Google, or Bing. “We are not doing directions, traffic, or navigation,” he points out. Rather, the API enables users to see all of the company’s most recent and cloud-free imagery to use in applications without these developers having to buy, download, and host the raster data.

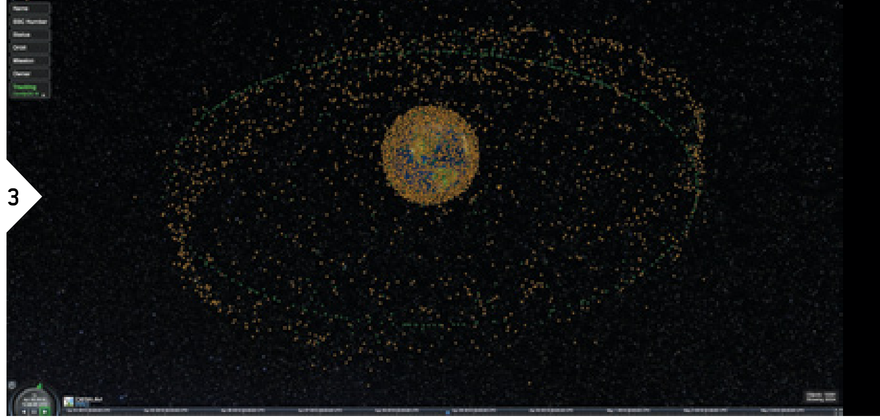
Finally, DigitalGlobe’s acquisition of Tomnod and its partnership with Geohive allows the company to incorporate crowdsourcing into its platform.

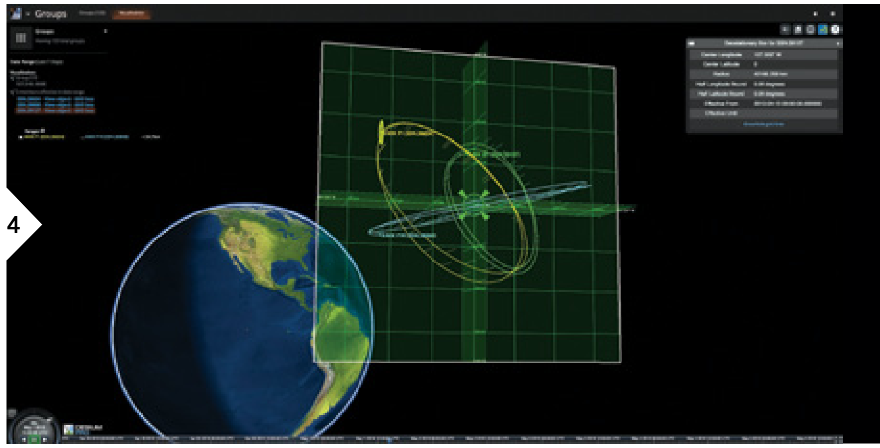
AGI’S CESIUM:

DISSEMENATING 3D MODELS

Since its founding in 1989, AGI, an aerospace engineering software company, has focused on displaying highly accurate physics-based models. “Visualizing very complex objects over space and time has always been important to us and to the users of our software,” says Smith. “At the core of that, 3D has always been very important.”

In 2012, AGI started the Cesium project. “The initial motivation was to be able to take those time-dynamic aerospace models and put them out over the Web without a plugin, so that people could view them, share them, and give them to their stakeholders,” Smith explains. The company made a big bet on WebGL, which was then an untested technology. “As WebGL grew, and as major software vendors adopted it, this has paid off for Cesium, which is all built out of WebGL.”





AGI decided to open source Cesium and it has been getting "viral adoption" in many different industries, says Smith. "We are focused on people and industries who are interested in being able to disseminate large amounts of heterogeneous data over the Web in 3D. Customers are telling us how they use Cesium in many different markets and unexpected ways."

Equally important, Smith says, is "viewing time as a first class citizen." As objects move in space and time, that is where Cesium really gets to shine, he says. "Cesium also works quite well with many different data types and streams them over the Web. It seamlessly handles transformations from Earth-center fix to an inertial frame, which derives directly from our aerospace roots." DigitalGlobe's Maps API is Cesium-compatible.

NEW OPEN FORMATS

At its core, Cesium is an SDK with which users can build implementations. It comes with a viewer, which many users employ to import their favorite map service or implement their KML data. AGI has done a lot of work with data formats, Smith points out. "This goes back to some of our core capabilities, because rendering traditional 2D formats effectively in a 3D scene is really complex, particularly if you are dealing with lots of data."

Hence, in parallel with Cesium, AGI has also developed four open formats: CZML, quantized mesh, glTF, and a new emerging format called 3D Tiles. "We expect these to become standards one day and not just open 3D formats," Smith says. "3D Tiles is able to stream massive amounts of heterogeneous data over the Web into a client like Cesium. We are developing server-based products that are able to take users' traditional formats and convert them into formats that stream really well over the Web into a 3D browser." At the beginning of May, AGI announced cesiumjs.com, an online offering that can be used behind firewalls and on private networks.

▼ FIGURE 7. Mapbox takes high-resolution imagery, including from DigitalGlobe, and adds context, like roads and labels.

Cesium is a business unit within AGI and the primary contributor to the Cesium project. "We provide a lot of input to the project, because other business units at AGI are really good users of Cesium," says Smith. "AGI has built solutions such as ComSpOC (Commercial Space Operations Center), as well as GLADS, on top of Cesium."

MAPBOX:

CLOUD-BASED GEOSPATIAL STACK

Mapbox began as a custom mapping consultancy. "We were building maps and visualizations for NGOs and governments in the development space, in the mid- and late-2000s," says Irwin. The company, he recalls, would do such things as take 30,000 pages of PDF elections results from Afghanistan and build maps and visualizations that would help spot provinces where fraud had likely occurred or instances of violence that had potentially reduced voter turnout at the ballot box. "Eventually, we realized that we had to build many of the tools that we used to build these maps and that building the tools and turning them into a platform was an equally interesting business model."

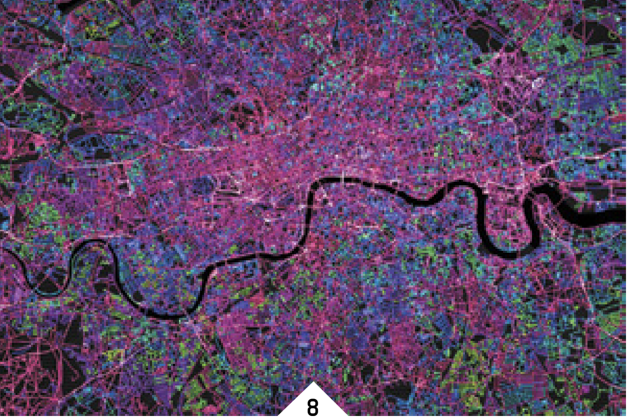
A decade later, Mapbox now has a cloud-based geospatial stack that offers all of the traditional map and location-based services that a developer would need to build a custom map for geospatial apps. "We offer everything from heavily curated basemaps to map and data design tools to directions matching to geocoding, via a set of cloud APIs and open source libraries and tools," says Irwin.

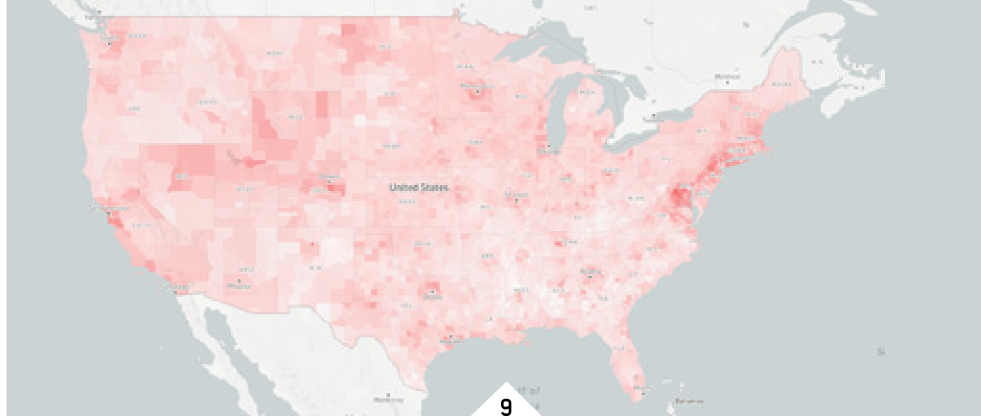
"Mapbox is a foundation for other platforms," says Irwin. "People will hit our cloud APIs, use our services, and build them into their own applications. You will never see a Mapbox app on your phone, but we will power apps ranging from Foursquare, which lets you check in at a restaurant you visit, to Strava which tracks your runs, hikes, and bike rides."

SUPPORTING OPENSTREETMAP

Mapbox believes that, over the long term, open data will be the most complete, up-to-date, and sustainable source of mapping data. "We always prefer using open data first and then contributing back to open data communities," says Irwin.

Probably the biggest community that Mapbox touches is OpenStreetMap (OSM). When OSM began, more than a decade ago, it was not taken seriously as a potential commercial mapping solution. It has since grown to rival the best available commercial map datasets and to surpass them in many parts of the world, especially in the developing world. "Mapbox's involvement there starts by building some of the tools that are used by these communities to add or process data," says Irwin. "For example, we built iD Editor, which is one of the popular tools that is used to trace roads and buildings in OSM."





◀ **FIGURE 8.** Mapbox contributes to the OSM community. This map shows ten years of OSM edits in London.

▲ **FIGURE 9.** Mapbox maps and libraries combine to build interactive data visualizations, like this choropleth map of income and population in the U.S.

Mapbox has also contributed to several of the geospatial tools in the imagery space, such as Rasterio, a popular tool used to manipulate and analyze raster imagery. The company also works with education and training, such as by publishing the documentation it uses to build its toolsets and holding map-a-thons so that anyone can learn how to use mapping tools.

THE ROLE OF COMMERCIAL DATA

Mapbox will also continue to purchase commercial data, such as from DigitalGlobe, "until the open datasets can rival the strength of some of the highly curated commercial datasets," says Irwin. Its platform is data source-agnostic, so that its users can bring in their preferred basemaps. "We can process their commercially-licensed datasets into a map for them. For example, we did this for MapQuest, which wanted to use the TomTom data that it had licensed. We were able to process that and turn it into a seamless map experience served out by our APIs."

The high resolution satellite and aerial imagery on Mapbox's basemap comes from DigitalGlobe, with the exception of some open ortho imagery, says Irwin. "We also helped DigitalGlobe put together their Maps API, which changes the way they are able to deliver pixels to their customers. Rather than having to ship large numbers of zipped geoTIFFs or put a hard drive in the mail, developers and imagery analysts can access this imagery as tiled maps via an API end point that we have built on behalf of DigitalGlobe."

Mapbox also employs a bring-your-own-data model for data types that its platform does not serve natively. People have used it to build maps for 3D building extrusions or photogrammetry or to import oblique imagery for damage assessment after tornadoes or cyclones.

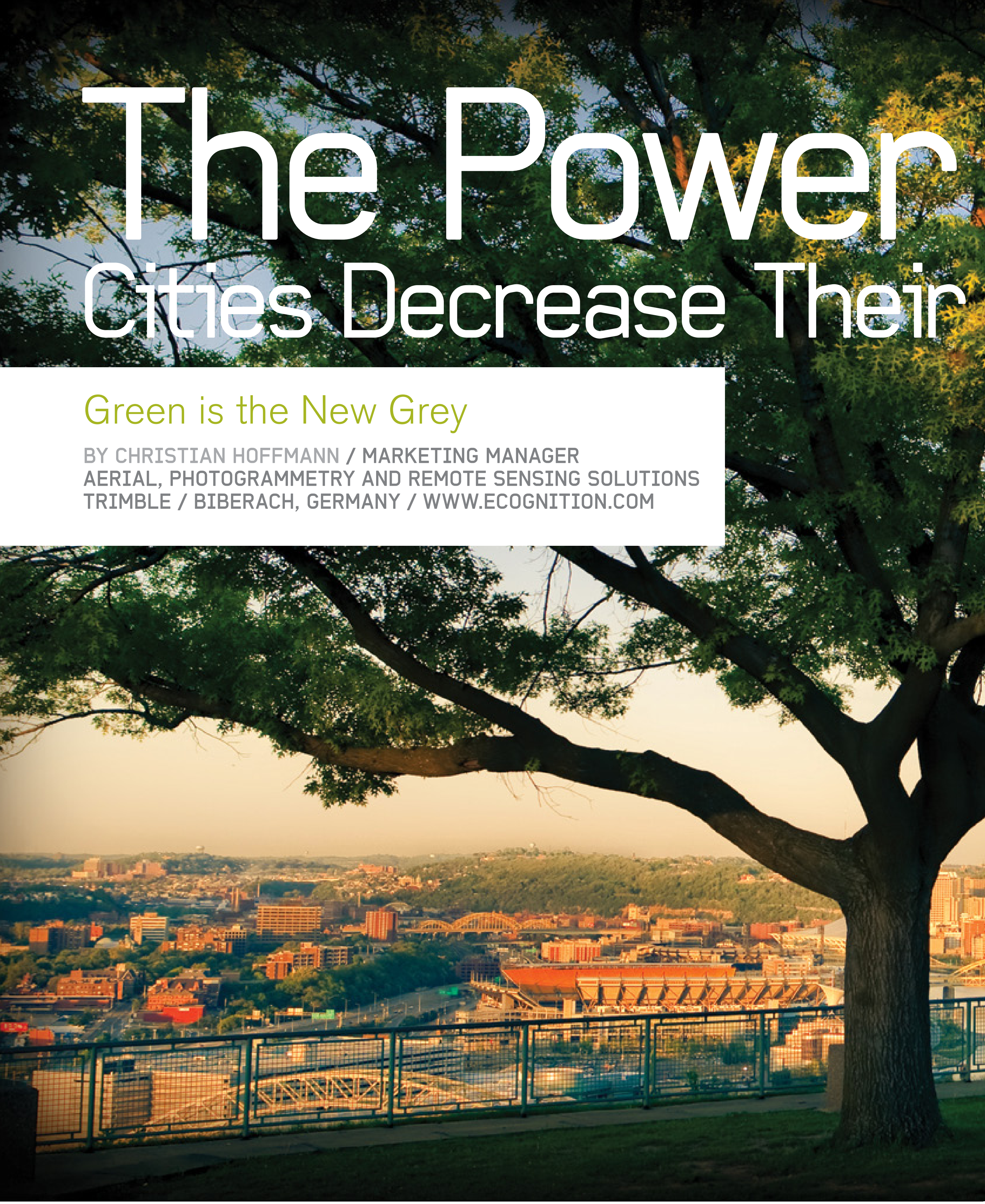
For DigitalGlobe's Maps API, Mapbox hosts imagery on behalf of DigitalGlobe and serves it out via its API. "Mapbox is a foundation for all the other platforms," says Irwin. "They own the curation of the imagery that is being served out over the APIs and the entire experience around integrating that into other tools, such as GBDX. It is something that we built and serve in the background but feels like a DigitalGlobe experience to a user. Mapbox has the platform and DigitalGlobe has the data and putting the two together just made sense."

People use Mapbox's ability to host and manipulate imagery on platforms for things like time-series comparisons for tracing and feature extraction from imagery into vector data. While the company is not working on a massive automated feature extraction pipeline, Irwin points out, its Maps API work with DigitalGlobe allows users to push a large amount of imagery to a platform like GBDX very quickly, without requiring a lot of spatial format manipulation. "We focus on enabling those kinds of analyses, rather than on building the actual operator that would perform that kind of work."

While Mapbox does not provide a viewer similar to Google Earth, its GL and WebGL framework underpin most of the globe-based technologies, says Irwin. "You can absolutely take Mapbox raster or vector tiles and wrap them on a globe. There are some commercial implementations that use Mapbox and Cesium." Irwin describes a tool chain that begins with DigitalGlobe's WorldView-3 beaming down 30-cm imagery of Central Africa; those pixels, as geoTIFFs, are then pushed through DigitalGlobe's processing tools and then into Mapbox's imagery pipeline. "We turn that into tiled maps, which are hosted on our infrastructure and served through our APIs. Some Cesium users point their globe implementation at those APIs and suck in these tiles and overlay them on a Cesium globe that is using Mapbox terrain for elevation or Cesium terrain for elevation. That's a really good example of how those three technologies play together. We just think of ourselves as the geospatial plumbing."

GBDX, Cesium, and Mapbox are very different but complementary platforms. They are making geospatial data and technologies accessible to an ever-growing number of users. As this series continues, we will explore additional geospatial platforms, capabilities, and use cases.

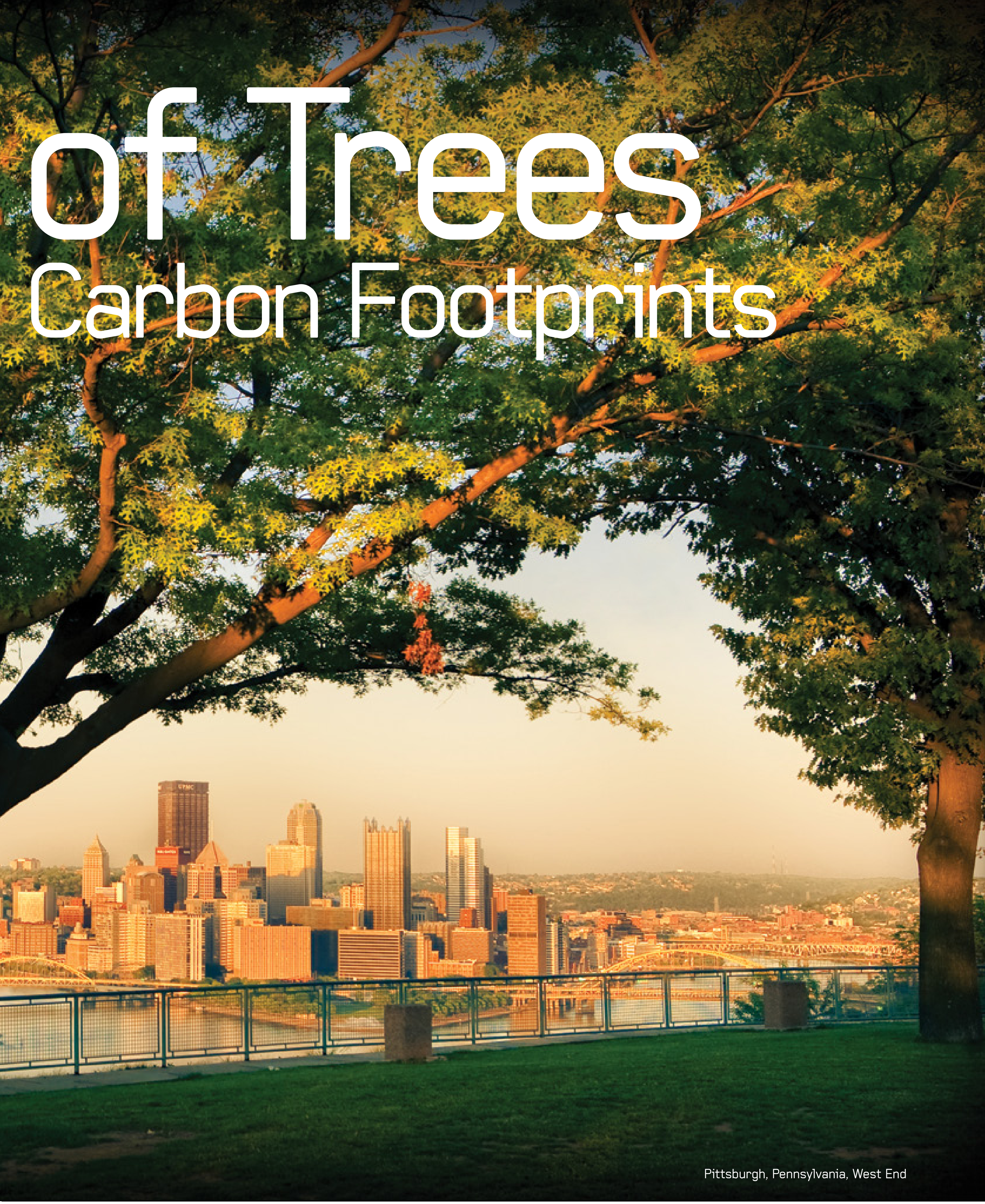
The Power Cities Decrease Their



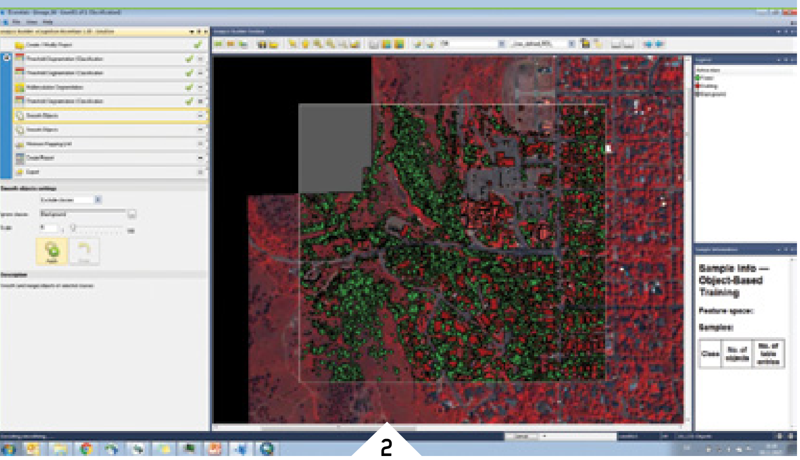
Green is the New Grey

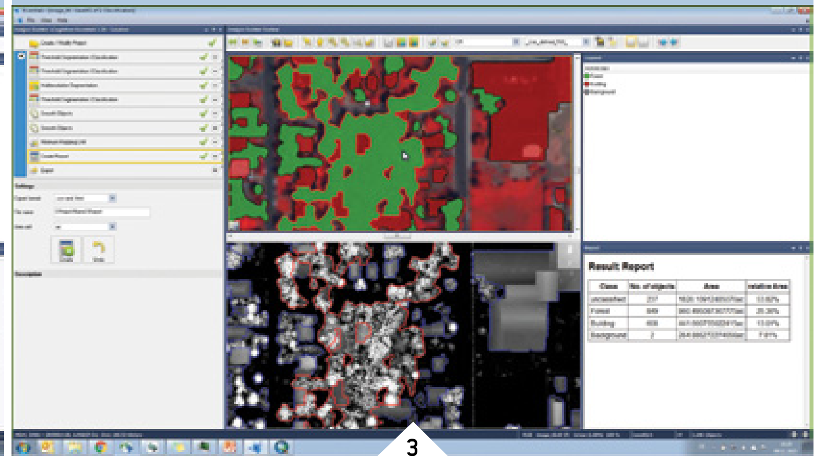
BY CHRISTIAN HOFFMANN / MARKETING MANAGER
AERIAL, PHOTOGRAMMETRY AND REMOTE SENSING SOLUTIONS
TRIMBLE / BIBERACH, GERMANY / WWW.ECOGNITION.COM

# of Trees
Carbon Footprints



Pittsburgh, Pennsylvania, West End

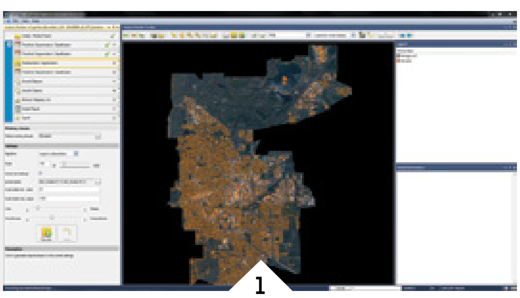




Natural resource management in cities is a tough gig.

Managers have to plan for the health and longevity of their city's green infrastructure, while Mother Nature constantly and unpredictably threatens the city's natural resources. With climate change producing ever more environmental challenges and stressors on cities' infrastructures, smart strategies for natural resource management have never been more critical for building resilient cities. Fortunately, managers in most cities have access to an untapped resource: Trees. Proven multi-taskers, trees have nearly 350 million years of experience in strengthening urban foundations.

Indeed, maintaining or increasing a city's urban tree canopy (UTC) can provide myriad benefits such as improving air quality, absorbing carbon dioxide, lowering the heat island effect, and reducing storm water runoff.



▲ FIGURES 1-3. Screenshots of eCognition, preparing the Boulder UTC

Over the past decade, many U.S. cities with visionary leaders who recognize the economic, environmental, and emotional benefits of trees, have launched ambitious tree-planting initiatives designed to make "green the new grey." Including the UTC as a strategic part of a natural resource plan is key, but to do so, city leaders and managers must first know the location and condition of their green infrastructure. Trimble's eCognition® software integrates geospatial imagery and GIS datasets, and analyzes the data to produce land-cover classifications of specific object types such as trees or buildings. These detailed assessments can enable cities to answer the "how much tree canopy do we have" question—core information needed to effectively design smart environmental programs.

MANAGING TREE CANOPY IN BOULDER

One city that recently asked that same "how much" question is Boulder, Colorado, a city that knows a thing or two about being resilient. In April 2016, the city released a Resilience Strategy, which in part, sets out an ambitious climate commitment plan to reduce its carbon emissions 80 percent by 2050. Both maintaining its existing tree canopy and strategically increasing it are two ways to help achieve its goal.

According to the city, Boulder's urban forest provides nearly $5.2 million in annual environmental, economic and social services benefits to the community, including air quality improvements, energy savings and stormwater runoff reduction. However, its urban tree canopy is also under threat from climate change impacts and the onset of diseases and exotic pests. Of particular concern are Boulder's ash trees, which make up 20 percent of its urban forest, and are the prime target of the invasive Emerald Ash Borer (EAB) beetle. Due to warming climate, these pests do not freeze during the winter, as they have in the past. The city estimates that 40 percent of Boulder's ash trees will be infested with EAB in 2016 and, if left untreated, 100 percent of its ash trees will be infested with EAB in 2020.

Given these factors and the need to develop a more robust set of urban forest management tools, Boulder partnered with Trimble and DigitalGlobe to determine a baseline UTC—the first step to advancing their tree-canopy development and management strategies.

Using DigitalGlobe WorldView-2 satellite imagery and existing LiDAR data, Trimble's eCognition Essentials software automatically classified and mapped Boulder's green infrastructure—down to the individual tree—giving them an accurate picture of their tree coverage citywide. This UTC assessment not only shows tree locations and coverage, it reveals how much potential tree canopy could be added. With this baseline, Boulder can begin to prioritize future management plans and track green infrastructure changes, whether those changes are losses due to EAB infestations or gains through green infrastructure improvements.

In addition, with the targeted training provided, managers gain the knowledge to create a repeatable image-analysis system to continually monitor and measure the effectiveness of their urban forest betterment plans.

Boulder is the latest to join a host of other cities including New York, Pittsburgh and Washington D.C. that have also used eCognition to accurately classify and map, as well as continually measure, their UTCs.

NEW YORK CITY

For New York, that critical, visual information enabled NYC Parks' managers to develop a strategic tree-planting model to help meet the city's "MillionTreesNYC" initiative by 2017. With the help of their UTC assessment, managers were able to identify streets and parks with tree deficits, prioritize planting campaigns and plant entire blocks of trees at a time. All of that effort culminated on Nov. 20, 2015, when city leaders planted the MillionTreesNYC initiative's one millionth tree in Joyce Kilmer Park two years ahead of schedule—adding one million trees to an urban forest that already boasts five million trees.

PITTSBURGH

Pittsburgh's UTC analysis has been a boon to Tree Pittsburgh, a local advocacy organization committed to extending the city's tree coverage by 20 percent in 20 years.

Although Pittsburgh's estimated UTC is 42 percent—higher than leafy Portland—it is a misleading number because large swaths of trees are on steep hillsides and are not doing the work of reducing storm water runoff and shading homes. The UTC analysis provides the intelligence to help resolve this imbalance.

Incorporating the UTC analysis with other tree-related data, Tree Pittsburgh created its urban forest master plan in 2011 to serve as a roadmap to effectively and proactively manage and grow the city's tree canopy. With such a tool, the organization has transformed their former plant-by-request model into a pre-planned, targeted approach to address tree inequities, as well as to energize public and private groups, businesses and property owners to help blanket the city in green.

WASHINGTON, D.C.

An eCognition-based UTC has also been a core source of intelligence for Casey Trees, a tree advocacy organization in Washington, D.C. that is striving to help the District achieve a 40-percent tree canopy goal by 2032.

From its peak of 50 percent in 1950, the former "City of Trees" has lost 2.5 percent of its tree canopy every decade. Based on the UTC assessment, Washington's tree coverage is 36 percent, but

◀ **FIGURES 4-5.** Data for Boulder's UTC

▲▼ **FIGURES 6-7.** Final Urban Tree Canopy for Boulder, Colorado

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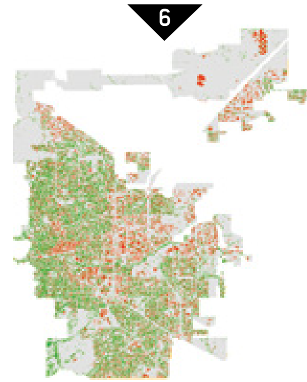
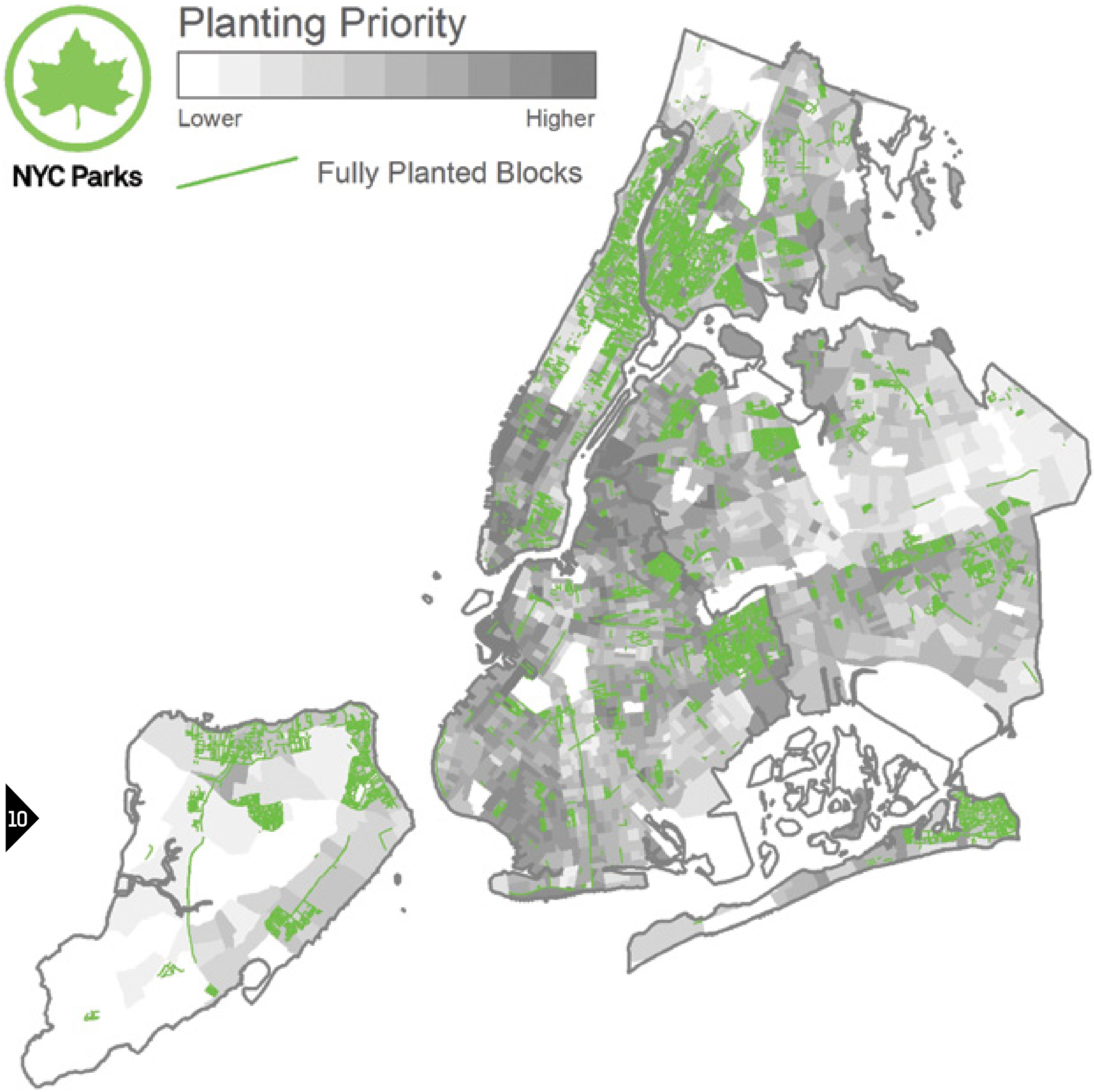
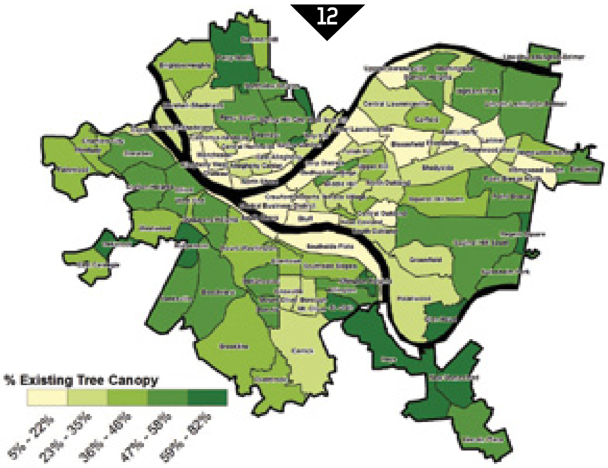




▼ FIGURES 8-9.
Before (2008) and after (2012) photos of NW corner of Post Avenue and Academy, in New York City

▶ FIGURE 10.
Prioritization Block Plan of New York City



its impervious surface coverage is 41 percent. The District aims to rectify this inequity.

To achieve D.C.'s tree canopy target, existing trees need to be preserved and new trees must be planted—216,300 total or 8,600 trees annually. Aided by the UTC analysis data, Casey Trees in partnership with government groups, have planted more than 48,400 trees since 2008, and devised maintenance strategies to protect its existing green landscape.

Although Boulder, New York, Pittsburgh and Washington D.C. all came to the tree-canopy table with diverse needs and goals, they are united in the benefits they glean from having UTC baselines; UTC baseline data enables each city to continually measure how well their green initiatives are helping them create a more resilient landscape.

Detailed, accurate UTC datasets not only provide planners with the tools they need to devise efficient, tactical greening strategies to maintain and better their canopies; they can help to strengthen the city's overall resilience against future shocks and stresses. That's smart. That's creating resilient cities.

▶ FIGURE 11. Pittsburgh, friends planting trees, as part of Tree Pittsburgh

◀ FIGURE 12. Pittsburgh, Pennsylvania Neighborhood Tree Canopy Map

▼ FIGURE 13. Residential area of Washington, D.C.

Synergy

More than ever before, companies are developing solutions on Open Source technology, or they're opening up their APIs for others to build upon in order to make their own software better. It's often an easy, cost-effective way for organizations to broaden their capabilities, without reinventing the wheel—or bringing on more resources to expand upon said wheel.

Esri and Voyager Search have successfully taken advantage of Open Source technologies and open APIs to form a mutually beneficial, synergistic relationship. As the world leader in geographic information system (GIS) solutions, Esri connects Fortune 500 companies, national and local governments, public utilities, and tech start-ups with maps, data, and apps through GIS.

Voyager Search focuses on geospatial technology by providing the connective tissue between various GIS systems. Voyager Search builds a COTS enterprise search engine that makes GIS data and services discoverable and manageable across the enterprise.

Editor's Note:
Other options for geospatial search and discovery include MarkLogic, HP Autonomy, and the Google search appliance. This article does not compare and contrast all services.

The company leverages the power of Solr/Lucene to create a catalog of data stored in stovepipe systems so that they can be found from a single, unified search interface. Voyager can index some 1,800 different formats—map data, imagery, PDFs, databases, map services, Excel files, Word documents, videos—and seamlessly access those items regardless of whether they are stored in the cloud, a database, a content management system, a server, or on the file system.

PUTTING SYNERGY TO WORK

Esri's Open Standards and open access to its APIs for their customers, coupled with Voyager's ability to search for just about every type of content imaginable, enables our two companies to intersect seamlessly in several ways, resulting in beneficial capabilities for customers who have both Voyager Search and Esri software.

Voyager can index all of Esri's content, which includes everything from vector data, raster imagery and LiDAR files, to the rows of shapefiles and Geodatabases, to web services and repositories of content like Esri's ArcGIS Online and Portal for

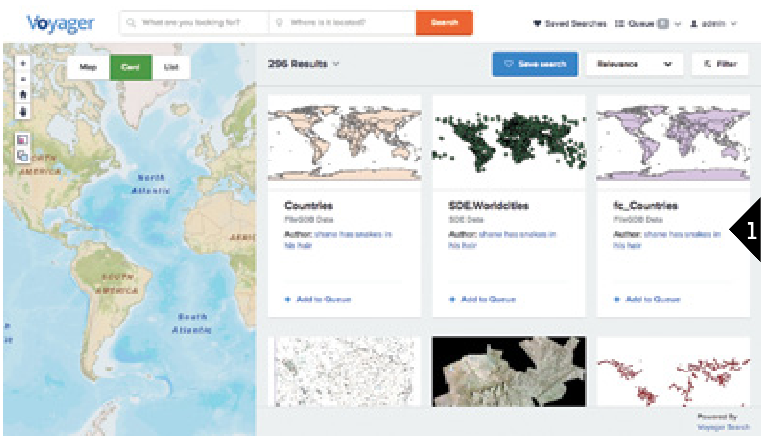
The Most Important Word In Technology Partnerships

BY BRIAN GOLDIN / CEO/CO-FOUNDER / VOYAGER SEARCH
REDLANDS, CALIF. / WWW.VOYAGERSEARCH.COM

ArcGIS, two of its signature products. Basically, whatever way people store their content, Voyager can index it and show relationships between the parts. For example, in the case of an ArcMap document or ArcGIS Online map, each of which is composed of layers based on web services or other data, Voyager recognizes these inherent relationships (among maps, layers and data) during indexing, enabling Esri users to understand the composition of their work and to repurpose existing layer configurations to save time. Data managers are now able to understand which datasets are being used more frequently so they can ensure people are accessing the most up-to-date information at all times—all within a single point of search across all of their content.

For any organization, but especially those that are large or that lack tight controls for how they store data, it takes a long time to figure out what they have and how to access it. Many companies have different departments, or groups, and each has its own infrastructure. This means individual departments have different ways of sharing and storing data and services.

By installing Voyager in each location, Esri customers can index all of the content in that office, whether it is in another city, state, or international location. Each office will then have a local index of its content that a team can use to find, share and utilize its data, and Voyager can easily link the indexes together from all of the offices to deliver a single point of search across the entire company, regardless of where the content is stored.



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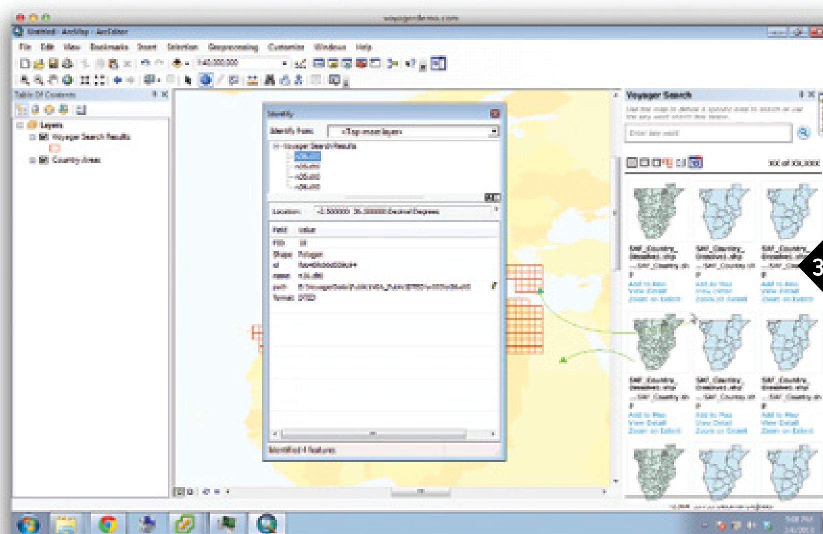
▲ FIGURE 1. Voyager Search results

▲ FIGURE 2. Voyager Search results detail page

EXPANDING THE INTEGRATION

Over the past year, Voyager has done a lot of integration with Esri's software, which includes everything from widening what we can index to supporting large distributed systems based on Esri deployments. One example includes adding a search feature inside Esri's ArcMap product. This enables people to search for content that might be applicable to their project while working on a map within ArcMap. They can query the whole corporate catalog and see what they find right in the application—never having to leave it to search elsewhere. As soon as they find what they need, they can then click to learn more and then add it to their project. If by chance they change their minds, they just click on 'remove,' and it's gone.

Another capability Voyager has created for Esri users is the ability to search within Esri's ArcGIS Online and Portal for ArcGIS. Within this Web mapping environment, Voyager's integration is twofold; first, as organizations increase their adoption of ArcGIS Online and the on-premise version of Portal for ArcGIS, Voyager is able to link all of these instances together by use of Esri's open APIs to index them into a single catalog, providing a single point of search. Second, Voyager has built on Esri's APIs to deliver a search widget for querying any of its corporate data from directly within the ArcGIS Online or Portal for ArcGIS Web-based map. This provides the ability to freely search any and all data, not just what is stored within that particular instance of Portal ArcGIS or on ArcGIS Online.



▶ **FIGURE 3.** Add-In for Esri's ArcMap within Voyager Search

Once an organization leverages Voyager to build a catalog of their data, they can use a traditional shopping cart experience to download and interact with their content. This is enhanced through integration with Esri's geoprocessing environment. Further, through the use of Esri's open APIs, customers are able to take Esri's existing geoprocessing tools, as well as new ones that they create, and use them to run tasks on the content of their cart, such as data, Web services, files and even rows in database tables. Example tasks can range from converting from one format to another; clipping data to obtain a small, more manageable subset; mosaicing data together; and fixing or replacing broken data sources (often a frustrating and labor intensive process); to running analytical models on select search results. People spend a lot of time building models within Esri's platform, but in order to run them, they need input data. Voyager allows them to find the content, add it to a list, and execute Esri's processing task—streamlining the process of how they use Esri's geoprocessing modeling tools and making them more accessible to the broader organization.

DRIVEN BY CUSTOMER DEMAND

With Open Standards and open APIs being such an integral part of how we do business, the interesting thing to note about Esri and Voyager Search's working relationship is that there wasn't a formal discussion between our two organizations in terms of who would build what. The driver to create these solutions was simply a matter of understanding customer needs and then mapping those needs to a synergistic use of each organization's APIs. That's the key to what makes this relationship work so well.

By putting the need to address specific user necessities as the focus of our working relationship, Voyager has helped Esri's customers benefit from the investment they've made in Esri's platform and assisted in their efforts to understand the breadth of all their content. This includes determining where they have duplicate data, finding ways in which they can improve efficiencies, and enabling employees to focus on their jobs, versus spending time looking for data.