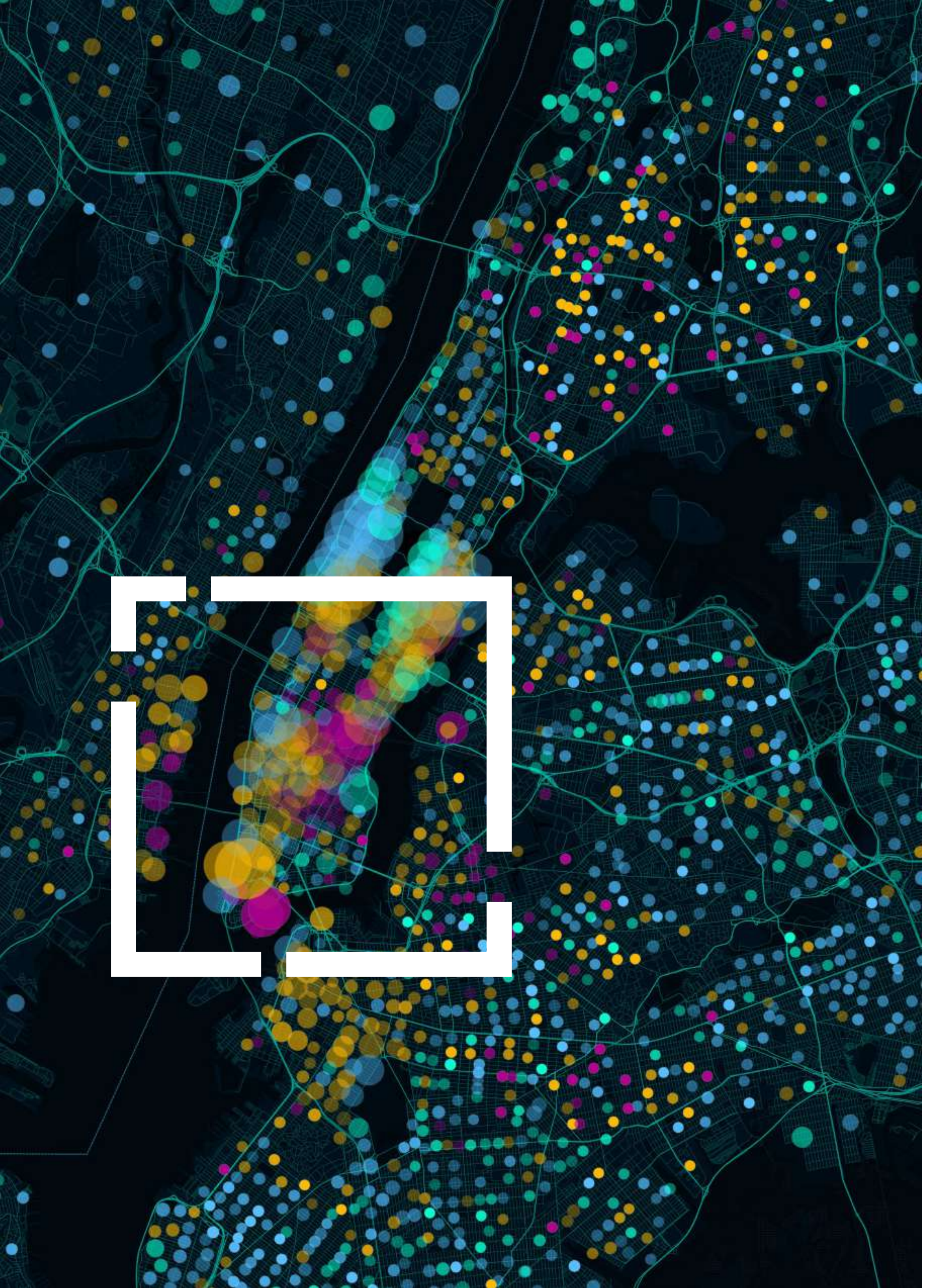
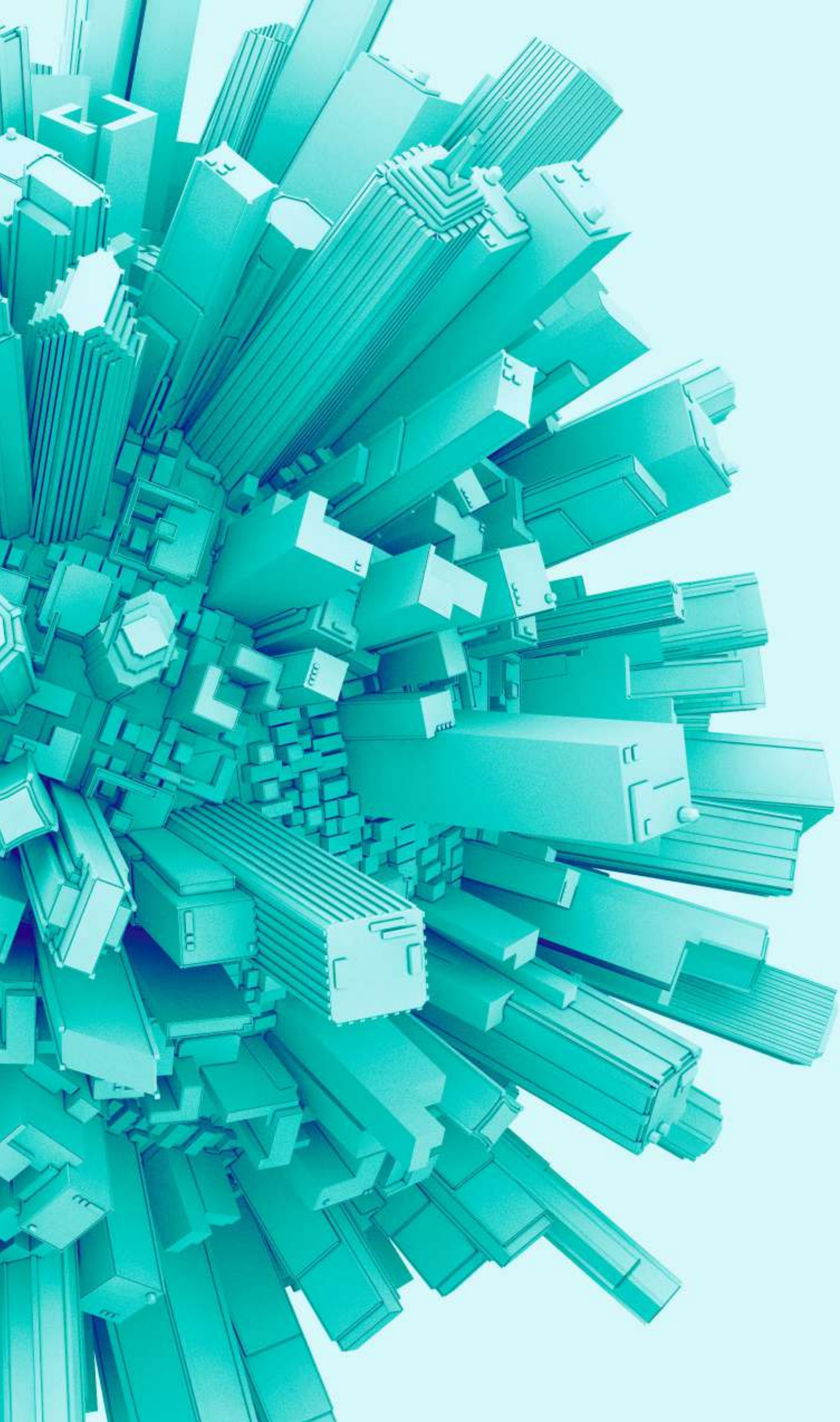
MODEL SOLUTIONS FOR THE REAL WORLD USING LOCATION INTELLIGENCE: SMART CITIES

Geospatial Technology Enables Leaders and Planners to Solve Problems, Realize a Better Future

esri THE SCIENCE OF WHERE®



WHAT'S INSIDE



Executive Summary

Solve Problems Holistically with Geospatial Infrastructure

The Big Idea

In creating impactful smart community solutions, engineers and planners are embracing geospatial infrastructure and all the insights that come with it. Geospatial infrastructure takes geographic information system (GIS) technology to the next level. It's a combination of content, mapping, analytics, and integration that enables holistic problem-solving and data-driven decisions.

Why

Smart communities make the lives of their residents better through technology. Rather than looking to a single application for making a community "smart," planners are now utilizing GIS and complementary technologies—the Internet of Things (IoT), artificial intelligence (AI), and more—that can holistically address multiple issues. Equipped with the right tools, planners can make better decisions that lead to better outcomes, not only for improved livability and convenience but also in terms of deeper social connection and stronger economic development.

The Details

All smart communities share four technology tenets, which are based on the following: planning and engineering, operational efficiency, data-driven performance, and civic inclusion. In this e-book, we'll examine each of these and share success stories as examples of best practices that can be replicated in your own smart community planning efforts. ■

SECTION 1

PLANNING AND ENGINEERING

Use Geospatial Infrastructure to Enable Better City Planning

Planners and engineers face new opportunities to shape the future of communities each day by employing transformational technologies and processes. Putting forward-thinking ideas into action requires a collaborative effort among government agencies, businesses, and residents guided by authoritative data and visualization.

Overall, smart approaches bridge the divide between technology and the ways that communities build for the future. When communities learn and adapt with data-driven workflows, they deliver intelligent infrastructure design that supports urban mobility, resiliency, and sustainability. This is critical because the decisions made today will affect communities for generations to come.

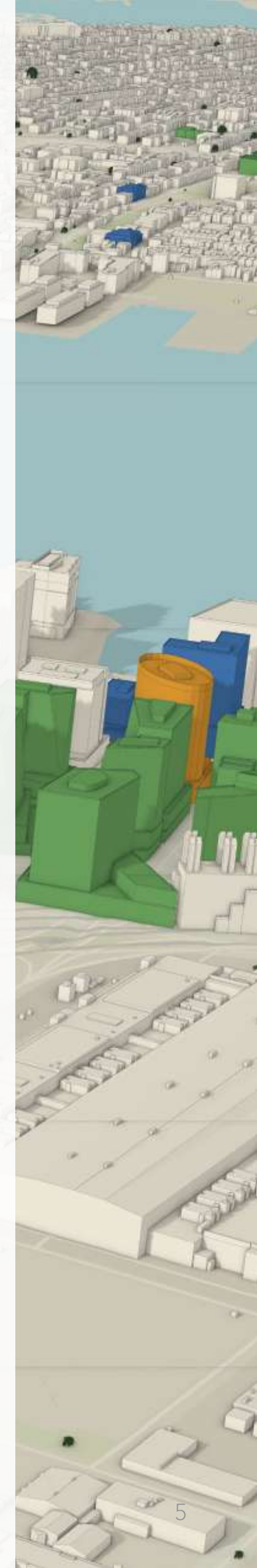
Geospatial infrastructure elevates planning and engineering by empowering communities to balance the needs of people, infrastructure, and the environment in a collaborative and evidence-based manner. Having a location-centered view of a project is crucial to meeting residents' needs, whether in deciding how to design a new stretch of roadway or determining where to place public parks. ▸

With the combined tools, planners can see a 3D model in context before they break ground—which can prevent rework and cost overruns.

Section 1 (continued)

To achieve these outcomes, architecture, engineering, and construction (AEC) firms must adopt solutions that support integrating data about people, networks, and the environment. When 3D design tools are combined with location intelligence, a project gains real-world context, and it becomes easier for planners to visually communicate the proposed and potential impacts of zoning changes, new construction, and other planning and engineering efforts. Likewise, when a plan is created within a collaborative and interactive GIS environment, government customers, residents, and business owners can better understand the implications of those plans and provide meaningful feedback.

Advanced technology is now enabling 3D building information modeling (BIM) to be integrated within a 3D GIS environment, creating a geographically anchored digital twin of any project or community. GIS helps stakeholders see a project modeled with interrelationships such as terrain and structures around proposed project sites, including underground utilities. BIM provides a detailed 3D view of the structure being built. With the combined tools, planners can see a 3D model in context before they break ground—which can prevent rework and cost overruns. ■



SINGAPORE

With an area of 722 square kilometers (279 square miles) and a growing population that stands at 5.5 million residents, the island city-state of Singapore needs to make use of all available space. The country's meteoric rise from low and middle-income nation to upper middle-income economy has meant that economic growth has far outpaced land growth. As a result, Singapore has been forced to get creative in making the most of its limited resources and landholdings.

Since its independence, Singapore has rallied around long-term plans to chart housing, job development, and infrastructure investments. These plans have focused on maintaining green spaces, recycling waste materials, and adapting to changing conditions. The recently added vertical gardens, called supertrees, have become iconic structures that symbolize this green country while increasing shade and adding oxygen.

Singapore's integrated map system, called OneMap, informs development plans and daily government operations. Singapore Land Authority creates and manages this centralized mapping platform using GIS technology. The platform acts as a point of truth about what is where in the country, delivering location-as-a-service data to a large number of purpose-built government and resident-oriented applications. A recently released mobile app for residents delivers live traffic feeds and routing, including highlighted walking routes that are sheltered from the frequent rains.

Singapore's living digital twin effort marks an important marriage of GIS and BIM data, integrating planning and construction documents within the broader context of the country. This project is progressing, using pilot tests to see how microwaves travel through high-density areas and thus detect gaps in cellular network coverage, and to model natural phenomena such as sea level rise and flash floods. ■

SECTION 2

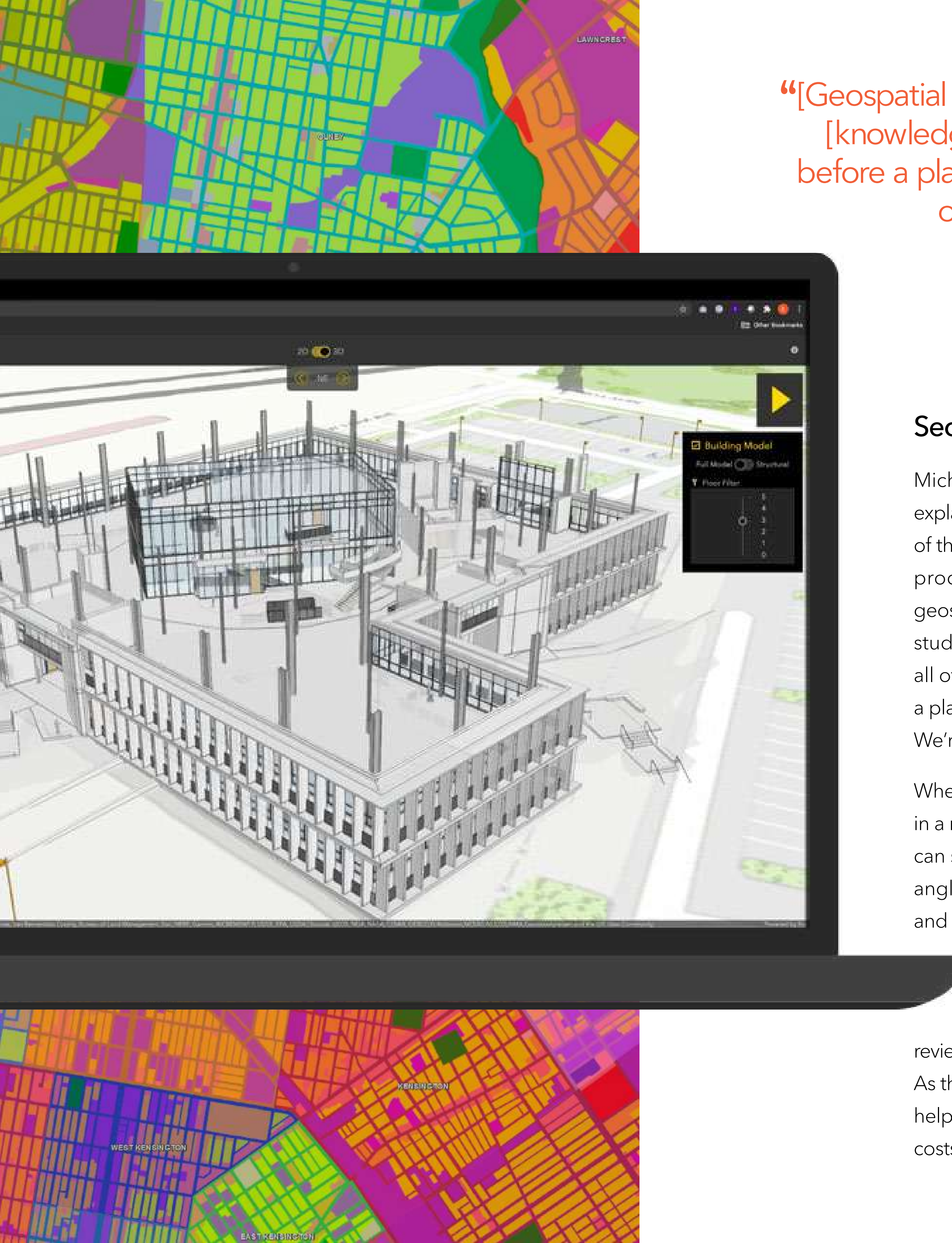
OPERATIONAL EFFICIENCY

Plan for Contingencies, Avoid Surprises

Between 10 and 25 percent of project costs are tied to errors, according to a 2017 study of the construction industry. This includes direct and indirect costs plus unmeasured costs. Upon further investigation, researchers discovered that many errors are rooted in the planning process, not the construction phase. Causes include late design changes, poor communication, and lack of coordination.

Smart communities make the lives of their residents better through innovative, groundbreaking technologies. Doing something that has never been done before is, by design, a risk. Even though errors may not emerge until the construction phase, the responsibility to ensure that smart community solutions are intelligent, data-driven, collaborative, and contextual falls on planners.

Traditionally, AEC firms would put large contingencies on projects and address problems as they emerged. But now, projects are getting larger and the planning process is increasing in complexity as the problems threatening communities become more complex themselves. Climate change, poverty, population density, and aging assets are just a few of the multilayered challenges that demand sophisticated solutions. Teams are tasked with solving these problems with smaller budgets; fewer contingency funds; and rising expectations from clients in terms of sustainability, resiliency, and level of personalized service. Failure to adopt modern, data-driven processes very early in the planning process leaves enormous opportunity for errors later in the project as well as the risk of not meeting customers' expectations. ▶



> **"[Geospatial infrastructure] enables us to bring all of that [knowledge] together and create real-world scenarios before a planner has even thought about doing any sort of detailed designs. We're de-risking earlier."**
>
> –Michelle Watson, Global Director of Geospatial Solutions, Jacobs

Section 2 (continued)

Michelle Watson, global director of geospatial solutions at Jacobs, explains how an intelligent geospatial approach can help mitigate many of the risk factors AEC firms traditionally expect during a design/build process. "I think the reason people are starting to take notice of geospatial [infrastructure] is it's not only enabling data-driven baseline studies within individual disciplines, but it also enables us to bring all of that [knowledge] together and create real-world scenarios before a planner has even thought about doing any sort of detailed designs. We're de-risking earlier."

When BIM and GIS are combined, a 3D model can be firmly grounded in a real-world context, enabling a smarter planning process. Planners can stand virtually in a location and see a proposed project from any angle, within the environment it will inhabit. Thus situated, designers and stakeholders can see the internal and external context of buildings during the conceptualization stage. A 3D model also provides a digital project environment that is inherently collaborative, allowing cross-functional teams and external stakeholders to review plans and provide feedback at every step of the planning process. As the single source of truth for a project, geospatial infrastructure can help teams cut down on the errors and redundancies that lead to rising costs during construction. ▶

Section 2 (continued)

Planners can also use a geospatial approach to see beyond a project checklist. It can help teams decide if repairing an aging bridge is actually the right solution for a community. Are people using the bridge as it was originally intended? Should it be replaced with a bridge that also has pedestrian and bike paths? How about one that also allows public trains to cross? In the case of operational maintenance, GIS can overlay operational data to make a connection between a repair punch list and the underlying root cause that's otherwise impossible to see.

"There's so much more data available now to really make sure that you're solving the right problem at the right time," says Watson. "We're now able to optimize outcomes, instead of a traditional linear approach where we just plugged away at the problem. I think you've got to take a step back sometimes to really understand all of that interconnectivity. The information gained through geospatial infrastructure allows us to create more sophisticated solutions and increases confidence that the decisions that we're making are the right ones." ■

CASE STUDY

LONDON

London has experienced incredible growth during the last three decades. Between 1997 and 2016, the city added 1.6 million jobs and the population grew by 1.7 million. During the same period, just 470,000 homes were added, creating a painful housing crisis in the city.

Lately there has been a record amount of building happening in the city, but recent audits have shown that just 13 percent of the new homes that receive planning permits are affordable. To turn this around, the mayor secured £3.15 billion funding to build affordable homes, with plans to add 90,000 homes by 2021.

Knight Frank, the world's largest privately owned independent property consultancy, was asked to help the city come up with smart solutions. Knight Frank staff members decided to leverage GIS from a very early stage to talk through evidence gathering, establish a baseline of understanding, discover what the property portfolio looked like, and frame their goals.

The consultancy started by analyzing current site utilization to determine where new homes might be built.

"We discovered clusters of buildings in some boroughs that occupy less than 10 percent of their site," said Ian McGuinness, head of geospatial at Knight Frank. These initial findings pointed to possibilities to help ease the chronic shortage of housing, and spurred the company to conduct further analysis on the utilization of land in London. ▶

London (continued)

One solution was the redevelopment of Lords View One, which added stories to the original building to match the tallest building on its block. This successful project turned into a template for Knight Frank's housing capacity analysis. Using GIS, analysts scanned each block to see where stories could be added, finding the greatest capacity in the core of the city where heights vary within single street blocks.

In the city of Westminster alone, the analysis uncovered 13.5 million square feet of unused airspace. The current real estate value of this space amounts to £31.6 billion, providing considerable incentive for developers to add more housing in the city's core.

Using location intelligence analysis and unprecedented collaboration, Knight Frank is helping the City of London uncover hundreds of thousands of new housing opportunities. ■

SECTION 3

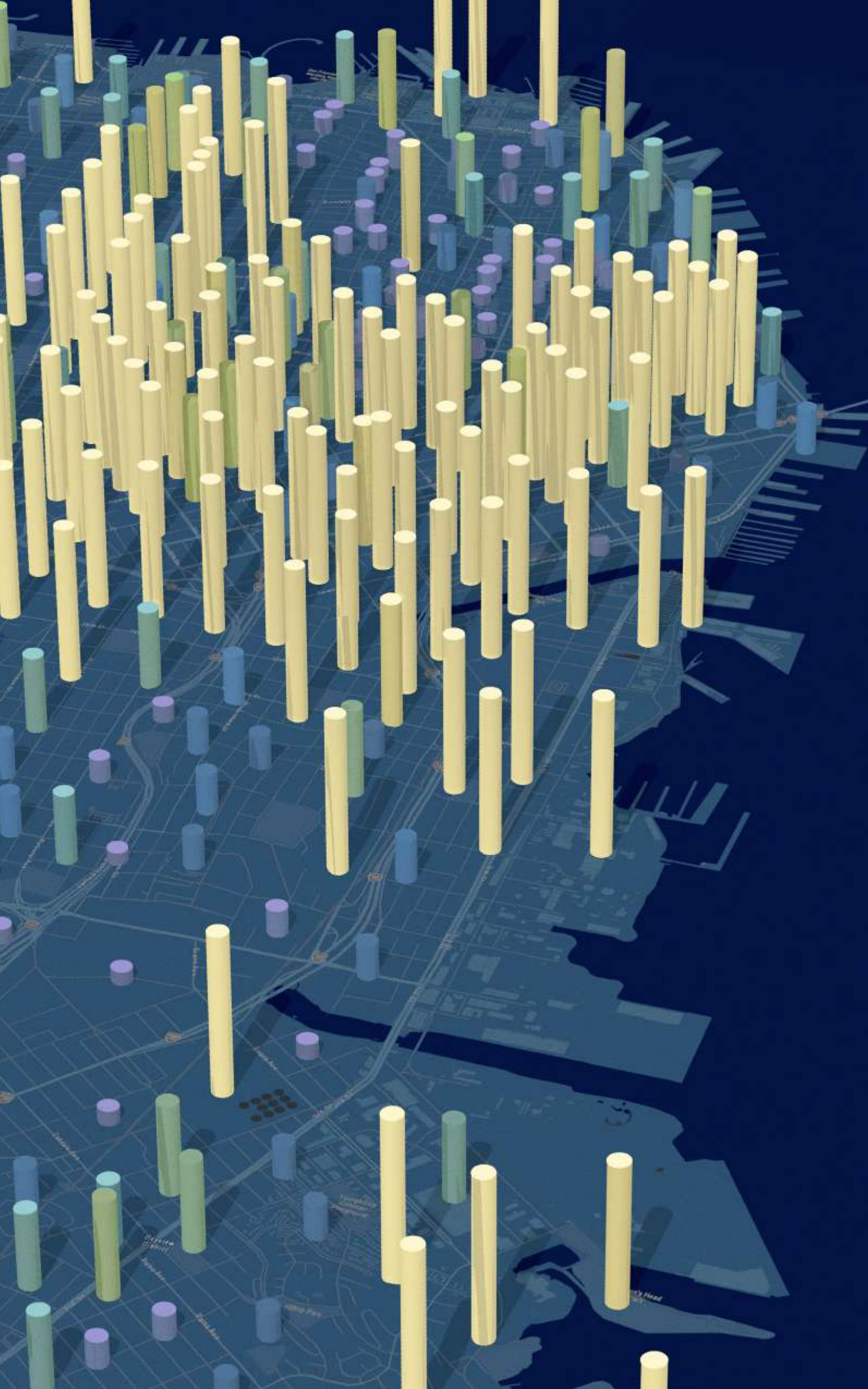
DATA-DRIVEN PERFORMANCE

Understand Why Smart Is Spatial

In recent years, the term *smart* has been applied to everything from appliances and light switches to networks and buildings—and, most especially, to cities. Initially, it was applied without much justification or explanation. *Smart* was an adjective—not a strategy—and was decoupled from results.

However, the concept of smart innovation has been evolving, thanks, in large part, to the engineers and planners creating smart solutions to complex problems. Implementing a smart strategy requires both data and technology. An integrated approach allows communities to identify priorities, improve processes, and achieve planning goals.

Smart, in the context of community planning, is associated with the use of real-time data, 3D visualization, the application of artificial intelligence to fill in data gaps, and other technologies that add automation and help optimize plans to improve the lives of residents. These technologies provide new ways to deal with challenges such as failing infrastructure, increased demands on government services, threats to the environment, and the need for social equity. ▶



The complex data needed for making a myriad of decisions is brought together by geospatial infrastructure so that it is easier to understand, analyze, and act on.

Section 3 (continued)

In community planning, location is never an afterthought. *Where* is what connects people around a project, and GIS provides context. Smart devices, the IoT, and the collaborative work of many disciplines feed data on the locations of people, nature, vehicles, and infrastructure into GIS. The complex data needed for making a myriad of decisions is brought together by geospatial infrastructure so that it is easier to understand, analyze, and act on.

Linking data with location to improve decision-making by using GIS is nothing new. The difference now is the striking increase in the amount of data that can be analyzed, incorporated, and communicated, as well as the parallel decrease in the time required to do this by using modern GIS. Real-time data harvested from mobile devices and IoT sensors can be analyzed using an ever-growing toolset, and rapidly shared with decision-makers using dashboards and other visualization tools enhanced with artificial intelligence capabilities.

GIS can also pull in lifestyle data, including current-year estimates and five-year projections of demographic data with 2,000 variables; Esri Tapestry Segmentation; and data on consumer spending, market potential, business locations, major shopping centers, traffic counts, and crime indexes.

Communities can thrive when location forms the foundation of planning and operations. ■

CASE STUDY

ATLANTA

For the past four years, Atlanta, Georgia, and the surrounding area, Cobb County, have been strategically moving down the path of digital transformation with GIS. The city's goal was to use technology to improve the way it conducts business and serves residents.

GIS was already in use in Cobb County's government because officials found that location intelligence allowed them to provide more proactive services to their constituents. Now, smart devices are part of the solution, but the county's smart community strategy is much broader and anchored firmly in GIS. Sharon Stanley, director of the Cobb County Information Services Department, said, "For us, being a smart community is [about] using technology to actually improve the lives of our citizens where they work, live, and play—anywhere where we can make it more convenient for our citizens to do things."

"Never have we had access to the kind and amounts of data we have now," Stanley continued. "It's not just about data. It's what you and I can do with that data that counts." ▸

Atlanta (continued)

Here are examples of transformational efforts that Cobb County has rolled out as part of its smart community strategy:

Planning Development–Last year, officials used 3D scenario planning to visualize new development and zoning in one of the fastest-growing economic development areas in the county. The digital twin provided real-world context for development options. The officials were able to consider traffic, the surrounding environment, road networks, and more, by building a representation of what the development would look like and how it would impact the area. Now the community development team is in the process of developing a 3D model of the entire county.

Modeling Traffic–When the Atlanta Braves professional baseball team relocated to a new stadium in 2017, it marked the most aggressive public-private partnership in county history. The county combined the powers of artificial intelligence with GIS to carry out a comprehensive traffic management plan to reduce gridlock during game days. The goal: ensure that all fans are parked before the first pitch, and return traffic flow to normal within 45 minutes after the game.

Preparing for Autonomous Vehicles–Cobb County Department of Transportation (DOT) is putting the infrastructure in place to support self-driving vehicles, which might be more ubiquitous on the road 10 years from now. The DOT is using AI, GIS, and other complementary technologies to make roads better.

Targeting Underserved Populations–Public health specialists use GIS to analyze data about the county's senior centers as well as other departments and public service agencies. Using GIS, they're able to quickly and easily communicate the work they do and show how their analyses help them understand what events resonate with the senior community and how staff can boost participation and target underserved populations. ■

SECTION 4

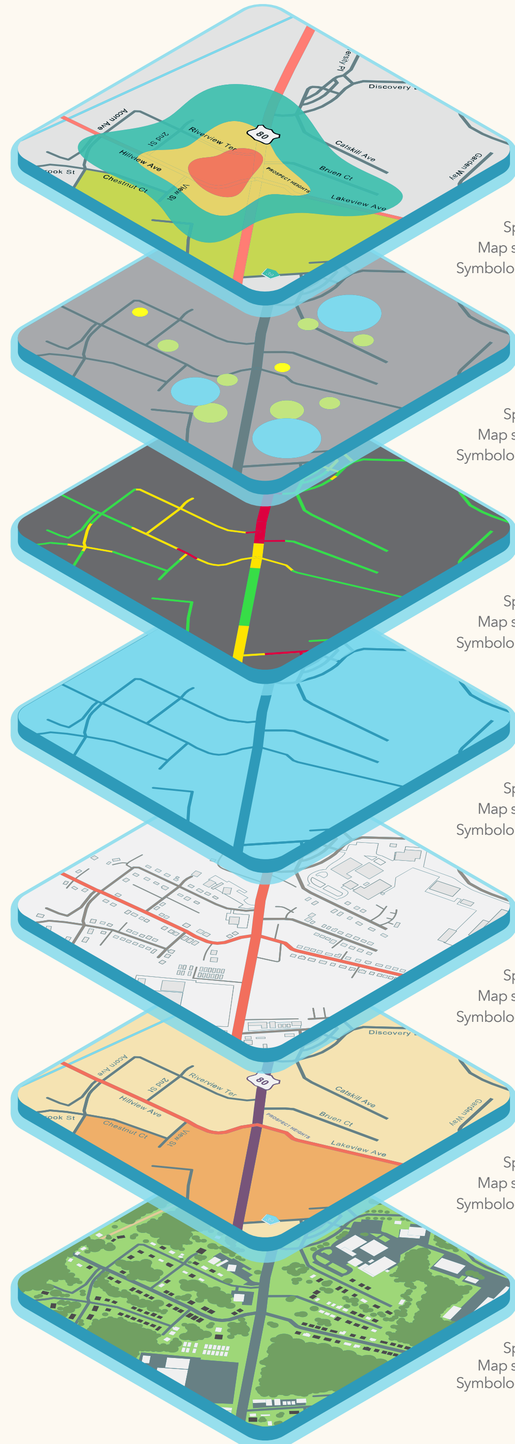
CIVIC INCLUSION

Empower Human-Centered Design

Human-centered design empowers an individual or team to design services, systems, and experiences that prioritize the beneficiary of those designs. What distinguishes human-centered design from other problem-solving approaches is its focus on understanding the perspective and needs of the person who experiences a problem, and determining whether the proposed solution is truly meeting those needs effectively.

Smart community planning is, by nature, a form of human-centered design since it strives to solve the problems faced by residents. Location plays a key role in this design process since every element of a community is centered around where current infrastructure is located, where a person has to go to use it, how a newly introduced element will affect the things around it, and so forth. Here are some examples of common questions:

- Will the traffic noise from a new roadway be audible in a nearby community baseball field?
- Are there enough electric vehicle charging stations and autonomous vehicle parking spaces strategically placed to support the needs of residents today and five years from now?
- Are residents in a certain neighborhood within reasonable walking distance of public transportation options, grocery stores, and parks? ▶



The Thematic Layers

Layer	**Navigation**
Map use	Routing, navigation, and logistics
Data source	Basemap features plus navigation properties
Representation	Edges, transfers, turns, travel costs
Spatial relationships	Topology networks sharing geometry with routes and basemaps
Map scale and accuracy	Typical map scales range from 1:24,000 to 1:250,000
Symbology and annotation	Varies with the source data product

Layer	**Point events**
Map use	Display and analyze DOT assets, activities, and incidents
Data source	Department of Transportation departmental systems
Representation	Linear-referenced point events
Spatial relationships	Point events occurring along routes
Map scale and accuracy	Based on route geometry and measures
Symbology and annotation	Typically drawn as circles colored by single attribute

Layer	**Line events**
Map use	Display and analysis of DOT assets, activities, and incidents
Data source	Department of Transportation departmental systems
Representation	Linear-referenced line events
Spatial relationships	Line events coincident with routes
Map scale and accuracy	Based on route geometry and measures
Symbology and annotation	Typically drawn as thick lines colored by single attribute

Layer	**Routes**
Map use	Display of events on DOT-maintained roads
Data source	State Department of Transportation
Representation	Polylines with measures
Spatial relationships	Should share geometry with basemaps and navigation
Map scale and accuracy	Typical map scales range from 1:24,000 to 1:250,000
Symbology and annotation	Typically drawn as thick lines colored by single attribute

Layer	**Reference layer**
Map use	A common underlying geometry for all transportation users
Data source	Multiple agencies; could be a national dataset
Representation	Lines and points
Spatial relationships	Could share geometry with routes
Map scale and accuracy	Typical map scales range from 1:24,000 to 1:250,000
Symbology and annotation	Simple gray lines as background reference

Layer	**Basemap**
Map use	Map background
Data source	Topographic maps and other cartographic data sources
Representation	Raster or vector maps
Spatial relationships	Should share geometry with routes and navigation
Map scale and accuracy	Typical map scales range from 1:24,000 to 1:250,000
Symbology and annotation	Detailed transportation symbolized by class such as bridges, overpasses

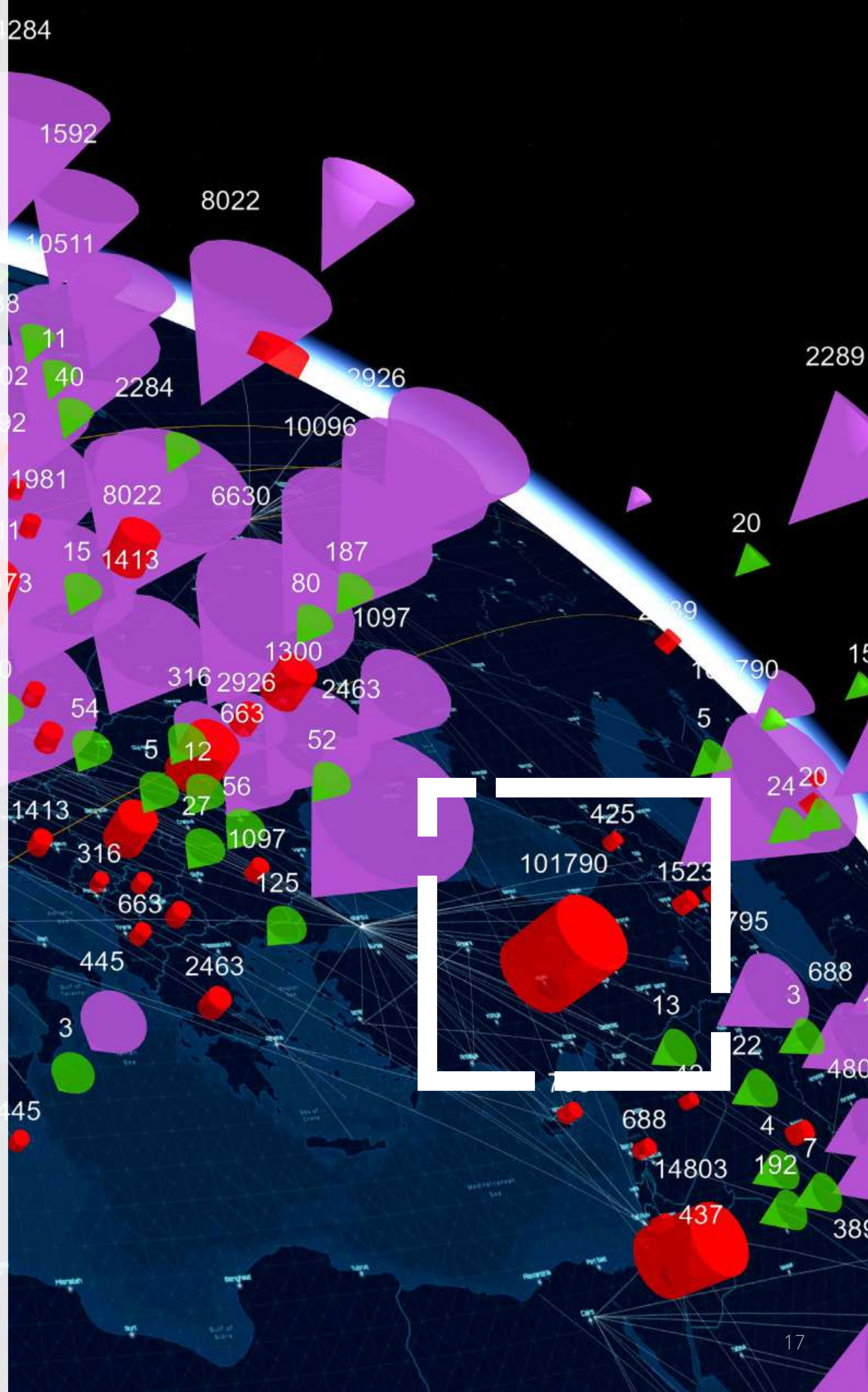
Layer	**Digital orthophoto**
Map use	Map background
Data source	Aerial photogrammetry and satellite sources
Representation	Raster
Spatial relationships	Raster cells covering the image area
Map scale and accuracy	1 to 2.5 meter cell size
Symbology and annotation	Tone, contrast, and balance of gray scale or color presentation

Section 4 (continued)

Geodesign is one sophisticated form of human-centered design. The essential component of this approach is that the design process occurs within the context of geographic space (where the location of the entity being created is based on a geographic coordinate system) as opposed to conceptual space (creating something in the imagination with no locational reference). When an entity being created or modified is referenced in the geographic space in which it resides, it means that it is also referenced in all other information relative to that space.

GIS acts as a technology enabler during this process since its capabilities go far beyond generating maps. It is also a data aggregator, meaning it can analyze and layer geographic, environmental, and societal information about a specific location from thousands of different sources, which a planner can then interact with to understand all facets of a project. Much of that data is demographic and focuses specifically on the lifestyles, movements, and everyday needs of the people who inhabit a specific place. When that data is displayed visually within a 3D rendering of a project space, planners can use it to balance the needs of people, infrastructure, and the natural environment, thus enabling geodesign.

Advanced modeling techniques can incorporate current-year estimates and five-year projections of resident data with 2,000 variables to understand the impacts of changing demographics and lifestyles. These techniques can also account for the effects of climate change and economic shifts on proposed designs. Geodesign forms the backbone of transparent and collaborative community planning by allowing stakeholders and the public to view the data-driven history of decision-making and proposed plans via easy-to-access portals and visualization tools. Collectively, this is the power of geospatial infrastructure and highlights the important role it plays in smart community planning. ■



CASE STUDY

GREATER TORONTO AREA

Brampton, a diverse and fast-growing city in Ontario's greater Toronto area, boasts a population of just over 600,000, with residents working in key industries such as retail and business services, aerospace technology, and telecommunications equipment manufacturing.

At the end of 2016, Brampton launched a sophisticated open data portal called the Brampton GeoHub, which is hosted on enterprise GIS technology. Employees in Brampton's information technology division understood that the city's data was useful for residents, developers, and city employees and wanted to improve services through transparency and community engagement. The GeoHub quickly became the one place where anyone could view and acquire the city's datasets—from asset, land-use, and infrastructure data to orthoimagery—as well as public data from the open data catalog.

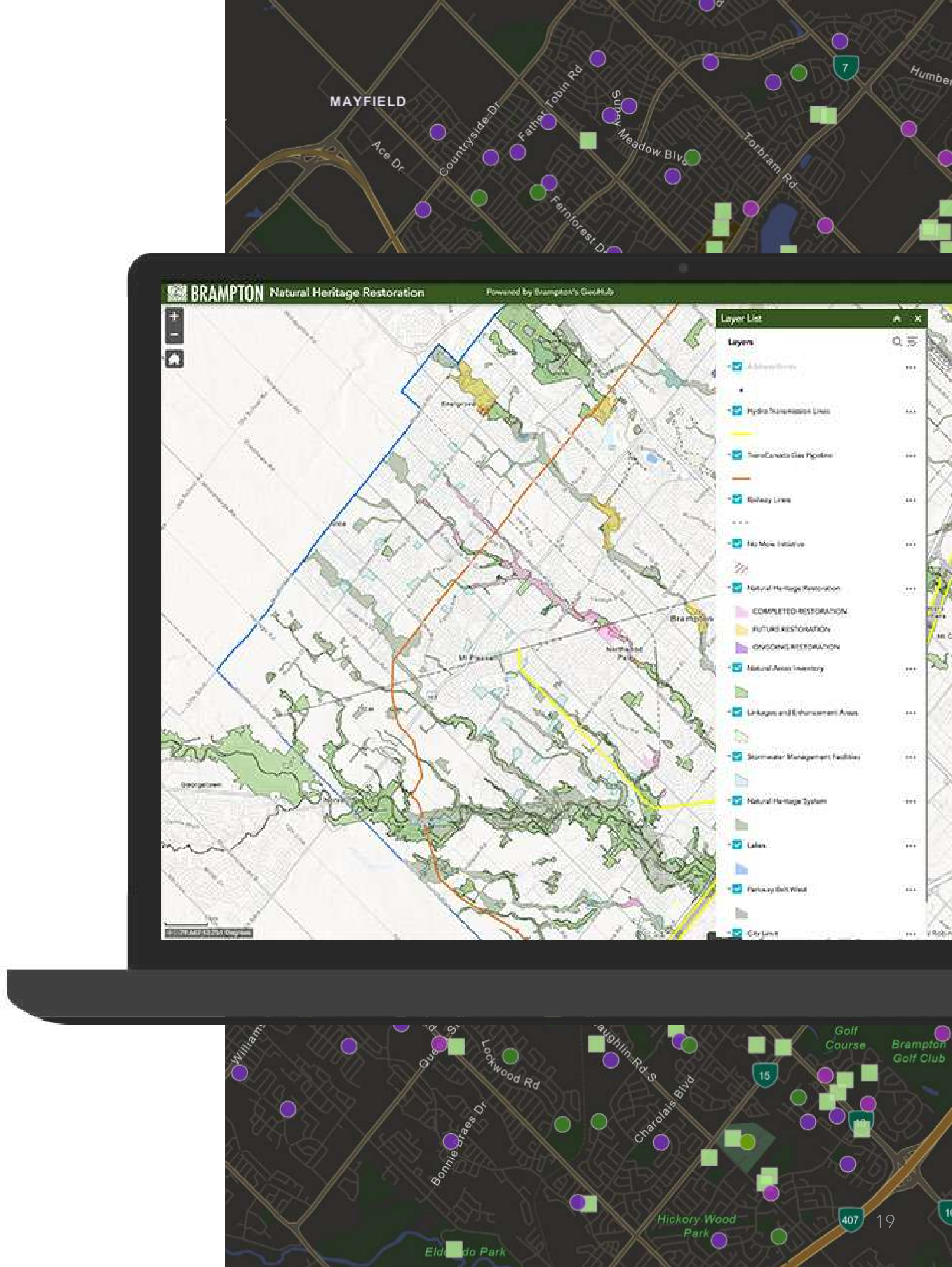
In the first year of using the GeoHub, the city saved 588 hours of staff's time by decreasing the number of data requests it received both from internal departments and from members of the public. Given that the GeoHub now has almost 300 datasets (a big jump from the 15 it started with), Brampton has virtually eliminated the need to process data requests, saving staff exponentially more time. ▶

Greater Toronto Area (continued)

"Promote your location platform everywhere—in every meeting and every hallway discussion," advised Gaea Oake, the program manager for the GIS and open data team. "Meet new people in the organization and talk about data with staff you haven't worked with in the past. Engage with the public. Data-driven governance and citizenship are gaining importance because it's a quick way to begin connecting citizens to strategic initiatives and show them that cities are aware of where they've come from, have a strategy in place, and will be held accountable for moving forward."

Next on Brampton's journey to becoming a smart community is putting its recently finished CityDashboard to good use. A public-facing performance dashboard, this online tool helps members of the community understand how the city's day-to-day undertakings produce positive outcomes. Residents can monitor categories such as Finances and Assets, Community Well-Being, and Livability and see whether the city is meeting its targets or needs improvement. In the Economy section, for example, users can see that Brampton is working to improve the jobs-to-population ratio, while under Customer Service, residents can find out whether the city is providing good-quality transit service.

"If you're going through the effort to open data, make it useful, make it purposeful, and build awareness—not only to the public, external agencies, and business but also to staff," said Matt Pietryszyn, the City of Brampton's information technology team lead for GIS and open data. "It's a great way to share authoritative information throughout the organization." ■



Learn More

Esri, the global market leader in geographic information system (GIS) software, location intelligence, and mapping helps customers unlock the full potential of data to improve operational and business results. Founded in 1969, Esri software is deployed in more than 350,000 organizations. With its pioneering commitment to geospatial information technology, Esri engineers the most advanced solutions for digital transformation, the Internet of Things (IoT), and advanced analytics.

Visit us at go.esri.com/geospatial.

esri

THE SCIENCE OF WHERE®

go.esri.com/geospatial

G1352100